# DEVELOPING VALUE ADDED AND DIVERSIFIED PRODUCTS FROM COCONUT (*COCOS NUCIFERA* L.)

BY

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## CERTIFICATE

Certified that this thesis entitled **"Developing value added and diversified products from coconut (*Cocos nucifera* L.)"**, is a record of research work done independently by **Neelofar IlliasKutty** under my guidance and supervision and that it has not previously formed the basis for the award of any degree, fellowship or associateship to her.

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# ABBREVIATIONS

| | |
|---|---|
| APPC | Asian Pacific Coconut Community |
| ARF | Amylose Rich Food |
| BOD | Biological Oxygen Demand |
| BIS | Bureau of Indian Standard |
| °C | Degree Celsius |
| CFTRI | Central Food Technology Research Institute |
| Cfu/g | Count forming unit per gram |
| CMC | Carboxyl Methylcellulose |
| COD | Chowghat Orange Dwarf (a variety of coconut) |
| CPCRI | Central Plantation Crops Research Institute |
| CD | Critical Difference |
| DMH | Dimethylhydrozine |
| FAO | Food and Agricultural Organisation |
| FPO | Fruit Products Order |
| g | Gram |
| GDP | Gross Domestic Products |
| HDL | High Density Lipoproteins |
| HTST | High Temperature Short Time |
| ISI | Indian Standard Institution |
| LDPE | Low Density Polyethylene |
| MT | Million Tonne |
| mg | Milligram |
| ml | Millilitre |
| NCIM | National Collection of Industrial Microorganisms |
| NFDM | Not fat dry milk |
| PAG | Protein Advisory Group |
| RTS | Ready To Serve |
| SMP | Skim Milk Powder |
| SNF | Solid Not Fat |
| TSS | Total soluble solids |
| viz. | Namely |
| WPC | Whey Protein Concentrate |
| % | Percent |

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# Introduction

# 1. INTRODUCTION

Coconut palm, eulogized as 'kalpaviriksha' is considered as a valuable gift to the mankind as it is a versatile source of food and drink to millions of people (Rajagopal and Arulraj 2002). Coconut is a traditional plantation crop grown in India for the last 30 centuries. Rethinam (2001) Coconut is grown in an area of 11.8 million hectares with a production of 10.26 million MT in 2002 and its products are utilised in more than 140 countries over the world.

India is one among the largest producers of coconut in the world with annual production of 12536 millions nuts from an area of 1.75 million hectares (Rethinam, 2003). The crop has significant impact on the national economy, contributing Rs 7000 crores to the GDP of the country and earns valuable foreign exchange. The southern states of India *viz*., Kerala, Karnataka, Tamil Nadu and Andhra Pradesh contribute more than 90 per cent of the country's coconut production. The average productivity of 7145 nuts/ha is the highest in the world.

According to Nampoothiri and Singh (2000) coconut is the third largest foreign exchange earner of the country and provide direct employment to approximately 0.15 million people of the state.

The importance of the coconut palm lies in the fact that not only does it supply food drink and shelter but also provides raw materials for a number of industries intimately connected with domestic as well as economic life (Shanmugavelu *et al*., 2002). It is pertinent to mention that all the parts of the wonder palm are useful to mankind in one way or other.

Small and marginal holdings, lesser-marketed surplus through unorganised marketing systems, lesser value addition and by-product utilisation are the major challenges faced by the Indian coconut industry. Of late, the stability of coconut-based economy of the major coconut producing countries especially India, has been threatened by the changes associated with trade liberalization brought about by globalisation.

In spite of the fact that India has made impressive stride in the area production and productivity, the coconut processing industry has not developed fully to cope up with increased production which is quite detrimental to the coconut based economy (Singh, 2003).

Romulo (1999) is of the opinion that coconut is projected in the world market not as an oil yielding seed but as a delicious fruit endowed with considerable health benefits. Tender coconut water contains life saving minerals and electrolytes, besides various sugars, whereas coconut kernel is potent source of carbohydrate and a rich source of plant protein with appreciable amount of fibre. Coconut oil has added advantage as a nutraceutical and possesses various therapeutic properties.

As nutrition science is moving from the concept of 'adequate nutrition to optimal nutrition, new food products which have the potential to improve mental and physical well being and also to reduce risk of diseases are being developed and promoted to a largest extent in the present context (Devi and Velayutham, 1978). Coconut can serve as an important raw material for developing such functional foods and nutraceuticals, which will flourish in the domestic and export market. Lack of modern technologies within the country for large-scale manufacture of value added coconut products is one of the major bottlenecks that lead to retarded growth of coconut industry (Pandiarajan, 2003).

Rajagopal (2003) remarked that coconut is perhaps the key resource of the state, which holds immense scope for the developing into multi purpose food products. The vast expatriate population of Keralites offers a ready market for coconut based food products as it forms an integral part dietary and culinary portfolio.

The food consumption pattern is undergoing a tremendous change in the country, as a result the demand for processed and ready-to–use packed foods enhanced to multifold.

Under the present global scenario, value addition through product diversification and by product utilisation is the major theme identified in the X plan for sustained development of coconut industry in India. It is viewed that there is a need for concerted efforts on the part of the research institutes to develop various viable technologies and to refine the existing technologies in post harvest processing of coconut. The nutritional aspects of coconut also need critical study so as to confirm the traditional claims.

Therefore the need of the hour for India is to accomplish product diversification either by development of indigenous technology or technology transfer so that the coconut based products and by-products can flourish both in the export and domestic markets.

Laying emphasis on above various facts, an in-depth investigation was taken up with the following objective.

**Objective**

To develop diversified and value added products utilising constituents derived from coconut and also visualise the assessment of organoleptic, physico-chemical characteristic, shelf life qualities and consumer acceptance of the products, in order to commercialise the same.

# Review of Literature.

# 2. REVIEW OF LITERATURE

Literatures pertaining to the study entitled "Developing of value added and diversified food products from coconut (*Cocos nucifera* L.)" are reviewed under the following titles

2.1 Coconut-A crop of human sustenance

2.2 Scenario of coconut production and productivity

2.3 Composition and nutritional characteristics of coconut

2.4 Health implications of coconut

2.5 Coconut in culinary use

2.6 Value addition in coconut and coconut based food products.

## 2.1 COCONUT - A CROP OF HUMAN SUSTENANCE

Coconut palm forms an important component in the socio-economic and cultural life of every Indian house hold (Rajagopal, 2002). According to Rethinam (2002), coconut is called as 'Tree of life', 'Heavenly Tree', 'Tree of abundance' and 'Nature's Supermarket'.

Rasotgil *et al.* (1998) stated that the word 'coco' is derived from Spanish word 'Macoco' which refers to three holes on the coconut that resemble the face of an ape.

Shanmugvelu *et al.* (2002) remarked that the importance of the coconut palm lies in the fact that not only it supplies food, drink and shelter, but also provides raw materials for a number of industries intimately connected with domestic as well as economic life. According to Aravindakshan (1995) coconut tree is one of the unique plants where each part has distinct use in the daily life of Keralites.

Thampan (1994) opined that coconut is a major component crop of the farming system in most of the small and marginal holdings of Kerala, and meet the day-to-day household requirements. According to Nampoothiri (1998) majority of people living in the coastal tracts of India depend upon coconut for their sustenance.

Rajagopal and Arulraj (2002) are of the opinion that coconut and its products have a greater stake to provide food, drink, medicines, health and eco-friendly aesthetic products to the ever-increasing population of the country.

Rethinam (2003) stated that the present global population of 6.1 billion as on 2003 is anticipated to reach 9.3 billion by the year 2050 and there will be a greater demand for food, nutrition, medicine and health foods for which coconut could play an important role.

Coconut day is celebrated every year on September 2nd, in order to make the world understand that this crop has a vital role to play in poverty alleviation, and to provide nutritional and health security (Rethinam, 2003).

## 2.2 SCENARIO OF COCONUT PRODUCTION AND PRODUCTIVITY

### 2.2.1 World Scenario

Rethinam (2003) reported that coconut is grown in more than 93 countries in the world and 90 per cent of the area and 87 per cent of the production are contributed by Asian and Pacific Coconut Community (APCC) countries. According to Rajagopal and Bosco (2002) among the APCC countries, four major coconut-growing countries, viz. Indonesia, India, Philippines and Sri Lanka, together contribute more than 77 per cent of the total coconut production and area in the world. Rethinam (2003) reported that coconut is grown in an area of 11.8 million hectares with a production of 10.26 million MT (copra equivalent) in 2002 and its products are utilised in more than 140 countries over the world.

According to Thampan (2003) among the major coconut growing countries Indonesia ranks first in production and second in area by contributing 15,119 million nuts from 3.68 million ha, sharing 28.82 per cent in area and 27.59 per cent in production.

The Philippines lead in the world area under coconut, accounting for 36.6 per cent (Shanmugavelu *et al.*, 2002). Rethinam (2003) stated that the total area and production in APCC member countries are estimated as 10.40 million hectares and 8.54 million MT which are 90 per cent and 83.20 per cent of world area and production respectively. Coconut is grown in Indonesia mainly by small holders and forms a major economic activity of about 2 million farm families.

Philippines and Indonesia, the two biggest producers grow coconut in an area of 3.1 and 3.7 million ha respectively. Rethinam (2003) reported that during 1990s there was a remarkable and continuing increase in coconut area in India, Indonesia and Philippines. Coconut hectarages in F S Micronesia, Papua New Guinea, Solomon Islands and Vanuatu have remained generally stable in recent years while a decreasing trend could be observed in Malaysia and Thailand.

The global coconut situation does not present a rosy picture. The productivity in many of the Asian and Pacific countries is low. According to Thampan (2003), coconut production in India has attained the level of 12.25 billion nuts surpassing the production level of major global players in the field, like Philippines and Indonesia.

According to Singh (2003) coconut's share to the GDP of the country is over 70,000 million rupees. Productivity remains low and some countries even experienced a declining trend.

Rethinam and Nandakumar (2002) opined that in line with increased population and per capita income, the domestic consumption of coconut is expanding rapidly. Rethinam, (2003) remarked that India, Thailand and

Vietnam are producing coconut mainly for domestic markets. Per capita consumption of coconut is the highest in Sri Lanka (109.8 nuts/year) followed by Indonesia (37.5 nuts/year) and the Philippines (33.5 nuts/year).

Thampan (2003) remarked that while world area under coconut increased by nearly three per cent per annum, coconut productions shows less than 4 per cent annual growth rate.

**2.2.2 Coconut Situation in India**

Coconut is the major small holder's plantation crop grown in the humid tropics and tropical regions of India, and one among the largest producers of coconut in the world (Rethinam, 2001).

According to Nampoothiri and Singh (2000), coconut is the third largest foreign exchange earner of the country and provides direct employment to 0.15 million people. Rethinam (2002) stated that the area under coconut that was only 1.08 million ha in 1980 increased to 1.84 million ha by the decade ending 2000-01.

The increase in area of production and productivity during the first decade (1981-91) was 0.431 million ha, with 3758 million nuts and 922 nuts per ha respectively. The corresponding increase over the next decade (1991-2001) was only 0.31 million ha, 2,517 million nuts and 255 nuts per ha respectively (Thampan, 2000).

According to Kumar (1998), the average productivity in the two major coconut-producing states in India (Kerala and Tamil Nadu) remains low. .Rethinam (2003) indicated that 470 nuts/tree/year is the highest average yield obtainable in selected super palms in the farmers' field of Kerala.

According to Thampan (2003), the productivity of coconut in nut equivalent varies from state to state. It is around 6,000 nuts in Kerala, and goes up to 12,000-15,000 nuts in many other states.

The southern states of India viz. Kerala, Karnataka, Tamil Nadu and Andhra Pradesh contribute more than 90 per cent of the country's coconut production. According to Poduval *et al.* (1998) among the four southern states, Tamil Nadu with 10599 nuts/ha tops in productivity followed Andhra Pradesh with 10342 nuts/ha. Karnataka has the lowest productivity of 5210 nuts/ha among the four southern states. The maximum productivity of 15013 nuts/ha has been reported from Maharashtra, though its share to overall production in the country is only around 1.0 per cent since the area in the state is only 15100 ha.

Thampan (1994) reported that in the present production level, the per capita availability of coconut in India is only about 11nuts. Per capita consumption of coconut in India is low at 11.9 nuts/year but the actual consumption is high when it is confined only to coconut producing regions such as Kerala, Tamil Nadu and Karnataka (Singh and Gopalakrishnan, 2002).

Kerala contributes to maximum production and has a productivity of 5747 nuts/ha. Thampan (1999) reported that in Kerala around 65 per cent of the annual production of coconuts for processing into copra. He has pointed out that household consumption of raw nuts in Kerala ranges between 22 and 43 per month per family, while the average consumption in other states is only around five nuts per month per family.

## 2.3 COMPOSITION AND NUTRITIONAL CHARACTERISTICS OF COCONUT

Coconut trees are permanent crops that bear fruit continuously up to 60 or 70 years. Batugal *et al.* (1998) stated that coconut provides a source of food with high nutritional value. Romulo (1999) is of the opinion that coconut is to be projected in the world market not as an oil yielding seed but as a dietary fruit endowed with considerable health benefits. According to

Banzon *et al.* (1990) coconut provides coconut water, coconut meat, coconut milk and coconut oil.

### 2.3.1 Coconut Water

Bawa (2003) commented that the liquid endosperm of coconut is the most nutritious wholesome beverage that the nature has provided for the people of the tropics to fight against sultry heat. He has viewed that coconut water is the fluid of life, a natural isotonic beverage with the same level of electrolytic balance as that of blood.

At the early stages of development, coconut water is sweet and refreshing and as the nut matures, the sweetness diminishes but still retains much of its chemical composition (Bosco, 1998). Maturity of the nut is established by shaking the nut to test for splashable water.

Chikkasubbana *et al.* (1990) pointed out that the optimum stage of harvest of tender nuts is between seven to eight months of maturity, during which, maximum concentration of sugar is seen. A large nut contains over 28 gm of sugar in solution. He has also reported that sugars in the form of glucose and fructose form important constituents of the tender coconut water.

Srivatsa *et al.* (1998) reported that the coconut fruit at seven to eight months maturity contains about 300 ml water, with 20 gm of sugar. Aldeba (1993) reported that the coconut water, which occupies the inner capacity of the nut, measures 425 ml at the $7^{th}$ month and decreases up to 165 ml at $12^{th}$ months. As reported by Balasubramaniam and Armughathan (1999), the major chemical constituents of coconut water are sugars and minerals and minor ones are fat and nitrogenous substances.

Thampan (1998) pointed out that the concentration of sugars in the nut water steadily increases from about 1.5 per cent to about 5 - 5.5 per cent in the early months of maturation and then slowly falls reaching 2 per cent at the stage of the full maturity. As the nut matures, the compositions also vary significantly. Concentration of invert sugar increases and reaches maximum at 220 days after which sucrose disappears (Coronacian, 2003). Bawa (2003) reported that coconut water has calorific value of 17.4 per 100 gm.

Chikkasubbana *et al.* (1990) found that coconut water contains small amounts of protein. He has also reported that the percentage of arginine, alanine, cystine and serene in the protein of tender coconut water are higher than those in cow's milk. Nandakumar (2003) reported that since it does not contain any complex protein the danger of producing shock is minimised. Alanine, 2-aminobutyric acid and glutamic acid constitutes about 75 per cent of the free amino acids of the fluid from mature fresh nuts, whereas glutamine, arginine, alanine and aspartic acid make up about 70 per cent of young green coconuts (Bawa, 2003).

Dhamodharan *et al.* (1993) expressed that tender coconut water contains most of the minerals such as potassium, sodium, calcium, phosphorous, iron, copper, sulphur and chlorides. Mathew (1991) reported that among the minerals more than half is potassium, the concentration of which is remarkably influenced by potash manuring. Tender coconut water being rich in potassium and other minerals plays a major role to increase the urinary output (Bawa, 2003).

Ratnambal (1999) found that tender coconut water contains both ascorbic acid and vitamins of B group. The concentration of ascorbic acid ranges from 2.2 to 3.7 mg per ml. Fardiaz *et al.* (1999) reported that the concentration of ascorbic acid ranges from 2.2 to 3.7 mg per ml, which gradually diminishes as the kernel surrounding the water begins to harden.

### 2.3.2 Coconut Kernel

Banzon *et al.* (1990) reported that the endosperm of coconut or the kernel is an important article of food in all the coconut-growing countries. Ediriweera (1991) indicated that the endosperm appears as a thin translucent layer at the age of 6 months, becoming progressively thicker and more opaque-white as the fruit matures. The amount of fresh kernel present in a mature nut shows much variation.

Hajenmaier (1980) reported that the chemical composition of wet meat varies with variety, stage of maturity and location. According to Thampan (1993) the moisture, protein and ash contents decrease with maturity, while fat content shows an increase with a peak at 12 and 13 months, which subsequently decreases until the fifteenth month.

Aldeba (1993) reported that the coconut meat (kernel or endosperm) increase from 20.3 g on the 7$^{th}$ month to 244.5 g on the 12$^{th}$ month. The meat becomes harder and thicker as the solid and oil content increases. Mukherjee (1993) reported that coconut kernel is a good source of carbohydrate, fiber and other nutrients.

According to Nareshkumar (1998), the ripe kernel derived from 11-12 month old nuts contain protein (5.5 per cent), fat (44 per cent), carbohydrates (10 per cent), crude fibre (3 per cent) and minerals (2.1 per cent). Coconut kernel also contains vitamins *viz.*, A, B, C and E.

Coconut meat is a rich source of plant protein and could well be an invaluable material for the preparation of milk substitutes (Singh, 1998). According to Silva (1998) coconut protein contain lysine and cardio protective amino acids arginine. Thampan (2000) commented that unlike other plant proteins, the coconut protein is high in sulphur containing amino acids, which is considered as an important criterion for food protein.

Coconut kernel contains on an average 40 per cent oil, and thus an appreciable amount of coconut oil is consumed through coconut Kernel (Rani and Rajamohan, 2003). Apart from coconut oil, coconut kernel contains 7-8 per cent dietary fibre, which is assumed to have a beneficial effect on health (Silva, 1999).

Hurtada and Raymundo (1992) opined that the ripe coconut kernel in its fresh form as well as in the processed forms is consumed in the households as well as by food industries. Fresh kernel is preferred as the common article in the households while processed form of kernels is preferred in the food industry (Sanchez *et al.*, 1996).

### 2.3.3 Coconut Oil

Ratnambal (1998) opined that the coconut oil is a colourless to pale brownish oil and in the temperate climate, appears as greasy, somewhat crystalline white to yellowish solid fat. According to Arumugan and Damodaran (1989) about 60 per cent of the coconut is consumed in the raw form, leaving the remaining for copra production and oil milling. Rajamohan (2003) pointed out that coconut oil contains 15 per cent of the total fatty acids as the saturated short chain C6:0, C8:0 and C10: 0 fatty acids. Nearly 50 per cent is medium chain, Lauric acid (C12:0) and coconut oil supplies only 2 per cent of the lenoleic acid (C18: 2), and 6 per cent oleic acid (C 18: 1), the only unsaturated fatty acids in coconut oil

Sunethra (2003) reported that coconut oil contains 48 per cent lauric acid, a saturated fatty acid that is referred to as lauric oil in the world market because of its high lauric acid content. The industrial application of coconut oil is mainly attributed to the presence of maximum lauric acid and glycerides, which are not present in any other vegetable oils (Jon, 2000).

Satyavathi *et al.* (1980) remarked that coconut has maximum digestibility coefficient and is more easily digested than any other fat including butter. Ananth and Vasudevan (2003) opined that coconut oil has added advantage as a nutraceutical and possess therapeutic values, which could be tapped by the health conscious consumers.

### 2.3.4 Coconut Milk

"Coconut milk" refers to the milky fluid, freshly extracted from the coconut kernel with or without added water. Coconut milk has an important place in the dietary habits of people in the coconut-producing countries, which is valued mainly for its characteristic nutty flavour and nutritional content (Bajaj, 1998).

Maturity of the coconut greatly affects the yield of coconut milk. Mature brown-husked nuts with no protruding sprouts produce higher yields of milk (Grimwood, 1975).

Sattyanarayana *et al.* (1991) reported that typical composition of coconut milk is 50 per cent moisture, 34 per cent oil, 7.3 per cent carbohydrates, 3.5 per cent protein, 3.0 per cent fibre and 2.2 per cent ash. According to Gonzalez (1991) coconut milk is an emulsion of oil, water and proteins. The emulsion separates on heating and the proteins are coagulated. The extracted milk has a fat content of 37-38 per cent and an average total solid content of 48 per cent.

Singh and Nandakumar (2003) pointed out that 'coconut milk' is a commercial term for the processed milk extracted from fresh mature coconuts. This is an instant product, which can either be used directly of diluted with water to make various preparations such as curries, sweets desserts etc. Processed and packed coconut milk has shelf life of six months and once opened it should be stored in refrigerator for subsequent use.

## 2.4 HEALTH IMPLICATIONS OF COCONUT

Silva (1999) remarked that coconut and coconut-based products have been in use from time immemorial for the promotion of health and for the treatment of various ailments.

Shivanandiah (1970) remarked that the tender coconut water by the virtue of its purity and nutritional safety is used as an intravenous injection fluid. Bosco (1998) stated that tender coconut water with its glucose and trace minerals considered as a life saving fluid for various disease conditions from time immemorial. Jose and Shajahan (2003) opined that Tender Coconut Water is wholesome for the heart and conquers 'pitta' and it relieves ailments like burning sensation, leucorrhoea and similar ones. Tender coconut kernel is palatable and cures diseases like thirst, leucorrhoea etc.

Ratnambal (1999) stated that the use of tender coconut water is recommended in the case for gastro enteritis and use as a substitute to saline glucose in intravenous infusion. It is also prescribed in severe case of diarrhea and vomiting. Bosco (1998) commented that it increases the blood circulation in the kidneys and causes profuse diuresis. The tender coconut kernel is good for convalescent patients also.

Vora (2000) stated that tender coconut water is an effective antidote against round worm induced vomiting in children. The inflorescence of coconut palm also has some therapeutic use. It is cooling and effective against dysentery, hemophilia, diabetes and leucorrhoea. It is also an ingredient in a decoction used to treat syphilis. Thampan and Iyer (1991) reported that the sap from inflorescence is used as liquid food, as well as for making jaggery and also as a medicine.

Enig (1995a) reported that coconut oil lower triglyceride level and enhance HDL significantly and act as a protective factor for heart. Thampan (1997) explained that coconut oil has the highest digestibility and is readily absorbed from the small intestine compared to any other oils containing fatty acids with long carbon chain.

Rajamohan (2003) is of the opinion that coconut oil is one of the few vegetable oils that can increase the HDL or good cholesterol in the blood, making a person less prone to cardiovascular disease or heart attack. Sunethra (2003) found that consumption of coconut kernel along with coconut oil lower the blood cholesterol level significantly. He has also reported that coconut oil consumption increase the level of HDL cholesterol. Rajamohan (1997) opined that coconut oil was found to have a beneficial effect of lowering lipid components.

Warrier (1995) narrated that the lauric acid component of coconut oil is considered as an ideal dietary fat due to its anti-microbial benefits. Human body utilizes lauric acid obtained from the diet to make monolaurin, which is reported to possess antiviral, antibacterial and antiprotozoal properties (Enig, 1995).

Vidyaprakash (1995) also reported the beneficial effects of lauric acid that include antiviral and antibacterial properties and even governance of myelination of nerves and consequently brain development.

Studies have indicated effectiveness of coconut oil in lowering the viral load of HIV/AIDS patients in the Philippines (Aldeba, 1993).

In a study conducted by Sunethra (2003) among adolescent Srilankan boys found that there is no subsequent increase in cholesterol level with increased intake of coconuts. This may be attributed to hypercholesterolemic effect of coconut fat, which was mitigated by a fibre-rich diet, with low animal fat.

Thampan (1996) revealed that medium chain fatty acids in coconut oil are absorbed directly and do not require emulsification and lipoproteins for their transport in the body. Ananth and Vasudevan (2003) commented coconut oil as the most easily digested and absorbed class of fats, which do not circulate in the blood stream and stored.

'Venthanna', otherwise referred as Virgin Coconut Oil is made by boiling aqueous coconut milk, which is usually given to infants to protect their intestine from pathogens. It is a potent wound healer (Ananth and Vasudevan, 2003).

Ulpalakshan (1994) opined that coconut oil has been used as an excipient in pharmaceutical and cosmetic formulations. It is being used as a base for ointments and a vehicle for oral and intra-muscular medicaments such as vitamins, hormones, antibiotics etc. Enig (1995) stated that natural coconut fat in the diets leads to normalisation of body-lipids and protect against alcohol damage to the liver and improves the immune system.

Rajamohan (1997) reported that coconut oil is used as a source of medium chain triglycerides in the dietary preparations of the patients with malabsorption syndromes. Thampan (1999) pointed out that coconut oil can be incorporated into infant foods as well as in low calorie diets.

Enig (1995) is of the opinion that coconut oil possesses anti-infective action against both gram positive and gram-negative bacteria and also against lipid coated viruses as well as fungi or protozoa. Thomas (2003) reported that coconut oil acts as an anti-peroxidative agent.

According to Nalini and Venugopal (2003) coconut consumption offers a significant protection against Dimethyl Hydrazine (DMH) induced colon cancer.

Mini and Rajamohan (2003) reported that coconut protein in alcohol fed rats decreased the concentration of lipid peroxide products and enhance the activities of anti oxidant enzymes and reduced glutathione content. Analysis of the coconut kernel protein indicated that it contains very high amount of amino acid L-arginine (24.5 per cent) that is mainly responsible for the antioxidant effect of coconut protein.

Kurup and Rajamohan (1995) opined that the proteins present in the kernel (5.17 per cent) and the dietary fibre (7.24 per cent) are known to lower serum cholesterol level. According to Trinidad *et al.* (2001) coconut flour is a good source of dietary fibre and has similar health benefits with other fibre sources.

Leon (1990) reported that coconut flour contains high levels of dietary fibre that can prevent and control colon cancer, constipation, diabetes mellitus and various heart ailments. Rumulo (1999) reported that coconut flour could also function as a laxative and contribute to reduce the problems of constipation as it contains high amount of insoluble fibre.

According to Thampan (1993a) tuba or toddy from the sap is stimulating, mild laxative, refrigerant and diuretic. According to Pangahas (1998) coconut vinegar is used in treating fever, tonsillitis and various skin diseases, it is also effective in reducing skin irritation caused by caterpillars with stinging hairs or spines.

In Brazil, the intestinal disturbances of infants were successfully treated by feeding coconut milk, which shows that coconut skim milk has the same protein level (1.6 per cent) as that of mother's milk, which can be well utilised by infants. Both produce a soft curd when acted by the gastric juice (Grimwood, 1975). Davida *et al.* (1993) remarked that Coconut yoghurt is consumed as a snack or as a daily food for therapeutic purposes helps in digestion for older people.

According to Duma *et al.* (1996) dessert called 'nata-de-coco' was introduced to Japan and believed it protects the body against colon cancer and it became "a boon for slimmers".

## 2.5 COCONUT IN CULINARY PURPOSES

Coconut is a much-relished nut, and is used in multifarious forms in human dietaries throughout the world. It finds entry in the common meal as an item of a thickening, flavouring, and binding agent and even as the main ingredient in the preparation like sweets or savoury (Thampan. 1996a). According to Sanchez (1990) the fresh kernel either grated, paste or milk form of ripe coconut constitutes an essential ingredient in the recipes of diverse food preparations in the households as well as in many food industries of different countries.

Mathew (1997) reported that coconut and coconut oil were introduced into the day-to-day life of Keralites as early as 500 years ago. Coconut kernel is a daily edible item in almost 99.9 per cent of the population of Kerala (Rajamohan, 2003). Singh and Nandakumar (2003) reported that more than

50 per cent of the coconuts produced in our country are used in the household sector for culinary purpose.

Philips (1965) commented that Indian cuisine is probably one of the most healthful in the world. Philips (2003) opined that foods from vegetable sources are combined so judiciously in the Indian meals, in which coconut acts as an essential ingredient in the form of base material, flavour enhancer, thickening agent and taste improver.

Kurup and Rajamohan (1995) reported that per capita consumption of fresh kernel varies from district to district in Kerala state. The average kernel intake is 52.44 g/day in Trivandrum district, where as it is 61.48 g/day in Quilon district. The quantity of free coconut oil consumed is rather low ranging from 5-15 g. The total coconut oil consumption including the free oil and that derived from the kernel varies from 15 to 60 g.

William (1983) remarked that coconut used for culinary purpose has important functions as improving the taste besides upholding the gastronomic quality of the curry.

Thampan (1998) was of the opinion that the old species of coconut plants like West Coast Tall and Komadan give more flavour and creamy taste than the modern hybrid varieties.

A typical Kerala breakfast, lunch or dinner is generally prepared by adding coconut constituents. Thampan and Iyer (1991) have stated that a Kerala feast, referred as 'sadya', is spread out temptingly on a clean green banana leaf, which is served with many dishes all of which contains coconut as an adjunct. Even the desserts 'payasam' utilise coconut milk as the base material. Mathew (1997) reported that vegetarian food such as sambar, rasam, olan, Kaalan, pachadi, kichadi, aviyal, thoran etc. contain coconut as one of the main ingredient.

According to Thampan and Iyer (1991), 'Appam' a kind of pancake made of rice flour fermented with a small amount of toddy and coconut milk is a delicacy of Keralites.

Jayalekshmy (2003) opined that coconut and coconut water are highly relished for unique flavour characteristics in the dishes, which are due to δ–lactones, ketones, alcohols and esters present in it. Roasting of coconut is practiced in Kerala, which leads to browning and enhancement of flavour.

Thampan and Iyer (1991) stated that coconut oil is widely used as frying and seasoning oil in the different food preparations of Kerala. Arvindakshan *et al.* (1994) reported that coconuts are also used in food processing sector, as a fat substitute in filled milk, surface spray on bakery products, cream or butter substitute in many processed food products. Thampan and Iyer (1991) reported that coconut jaggery is widely used in the rural households in place of cane sugar for the preparation of sweet dishes and other delicacies.

Apart from the preparation of common household cuisines, coconut water and kernel products are also utilised for the preparation or special delicacies such as nata de coco, coco cheese, fermented beverages etc. for direct consumption in households (Sanchez, 1993).

## 2.6 NEED FOR VALUE ADDITION IN COCONUT AND COCONUT BASED FOOD PRODUCTS

Singh and Nandakumar (2003) is of the opinion that the present scenario of increased production and productivity of coconut in the country, product diversification and by-products utilisation in coconut is to be attempted to strengthen the coconut economy of the country.

Sanchez (1990) commented that there is a need for diversification in coconut especially for food to increase the demand for coconut, thus relieving the coconut farmers from the effect of fluctuation of prices and income stability. Markose and Poduval (1993) remarked that, taking into consideration of the increased demand of fresh coconut due to growing population and also due to greater demand for convenient food products, importance must be given to develop and standardize new coconut products for commercial exploitation.

Markose (1998) is of the opinion that one of the futures' thrusts for coconut development in the country should be for developing technologies for product diversification, by-product utilisation and infrastructure developments for technology adoption.

Pangahas (1994) commented that application of advanced scientific knowledge and technologies has contributed to the diversification in coconut products thus creating new coconut based industries.

Singh (1998) is of the opinion that today, technologies are available to produce an array of coconut based food products like coconut cream, coconut milk powder, sweet coconut flakes, coconut milk based consumer products, spray dried coconut milk powder, coconut jam, nata-de-coco, coconut vinegar and coconut water beverages. However the products have not gained much popularity in our country.

Rajagopal (2003) remarked that apart from those products, which can find domestic markets, there are some, which could be successfully introduced in the export markets. Coconut sugar, tender coconut, coconut skim milk and water based products, coconut kernel based convenience foods, etc. has potential to attract consumers both within and abroad on quality considerations. Marketing support is essential for the traditional and non-traditional products emanating from the coconut

### 2.6.1 Coconut based Food Products

**Tender Coconut**

Shiv *et al.* (2003) remarked that tender coconuts are valued both for sweet water and for its gelatinous kernel, which is a delicious food.

Ratnambal (1999) pointed out that Chowghat Orange Dwarf released by CPCRI; Kasaragod is the most suitable variety for tender coconut water purpose. Shiv *et al.* (2003) is of the opinion that regional variation was observed in the consumption pattern of tender coconut.

Singh (1998) reviewed that in West Bengal more than 80 per cent of the total coconut production is consumed as tender nuts, as against 25 per cent in Karnataka. In Kerala its use as tender nut is negligible Subburaj and Singh (2003) observed that the annual consumption of tender coconut is less than 11 per cent of the total coconut production in India.

Srivatsa and Arya (1998), reported that consumption tendernut has to be increased at least 15 per cent level. Singh and Nandakumar (2003) and Bosco (2003) reported that tender coconut water can be processed and marketed as a nutritious soft drink

According to Srivatsa *et al.* (1998), the characteristic flavour of tender coconut water is contributed by heat sensitive lactones, and hence partial heat treatment combined with certain preservative was proved effective. To obtain a uniform taste, some of the sweetening agents can be added which will improve the acceptability of the product.

Papa (1986) reported the coconut water concentrated can be manufactured by reverse osmosis procedure. The concentrated coconut water has been used successfully in brewery industry.

Aldeba (1993) also reported that waste coconut water from a desiccated coconut factory could be concentrated by reverse osmosis. This method involves infiltration through a semi permeable membrane under high pressure.

According to Rajagopal and Bosco (2002) coconut water concentrate can be frozen or preserved in cans and it can be used as a base for the production of carbonated and non-carbonated coconut beverages. Frozen coconut water is also obtained by passing the centrifuged coconut water through a mixed-bed ion-exchange resin (Rajagopal and Bosco 2002).

Rosario and Rubico (1979) formulated non-carbonated beverages from matured coconut water obtained from a local desiccated coconut plants with a total soluble solids 10 to 12 per cent and pH 4.2 adding an acidulant at 0.1 to 0.15 per cent. Pinwale and Gonzalez (1988) developed a process for the manufacture of non-carbonated and carbonated coconut water beverages from mature nuts with HTST method.

Aldeba (1993) found that coconut water from desiccated coconut factory could be used for the production of yeast, which can be used in meat soup and flour preparation for human consumption.

Mital and Anmol (1992) reported that a process has been developed at Regional Research Laboratory, Thiruvananthapuram for upgrading the matured coconut water to the level of tender coconut water. Upgrading was done by supplementation with additives including sugar and preserved by judicious combination of heat pasteurisation along with permitted chemicals.

Fardiaz *et al.* (1999) developed a fermented coconut water drink by inoculating coconut water with two different cultures, *viz.*, *Streptococcus thermophillus* or *Lactobacillus bulgaricus* and *Lactobacillus casei*. Refrigerated storage of the product showed an increase in the total mold and yeast counts and decline in viability of lactic acid bacteria.

**Coconut Sap (Neera)**

According to Thampan (1993) the fresh and unfermented sap that drips from the stimulated part is referred as "Sweet Toddy or Neera". Neera is rich in carbohydrate with sucrose as the main constituent. Ohler (1984) and Bawa (2003) stated that Toddy is obtained from the inflorescence before the flowers fully develop.

Coconut tree yields up to 300 litres of sap during 6 months of tapping with an average yield of about 50 liters per spadix. According to Bawa (2003), an average of 1.5 litre sap per day per tree could be obtained. The fresh and unfermented coconut sap is sweet, oyster white and translucent, with nearly neural pH.

Nutrient composition of coconut sap estimated by Sanchez (1990), indicated total solids as 17.5 to 18.7 per cent; sucrose, 14.85 to 16.6 per cent, reducing sugar trace to 0.3 per cent; crude protein, 0.2 to 0.6 per cent, ash 0.26 to 0.40 per cent; and acidity 0.90 per cent. As pointed out by Rajagopal (1998), Toddy becomes an alcoholic drink upon fermentation while arrack can be produced from the fermented toddy.

Thampan (1991) viewed that toddy tapping is a highly remunerative venture, which can be popularised, which will fetch good returns to the coconut farmers. He is also of the opinion that fresh coconut toddy without fermentation can be promoted as a sweet natural drink. Bawa (2003) standardised the preservation and bottling of fresh coconut toddy for a period of six months by heat sterilisation at $80^{0}$ for 25 minutes.

**Coconut vinegar**

Den and Marquez. (1987) pointed out that vinegar produced from matured coconut water using vinegar generator is gaining acceptance as an organic health friendly product. Vinegar has extensive use as a preservative in the pickle industry and flavouring agent in food processing sector.

Pangahas (1998) also reported that coconut vinegar enjoys a wide market segment as a preservative in pickling industry and as a flavoring agent in food products. Quick method of vinegar production from coconut water has been developed by Markose (1991), and it is being utilised on commercial scale by entrepreneurs

As pointed out by Poduval *et al.* (1998) in the manufacture of vinegar, the fortified coconut water is first fermented by inoculating the solution with yeast, and then is oxidised to acetic acid. The acetified vinegar is aged before bottling

**Coconut jaggery**

According to Rajagopal (1998), the manufacture of coconut jaggery from coconut sap holds promising and viable commercial venture. Sweet toddy after boiling to 118°C to 120°C is allowed to cool for solidification, a solid mass is obtained which is known as coconut jaggery or Gur. Coconut jaggery contains 10.92 per cent moisture, 68.35 per cent Sucrose, 6.58 per cent reducing sugar, 1.64 per cent protein, and 6.24 per cent pectin (Thampan and Rohini, 1993).

Molded brown sugar is a traditional product made from the sap of coconut palm (*Cocos nucifera* L.) *Arenga pinata* Merr., *Borasus flabellifer* L., and nipa palm (*Nipa frutticans*).

**Nata de coco**

Hegde, (1995), reported that nata de coco is produced by the action of a microorganism Acectobacter xylinium in a culture medium of coconut water. According to Poduval (2002) and Rajagopal and Bosco ( 2002), the product has great export potential in Japan, Taiwan and Korea for use as a dessert and as an ingredient in ice cream and fruit cocktails.

As pointed out by APCC (1996) the yield of raw nata from one kg of coconut water is approximately 750-800 g. Preliminary studies conducted by the Coconut Development Board, it was found that 100 litres of coconut water would yield about 30 kg of raw nata ( Singh and Reddy 2002).

The processed nata can be served as a dessert either mixed with other fruits or baked into a delicious cream pie or simply served with flavoured syrup (Palo *et al.*, 1989). Hegde (1997) stated that nata is a favoured delicacy as it is low in calorific value.

**Coconut oil**

In world, coconut oil production has increased from 1,993000 MT (1960-1990) to 4,036,000MT in 2001, but the per cent share of coconut oil has considerably reduced from 9.58 to 5.99 per cent for the above period (Rethinam, 2003). Singh (2003) reported that on an average 0.35 million tonne of oil output has been added in each decade.

Coconut oil is the single largest commodity exported from India followed by desiccated coconut (Singh, 2003). Domestic prices of copra and coconut oil in India are always higher than of the two largest coconut-producing countries, the Philippines and Indonesia (Rethinam 2003).

Coconut oil is produced in India mainly by rotaries and the oil expellers, the expellers dominating the scene. Rajagopal and Bosco (2002). There are about 1400 oil mills producing about 4,50,000 tonnes of oil annually. Singh and Reddy (2002).

Kerala is the main consumer of coconut oil for edible purpose. Madhavan, (1998) reported that it is estimated that in Kerala, 55 per cent of the local production of coconut oil is consumed for edible use, 16 per cent for toiletry and 6 per cent for industrial and the balance is moved to other States. According to Singh and Reddy (2002) the price of coconut is depended on the price of the coconut oil.

Prescilla *et al.* (1996) reported that coconut oil is also a source of many oleochemicals. Coconut oil as a bio fuel, an ecofriendly, non-conventional energy source, has greater applications in many Asian and Pacific countries (Singh and Gopalakrishnan (2002).

**Copra**

The dried coconut endosperm is called copra, with the richest source of fat (65 to 70 per cent) (Rajagopal 1998).

Copra making and oil milling are the popular coconut based processing activities developed in India (Thampan, 1998a). There are about 12,000 copra-making units in the southern states (Singh and Reddy, 2002).

Thampan (1991) stated that copra is of two types – edible copra and milling copra. Production of edible copra is mainly in the unorganised sector and is estimated to be about 1.35 lakh tonnes annually (Singh and Reddy, 2002).

Edible copra is available as ball copra and cup copra. Ball copra is traditionally made from the fully matured whole unsplit nuts by storing in the shade for 8 to 12 months period allowing coconuts to dry naturally. According to Ratnambal (1998), the cultivar Lakshadweep Micro, a local type grown in Lakshadweep Islands is considered to be the best for ball copra.

Cup copra is matured spilt copra. The production of cup copra is localised in Kerala and Andhra Pradesh (Thampan, 1993a). The milling copra is mostly in the form of cups and to a very small extends in the form of chips. The milling copra production in India varies annually between 600 and 650 thousand tonnes (Singh and Reddy, 2002).

According to Bernd and Amal (1999) methods generally used for drying copra are solar drying, smooth drying or kiln drying and indirect hot air drying.

For obtaining good quality of copra, fully matured nuts from selected varieties with proper storage, seasoning of nuts for a few days and adequate drying to bring down the moisture content to 5 to 6 per cent are the basic requirement (Ratnambal, 1998). According to Ramanujan (1998), the copra should be stored in gunny bags lined with polythene sheets in well ventilated godowns and sulphuring should be carried out periodically when copra is to be stored for longer periods.

The share of Kerala in the production of milling copra decreased to 56 per cent from a level of 90 per cent a decade ago, while the contributions of Tamil Nadu upto 38 per cent in oil production increased (Thampan, 1993).

**Virgin oil**

Arumugan (1998) is of the opinion that traditionally prepared virgin oil from coconut milk is mainly used in ayurvedic medicines. Vidyaprakash (1995) reported that 'urukku velichenna' has an important place in ayurvedic medicines. Virgin coconut oil is considered to have high purity oil when compared to copra oil since it contains more polyphenolic compounds and vitamin E and lowers lipid level (Arumughan, 1998). According to Poduval *et al.* (1998) a method is standardised for production of virgin oil by a process called phase inversion in which coconut milk is filtered, concentrated and cream is separated by centrifugation. The oil thus obtained is very clear, nutritious and has got a longer shelf life. According to Nevin and Rajamohan (2003) virgin coconut oil is more beneficial than copra oil since it retains most of the minor components in the active form and make virgin coconut oil a potential hypolipidemic and antiperoxidative agent.

**Desiccated coconut**

Madhavan (1998) is of the opinion that desiccated coconut is hygienically prepared dehydrated disintegrated coconut meat, with moisture content of less than 3 per cent. According to Arumughan (1998) it is the white kernel of the coconut, comminuted and desiccated to moisture content of less than 3 per cent. Leon (1990) reported that desiccated coconut has a pleasant coconut odour as well as imparts chewiness and characteristic flavour.

Rajagopal and Bosco (2002) reported that Sri Lanka and Philippines are the major desiccated coconut producing countries. According to Hurtada and Raymyndo (1994), the main production centers of desiccated coconut are situated in the southern parts of the country but consumption is mainly in northern parts of the country. According to Poduval (2002), there are about 66 units of desiccated coconut in the country which is mostly concentrated in Karnataka, Tamilnadu and Andhra Pradesh. The total production of the desiccated coconut in the country is estimated to be about 40,000 tonnes annually (Poduval 2002).

Rasotgil *et al.* (1998) pointed out that desiccated coconut is mainly used in biscuits, sweets, bakery products and other food preparations.

Retinam (1993) pointed out that Regional Research Laboratory; Trivandrum has developed a method for partial extraction of oil from desiccated coconut in order to produce a low cost, low fat desiccated coconut and superior quality oil.

**Coconut flour**

During the processing of coconut cream and other related products, the fibrous residue obtained after expelling the milk is dried and powdered to obtain coconut flour. Rajagopal (1998) remarked that in the processing of coconut milk, coconut flour is produced which is not only a value-added product, but also a nutritious and a healthy source of dietary fibre for the consumer. Coconut flour has an off white colour and is comparable with other cereal flours in the market in terms of energy, carbohydrates and fat content (Trinidad and Trinidad, 2001).

Arancon (1999) reported that coconut flour, nutritionally comparable to most of the common grain flour, contains protein (22-24 per cent), crude fibre (10 per cent) and ash (5 per cent) and has a shelf-life of more than one year when stored at 20°C, 14 months at 30°C and 9 months at 40°C. Rasotgil, (1998) opined that the most significant property is high water absorption capacity, which could be exploited in product formulations.

Central Food Technological Research Institute, Mysore, has developed a process for the manufacture of edible coconut flour (Singh and Nandakumar, 2003). The shelf life of the flour stored in sealed aluminum foil pouches is 4 to 6 months at ambient temperature and more than one year under refrigerated conditions (Rasotgil, 1998). He has also reported that it contains high percentage of dietary fiber (19.3 per cent), which is beneficial to human health. Dina (1997) stated that coconut flour is low in fat with high-energy content and is a good ingredient for functional foods and nutraceuticals. Coconut flour can be used as fillers, bulking agents and substitute for wheat flour, rice flour and potato flour and barbecue flavoured snack foods.

**Coconut milk**

Pandiyan and Geevarghese (1999) explained that coconut milk and milk products are prepared from fresh matured coconuts. In this process the white coconut kernel is ground into slurry from which coconut milk is separated by pressing. The coconut milk is then centrifuged and further processed to get milk concentrate, coconut cream and milk powder.

Hittu *et al.* (1991) reported that the coconut milk serves as a fat carrier in the blend to substitute for buttermilk. The technology for the preservation of coconut milk in the concentrated form has been standardised and its economic viability established through pilot testing by Regional Research Laboratory, Trivandrum (Arumughan 1998). The product has also shown encouraging consumer acceptance in the domestic market.

**Coconut cream**

Coconut cream is an instant product that can either be used directly or diluted with water to make various preparations such as curries, sweets, desserts, puddings (Rajagopal and Bosco, 2002). According to Arumughan (1998) coconut cream is the concentrated coconut milk extracted from fresh matured coconut kernel. Coconut cream can be used in the manufacture of bakery products and for flavouring foodstuffs. Processed and packed coconut cream has a shelf life of six months and once opened it should be stored in refrigerator for subsequent use (Arumughan, 1998).

**Coconut milk powder**

The Coconut Development Board in collaboration with Central Food Technological Research Institute, Mysore has developed the technology for spray dried coconut milk powder (Singh and Nandakumar, 2003).

Thampan (1995) asserted that spray drying is a potential method for the preservation of coconut milk, which has a tremendous market potential both in India and international market. It can be used as a substitute for freshly squeezed coconut milk in household/hotel for food preparation, kheer and beverages. According to Poduval *et al.* (1998) on an average two thousand coconuts would yield about 99.6 kg of spray dried coconut milk powder. According to Arumugan (1998) coconut milk is a high fat product (50–60 per cent) and highly hydroscopic requiring good quality packaging material with moisture barrier properties. According to Rajagopal (1998), it is a good source of quality protein for the preparation of many useful allied food products or as supplementary protein source in places where animal protein is deficient.

### 2.6.2 Other Processed Products from Coconut

**Coconut chips**

Bosco *et al.* (2002) standardised sweet coconut chips from mature coconut kernel by osmotic dehydration. Coconut chips as any other chips is a ready to eat snack food and is prepared either salted or sweetened with flavours (Nandakumar, 2003).

Bosco *et al.* (2002) reported that the coconut chip was well accepted among consumers and it can be stored for a period of 6 months in Aluminum foil laminated with LDPE pouches, which will maintain its flavour and crispness up to six months without affecting its microbial and biochemical qualities.

**Snow Ball Tender Coconut**

According to Singh (2003) 'Snow Ball Tender Coconut' is a tender coconut without husk, shell and testa which is in ball shape and white in colour. This white ball will contain tender coconut water; can be consumed by inserting a straw through the top white tender coconut kernel. Bosco (1998) reported that making groove in the shell before scooping out the tender kernel with water is the one of the important unit operation in the preparation of 'snow ball' for which a suitable machine has also been developed by CPCRI, Kasaragod.

The 'snow ball tender nut' can be individually packaged and refrigerated under hygienic conditions which could increase the shelf-life of this product (Bosco, 1998).

**Coco spread/Pasties**

Mabesa (1979) standardized consumer acceptable coco spread from coconut milk, in which legumes flour was incorporated. A ready to drink cultured coco nutri- beverage was developed by Sanchez *et al.* (1984) by the action of *lacto bacillus bulgaricus* on the mixture of coconut skim milk (50 per cent) and non – fat dry milk (50 per cent), which was found to have a shelf life of two months at 27°C.

According to Ediriweera (1991) coconut pasties is a smooth paste, oil in water emulsion prepared using fresh coconut kernel. The product can be reconstituted by mixing with water into coconut milk. It can be used as a base for cooking for pudding, desserts, ice cream and confectionery.

Rasotgil *et al.* (1998), pointed out that products like coconut jam, coconut sauce, coconut pudding and coconut lemonade, coconut lassi can be prepared by utilizing coconut water and coconut milk.

**Coconut Chutney mixes**

Coconut chutney mixes were made out of coconut bits, roasted Bengal gram flour and with/without green chilies (Thampan and Iyer, 1991). Normally, it is prepared as fresh and consumed along with fermented foods like idly, dosai and sometimes with savory snacks. Srivasta *et al.* (1998) reported that technology has been developed for making a ready-to-eat, dehydrated chutney powder that lasts for a period of six months.

Satyanarayana *et al.* (1991) reported that dehydrated chutney reconstitutes well in cold water and had all the characteristics of fresh chutney. The product had a shelf life of 3 months at 37°C and 6 months at ambient temperature when packed in flexible pouches. The dehydrated coconut chutney is a good source of fat, fibre with a calorific value of 635 Kcal/100g (Bawa, 2003).

**Coconut Jam**

Coconut jam is a recently introduced product, which is prepared from coconut kernel (Rajagopal 1998). The kernel is squeezed to extract coconut milk that is mixed with sugar, glucose and citric acid to a thick consistency at low heat with constant stirring. (Singh and Gopalakrishnan 2002). Coconut jam is an ideal spread for bread. According to Poduval (2002) the product is likely to find export in the Middle East and European countries.

**Coconut Burfi**

It is popular sweet meat, made out of grated coconut and sugar (Thampan and Iyer, 1991) that was found to have low shelf stability. Srivatsa *et al.* (1998) reported that controlled processing techniques would improve the qualities of coconut burfi.

The coconut palm provides minor products of food value such as the spongy ball like haustorium that develops inside the germinating nut, which is a delicacy (Thampan and Iyer, 1991). In effect, the coconut palm has characteristics as a regular and consistent food supplier to mankind throughout the year, which no other tree crop could be said to possess.

# Materials and methods

# 3. MATERIALS AND METHODS

The present study entitled "Developing diversified and value added products from coconut (*Cocos nucifera* L.)," is aimed at developing beverages, bioprocessed products, protein enriched products, simulated dairy milk products, bakery and confectionary products by utilising coconut water (tender as well as mature), coconut milk, coconut kernel (tender as well as mature) as well as with desiccated coconut and coconut powder. The products developed were studied for its chemical, nutritional, organoleptic and shelf-life qualities along with packaging, consumer acceptance and preference cost effectiveness.

The methodology adopted for the study is presented under the following headings.

3.1 Selection of coconut for the study

3.2 Selection of constituents of coconut for product development

3.3 Selection of products to be developed

3.4 Standardisation of products and product development.

3.5 Analytical work carried out in the developed products.

## 3.1 SELECTION OF COCONUT FOR THE STUDY

The term "coconut "(*Cocos nucifera* Linneaus, abbreviated as *Cocos nucifera* L.) is a drupe which contains a unique range of oils, protein, carbohydrates including dietary fiber and sugars, minerals and water and an aqueous sap from inflorescence (APCC STAN 1: 1995D). According to Lopez (2002), coconut is god's gift to mother nature as it is the health pack of essential nutrients with high commercial value.

India is one of the leading coconut producing countries in the world with an annual production of about 5733.6 million nuts covering an area of

10,82900 hectares (Shanmugandvelu *et al.*, 2002). However, unlike in the other coconut growing countries viz., Philippines, Srilanka and Indonesia the post harvest processing and marketing sector of coconut in India is weak and still at its infancy stage which is quite detrimental to the coconut based economy of the country (Poduval *et al.*, 1998).

Coconut places a pivotal role in the socio-economic scenario of Kerala as it provides employment for millions with many industries linked with coconut products. Almost all parts of the coconut are useful both for domestic purposes and in industrial units (Rajagopal, 1998).

Markose and Poduval (1993) pointed out that, there is an increased demand for fresh coconuts for the formulations of convenience-oriented coconut products and more research work in the field of coconut product diversification and by-product utilisation is to be undertaken to improve the overall market spectrum of coconut products. Singh and Nandakumar (2003) expressed that the product diversification and by-product utilisation in coconut, besides creating awareness on the nutritional properties of coconut and its products are essential to strengthen the coconut-based economy of Kerala.

Taking the above facts into account of the present investigation aimed at developing indigenous and novel technology for product development, based on coconut and its constituents, which can top both the export and domestic market was undertaken.

## 3.2 SELECTION OF CONSTITUENTS OF COCONUT FOR PRODUCT DEVELOPMENT

In the present study, the following constituents of coconut and its derived products were used for product formulation.

### 3.2.1 Coconut Water (tender and matured)

The "coconut water" shall mean exclusively the natural aqueous endosperm of the coconut drupe or the loose liquid within the coconut kernel including the soluble proteins and sugars (APCC STAN 1: 1995D). 'Coconut water' is naturally clear to slightly turbid and contains at least 90 per cent of the loose liquid from coconut endosperm. Studies revealed that the coconut fruit at seven to eight months' maturity contain about 300 ml water, with 20g sugar and 2 g of potassium (Thampan1996). The water from young tender coconut has high amounts of potassium, sodium and chlorine. The pH of tender nut water varies between 4.8 and 5.3, and it has high amounts of ascorbic acid (vitamin C) and other vitamins of B group. Chowghat Orange Dwarf released by CPCRI is considered as the most suitable variety for tender nut purpose (Ratnambal, 1999).

### 3.2.2 Coconut Kernel (tender and matured)

The term Coconut kernel shall refer exclusively to the moist solid endosperm of the coconut drupe consisting of a white cellular layer (also known as the coconut flesh or meat) containing coconut oil and other nutrients, which is covered by a brown testa (APCC STAN 1: 1995D). According to Madhavan (1998) the sweet and gelatinous kernels of young tender coconut are refreshing and nutritious. The endosperm of the fruit contains 20 per cent carbohydrate, 36 per cent fat, 4 per cent protein and 50 per cent moisture level.

The wet and fresh kernel of ripe coconut constitutes an essential ingredient in the recipes of diverse food preparations in the households of different countries. In household food preparations fresh coconut kernel is used both in the grated form and in the form of milk extracted from gratings. Depending on the type of food preparation, the gratings are used either as such or in the form of a finely ground paste.

### 3.2.3 Coconut Milk

Coconut milk is prepared from coconut endosperm and optionally with potable water, and contains the minimum amount of non fat coconut solids in proportion to coconut fat as established by international or national technical regulations or standards (APCC STAN 1: 1995D). Coconut milk contains 47 per cent to 56 per cent moisture, 27 per cent to 40 per cent fat (Banzon, 1978).

### 3.2.4 Desiccated Coconut

It is the dehydrated, shredded, white kernel of the coconut. It is produced from fully ripe coconut kernel under strict hygienic conditions for human consumption (Poduval, 2002). Desiccated coconut is dried to less than 4 per cent moisture and used both in household food preparations as well in processed food sector particularly in ready-to-cook mixes.

### 3.2.5 Coconut milk powder

The formulated soluble powder prepared by dehydrating comminuted and expelled coconut endosperm that is dried, manufactured, and suitably packed under hygienic conditions is called 'coconut milk powder' (Hagenmaier, 1980).

### 3.2.6 Coconut Jaggery

Palm jaggery is manufactured from neera tapped from palm trees, which has been a poor man's beverage from time immemorial Shobha and Prakash (2001). Jaggery is also recommended for its high iron content. Palm jaggery is used to sweeten various food preparations.

## 3.3 SELECTION OF PRODUCTS TO BE DEVELOPED

The following products were proposed to be developed in the present investigation.

### 3.3.1 Beverages

Products of the beverage industry have gained worldwide acceptance and are extensively consumed item (Bosco, 1998). Beverages worth of millions are manufactured annually and marketed. Though they are low in food value their popularity persists due to its thirst quenching properties

(Srivatsa *et al.*, 1998). In India the most popular beverages are carbonated beverages or soft drinks and non-carbonated artificial fruit drinks.

Carbonated beverages are generally prepared from a flavour-based syrup, which is diluted, sweetened, acidified, coloured and treated with chemical preservatives and carbon dioxide (Bosco, 1998). Bawa (2003) opined that the water of the tender coconut (liquid endosperm) is the most nutritious wholesome beverage that nature has provided for people of the tropics to fight against sultry heat. The demand for natural drinks all over the world is on the rise; owing to increasing needs of the health conscious consumers are increasing. No other drink lends itself to such a diversity of applications and uses of tender coconut water.

Thus there is a great potential for commercialisation of beverages based on coconut and from other natural ingredients in the domestic market as well as in the international market. Such natural health drinks will go a long way in developing and expanding the beverage industry in India and abroad.

### 3.3.2 Bioprocessed Products

Products, which are formed naturally on the surface of food by the action of beneficial microbes, are known as bioprocessed foods (Palo *et al.*, 1989). One of the advantages of bioprocessing of coconuts is its novel delicacy par excellence and long keeping quality. According to Metcalfe (1994) bacterium named *acetobacter xylenium* strain is capable of bioconverting coconut water, coconut milk etc. into gels. It has high export potential and commercial viability. Bioprocessed coconut products provide fibre in the diet and blends well with other processed foods.

### 3.3.3 Simulated Dairy Milk Products

Simulated dairy milk beverages are dairy milk substitutes formulated to contain nutrient approximating those of their dairy milk counterparts. The development of such types of products was motivated by the shortage of the dairy milk in certain parts of the world particularly in tropical countries

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Simulated dairy milk beverages are dairy milk substitutes formulated to contain nutrient approximating those of their dairy milk counterparts. The development of such types of products was motivated by the shortage of the dairy milk in certain parts of the world particularly in tropical countries where an adequate and stable supply of milk and milk products cannot be assured due to lack of sizeable dairy industry (Bosco, 1998). It is a cultured product resulting from the activity of one or more species of microorganism, particularly lactic acid bacteria, on pasteurised milk. Fermentation process causes physical and chemical changes in the milk. The type of fermentation that occurs varies from place to place and is influenced to a considerable degree by the environment (Sanchez, 1990).

Fermented products like coconut curds and coconut yoghurt can improve human nutrition as they have a therapeutic effect, especially in preventing intestinal distress. They also serve as an excellent food, particularly ideal for elderly people, being easily digestible, organoleptically acceptable and give bulk to the food (Hittu *et al.*, 1991). In addition, fermentation improves nutritional value by synthesis of vitamin C and B-complex vitamins like riboflavin by the friendly bacteria.

**3.3.4 Protein Enriched Products**

India was reported to have the highest percentage of moderately and severely underweight children, when compared with selected Asian countries and percentage of children belonging to underweight, wasted and stunted category were found to be 63, 27, 65 respectively (Grant 1990). Reddy *et al.* (1990) while reviewing the nutritional trends in India observed the major nutritional deficiency diseases seen among children as Protein Energy Malnutrition (PEM) (Kwashiorkar and Marasmus), Vitamin A deficiency (Bitot spots) and Vitamin B complex Deficiency (angular stomatitis). Soman (1995) reported that in Kerala 75.50 per cent of the children were found to be suffering from mild to moderate forms of malnutrition. Therefore, there is a need to develop indigenous protein enriched supplement that has low dietary bulk, high in protein, calorie dense, easily digestible, nutritionally adequate and acceptable to the local children.

Krishnaswamy *et al.* (1971) stated that properly blended and fortified proteins from plant sources could replace animal proteins. In this context, Vora (2000) pointed out that the coconut industry can enter into its own brand of health drinks and protein enriched supplement that will help to solve the problem of protein energy malnutrition.

### 3.3.5 Bakery and Confectionary Products

During the last two decades, snack and convenience food market has witnessed a very rapid growth all over the world. In our country too many products which were hitherto prepared in homes or by food service establishments are marketed by food processing industries (Mathew, 2000).

Bakery products, especially soft dough biscuits command wide popularity in rural as well as urban areas in India among people of all age groups (Agarwal, 1990). Some of the reasons for such wide popularity are low cost among other processed foods, varied taste, textured profiles, easy availability in attractive packaged form and longer shelf-life to suit easy marketing. U S Wheat Associates (1988) viewed that the protein fortified bakery products carry nutrients in concentrated form, and compliment essential amino acids, which could be attained by using various protein-rich non-wheat flours.

According to Rao (1993) the popularity of the baked products is due to their ready to eat convenience nature, unique taste and ready availability at reasonable cost in different parts of the country including remote and rural areas. Mathew (2000) pointed out that the coconut is a tasty food adjunct, which can be used for making bakery and confectionery products and various ready to use sweetened foods, which can be used conveniently. Coconut meat imparts delicate flavour, in the preparation of convenience foods and hence suitable to incorporate in the bakery and confectionary products.

## 3.4 STANDARDISATION OF PRODUCTS AND PRODUCT DEVELOPMENT

Processing is a method of reducing post harvest losses of perishable foods. Rao (1989) has defined the processing as adding value to conventional and innovative basic food items through various permutations and combinations providing protection, preservation, packaging, convenience, and disposability. Crusius (1984) reported that the standardisation of recipes is an essential strive for the development of high quality products.

Poduval and Pillai (1998) opined that one of the foremost purposes of standardisation is to facilitate the movement of materials and products through all stages of production in any industrial activity starting from the raw material to the finished products; then to the dealer and finally to the retailers and consumers. Standards make it possible to carry on trade in an economic and efficient manner, and it makes possible quantitative measurement, physical and chemical analysis, and manufacture of products of constant and uniform quality (Mitzner *et al.*, 1984).

First step for the standardisation procedure is the collection of novel recipes from the standard cookery books, journals and magazines. Necessary modifications in the basic recipes are to be made at the laboratory level and the recipes are finalised. Next step is the preparation of the products according to the recipe formulated. In this procedure, the ingredients are to be accurately weighed and cooked at a specified temperature in accordance with the finalised standard recipe. The finished products are then tested by the panel judges. Necessary modifications are to be made in the recipes based on the suggestion offered by the panel of judges. The preparations are to be repeated and scored in order to get a standardised product. In the present study each product developed were subjected to the standardisation procedure before the product is finalised.

### 3.4.1 Standardisation of Ready to Serve (RTS) Beverages Utilising Coconut Water

Beverages are delicious and have universal appeal unlike any other food products. Kaur and Khurdiya (1993) has pointed out that about 65 per cent of the total processed products manufactured under FPO licenses in India are sweetened aerated water. Pepsi and Coca Cola engulfed the Indian soft drink markets, which are growing at a faster rate of 12 to 14 per cent a year (Rajath, 2003).

Ready to serve (RTS) beverage is a drink in which any base material such as fruit juice/milk/ coconut water is considerably altered in composition with sugar and water during preparation so that no further dilution is necessary prior to serving and hence considered in the ready to serve form (Deko, 2000).

Sainathan *et al.* (2002) expressed that functional drinks from coconut have potential not only in domestic but also in international markets. Beverages based on natural food materials have immense value in the context of recent upsurge against Coco Cola containing high levels of pesticides causing carcinogenic effect and immune system breaks down.

***3.4.1.1 Procurement of Raw Materials for the Standardisation of Beverages***

For the formulation of the tender coconut water beverages, seven months old tender coconuts were utilised and for matured coconut water beverages twelve months old coconuts were used. According to Ronate *et al.* (1992), to obtain a high quality product free from, bitterness, harvesting must be planned and scheduled according to processing and maturity. Hybrid COD (Chowghat Orange Dwarf) variety recommended by CPCRI was taken as control whereas commonly used cultivars were used for formulating plain and blended coconut beverages using tender and matured coconut water.

The coconuts were procured from the instructional farm, Vellayani for standardisation purpose and later from CPCRI, Kasaragod for further investigation.

In the formulation of coconut beverages treatments proposed were, acidulant blended, pineapple blended and lemon blended beverages. Tender coconut water and matured coconut water were kept as control samples for comparison.

### *3.4.1.2 Standardisation Procedure*

In the formulation of each category of beverage in the present study different proportions of ingredients were taken as in the standard recipe and different combinations were formulated by 'trial and error'. Each type of beverage was prepared separately and presented simultaneously before the technical experts, to identify the best combination under each category using a scorecard developed for the purpose. The above exercise was repeated thrice with an interval of one week to get uniform results. Among the various proportion tried under each category of beverage, the best combination was identified, based on the overall acceptability score. The proportions of the different ingredients is thus finalised and the proportion of each combination of beverage along with organoleptic scores are presented in Table 1. Thus three RTS beverages from tender coconut water and three from matured coconut water along with the control beverages were standardised in the laboratory.

Table 1. Composition of RTS beverages standardized from coconut water

| Treatments | Beverages standardised | | | |
|---|---|---|---|---|
| | Tender coconut water | | Matured coconut water | |
| | Proportions | Overall acceptability score | Proportions | Overall acceptability score |
| $T_0$ C: S | 1: 0 | 3.44 | 1:05 | 3.34 |
| $T_1$ C: S: A | 1:0.08:0.002 | 3.42 | 1:0.1: 0.002 | 3.26 |
| $T_2$ C: S: P | 1:08:0.25 | 3.50 | 1:0.1:0.25 | 3.34 |
| $T_3$ C: S: L | 1: 0.10:0.08 | 3.44 | 1:0.12:0.08: | 3.36 |

$T_0$ –Plain, $T_1$– Acidulant blended, $T_2$–Pineapple blended, $T_3$–Lemon blended, C-Coconut water, S-Sugar, A-Acidulant (citric acid, sodium citrate), P-Pineapple juice L-Lemon juice

### *3.4.1.3 Selection of the Beverages for in-depth Investigation*

Matured coconut water beverages though organoleptically acceptable, were found to develop off flavour within a short spell of time (3 to 4 days) and hence not considered suitable as a RTS beverage for commercial purpose. Hence detailed investigations were carried out only in the RTS beverages based on tender coconut water.

### *3.4.1.4 Preparation of RTS Beverages*

**Filtration**

Coconut water was collected after dehusking and breaking the shell, which contains varying amounts of suspended particles. The coarse particles in suspension in the juice were removed by straining through blotting cloth (mira cloth). The presence of these constituents causes deterioration in the quality of the finished product. The coconut water is then pasteurised.

**Blending**

According to Annapoorna *et al.* (1977) reuniting flavour, eliminating undesirable components of the same, become the basis for blending of a wide variety of flavour, colour and consistency. Rao (1989) reported that blends might go a long way in reducing cost of the beverages and also to introduce a new product with different taste and flavour.

Fruits *viz.*, pineapple and lime were selected for the preparation of blended coconut beverages. The pleasing colour and intense flavour of pineapple and lime are assumed to be ideal for blending. Moreover, colour of the above juices blends well with the coconut water. Pineapple is a rich source of vitamin C, thiamine and sugars, whereas tender coconut is rich in potassium, sodium and B-vitamins, so it forms a nutritious blend. Rao (1989) revealed that bromelin an enzyme present in pineapple ensures good digestion too.

Lime is juicy and very aromatic. Gopalan *et al.* (1999) pointed out that the lime is a rich source of vitamin C and it has beneficial effect on building up resistance against infection.

**Formulation of the beverages**

Tender coconut water and fruit juices were separately collected, filtered and pasteurised. On an average, around 300ml of tender coconut water is available from one tender coconut, whereas the quantity of water obtained from matured coconut water is approximately 150-200 ml.

Sugar is a principal component for the formulation of the beverages. It contributes flavour, sweetness, mouth feel and facilitates water absorption. Synthetic acidulants *viz.*, citric acid (0.5 per cent) and sodium citrate (0.5 per cent) were added for acidulant blended coconut beverage.

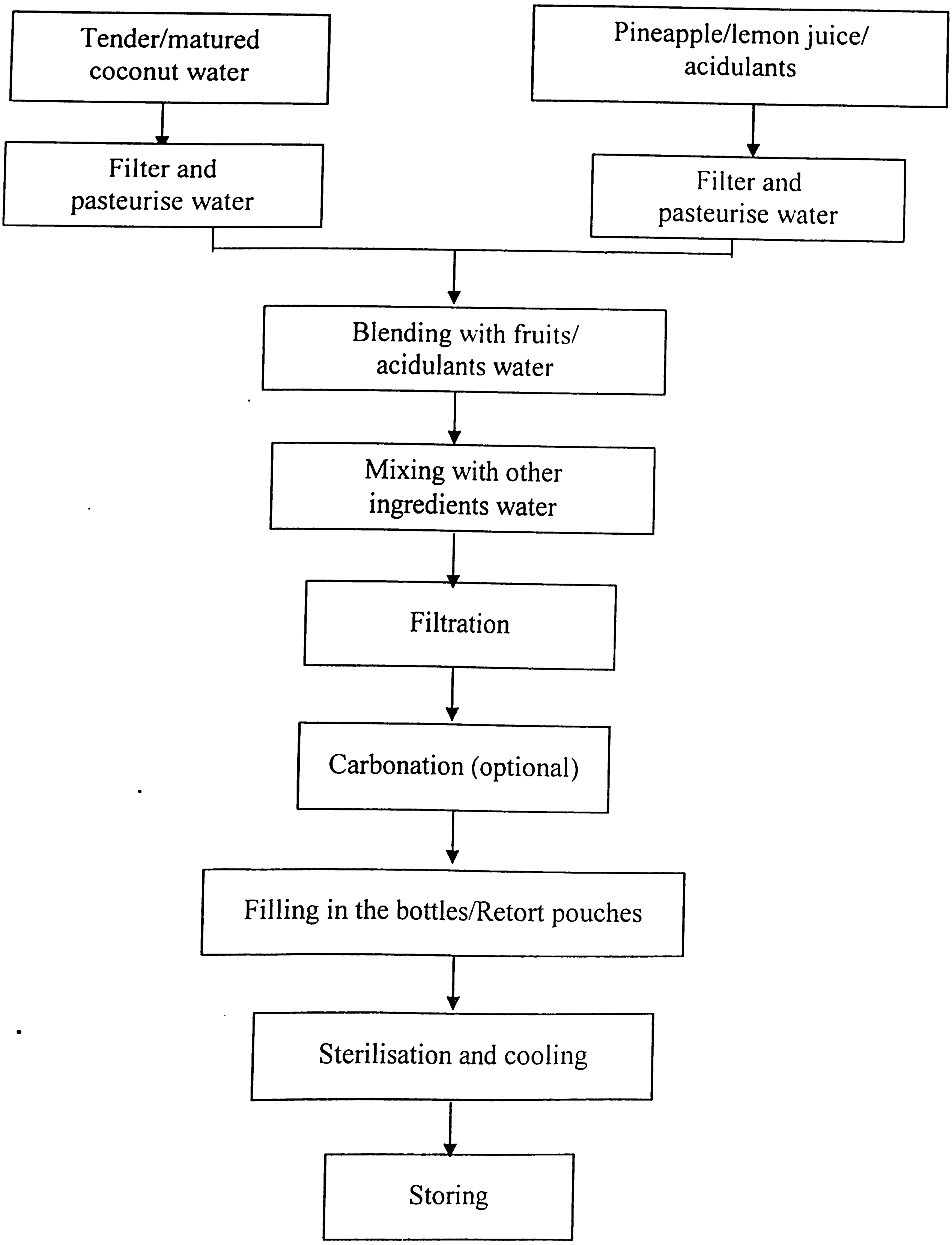
**Carbonation**

Carbonation enhances the shelf life of the products. The beverages were carbonated and then filled in sterilised bottles and retort pouches leaving about 1.2–2.5 cm of headspace. The concentration of carbon dioxide in the drink is to be approximately 1 to 2 gm per 250 ml mixture (Rokade *et al.*, 2001).

**Sealing and Sterilisation**

The bottles and retort pouches were sealed and again sterilised dipping the bottles in the water and heating upto 65°C. The bottles were kept horizontally when it was hot and later stored in cool and dry place for shelf life studies (Fig. 1).

**Fig. 1 Flow chart for coconut water beverages**



### 3.4.2 Standardisation of Bioprocessed Products

The processing of coconut for culinary purpose or for production of copra to extract coconut oil result in the wastage of large quantity of coconut water as a by-product (Madhavan, 1998). It has been estimated that more than 250 million litres of coconut water, with a biological oxygen demand (BOD) of 40 g/l is generated and disposed off annually in Kerala alone (Satyavathi, 1995) resulting in huge food loss and creating environmental pollution. Coconut water thus wasted was utilised for the formulation of a value added bioprocessed product in the present investigation.

'Nata de coco' is a chewy, translucent, traditional Philippine dessert, which is formulated from coconut water by bacterial fermentation (Hubies, 1996). The method of making nata de coco is simple and cost effective without the requirement of high-tech machinery.

Thomas *et al.* (1987) stated that coconut water possesses growth-promoting activity and serve as a good media for microorganisms. Bernardo *et al.* (1998) isolated and characterised cellulose-producing bacteria namely *Acetobacter xylinus* and *A. hansenii* and utilised them for 'nata' production in Philippines. Hegde (1997) reported that the bacterium used for 'curdling' the coconut water is so far not known to cause any disease or health hazards in man or animals. The increasing popularity of 'nata' is due to several health benefits ascribed to it besides its uniqueness in taste and flavour (Sanchez, 1990). It is high in fibre, good for the digestive system, and is low in calories and contains no cholesterol. Kulvadee *et al.* (1996) reported that the addition of different flavouring extracts (almond, banana, lemon, strawberry, and vanilla) could improve the acceptability of nata produced.

Three different substrates namely, plain coconut water, coconut water with pineapple extracts and coconut water with soya milk was used for the production of nata under the present investigation.

### *3.4.2.1 Preparation of the Culture*

The culture *Acetobacter xylinium* was obtained from National Chemical Laboratory, Pune, from which subculture was prepared as suggested by NCIM (1997).

### *3.4.2.2 Preparation of the Media for 'nata' Production*

Subculture was inoculated to the substrate for the production of nata. The basic ingredients for the preparation of nata are given in table 2.

Table 2. Basic ingredients used for the preparation of nata.

| Ingredients | Quantity |
|---|---|
| Coconut water | 1,000ml |
| Starter culture | 20g |
| Starter liquor | 100ml |
| Refined sugar | 30-60g |
| Glucose | 10-20g |
| Sucrose | 20-40g |
| Ammonium phosphate mono | 5.0 g |
| Glacial acetic acid | 15-20ml |
| pH of the medium | 3.5 |

The medium was prepared by mixing coconut water with other ingredients. The medium was left undisturbed in wide-mouthed glass jars covered with a thin cloth for 15-18 days. During this period, 'nata' began to develop as a thin, slimy, transparent layer on the surface of the medium and slowly thickened with age (Plate 2).

For the standardisation of nata, different proportions of basic substrates and different proportions of pineapple extract and soymilk along with coconut water was tried by 'trial and error'. The above procedure was repeated until an acceptable 'nata' growth in the medium was achieved. Proportion of different ingredients was thus identified.

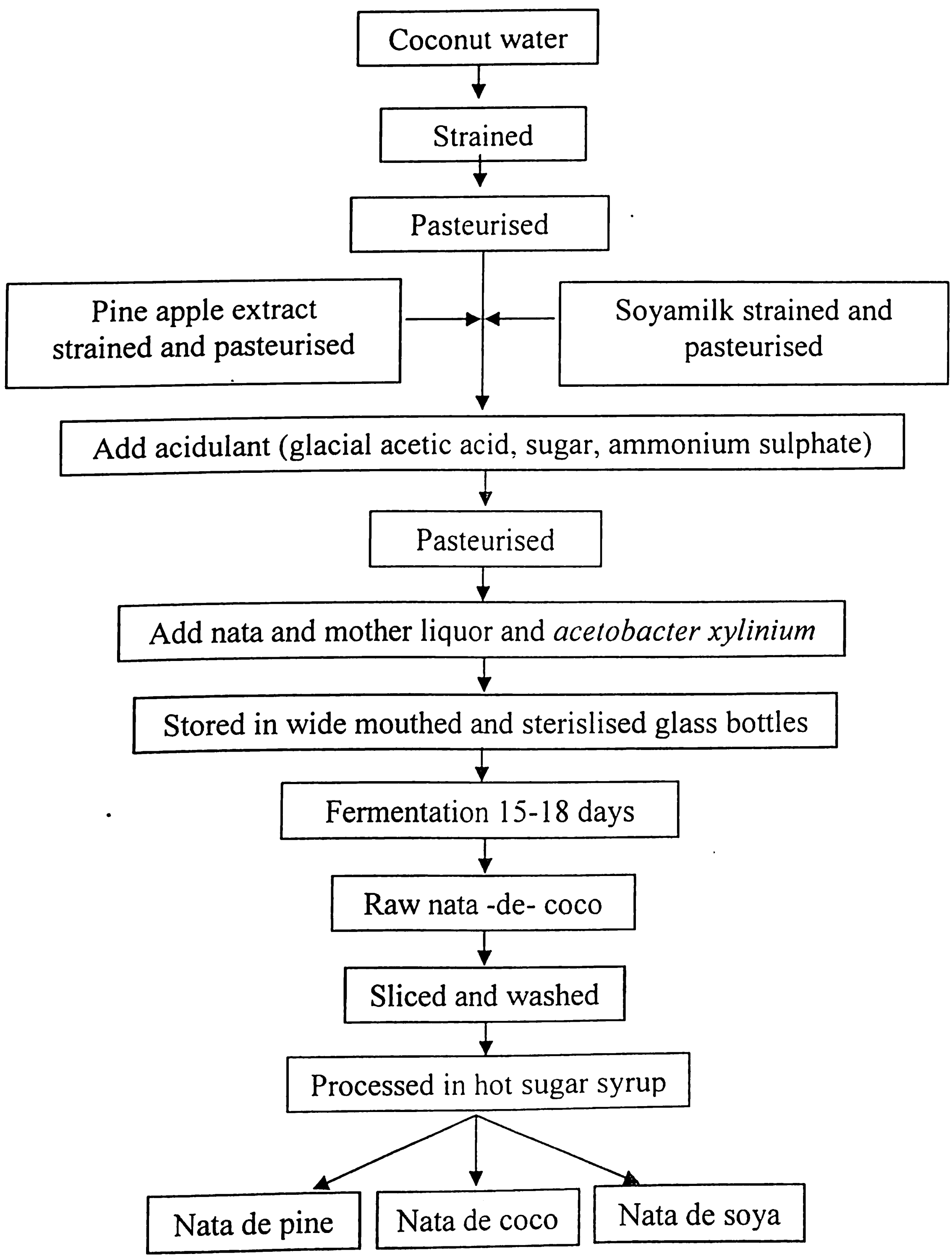
The proportions identified under investigation for active growth of 'nata' were plain coconut water, 30 per cent replacement of coconut water by pineapple extract and 20 per cent replacement with soya milk to produce 'nata de pine' and 'nata de soy'. Soymilk was prepared as suggested by Gandhi (2000). The sugar, glucose, sucrose and glacial acetic acid were adjusted to make the TSS content of the media 8-9 and pH 3.5.

Thus three types of bioprocessed nata viz., plain nata, nata-de-pine and nata de soya were standardised under the present study.

### *3.4.2.3 Processing of the Nata Developed*

'Nata' developed when attained 3 cm thickness was picked up from the media in which it was grown. It was washed thoroughly to remove the sour taste and sliced as desired. Sliced nata was then boiled in sugar syrup with addition of flavour and packed in sterile bottles and cans for further investigations (Fig. 2).

**Fig. 2 Flow Chart for Nata**



### 3.4.3 Standardisation of Simulated Dairy Milk Products

Milk produced in the country (54.9 million tonnes) is far short of requirements to meet the nutritional demands of the people (Sarkar and Mishra 1996). The high cost of milk products has made dairy products a luxury item, which cannot be affordable by people of low-income group. According to Pavithran (1994) substitution of milk fat with cheaper fats can substantially reduce the cost of diary products. The fat of choice for Keralites is that from coconut oil because of its easy availability, low cost, pleasant flavour and familiarity (Pavithran, 1994).

Coconut milk is not only high in fat (oil) but also contains protein. Gonzalez (1991) reported that coconut protein is known to produce a soft curd enhancing its digestibility and is therefore expected to be a valuable component of baby foods. Rajendran (1998) is of the opinion that the use of coconut milk for substituting cow's milk is suitable for small-scale industry in remote places of the country where coconuts are abundant throughout the year for a cheaper price.

#### *3.4.3.1 Coconut Milk Yoghurt*

Yoghurt is a pasteurised milk or low-fat milk coagulated to custard like consistency with a mixed lactic acid culture containing *lactobacillus bulgaricus* and *streptococcus thermophilus* (Madan *et al.*, 1986). According to Lee *et al.* (1990) yoghurt helps to replace valuable bacteria in the gut killed by antibiotic and boost the immune system.

Yoghurt is most often flavoured with fruit preserves or other ingredients but is also consumed unflavoured. Pineapple flavoured yoghurt was developed in Philippines from a cheaper blend of water extracted coconut milk and skim milk powder using a low cost technology (Davida *et al.*, 1993). Balasubramanyam and Kulkarni (1991) reported that yoghurt is a valuable source of calcium, phosphorus and Vitamin B complex. Markose and Poduval (1993) remarked that the increasing popularity and demand for yoghurt, is due to its perceived therapeutic value.

The composition of conventional plain yoghurt is 3.2-3.5 per cent fat 10-15 per cent solid-not-fat (SNF), and 3.5 per cent protein. In the present study, attempt has been made to standardise coconut yoghurt and coconut curd from coconut milk by replacing cow's milk partially. Two treatments for coconut yoghurt and two for coconut curd were applied. One by substituting cow's milk with coconut milk and skim milk powder and other by using coconut milk with soya milk.

### *3.4.3.2 Steps Involved in the Formulation of Yoghurt*

Extraction of coconut milk Coconut milk (CNM) was obtained from freshly grated meat using a stainless steel extractor as suggested by Agrawal *et al.* (1991). To get 400 ml of coconut milk, the first extraction was made at the rate of 100 ml cows milk diluted with100ml of coldwater per 350 g of coconut gratings, and the second extraction was made with 80 ml of water. The extracts were mixed together, strained through the double muslin cloth and pasteurised.

Enrichment with skim milk powder Skim milk powder (SMP) without sweetener was purchased from local market. For every 100ml of warm coconut milk 20 g of skim milk powder was added. Coconut milk was thus enriched by adding 20 per cent skim milk powder.

Soymilk substitution Soybean is the major source of vegetable proteins and fat contributing approximately 40 per cent protein and 20 per cent oil. Soymilk has a great potential to supplement the dairy milk as it is nutritionally rich and contain all essential amino acids. It is devoid of lactose to which many are sensitive (Gandhi 1998). The nutritive value of coconut milk can be enhanced by the incorporation of protein and unsaturated fat containing essential fatty acids as in soya milk.

Soymilk was prepared by the method suggested by Nsofor and Chukwu (1992). From 100 g of soya bean, 750 ml of soya milk was prepared and pasteurized at 85° C for 20 - 30 minutes. Coconut milk was substituted with 50 per cent soymilk and 10 per cent skim milk.

**Addition of starters for yoghurt preparation**

Starter cultures of *Streptococus thermophilus* and *Lactobacilus bulgaricus* for yogurt manufacture were obtained from National Chemical Laboratory, Pune and propagated into bulk starters on the substrate specified by NCIM (1997).

**Formulation of yoghurt**

The homogenised milk base was pasteurised at 85°C and to this added 5 per cent refined sugar, and cooled to 45°C. It is then inoculated with 2 per cent of 14-16 hr old *S. thermophilus* and when the milk base is cooled to 35°C, inoculated with 2 per cent of 14-16 hr old *L. bulgaricus*. Coconut milk added with starters was stirred and kept in 150ml plastic cups and steel containers with lids. Allowed to ferment at 42°C for 3 hours or till titratable acidity became 0.75 per cent. It was chilled overnight (15-18) hr at 10°C in order to improve the acceptability. Different proportion of coconut milk, skim milk and soya milk was tried for the formulation of yoghurt and the best proportion was selected for the final standardisation. Thus two types of yoghurt *viz*., Plain coconut yoghurt with skim milk powder and coconut yoghurt with soymilk were standardised in the study.

**3.4.3.2 Coconut Milk Curds**

Curd is commonly prepared in Indian homes by seeding boiled and cooled milk with a small quantity of lactic curd and allowing it to stand at room temperature for 8-12hours (Krishnaswamy *et al*., 1971). The nutritive value of lactic curds is similar to that of milk from which it is prepared.

Curds provide beneficial bacteria to the human gut, alleviating the lactose intolerance and reduce hypertension.

Extraction of coconut milk Extraction of coconut milk was carried out as suggested by Agrawal *et al.* (1991).

Enrichment with Skim milk powder (SMP) without sweetener was purchased from the local market. For every 100ml of warm coconut milk 20g of skim milk powder was added.

**Soyamilk substitution**: Soyamilk was prepared as followed by Nsofor and Cukwu (1992).

**Addition of starters**: Starter cultures which contain *Streptococcus lactase* and *Streptococcus diacetyl lactate* was obtained from Dakshina Kannada Cooperative Milk Producer's Union Limited, Mangalore and propagated into bulk starters on cows' milk.

**Formulation of curds**: The homogenized coconut milk base was pasteurised at 85°C, and cooled to 35°C and inoculated with 2.5 per cent of the starter culture. The fermented milk was later stirred and packaged in plastic cups and steel containers of 150 ml capacity with lids. It was then fermented at room temperature for 4 hours, or till titrable acidity becomes 0.75 per cent, and then chilled overnight for 10°C.

Standardisation procedure as described for the earlier product was observed in the standardisation of curds also. The final proportion selected for the standardisation of curd was based on the repeated scores obtained by the panel judges.

Table 3. Composition of curd and yoghurt from coconut milk.

| Products | Ratio | Proportion |
|---|---|---|
| Coconut Curd | A: B<br>A: C: B | 5: 1<br>6: 3: 1 |
| Coconut yoghurt | A: B: D<br>A: C: B: D | 5: 1<br>6: 3: 1 |

A: coconut milk, B: skim milk powder, C: soya milk, D- sugar

### 3.4.4 Standardisation of Protein Enriched Coconut Supplements used as Base Mix

#### *3.4.4.1 Supplementary Snack Food*

#### *3.4.4.2 Health Drink Mix*

The most promising additional sources of proteins available for improving diets in the less developed countries are various edible oilseeds, nuts and their meals (Swaminathan, 1973). Surveys have shown that oilseeds, nuts and their meals can provide about 10g additional protein per day/capita if used fully for human consumption (Gonzalez, 1983). Cereals and pulses constitute an important source of dietary calories and protein for much of the world's population, especially in developing countries. Besides being good sources of protein and energy, coconut serve as good sources of minerals in the human diet (Den *et al*., 1986) is of the opinion that the main objective for formulation of a protein enriched coconut supplement is that. it should be pre-cooked, nutritious, ready to eat, easy to digest, palatable and reasonably priced. The development and utilisation of simulated products from an indigenous protein source would solve present protein deficiency problems to some extent.

### 3.4.4.1.1 Steps Involved in the Standardisation of Protein Enriched Supplementary Food and Health Drink Mixes

**Procurement of Raw Materials**

Coconut was procured from the instructional farm, College of Agriculture, Vellayani and also from CPCRI, Kasaragod. The other ingredients viz., desiccated coconut; soybean, peanut, rice and jaggery were procured from the local markets.

**Processing of the raw ingredients**

**Coconut** was grated and roasted in a non-stick pan on low flame until golden brown colour was attained.

**Soybean** is the cheapest source of protein among different vegetable proteins, supplying 40-50g/100g. It was cleaned manually, germinated and malted as the procedure suggested by Vaidehi (1981).

**Peanut** was cleaned manually and roasted in iron kadai cooled and peeled, Oilseeds like groundnut is inexpensive and at the same time is a concentrated source of energy and protein. It is also a good source of minerals and vitamins.

**Rice** is the vital food material for more than half the world's population, and parboiled rice is the preferred staple cereal among majority of Keralites.

Raw rice was cleaned separately and soaked in water for five minutes, and then heated separately in iron kadai till puffed. Danur (1985) had pointed out that the mineral content of rice was found to increase as a result of parboiling. Usually rice and wheat is used as the cereal base for supplementary foods (Anonymous, 2000). The purpose is to dilute the protein and provide the calories. Rice provides characteristics like smoothness of the reconstituted product, desirable flavour, colour and taste to the finished product.

**Jaggery** Coconut palm jaggery was used for sweetening and flavouring. It is said to have many curative properties.

### *3.4.4.2 Formulation of the Supplementary Foods*

To formulate an adequate multi-mix, four components are essentially needed- a basic staple, an energy rich supplement, a protein supplement and mineral & vitamin supplement which has been illustrated by PAG (1975) as Food square. Following the above principle, a base mix was standardised by selecting ideal components from the food square.

**Composition of base mix developed**

Several combinations formulated for the base mix was tested organoleptically. The base mix combinations were prepared simultaneously and presented to technical experts to identify the best one. The above exercise was repeated thrice with an interval of one week to get uniform reaction. Based on the score, the best proportion was identified. Feasibility of the base mix for making traditional preparations *viz.*, Laddu and Burfi were also tested.

Based on the critical evaluation and sound judgment supplementary base mix to be used in the preparation of snack food was finalized composition of which is given in table 4.

Table 4. Composition of base mix

| Ingredients | Quantity in Percentage |
|---|---|
| Coconut gratings (Roasted and powdered) | 30 |
| Soyabeans (malted and powdered) | 10 |
| Groundnuts (roasted and powdered) | 10 |
| Rice (puffed and powdered) | 15 |
| Coconut jaggery | 35 |

Method of preparation for the base mix is given in the appendix I.

### *3.4.4.2 Formulation of Health Drink Mixes*

Many health drinks are available in the market in the form of energy drinks, medicinal drinks, protein drinks that are in the powder form or as beverages. In the present study, two health drink mixes viz., malted health drink and therapeutic health drink using coconut milk powder was standardized. In malted health drink mix wheat and barley were used in addition to coconut where as in therapeutic health drink mix condiments like coriander seeds, cumin seeds, fenugreek seeds, cardamom, tulsi seeds, and coconut palm jaggery were used along with coconut milk powder. (Fig 3)

#### 3.4.4.3.1 Procurement of Raw Materials

**Malted wheat flour** was prepared by the method suggested by Litty and Chellammal (1998).

**Malted barley powder** was prepared by the method suggested by Neeraja and Rajyalakshmi (1996). Pioneering work has been done in this area at CFTRI, Mysore and it was reported that addition of 5 per cent malted barley flour reduced the viscosity of 15 per cent hot paste slurry of the commercial supplementary foods (Desikachar 1982).

**Arrowroot powder** was used as thickening agent. It was procured from local market.

**Coco powder** was used for flavouring the health drinks. It is procured from the local market.

**Defatted soya flour** was used for fortification of health drinks. It was procured from Shakti soya private limited, Coimbatore.

**Coconut milk powder** Spray dried coconut milk powder easily dissolves in water to form a milky-white liquid with the flavour and texture of coconut milk. Coconut milk powder was procured from the local market.

**Fenugreek** Commonly known as Methi and is widely used in Indian culinary preparations. It stimulates the digestive process as well as the metabolism in general(Neeraja and Rajyalakshmi, 1996).

**Cardamom** It is mainly used to add flavour to the health drink mix.

**Coriander seed** The seeds contain about 0.5 to 1 per cent essential oil, which has an active principle – coriandrol, an isomer of geranial.

**Cumin seed** The seed contain about 2 - 4 per cent essential oil. The active principle is an aldehyde, cuminol.

**Ginger** Dried gingers contain about 1-3 per cent essential oil.

**Pepper** *Piper nigrum* contains about 2-2.5 per cent essential oil, which is responsible for the characteristic flavour.

All the condiments mentioned above were procured from the local markets, cleaned, roasted, powdered and sieved separately.

**Jaggery** is recommended in therapeutic drink mix due to its high iron content. Jaggery contains 0.1 - 0.6 per cent protein, 8-14 mg calcium, 14-112 mg phosphorous and 2.0-7.0 mg, iron per 100 g. Shobha and Prakash (2001) reported that palm jaggery possess many curative properties and unique flavour.

The above ingredients were mixed in different proportions to get an acceptable combination, which was evaluated by the technical experts. Method of preparation for the Health drink mix is given in the appendix II.

Based on the critical evaluation and sound judgment therapeutic drink mix with the following composition was finalized.

## FIG: 3 FLOWCHART FOR HEALTH DRINK MIXES

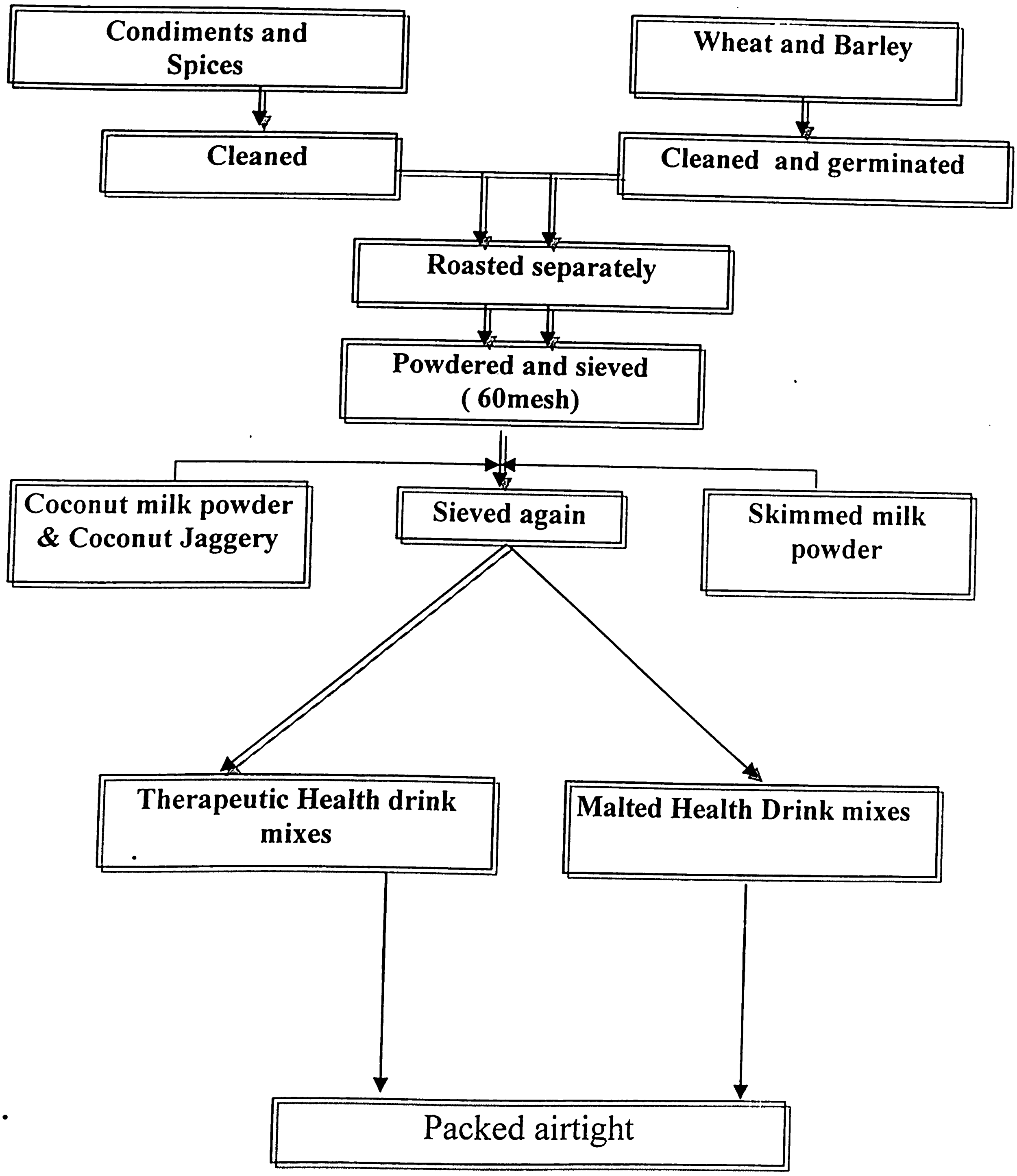


Table 5. Composition of health drink mixes

| Therapeutic drink mix | | Malted health drink mix | |
|---|---|---|---|
| Ingredients | Quantity in percentage | Ingredients | Quantity in percentage |
| Coconut milk powder | 35 | Coconut milk powder | 40 |
| Skim milk powder (cow's) | 15 | Skim milk powder (cow's) | 15 |
| Coconut palm jaggery | 20 | Malted wheat flour | 20 |
| Coriander powder | 10 | Malted barley powder | 8 |
| Pepper | 5 | Defatted soya flour | 5 |
| Dried ginger | 5 | Glucose | 4 |
| Cardamom | 2.5 | Arrowroot powder | 4 |
| Cumin seeds | 5 | Coco powder | 4 |
| Tulsi powder | 1 | Sorbitol(aspreservative) | 0.5 |
| Fenugreek | 1.5 | | |

### 3.4.5 Standardisation of Bakery Products and Preserves

#### *3.4.5.1 Standardisation of Biscuits and Cookies*

Baking is a convenient, timesaving and profitable cooking method that can be taken up by the cottage industries. Biscuits, cookies and crackers represent the largest category of snack items among the baked foods in India (Pratim *et al.*, 2000). Protein fortified biscuits are of current interest because of the nutritional awareness of the consumer. As reported by Arnold (1982) biscuit is essentially a bakery confectionary dried down to low moisture content. It is made from soft flour, mostly rich in fat and sugar and with high energy content.

The nutritive value of baked products like biscuits and cookies can be improved by incorporating coconut kernel and desiccated coconut. Since fat is a major ingredient in baking, coconut kernel will be a boon to the bakery industries. Its pleasant flavour is an additional gain.

**Procurement of raw materials**

The different raw materials selected for the formulation of coconut biscuits include coconut gratings, desiccated coconut, refined wheat flour, coconut honey, sugar and fat. Raw materials were purchased form the local market. Coconut honey was prepared in the laboratory. The principles governing the selection of the combination were protein content, cost and appearance.

Different proportion of the above mentioned ingredients were blended in a standard recipe during standardisation of the coconut biscuit. The process was repeated and evaluated separately by the panel judges. Based on the acceptability score the best combination identified was taken as the final trial, and the composition is given below.

**Composition of coconut biscuit**

Ingredients: Refined flour-120g, desiccated coconut-60, Fat-120 gm, Powdered sugar-120 gm, lemon juice-3 tsp, Coconut Honey-1 tbsp.

Method of preparation is given in Appendix I.

***3.4.5.2 Standardisation of Coconut Cookies***

Cookies come in many different shapes, forms and flavour. The consistency and the nature of the cookies are determined by the kind and amount of ingredients used. Patel and Rao (1996) indicated that supplementation of fine commercial defatted soyflour will improve the physical and sensory characteristics of cookies. The raw materials taken for the standardisation viz., grated coconut, refined flour, fat and sugar were purchased from the local market.

Different proportions of various ingredients were blended in the standard recipe while standardising the coconut cookies. The process was repeated and evaluated separately by the panel judges. Based on the evaluation score the best combination identified was taken for the final trial.

**Composition of the coconut cookies**

Refined flour – 500 g, Fat-250 g, Sugar-250 g, Roasted coconut gratings – 400g, Granulated sugar- 150 gm, milk for mixing.

Procedure is given in appendix I.

*3.4.5.3 Standardisation of Preserves*

Lal *et al.*(1988) have defined 'candy' as a fruit impregnated with sugar and glucose and subsequently drained and dried'. The fresh kernels left after the use of tender nut water is not put to effective use though it has high nutritional qualities. A low cost technology was developed for production of preserves from tender coconut kernel. Candied fruit covered with a thin attractive transparent coating of sugar is called a glazed fruit. (CFTRI, 1999) When candied fruit is coated with sugar or allowed sugar crystals to deposit on it, it is called crystallized fruit. Glazed preserves made from tender coconut kernel can be incorporated in bakery products like cakes, cookies, toppings for ice creams, desserts etc. Crystallised candy made with tender coconut kernel can also be consumed as a snack.

Two types of coconut preserves from tender coconut kernel and two types of coconut honey from coconut milk were standardized under the present investigation.

| **Tender Coconut Preserve** | **Coconut milk honey** |
|---|---|
| Glazed candy | Brown honey |
| Crystallised candy | White honey |

**Procurement of materials**

**Tender coconut kernel** Eight-months-old coconut was utilised for the standardisation candies. Approximately 250 gm of kernel is available from a single nut. Tender coconut kernel was procured from Instructional farm, college of Agriculture Vellayani, for standardisation process and later from CPCRI, Kasaragod for furthur investigation.

**Liquid glucose** This helps to give glazing effect to candies. It was procured from Durga Chemical Ltd, Mangalore.

Sugar, flavour and essence were procured from local markets.

### 3.4.5.3.1 Standardisation of Crystallised Candies

Young coconut is washed and spilt open to remove water and soft kernel is scooped out. This is then cut into cubes of 1'x 1'. Soft kernels were pricked with stainless steel forks or bamboo procures. Then the pieces were immersed in dilute limewater (1.5 per cent) or alum (2 per cent) for 4 – 6 hours before further processing. Wash the pieces 3-4 times with fresh running water.

Blanched the pieces for 5 minutes in boiling water to make them soft, which assists in absorption of sugar and to prevent enzymatic browning. Half the quantity of sugar was taken and spread on the blanched pieces in alternative layers, allowed to stand for 24 hours. Next day drained off the syrup, added enough sugar to raise the thickness of syrup to about $60^{\circ}$ brix. To this added the coconut pieces, boiled and kept for 24 hours. Flavours such as cardamom, dry ginger, vanilla and light colour were added in order improve the taste and appeal. Repeat the process till the residual syrup reached $100^{\circ}$ brix. Drained off the syrup and dried in sun or hot air drier. Dust with powdered sugar and stored in bottle or polythene bags.

### 3.4.5.3.2 Standardisation of Glazed Candy

Repeat the procedure as in the making of crystallized candy. Repeated the process next day till the residual syrup reaches 70-75$^{\circ}$ brix. Citric acid was added at rate of 0.1 per cent as preservative and 25 per cent of sugar was replaced by liquid glucose. Flavours such as pineapple, strawberry, lemon and dark colour like red or green could be added. Drained off the syrup. Dry in sun or hot air drier. Store in bottle or polythene bags.

### 3.4.5.3.3 Standardisation of Coconut Honey from Coconut Milk

Coconut honey is a translucent, free flowing liquid with the characteristic creamy, and nutty flavour. It is made of coconut milk (Gonzalez, 1990). It can be used as a mixer in drinks, toppings for the bakery products and waffles. It can be diluted in water and used in cooking rice cakes and other delicacies. It is a low cost technology, which can be taken up as a cottage industry with very less investment.

**Processing of Brown Honey from Coconut Milk**

Raw materials Sugar, glucose and coconut jaggery, were procured from the local market where as adjunct like carboxyl methyl cellulose (CMC) or sodium alginate was obtained from Durga Chemicals Ltd, Mangalore.

The coconut milk is extracted from the gratings of unpared meat after adding an equal quantity of water. To this extracted coconut milk, 50 per cent by weight of caramalised sugar and 30 per cent by weight of glucose are added and then boiled until a thick consistency is reached. Lastly 10 g of coconut jaggery are added. To reduce the fat content of the coconut honey, cream or fat can be removed from the coconut milk before preparation by refrigerating the coconut milk for two hours. The final product is a golden coloured thick paste with a good flavour. This can also be used as an excellent base for soft drinks. Stabilizer *viz*., carboxyl methyl cellulose (CMC) or Sodium alginate is added at the rate of 0.5 per cent to get a homogenized product. The product is then hot-filtered in lacquered tin containers or bottles and sealed. During the standardization of honey various proportions of different ingredients were taken to get a consumer acceptable honey. Each time the product was subjected to sensory analysis by the expert panel and an ideal proportion was selected. Trials were repeated to get a similar result. Based on the acceptability score proportion of the various ingredients were finalized.

**Processing of white honey from coconut milk**

Coconut milk is extracted from grated coconut by adding 25 per cent of potable water. Coconut milk, sugar (60 per cent) and glucose (30 per cent) are heated together with constant stirring for 15 minutes till the TSS reaches 68-70 $^{o}$brix. Stabilizer viz., carboxyl methyl cellulose (CMC) or Sodium alginate is added at the rate of 0.5 per cent to get a homogenised product. The hot honey is poured in sterilised bottles and sealed.

## 3.5 ANALYTICAL WORK CARRIED OUT IN THE STUDY

### 3.5.1 Assessment of Chemical and Nutritional Characteristics of the Products

Quality is the ultimate criterion of the desirability of any food product to the consumers. Cameron (1998) opined that quality standards are of great importance in facilitating both national and international trade. Quality standards simplify industrial transactions and improve international trade relations. This in turn creates a proper environment for trade, thus promoting industrial development.

According to Zacharia (2003) quality assurance in food industry is an ordered set of planned and systematic actions. necessary to provide adequate confidence regarding processed products and services satisfying the requirement of quality. Quality of the product is determined by its chemical and nutritional composition.

Table 6. Chemical and nutritional characteristics analysed in the developed products are given below.

| Chemical and nutritional characteristics | Methods adopted |
|---|---|
| pH | Digital pH meter |
| Total soluble solids | Refractrometer |
| Acidity | AOAC 1965 |
| Reducing sugar | AOAC 1965 |
| Total sugar | AOAC 1965 |
| Moisture | AOAC 1976 |
| SNF | APHA 1976 |
| Peroxide | AOAC 1976 |
| Viscosity | APHA 1976 |
| Free fatty acid | AOAC1976 |
| Calories | Swaminathan (1984) |
| Protein | Sadasivan *et al.* (1984) |
| Minerals | Jackson (1973) |
| Fiber | Raguramulu *et al.* (1983) |
| Vitamin C | Sadasivan *et al.* (1984) |

### 3.5.2 Assessment of Organoleptic Features of the Products

Organoleptic qualities of the products play an important role in evaluating the quality of any food products. For judging the consumer acceptability, organoleptic evaluation of any product is essential. According to McDermott (1992) when the quality of food is assessed by means of human sensory organs, the evaluation is said to be sensory analysis. Sensory method in which palatability is evaluated by a panel of judges is essential to every standardization procedure because they answer all-important questions of the food viz., taste, flavour, appearance and texture. For the conduct of sensory evaluation panels of judges are to be selected.

#### *3.5.2.1 Selection of the Panel of Judges*

Ylimaki *et al.* (1989) stated sensory analysis is a multi-disciplinary science that uses human panelists and their senses to measure their sensory characteristics and acceptability of food products. It is applicable for product development and quality control. Watts *et al.* (1989) reported that the information on specific sensory characteristic of a food must be obtained by using product-oriented tests.

According to Larmonde (1987), the panel is the analytical tool in sensory evaluation. He is of the opinion that value of this tool depends on the objectivity, precisions and reproducibility of the judgment of the panelists. Panels of ten expert judges were selected after initial screening through triangle test as suggested by Jellinick (1986). Procedure for the conduct of triangle test is given in appendix II. Out of the 25 persons who had participated in the screening test, 10 were selected as judges.

Sensory parameters important for the assessment of product evaluation are colour, flavour appearance, texture, taste, and overall acceptability. Above sensory qualities were evaluated in the products standardized using '5 point scale' scorecard developed for the purpose. Scorecard formulated for the purpose is given in Appendix III.

## 3.6 ASSESSMENT OF SHELF STABILITY AND SUITABILITY OF STORAGE MEDIA FOR PRODUCTS

Shelf-stability, of the products was influenced by the storage conditions and type of storage media used. Storage conditions selected for the study was ambient and refrigerated condition. Containers ideal for each category of products viz., glass bottles, metal cans, retort pouches, polypropylenes covers and laminated pouches etc were used for storing the products formulated.

**Storage containers used for the study**

Glass bottles, polypropylenes covers were procured from local market, metal cans from Fresto Food Industries, Mangalore, retort pouches from CIFT, Kochi, and laminated pouches from CPCRI, Kasaragod.

The shelf–life behaviour of the products was monitored at regular intervals depending upon the type of products-daily interval for simulated products, weekly interval for products viz., supplementary snack foods, glazed candy, fortnightly for products viz., beverages, honey and crystallized candy and monthly for products like bioprocessed products, health drinks and bakery products.( Plate I)

Table 7. Presents the type of the storage media, storage condition and interval of analysis of the products standardised in the study.

Table 7. Type of the storage media, storage condition and interval of analysis of the products standardised

| Products | Storage media | Quantity stored | Storage periods | Interval of analyses |
|---|---|---|---|---|
| Beverages | Retort pouches<br>Bottles | 200ml ×100 | 2 months | Weekly |
| Preserved 'nata' | Cans<br>Bottles | 200ml ×50 | 6 months | Monthly |
| Coconut curd<br>Coconut yoghurt | Steel container<br>Plastic container | 100ml ×50 | 4days | Daily |
| Supplementary snack mix | Laminated pouches<br>Polythene bags | 100g ×20 | 1month | Weekly |
| Health drink mix | Laminated pouches<br>Polythene bags | 100g× 25 | 5months | Monthly |
| Bakery products | Laminated pouches<br>Polythene bags | 100g ×25 | 5months | Monthly |
| Crystallised candy<br>Glazed candy | Laminated pouches<br>Polythene bags<br>Laminated pouches<br>Polythene bags | 50g ×10<br>50g ×10 | 2months<br>1month | Fortnightly<br>Weekly |
| Honey | Bottle | 200ml ×10 | 2 months | Fortnightly |

Packaging materials for coconut products

Plate : I

### 3.6.1 Assessment of Changes in the Nutritional and Chemical Characteristics with Storage

Chemical and nutritional qualities in the products were investigated initially analysed at prescribed periods to observe the effect of storage on keeping quality. Samples were drawn from each category of products randomly in required quantities (in triplicate) for analysis.

### 3.6.2 Assessment of Changes in Sensory Qualities

According to Jellinick (1986) chemical indices of deterioration alone will not decide the quality changes and it should be correlated with sensory evaluation of stored products. Hence periodical evaluation of the products was carried out with respect to the sensory parameters using a scorecard by the selected panel to understand the deteriorative changes occurring in the stored products.

### 3.6.3 Microbial Profile of the Products

The pour plate method (Taylor, 1962) was employed to estimate the population of the number of viable micro-organisms in food products. Ten gram weight of the food products were transferred to 90 ml sterile quarter strength Ringers solution (Wilson, 1935) taken in 100 ml Erlenmayer flasks above the flame of Bunsen burner under aseptic conditions in laminar floor chamber. Uniform suspension was prepared by shaking the flasks in a rotary shaker for five minutes. Serial dilutions of the suspension were thus prepared in the sterile diluents. One ml aliquots of the suspension was withdrawn from the first dilution using a sterile pipette and added to 9 ml portions of sterile diluents taken in test tubes of 25 ml capacity to prepare 10-2 dilution. Further dilutions were prepared using a fresh sterile pipette in each case. One ml of each dilution was poured into a sterile petri dish using a sterile pipette and 15 ml of molten agar at 45°C was poured inside Laminar Airflow Chamber. The contents were mixed by circular movements in clock wise and anticlockwise directions. The molten agar was allowed to solidify and the plates were kept in an inverted position in BOD incubator set at the required temperature for each organism. After the incubation, the colonies developed on agar surface are counted and the counts were recorded as colony forming units by multiplying with the dilution factor.

The following media are the culture (as per the composition in ATCC, 1984) and incubation temperatures for different groups of microorganisms.

General viable count- Plate counts Agar. Incubation temperature - 30°C.

Yeast and moulds – Malt Extract Agar. Incubation temperature-30°C

Staphylococcus aureus-Baired-Parkers medium. Incubation temperature 37°C.

The coliform counts were carried out by dilution tube method using brilliant green lactose bile broth. Incubation was at 37°C for 24 hours (William and Dennis1995). Tube showing acid formation together with sufficient gas is considered as positive.

**Isolation and identification of microbial cultures**

The representation cultures were isolated and purified by streaking solidified agar medium recommended for the group of organisms. The morphological, cultural and biochemical characteristics were determined as per the procedure outlined in Harrigan and McCanu (1966).

## 3.7 ASSESSMENT OF CONSUMER PREFERENCE AND CONSUMER ACCEPTANCE

Consumer awareness and preference decide the success of food products standardised. According to Watt *et al.* (1989) acceptance and preference are consumer-oriented tests. He has also opined that in consumer testing, a large random sample of people, representatives of the target population or potential users, is to be selected to obtain information on.

consumer attributes and their preferences towards the products. The scorecard designed for the acceptability test was used for field-testing among 25 consumers drawn at random.

According to Swaminathan (1984) for preference tests a large number of people are required and based on their judgment evaluation should come spontaneously.

'Hedonic' scale (nine to one) was used for the purpose. The test was conducted among 100 consumers drawn at random and were asked to rank the products according to their preferences. Steps were taken to avoid discussion during the rating. They were permitted to take enough time to score. Score card for preference test is given in appendix IV.

## 3.8 COST BENEFIT ANALYSIS OF THE PRODUCTS

The economics of the product depends much on the cost of ingredients used for the preparation of products. According to How (1990) information as accurate and up to date as possible on supply, demand and prices is essential for anybody directly involved in the business of food product industry. The cost of product in this study was calculated by taking into account of the expenses of raw materials used, packaging accessories, and fuel and also on accounting the labour cost. Labour costs were also taken into consideration while deriving the individual cost of the product.

Kumbhar and Singh (1991) reported that the cost of processed products depends on the purchase cost of the raw materials, cost involved in processing, packaging, marketing and profit margin set up by the industry.

Cost analysis of the each product standardized was computed taking into consideration of the pre market price of the ingredients used and cost involved in processing.

## 3.9 PRODUCT YIELD RATIO

Information on product yield ratio is indispensable in ensuring the total turnover of the finished product out of certain quantity of raw materials. This was analysed by considering the quantity of basic raw materials used to produce a particular unit of each product.

## 3.10 STATISTICAL ANALYSIS OF THE DATA

The data generated during the study were complied, analysed and interpreted statistically and presented under results and discussion.

# Results

# 4. RESULTS

Results of the present investigation entitled "Developing diversified and value added products from coconut (*Cocos nucifera* L.) are presented in this chapter under the following sections.

4.1 Assessment of chemical, nutritional, organoleptic and shelf stability features of the **Beverages developed** with tender coconut water.

4.2 Assessment of chemical, nutritional, organoleptic and shelf stability features of the **Bioprocessed products developed** from coconut.

4.3 Assessment of chemical, nutritional, organoleptic and shelf stability features of the **Simulated products** developed from coconut.

4.4 Assessment of chemical, nutritional, organoleptic and shelf stability features of the **Protein enriched supplements** developed from coconut.

4.5 Assessment of chemical, nutritional, organoleptic and shelf stability features of the **Bakery and preserved products** developed from coconut.

4.6 4.6 Assessment of **Microbial profile** of the products developed from coconut with storage.

4.7 Assessment of **FPO and IS** standards in the developed products.

4.8 Assessment of **Cost effectiveness** and **Product yield.**

4.9 Assessment of **Consumer acceptance and preference** of the products.

## 4.1 ASSESSMENT OF THE CHEMICAL AND NUTRITIONAL CHARACTERISTICS OF THE COCONUT BEVERAGES

According to Potter (1986), the knowledge of the constituents of foods and their properties is the basis of understanding the quality of the products.

The chemical components present in foods are sugars, acids, Total soluble solids, vitamins, minerals, polyphenols and enzymes. Analysis of the chemical constituents in the products provides valuable information about the nature of the product and their susceptibility to deterioration (Mehta *et al.* 2002).

Tender coconut water a natural nutritious drink, was explored under the present investigation for value addition due to its short shelf stability and bulk in handling. Three types of ready to serve beverages were standardised from tender coconut water and another three from mature coconut water. Beverage formulated from mature coconut water though acceptable organoleptically, was not commercially viable as indicated in the methodology, due to high variability in constituents, with low shelf stability. Therefore detailed investigations were taken up only in the beverages formulated from tender coconut water, which can be promoted for commercialisation purpose.

### 4.1.1 Chemical and Nutritional Constituents of RTS with Storage

Chemical constituents in the coconut and that of fruits used for blending will influence the chemical constitutions of the RTS beverages formulated. Analysis was carried out with respect to pH, acidity, total sugar, total soluble solids (TSS), reducing sugar, vitamin C and minerals like calcium, phosphorus, iron, sodium and potassium in the developed beverages under study.

Table 8 depicts the chemical and nutritional characteristics of the beverages standardized using tender coconut water viz., acidulant blended RTS ($T_1$) pineapple blended RTS ($T_2$) and lemon blended tender coconut RTS ($T_3$), along with control (Plain tender coconut water ($T_0$)). Analysis of chemical and nutritional characteristics of the tender coconut water blended beverages (RTS) indicated that pH level ranged from 3.38 to 4.52 and acidity from 0.16 to 0.29 per cent. Total soluble solids of tender coconut water was found to be 5.42°Brix and that of total sugar and reducing sugar was 5.80 and 4.69 per cent respectively, where as in the formulated blended beverages total soluble solids ranged between 6.43 to 14.64 per cent, total sugar ranged between 7.37 to 14.42 per cent and that of reducing sugar 5.28 to 9.16 per cent.

Table 8. Chemical and nutritional characteristics of RTS standardised from the tender coconut water

| Chemical characteristics | Mean value of tender coconut water based RTS | | | | | |
|---|---|---|---|---|---|---|
| | $T_0$ | $T_1$ | $T_2$ | $T_3$ | $F_{160,3}$ | CD |
| pH | 4.52 | 4.45 | 3.41 | 3.38 | 94.05** | 0.01 |
| Acidity% | 0.16 | 0.17 | 0.29 | 0.20 | 39.10** | 0.02 |
| Reducing sugar% | 4.69 | 5.28 | 6.24 | 9.16 | 5021.35** | 0.07 |
| Total soluble solids °Brix | 5.42 | 6.43 | 12.45 | 14.64 | 300218** | 0.02 |
| Total sugar % | 5.80 | 7.37 | 14.42 | 12.16 | 44652** | 0.11 |
| Vitamin- C % | 3.29 | 2.58 | 8.48 | 10.63 | 1228.66** | 0.05 |
| Calcium mg | 25.00 | 23.33 | 34.33 | 51.67 | 2131.81** | 0.77 |
| Phosphorus mg | 11.83 | 12.67 | 42.23 | 60.67 | 3839.40** | 1.06 |
| Iron mg | 0.11 | 0.21 | 2.43 | 0.83 | 64706** | 0.01 |
| Sodium mg | 45.50 | 45.00 | 46.50 | 39 .00 | 4190** | 0.67 |
| Potassium mg | 288.17 | 288.33 | 251.67 | 346.67 | 625.75** | 4.35 |
| ** Significant at 1 per cent level | | | | | | |

$T_0$ –Control $T_1$– Acidulant added RTS $T_2$–Pineapple blended RTS $T_3$–Lemon blended RTS

Vitamins and minerals present in the beverages were also analysed. Vitamin C content of the prepared RTS ranged from 2.58 to 10.63 per cent, calcium 23.33 to 51.67 mg, phosphorus 11.83 to 60.67 mg, iron 0.11 - 2.43mg, sodium 39 mg - 46.50 mg and potassium 251.67mg - 346.67mg. Comparative analysis of the data revealed that pH level was lowest in lemon blended RTS and highest in plain tender coconut water. Lowest acidity (0.16 per cent) was recorded in plain RTS, followed by acidulant blended one (0.17 per cent) and lemon blended RTS (0.20 per cent) and reducing sugar content of 9.16 per cent was highest in the beverage blended with lemon and lowest for Plain tender coconut water (4.69 per cent).

Total soluble solids was highest in lemon blended RTS (14.64 per cent), followed by pineapple blended RTS (12.45 per cent) and acidulant blended RTS (6.43 per cent). Total sugar was recorded higher in pineapple blended RTS (14.42 per cent) followed by lemon blended RTS (12.16 per cent). Vitamins C was the highest for lemon blended RTS though the level was not appreciable. Calcium and phosphorus level were also in favour of lemon blended RTS (51.67mg and 60.67mg respectively) followed by pineapple blended RTS.

Iron content was found to be the highest in pineapple blended RTS, (2.43 mg) as against the lowest value of 0.11 mg in plain tender coconut RTS. Potassium level was recorded the highest in lemon blended RTS (346.67 mg). Sodium level was found to be almost similar in beverages formulated (39 mg – 46.50 mg) except for lemon blended RTS (39 mg).

As inferred from the CD values, it is clear that all the chemical and nutritional characteristics analysed in the formulated beverages namely pH, acidity, reducing sugar, total soluble solids, total sugar, vitamin C, calcium and phosphorus were found to vary significantly with each other.

### 4.1.2 Organoleptic Qualities of the Coconut Beverages with Storage

On assessing the sensory attributes of RTS beverages, it was found that overall acceptability score of standardised RTS ranged between 3.9 – 4.4 out of maximum score of 5 indicating well acceptance of the products among the panel members.

Table 9 Sensory attributes of RTS Beverages from tender coconut water.

| Products | Mean score for sensory attributes | | | | | |
|---|---|---|---|---|---|---|
| | Appearance | Colour | Flavour | Taste | Clarity | Overall Acceptability |
| $T_0$ | 4.3 | 4.5 | 3.2 | 4.3 | 3.7 | 4.0 |
| $T_1$ | 4.1 | 4.1 | 3.5 | 3.9 | 3.6 | 3.9 |
| $T_2$ | 4.6 | 4.6 | 4.4 | 4.4 | 3.9 | 4.4 |
| $T_3$ | 4.6 | 4.6 | 4.2 | 4.3 | 3.8 | 4.3 |
| $F_{720,3}$ | | | 9.48* | 11.97* | 13.09* | |
| CD | NS | NS | 0.19 | 0.19 | 0.20 | NS |

* Significant at 5 per cent level.

$T_0$ – Control $T_1$ – Acidulant added RTS $T_2$ – Pineapple blended RTS, $T_3$ – Lemon blended RTS

Table 9 Depicts the organoleptic attributes of RTS Beverages from tender coconut water.

As indicated from the organoleptic scores, sensory attributes viz. appearance, colour and taste was found to be highest and almost similar in pineapple and lemon blended coconut RTS when compared to others..

Appearance and colour scores were lowest (4.1) in acidulant blended RTS. For taste attribute pineapple blended RTS scored the highest (4.4) followed by a score of 4.3 in lemon blended RTS and control. The mean score for clarity character in the formulated RTS ranged between 3.6 to 3.9, highest being in pineapple-blended beverage. (3.9), followed by Lemon blended (3.8), control (3.7) and lastly by acidulant blended RTS. Pineapple blended coconut beverage excelled all others in all the organopleptic features. Lowest acceptability was recorded for acidulant blended coconut beverage. It could also be noted that overall acceptability percentage of the beverages standardised among the judges was 78 to 88 per cent with a mean score range of 3.9to 4.4. In overall acceptability also pineapple blended RTS adjusted to be the best. CD values indicate significant difference in organoleptic characteristics in the beverages standardized with respect to flavour, clarity and taste. However, 'appearance' and 'colour' of beverages seemed to be alike.

### 4.1.3 Changes in the Chemical and Nutritional Constituents of RTS with Storage

Beverages when stored undergo changes with respect to chemical and nutritional constituents, which will give an indication of the deteriorative changes occurring in the products. Shelf stability of the formulated beverages can thus be ascertained. Formulated beverages were stored in two types of containers in two different conditions and periodically evaluated during different storage periods.

Following tables give a detailed description of the changes occurring in the constituents of the beverages including the effect of storage condition, storage media and storage periods.

**pH** is an indirect measure of sweetness or sourness in the products. It is of importance as a measure of the acidity, which not only influences the flavour or palatability of a product but also affects the keeping quality and the processing requirement of a product (Mehta *et al.* 2002).

As inferred from the CD value (0.08), significant difference in pH was recorded between the beverages standardised irrespective of the storage conditions, storage containers, and storage periods.

The control as well as the formulated beverages when kept for storage study at ambient temperature, the pH was found to be decreased significantly (4.47-3.40) and at a higher level compared to the beverages kept at refrigerated condition (4.57-3.36) as indicated from the CD value (0.025). Detailed table is given in the appendix V.

The containers (glass bottles and retort pouches) in which beverages were stored were found to influence the pH level of the beverages. (0.02). The pH was found to be decrease when stored in retort pouches compared to the glass containers.

Over a period of 60 days the pH level of all the formulated beverages decreased irrespective of storage media and storage condition. However, the decrease was more rapid after 15 days in plain RTS (4.94 – 4.14) and pineapple blended RTS (3.53 – 3.25). In acidulant blended beverage, there was a sudden increase in pH after 15 days (appendix V) after which there was a gradual decrease. In lemon-blended beverages, the decrease in pH was more prominent only after 45 days of storage in refrigerated condition.

Table 10 Changes in pH of RTS and its interaction between products, containers and storage periods

| Treatments | Mean scores of pH | | | |
|---|---|---|---|---|
| | $T_0$ | $T_1$ | $T_2$ | $T_3$ |
| $R_1$ | 4.47 | 4.31 | 3.44 | 3.40 |
| $R_2$ | 4.57 | 4.58 | 3.39 | 3.36 |
| $P_0$ | 4.94 | 4.52 | 3.53 | 3.45 |
| $P_1$ | 4.58 | 4.64 | 3.44 | 3.41 |
| $P_2$ | 4.53 | 4.55 | 3.44 | 3.35 |
| $P_3$ | 4.32 | 4.38 | 3.40 | 3.36 |
| $P_4$ | 4.14 | 4.14 | 3.25 | 3.33 |
| $C_1$ | 4.54 | 4.48 | 3.48 | 3.38 |
| $C_2$ | 4.51 | 4.41 | 3.34 | 3.39 |
| $F_{160,3}$ - T 9405.14**, TR 141.60**, TC 23.32**, CD-T 0.08, TR-0.025, TC 0.02 | | | | |

$T_0$ – Plain Coconut water, $T_1$– Acidulant added, $T_2$– Pineapple blended, $T_3$ – Lemon blended, $R_1$ -Ambient temperature, $R_2$- Refrigerated condition, $C_1$ - Retort pouches, C -Glass bottle

** Significant at 1 per cent level

**Acidity:** Mehta *et al.* (2002) reported that acidity indicates flavour as well as wholesomeness of the product.

As inferred from the CD values (0.028), significant difference was recorded between the beverages standardised, irrespective of storage condition, storage media and storage periods.

A significant difference was also observed with storage condition.(CD 0.039) The control as well as the formulated beverages when kept under storage study at ambient temperature, an increase in acidity was observed

Table 11. Changes in acidity of RTS and its interaction between Products, Containers and Storage Periods

| Treatments | Mean scores of acidity | | | |
|---|---|---|---|---|
| | $T_0$ | $T_1$ | $T_2$ | $T_3$ |
| $R_1$ | 0.19 | 0.17 | 0.29 | 0.18 |
| $R_2$ | 0.13 | 0.16 | 0.30 | 0.22 |
| $P_0$ | 0.11 | 0.16 | 0.21 | 0.17 |
| $P_1$ | 0.12 | 0.16 | 0.25 | 0.18 |
| $P_2$ | 0.14 | 0.17 | 0.32 | 0.18 |
| $P_3$ | 0.15 | 0.17 | 0.34 | 0.19 |
| $P_4$ | 0.29 | 0.17 | 0.37 | 0.27 |
| $C_1$ | 0.16 | 0.16 | 0.26 | 0.21 |
| $C_2$ | 0.17 | 0.17 | 0.34 | 0.19 |
| $F_{160}$ -T 39.10** , TR 4.13**, TC 4.99** CD-T 0.028, TR 0.039, TC 0.039 | | | | |

$T_0$ – Plain Coconut water, $T_1$– Acidulant added, $T_2$– Pineapple blended, $T_3$ – Lemon blended, $R_1$ -Ambient temperature, $R_2$- Refrigerated condition, $C_1$ - Retort pouches, C -Glass bottle

** Significant at 1 per cent level

With storage period, there was a gradual increase in acidity in the control beverage (0.11-0.29), as well as in blended beverages (pineapple blended beverage (0.21-0.37), lemon blended beverage (0.17-0.27) after 45 days (appendix V). But in acidulant added beverages acidity remained almost unchanged with the storage periods. (0.16-0.17).

The containers (glass bottle and retort pouches) in which beverages were stored were also found to influence the acidity level of the products. (CD-0.039).

**Reducing Sugar**: Considering the reducing sugar level of the tender coconut beverages standardised, there was a significant difference in reducing sugar content with storage periods, storage media and storage conditions. As inferred with CD value (0.077), the reducing sugar status was higher for Lemon blended RTS (9.47) and pineapple blended RTS (6.33) compared to control (4.71) and acidulant-blended product (5.41). Beverages when stored at ambient condition, there was an increase in the reducing sugar content, except for acidulant added RTS ($T_2$), (CD 0.109). In lemon blended RTS, there was an increase in reducing sugar level after 30 days of storage (8.84-9.47), but in other three beverages the increase was gradual and was on par (appendixV).

The type of containers (glass bottles/retort pouch) found to influence the reducing sugar level of the beverages (CD 0.109) When compared with retort pouches, the level of reducing sugar content in glass bottle was high in all the three beverages except for pineapple-blended beverages .

Table 12. Changes in reducing sugar of RTS and its interaction between Products, Containers, Storage Periods

| Treatments | Mean scores of reducing sugar | | | |
|---|---|---|---|---|
| | $T_0$ | $T_1$ | $T_2$ | $T_3$ |
| $R_1$ | 4.69 | 5.25 | 6.19 | 9.24 |
| $R_2$ | 4.69 | 5.32 | 6.28 | 9.09 |
| $P_0$ | 4.67 | 5.25 | 6.26 | 8.84 |
| $P_1$ | 4.68 | 5.25 | 6.27 | 8.89 |
| $P_2$ | 4.69 | 5.25 | 6.28 | 9.16 |
| $P_3$ | 4.70 | 5.25 | 6.05 | 9.46 |
| $P_4$ | 4.71 | 5.41 | 6.33 | 9.47 |
| $C_1$ | 4.68 | 5.25 | 6.28 | 9.05 |
| $C_2$ | 4.70 | 5.32 | 6.20 | 9.28 |
| $F_{160}$ -T 5021.35** , TR 3.50**, TC 5.39** CD-T 0.077, TR 0.109, TC 0.109 | | | | |

$T_0$ – Plain Coconut water, $T_1$– Acidulant added, $T_2$– Pineapple blended, $T_3$ – Lemon blended, $R_1$ -Ambient temperature, $R_2$- Refrigerated condition, $C_1$ - Retort pouches, C -Glass bottle

** Significant at 1 per cent level

**Total Soluble Solids** give an indication of sweetness in the product, which is an important criteria influencing the acceptability of the products (Mehta *et al.*, 2002).

As inferred from the CD values (0.022), significant difference was recorded in TSS between the beverages standardised irrespective of storage conditions, containers, and storage periods.

A significant difference was observed in total soluble solids with storage conditions( CD 0.032) and storage periods ( CD 0.05). The decrease was more rapid in plain RTS (5.49 per cent - 5.32 per cent) and lemon blended RTS (14.90 per cent -14.24 per cent). In acidulant and pineapple blended beverages the decrease in total soluble solids was uniform and more prominent only after 45 days storage in non-refrigerated condition when compared to refrigerated condition (appendixV).

The containers (glass bottle and retort pouches) in which beverages stored were found to influence the total soluble solids level of the products (CD 0.03). The total soluble solids level of the products was high for retort pouches than in glass bottles. The change in the TSS was found to be more in plain and lemon blended beverages.

Table 13. Changes in Total soluble solids of RTS and its interaction between Products, Containers and Storage Periods

| Treatments | Mean scores of total soluble solids | | | |
|---|---|---|---|---|
| | $T_0$ | $T_1$ | $T_2$ | $T_3$ |
| $R_1$ | 5.69 | 6.43 | 12.45 | 14.62 |
| $R_2$ | 5.45 | 6.43 | 12.45 | 14.67 |
| $P_0$ | 5.49 | 6.46 | 12.48 | 14.90 |
| $P_1$ | 5.47 | 6.44 | 12.47 | 14.80 |
| $P_2$ | 5.41 | 6.44 | 12.45 | 14.75 |
| $P_3$ | 5.41 | 6.42 | 12.43 | 14.53 |
| $P_4$ | 5.32 | 6.40 | 12.42 | 14.24 |
| $C_1$ | 5.42 | 6.43 | 12.47 | 14.73 |
| $C_2$ | 5.41 | 6.43 | 12.44 | 14.56 |
| $F_{160,3}$ -T 300** , TR 3.52**, TP 39.12** TC22.58** CD-T 0.022, TR 0.032, TP 0.05 TC 0.03 | | | | |

$T_0$ – Plain Coconut water, $T_1$– Acidulant added, $T_2$– Pineapple blended, $T_3$ – Lemon blended, $R_1$ -Ambient temperature, $R_2$- Refrigerated condition, $C_1$ - Retort pouches, C -Glass bottle

** Significant at 1 per cent level

**Total sugar**: Significant difference in total sugar level was observed between the beverages formulated (CD 0.052).

Mean value for the total sugar in the beverages stored at ambient temperature, was 5.83, 7.45, 14.58 and 12.26 respectively in $T_0$, $T_1$, $T_2$, and $T_3$ and 5.78, 7.30, 14.25 and 12.06 respectively in refrigerator condition. Total sugar content was found to increase at a higher level in the beverages kept at non-refrigerated condition (CD 0.075). When the products were stored for 60 days, there was a sudden increase in total sugar level in the beverages stored at ambient condition while a gradual increase in total sugar level was recorded in the beverages stored at refrigerated conditions, irrespective of storage condition and storage media. In pineapple blended and lemon-blended beverages, a sudden rise in total sugar level was recorded in beverages after 30 days of storage irrespective of storage conditions (CD 0.07). There was no apparent impact of storage containers on total sugar content in the beverages however level of total sugar content in retort pouches was found to be less influenced when stored in glass bottles.

Table 14. Changes in Total sugar of RTS and its interaction between products, containers and storage periods

| Treatments | Mean scores of total sugar | | | |
|---|---|---|---|---|
| | $T_0$ | $T_1$ | $T_2$ | $T_3$ |
| $R_1$ | 5.83 | 7.45 | 14.58 | 12.26 |
| $R_2$ | 5.78 | 7.30 | 14.25 | 12.06 |
| $P_0$ | 5.70 | 7.02 | 13.80 | 11.60 |
| $P_1$ | 5.69 | 7.20 | 13.91 | 11.99 |
| $P_2$ | 5.74 | 7.32 | 14.32 | 12.25 |
| $P_3$ | 5.82 | 7.53 | 14.86 | 12.39 |
| $P_4$ | 6.07 | 7.79 | 15.21 | 12.55 |
| $C_1$ | 5.76 | 7.18 | 14.30 | 12.04 |
| $C_2$ | 5.85 | 7.57 | 14.53 | 12.28 |
| $F_{160,3}$-T 44652**, TR 9.29**, TC 10.90**, CD-T 0.052, TR 0.075, TC 0.07 | | | | |

$T_0$ – Plain Coconut water, $T_1$– Acidulant added, $T_2$– Pineapple blended, $T_3$ – Lemon blended, $R_1$ -Ambient temperature, $R_2$- Refrigerated condition, $C_1$ - Retort pouches, C -Glass bottle

** Significant at 1 per cent level

### 4.1.4 Changes in the Organoleptic Qualities of the Coconut Beverages with Storage

According to Kramer and Twigg (1970), food quality detectable by our senses can be broken down into the main categories viz., appearance, texture and flavour. As pointed out by Herrington (1991), sensory evaluation of food is assumed to be of

Table 15 Effect of treatment, containers and duration of storage on organoleptic quality of coconut based blended RTS

| Attributes | $T_0$ | | | | $T_1$ | | | | $T_2$ | | | | $T_3$ | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | $R_1$ | $R_1$ | $R_2$ | $R_2$ | $R_1$ | $R_1$ | $R_2$ | $R_2$ | $R_1$ | $R_1$ | $R_2$ | $R_2$ | $R_1$ | $R_1$ | $R_2$ | $R_2$ |
| | $C_1$ | $C_2$ | $C_1$ | $C_2$ | $C_1$ | $C_2$ | $C_1$ | $C_2$ | $C_1$ | $C_2$ | $C_1$ | $C_2$ | $C_1$ | $C_2$ | $C_1$ | $C_2$ |
| Appearance | (4.3) 2.2 | (4.1) 2.3 | (4.4) 3.3 | (4.1)2.6 | (4.1)2.1 | (3.8)3.8 | (4.5)3.6 | (4.5)4.3 | (4.6)2.8 | (4.3)2.4 | (4.5)2.7 | (4.6)2.2 | (4.5)4.1 | (4.5)3.3 | (4.6)2.7 | (4.3)2.3 |
| Colour | (4.3) 3.2 | (4.2) 2.8 | (4.5) 2.5 | (4.0)2.3 | (4.1)2.9 | (3.9)2.2 | (4.6)3.8 | (4.6)3.6 | (4.6)2.9 | (4.3)2.4 | (4.5)2.5 | (4.6)2.3 | (4.5)4.0 | (4.4)3.2 | (4.6)2.4 | (4.4)2.2 |
| Flavour | (3.6) 2.4 | (3.3) 2.2 | (3.5)3.3 | (3.5)3.4 | (3.2)3.1 | (3.2)2.8 | (3.4)3.1 | (3.1)2.6 | (4.1)2.3 | (4.2)2.0 | (4.4)3.7 | (4.3)3.2 | (3.7)2.1 | (3.5)2.3 | (4.1)3.9 | (3.9)3.4 |
| Clarity | (3.3) 2.5 | (3.2) 1.9 | (3.9)3.1 | (3.6)2.8 | (3.7)3.2 | (3.8)2.4 | (4.3)3.6 | (4.0)3.2 | (4.1)3.1 | (4.3)2.3 | (4.4)2.5 | (4.4)2.4 | (4.1)2.8 | (3.8)2.3 | (4.1)3.4 | (4.3)2.9 |
| Taste | (3.6) 3.5 | (3.6) 3.3 | (3.7)3.4 | (3.7)3.4 | (3.3)3.6 | (3.7)3.5 | (3.6)3.5 | (3.4)3.1 | (4.2)2.4 | (4.0)2.3 | (4.2)2.1 | (4.1)2.3 | (3.9)2.3 | (3.7)1.9 | (4.0)2.3 | (3.8)2.0 |
| Overall Acceptability | (3.8) 2.8 | (3.8) 2.5 | (4.0)3.0 | (3.8)2.9 | (3.9)3.0 | (3.7)3.0 | (3.9)3.5 | (3.9)3.3 | (4.2)2.6 | (4.3)2.2 | (4.4)2.8 | (4.0)2.5 | (4.2)3.0 | (4.0)2.7 | (4.3)3.0 | (4.2)2.6 |

Appearance - CD- T-ns, R-0.12** P-0.19**, C-0.12** TR-0.23*, TP-0.37**, TC-0.23**, TRC -0.52**, TRCP -ns
Colour - CD- T-ns, R-0.12**, P-0.19**, C-0.12** TR-0.24**, TP-0.38**, TC-0.24**, TRCP -ns
Flavour - CD- T-0.19**, R-0.14**, P-0.21**, C-ns, TR-0.27**, TRCP -ns
Taste - CD- T-0.19**, R-0.13**, P-0.21**, C-0.13** TR-0.26**, TP-0.37**, TC-0.23**, TRC -0.52**, TRCP -ns
Clarity -CD T-0.20**, P-0.22**,TP-0.44**, TRCP -ns

$T_0$-Plain Coconut water, $T_1$ Acidulant added, $T_2$ Pineapple blended, $T_3$ Lemon blended, $R_1$ Ambient temperature, $R_2$ Refrigerated condition, $C_1$ - Retort pouches, $C_2$ -Bottle

Initial values are given in parenthesis

increasing significance as this provides information, that may be utilized for product development.

The organoleptic qualities of the beverages formulated from tender coconut water were assessed periodically so as to assess the shelf stability of the products. Due to short shelf life of RTS beverages, assessment of changes in the organoleptic qualities is of utmost importance.

The overall appeal of a product is more important than taste and odour. When **appearance** of the tender coconut beverages were taken into account, the mean score for appearance attribute was recorded high in all the products (4.1-4.6). No significant difference was observed in appearance character of the products with storage. However, storage condition influenced the mean score of the appearance of the beverages (CD 0.12). Refrigerated beverages scored better in appearance attribute when compared to beverages kept at room temperature. Storage periods were also found to influence the mean score of the appearance of the beverages (CD 0.23). As the storage advanced, duration of storage there was decrease in scores for appearance in the products. The difference was conspicuous after one month of storage, irrespective of storage containers (CD 0.19). As far as storage containers are concerned, significant difference in appearance attribute was recorded (CD 0.12). For control beverage and acidulant blended beverage kept in retort pouches were found to be better in appearance than in glass containers while pineapple and lemon blended beverages appeared more appealing in glass containers (CD 0.23).

**Colour** improves the attractiveness of a product. It was also considered as the maturity index and is associated with flavour and wholesomeness, of the product. Pale and dull appearance makes the product unattractive and not preferred by the consumers (Kramer and Twigg, 1970).

When colour of the tender coconut water beverages, was taken into account, the mean score for colour attribute was high in all the products (3.9-

4.6). No significant difference was observed in colour attribute between the products with storage. But storage conditions influenced the mean colour score in the beverages standardised (CD 0.24). Refrigerated beverages scored better in colour attribute when compared to the beverages kept at room temperature (CD 0.12). Storage periods also influenced the mean score of the colour of the beverages (CD 0.38). With the passage of time, decrease in scores was recorded in colour of the products. The difference was conspicuous after one month of storage irrespective of storage containers (CD 0.19). The difference in mean scores for colour attribute in pineapple and lemon blended beverages was more prominent with storage periods. As far as storage containers are concerned, significant difference was recorded in colour attribute (CD 0.12). Control and acidulant blended beverages stored in retort pouches .scored better in colour than in glass containers but in pineapple and lemon blended beverages the colour attribute scored better in glass containers (CD 0.24).

**Flavour** is the combination of taste and smell. Taste includes sweet, salty and sour characters in a product. While smell could be fragrant, acidic, burnt etc., due to enzymatic, physiological or chemical changes.

When flavour profile of the tender coconut beverages was taken into consideration, the mean score ranged between 3.1-4.4. Significant difference was observed in flavour of the formulated beverages with storage with CD 0.19. Highest mean score was recorded in pineapple blended (4.4) beverage followed by lemon blended (4.1), control and lastly by acidulant added beverage (3.4). Storage conditions influenced the mean score of the flavour of the beverages (CD 0.14). Refrigerated beverages scored better in flavour attribute when compared to beverages kept at ambient temperature. Storage period was also found to influence the mean score of the flavour attribute of the beverages (CD 0.27). Flavour scores decreased with the storage irrespective of storage condition and storage period. No significant difference was observed in the flavour character in the beverages stored in glass and retort pouches.

According to Kramer and Twigg (1970), among the various quality attributes, **taste** is the primary and the most important quality parameter

Mean score for taste attribute ranged (3.3 - 4.2). Among the different beverages formulated with coconut water significant difference was observed in taste of the beverages with storage (CD 0.19). Highest mean score was recorded for pineapple blended beverages (4.2) followed by lemon blended (4.0), control (3.7) and lastly by acidulant added beverage (3.3). Storage conditions influenced the mean score of the taste of the beverages (CD 0.13). Refrigerated beverages scored better in taste attribute when compared to beverages kept at room temperature (CD 0.26). Storage periods also influenced the mean score of the taste of the beverages (CD 0.37). Taste attribute score decreased with the passage of time. As far as storage containers are concerned there was significant difference in taste attribute in the beverages (CD 0.23). Control and acidulant blended beverage tasted better in retort pouches than in glass containers, while pineapple and lemon blended beverages, the score was better in glass containers than in retort pouches.

**Clarity** of the tender coconut beverages of control as well as blended RTS when compared, significant differences were observed in clarity attribute of the beverages with storage (CD 0.20). Mean score for clarity attribute ranged between (2.4 - 4.4) in the beverages formulated. Highest mean score was obtained for pineapple blended beverage (4.4) followed by lemon blended and acidulant, (4.3) each and lastly by control (3.9). Storage condition and storage containers do not influence the mean scores of the clarity of the beverages. Clarity attribute decreased with the storage irrespective of storages condition and storage containers (CD 0.22). Clarity of pineapple, lemon blended and control beverages were affected with storage, where as it was unchanged in acidulant added beverages with the storage (CD 0.44).(PlateII)

# COCONUT WATER BEVERAGES


Plate: II

**Overall acceptability**

When overall acceptability, of the beverages formulated was analysed, the mean score ranged between (3.7 - 4.4) with storage. The mean score for overall acceptability was recorded highest in pineapple-blended beverage (4.4-4.2) followed by lemon-blended beverage (4.3- 4.0), acidulant blended, (3.9- 3.7), and control (4.0- 3.8),. Storage conditions influenced the mean score of the overall acceptability of the beverages (CD 0.12). Refrigerated beverages scored better in overall acceptability attributes when compared to beverages kept at room temperature. Storage periods also influenced the mean score of the overall acceptability of the beverages (CD 0.20). As the days of storage increased there was decrease in scores for overall acceptability in the products. Acidulant blended beverage and lemon-blended beverages secured better score for overall acceptability when compared to control and pineapple blended beverages with storage. As far as storage containers are concerned there was no significant variation was noted in overall acceptability scores.

## 4.2 ASSESSMENT OF CHEMICAL, NUTRITIONAL, ORGANOLEPTIC AND SHELF STABILITY FEATURES OF THE BIOPROCESSED PRODUCTS DEVELOPED FROM COCONUT

Under present investigation, simple technology of production of 'nata' was standardised under Indian climatic condition where three different substrates viz., plain coconut water, coconut water with pineapple extracts and coconut water with soymilk with *acetobacter aceti subsp. xylinium* as starter culture.

Nata de coco is a chewy, translucent, traditional Philippine dessert, which is formulated from coconut water by bacterial fermentation. The increasing popularity of 'nata' is due to several health benefits ascribed to them besides their uniqueness in taste and flavour APCC (1996). It is high in fiber, good for the digestive system, and is low in calories and contains no cholesterol. The addition of different flavouring extracts (almond, banana, lemon, strawberry, and vanilla) could improve the acceptability of nata produced (Singh and Gopalakrishnan, 2002).

### 4.2.1 Chemical and Nutritional Characteristics of 'nata' Products

Table 16 Chemical and nutritional characteristics of 'nata' standardised

| Characteristics | Types of products | | | $F_{60,1}$ | CD |
|---|---|---|---|---|---|
| | $T_1$ | $T_2$ | $T_3$ | | |
| Moisture (%) | 67.66 | 67.63 | 67.0 | | NS |
| PH | 3.39 | 2.88 | 3.82 | 2526** | 0.026 |
| Acidity (%) | 0.43 | 0.44 | 0.42 | | NS |
| TSS °Brix | 9.19 | 9.21 | 9.32 | 89.53** | 0.020 |
| Total sugar (%) | 8.58 | 11.76 | 9.38 | 4575** | 0.021 |
| Reducing sugar (%) | 3.07 | 3.31 | 3.83 | 1008** | 0.034 |
| Protein (g) | 1.84 | 1.53 | 2.02 | 373** | 0.087 |
| Fiber (g) | 1.21 | 1.25 | 1.09 | | NS |
| Significant 1 % level | | | | | |

$T_1$: Nata-de-coco $T_2$: Nata- de-pine $T_3$: Nata-de-soya ** Significant at 1 per cent level

Analysis of the chemical and nutritional characteristics of the 'nata' developed indicated that moisture content of the products was similar and recorded as 67 per cent, pH ranged from 2.88 to 3.82, acidity 0.42-0.44 per cent, total soluble solids 9.19 to 9.32° Brix, total sugar 8.58 to 11.76 per cent, and reducing sugar 3.07 to 3.83 per cent. Comparative analysis of the data revealed that the moisture content was on par in the three types of nata formulated. Lowest pH value was seen in nata-de-pine and highest in nata-de-soya. There was no significant difference in acidity in the three products developed. Total soluble solids were found to be highest in nata-de-soyand the lowest for nata-de-coco. Nata-de pine recorded the highest value for total sugar followed by nata-de-soyand nata-de pine.

Among the nutritional characteristics, protein content of the product was found to be varying from 1.84 to 2.02g and fibre 1.09 to 1.25 per cent. Nata de soy recorded higher value for protein as expected, while nata de pine the lowest. Significant difference was observed in the chemical and nutritional characteristics analysed in the products, *viz.*, pH, total soluble solids, total sugar, reducing sugar and protein as indicated from the F values.

### 4.2.2 Organoleptic Features of Bioprocessed Nata Products

Organoleptic characteristics of the products were assessed, in order to determine the acceptability of the products among the judges (Table 17).

Table 17. Sensory attributes of preserved 'nata'

| Products | Mean score for sensory attributes | | | | | |
|---|---|---|---|---|---|---|
| | Appearance | Colour | Flavour | Taste | Texture | Overall acceptability |
| $T_1$ | . 2.6 | 3.2 | 3.2 | 3.4 | 3.2 | 3.12 |
| $T_2$ | 3.0 | 3.3 | 3.3 | 3.5 | 3.1 | 3.24 |
| $T_3$ | 2.3 | 3.2 | 3.0 | 3.3 | 3.1 | 2.98 |
| $F_{270,1}$ | 6.21* | 4.31* | 12.92* | 11.41* | 7.59* | |
| CD | 0.26 | 0.20 | 0.20 | 0.17 | 0.19 | |
| *Significant at 5 per cent level. | | | | | | |

$T_1$: Nata-de-coco. $T_2$ :Nata- de-pines. $T_3$: Nata-de-soya. OA: Overall acceptability

Appearance score of the 'nata' ranged between 2.3 to 3.0 being the highest in nata de pine (3.0) and lowest in nata de soya (2.3). Colour, flavour and taste scores were also found to be the best in 'nata de pine' 3.3 each for colour and flavour and 3.5 for taste. Colour character was similar in nata de coco and nata de soy (3.2 each) while flavour was the lowest in 'nata de soya' (3.0). Taste scores were 3.4 and 3.3 respectively in nata de coco and 'nata de soya'. Texture attribute was similar in nata de pine and 'nata de soya', however scores were lesser than that nata de coco. Overall acceptability of the products ranged between 58-64 per cent, with mean score of 2.98 to 3.24. Overall acceptability seems to the best in nata de pine (3.24) followed by 'nata de coco' (3.12). Significant difference was noted in the 'nata' products with respect to colour, flavour, taste and texture as indicated by the 'F' values. However not much variation could be seen in overall acceptability of the products.

Table18. Changes in the Chemical and nutritional characteristics and interaction with bioprocessed products, containers and storage periods.

| Chemical/ nutritional constituents | Types of Products (T) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | $T_1$ | | | | $T_2$ | | | | $T_3$ | | | |
| | C1 | | C2 | | C1 | | C2 | | C1 | | C2 | |
| | I | $I_2$ | I | $I_2$ | I | $I_2$ | I | $I_2$ | I | $I_2$ | I | $I_2$ |
| PH | 3.46 | 3.25 | 3.46 | 3.4 | 3.0 | 2.7 | 3.0 | 2.9 | 4.0 | 2.9 | 4.0 | 2.6 |
| $F_{60.4}$- T –2526**, P –67.41**, C -139.82**, TP – 5.00, **CD**- T – 0.026, P-0.034, C - 0.0216, TP – 0.059, CP -0.046 | | | | | | | | | | | | |
| Reducing sugar % | 2.9 | 3.5 | 2.9 | 3.2 | 3.2 | 3.5 | 3.2 | 3.4 | 3.8 | 3.9 | 3.8 | 3.8 |
| $F_{60.4}$- T –1008**, P –38.39**, C -31.71**, TP – 7.27, **CD**- T – 0.034, P-0.044, C - 0.028, TP - 0.077,CP -0.062 | | | | | | | | | | | | |
| TSS °B | 9.2 | 9.2 | 9.17 | 9.2 | 9.2 | 9.2 | 9.2 | 9.2 | 9.37 | 9.27 | 9.33 | 9.23 |
| $F_{60.4}$- T –89.53**, P –ns, C -ns, TP –7.30**, **CD**- T – 0.020, TP - 0.045 | | | | | | | | | | | | |
| TS % | 8.56 | 8.6 | 8.56 | 8.59 | 11.67 | 11.93 | 11.67 | 11.82 | 9.33 | 9.45 | 9.33 | 9.39 |
| $F_{60.4}$- T –4575**, P –21.27**, C -21.27**, **CD**- T – 0.021, P-0.028, C - 0.017, CP -0.048 | | | | | | | | | | | | |
| Protein g | 1.01 | 1.04 | 1.02 | 1.03 | 1.56 | 1.56 | 1.57 | 1.38 | 2.02 | 2.02 | 2.02 | 2.02 |
| $F_{60.4}$- T –373**, P –6.73**, C -ns, TP – 3.94**, **CD**- T – 0.087, P-0.113, TP - 0.196,CP -0.011 | | | | | | | | | | | | |
| • | ** Significant at 1 % level. | | | | | | | | | | | |

$T_1$-Nata-de-coco$T_2$-Nata-de-pine$T_3$-Nata-de-soya;$C_1$-Glassbottle, $C_2$-Cans$I_1$Initialvalues,$I_2$-Final values

### 4.2.3 Changes in the Chemical, Nutritional and Organoleptic Characteristics of 'Nata' and Interaction with Products, Containers and Storage Periods

Nata de coco, nata de pine and nata de soy were stored in cans and glass bottles at ambient temperature for a period of six months. Changes in pH, TSS, total sugar, reducing sugar and protein were monitored in the products with storage.

When pH level was compared there was a significant difference in the bioprossed products developed (CD 0.026). The mean pH value was lowest for nata de pine and highest for nata de soya. The pH level decreased with the storage period (CD 0.034). A sudden decrease in pH was recorded towards the end of 3 months. Containers were also found to significantly affect the pH of the products (CD 0.216). The pH level was low when stored in glass container. Interaction effect between containers and storage periods was also found to be significant (CD 0.046).

Taking into account the total soluble solids, there was a significant difference among the products (CD 0.020). The total soluble solid content decreased during storage. However, the decrease was not significant with storage period and storage containers.

Total sugar of the products was found to vary significantly among the products (CD 0.21). Variation was also seen in total sugar with storage periods (CD 0.028). The highest mean score for total sugar was seen for nata de pine, and lowest for nata de coco.

Containers significantly affect the total sugar contents of the products (CD 0.017). Increase in total sugar with storage period was conspicuous after 30 days of storage, but significant increase in total sugar was seen in nata de pine with storage periods. When the interaction between the product and storage period was considered there was a significant difference in the products standardized (CD 0.048).

Significant difference in reducing sugar was observed among the 'nata'products with storage (CD 0.034). The reducing sugar level increased with storage (CD 0.044). The initial value for reducing sugar content in nata de coco, nata de pine and nata de soy when stored in cans were 2.9, 3.2 and 3.8 respectively and towards the end of storage period, it was 3.2, 3.4 and 3.8 respectively. A significant increase in reducing sugar was recorded after 3 months of storage irrespective of products and storage containers except in nata de soya. The level of reducing sugar was more in nata de coco, followed by nata de pine and nata de soy with storage. The type of containers also influenced the reducing sugar content of the products (CD 0.028). Interaction effect between containers and storage periods was also to be found significant (CD 0.062).

Among the nutritional characteristics, variation was seen in protein content among the products (CD 0.087). Not much change in the protein content were observed as the storage time advanced. The value for protein content in nata de coco, nata de pine and nata de soy when stored in glass were 1.01, 1.56 and 2.02 respectively whereas in cans it was 1.02, 1.57 and 2.02, and at the end of the storage period of six months in glass were 1.04, 1.56 and 2.02 respectively whereas in cans it was 1.03, 1.38 and 2.02 respectively. A significant increase in protein was recorded after 3 months of storage irrespective of products and storage containers (CD 0.011).

### 4.2.3.2 Changes in the Organoleptic Qualities of the Nata Products with Storage

The organoleptic qualities of the bioprocessed products was assessed till the end of shelf-life, details of which are discussed below.

When appearance attribute of 'nata' products was taken into account, the mean score for appearance attribute varies from 2.3 – 3.0. A significant difference was observed in appearance of the products (CD 0.26).

**Table 19. Effect of containers and storage periods on organoleptic qualities of nata products**

| Attributes | NC | | | | NP | | | | NS | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | $C_1$ | | $C_2$ | | $C_1$ | | $C_2$ | | $C_1$ | | $C_2$ | |
| | $P_0$ | $P_1$ | $P_0$ | $P_1$ | $P_0$ | $P_1$ | $P_0$ | $P_1$ | $P_0$ | $P_1$ | $P_0$ | $P_1$ |
| Appearance | 2.6 | 2.1 | 2.6 | 2.1 | 3.0 | 2.7 | 2.9 | 2.5 | 2.3 | 2.0 | 2.5 | 2.0 |
| $F_{270,4}$- T – 6.21*, P – ns, C -ns TP – ns., CD- T – 0.26, | | | | | | | | | | | | |
| Colour | 3.2 | 2.6 | 3.3 | 3.1 | 3.3 | 2.8 | 3.4 | 3.4 | 3.2 | 2.6 | 3.3 | 3.0 |
| $F_{270,4}$- T – 4.31*, C -10.86*, CD- T – 0.20, C - 0.17 | | | | | | | | | | | | |
| Flavour | 3.2 | 2.7 | 3.0 | 2.3 | 3.3 | 3.3 | 3.4 | 2.7 | 3.0 | 2.6 | 2.9 | 2.2 |
| $F_{270,4}$- T – 12.92**, C - 14.05**, CD- T – 0.20, C - 0.16 | | | | | | | | | | | | |
| Taste | 3.4 | 2.9 | 3.5 | 3.3 | 3.5 | 3.0 | 3.5 | 3.0 | 3.1 | 3.0 | 3.2 | 2.2 |
| $F_{270,4}$- T – 11.41*, P – 5.87*, C -22.84*, TC – 3.08*, PC-2.75*<br>CD- T – 0.17, P – 0.22, C - 0.14, TC - 0.24, PC – 0.31 | | | | | | | | | | | | |
| Texture | 3.2 | 3.0 | 3.2 | 2.8 | 3.1 | 2.8 | 2.9 | 2.6 | 3.1 | 2.8 | 2.7 | 2.5 |
| $F_{270,4}$- T –7.59*, P –ns, C -17.06*,<br>CD- T – 0.22, , P – 0.35, C - 0.22 TP - 0.50 PC – ns, | | | | | | | | | | | | |
| O A | 3.1 | 2.7 | 3.1 | 2.7 | 3.2 | 2.9 | 3.2 | 2.8 | 3.1 | 2.6 | 2.9 | 2.4 |
| * Significant 5 per cent level. | | | | | | | | | | | | |

$T_1$: Nata-de-coco $T_2$: Nata- de-pine $T_3$: Nata-de-soya; $C_1$-Glass bottle, $C_2$-Cans

$P_0$-Initial values, $P_1$- Final values OA: Overall acceptability

When colour attribute of nata was taken into account, a significant difference was observed in colour of the products (CD 0.20) and the mean score varied from 3.2 - 3.4 between the products. Storage container (CD 0.17) was found to influence colour of the preserved nata. Difference in colour with storage periods was noticeable in the nata products stored in cans. The change in colour was seen after six month of storage in cans. The nata stayed better in glass containers than in cans. Significant difference was also observed in flavour attribute of the products (CD 0.20) and significant change was recorded in flavour with storage periods. Storage containers significantly influenced the mean score of the flavour of the 'nata' (CD 0.16). There was slight darkening in the nata products after storage in cans when compared to glass containers.

However no significant difference was also observed in taste of the products with storage (CD 0.17). Changes in taste attribute were detectable with the passage of time. Storage periods affected the mean score of the taste of the 'nata' products (CD 0.22). The scores decreased in the products with storage. Containers in which nata was stored also influenced the taste of the products (CD 0.14). Taste character was not found to affect products stored in glass container when compared to cans.

When texture attribute of 'nata' was taken into account, the mean score was ranged from 2.9 - 3.2 in the products. A significant difference was observed in the texture of products (CD 0.22). Storage periods found to have an impact on the mean score of the texture of the 'nata' products (CD 0.35) so also the containers in which it was stored (CD 0.22). Texture of the products was not affected in glass container when compared to cans.

Storage periods influenced the mean score of the overall acceptability of the 'nata' products. As the storage period advanced there was decrease in scores for overall acceptability of the products. It was encouraging to note that overall quality decreased only after six months of storage. 'Nata' products remained better in glass bottles than in cans. Nata de pine scored highest in overall acceptability followed by nata de coco and nata de soya, though nata de soy was nutritiously superior. (Plate 3)

## Bioprocessed products from coconut



Plate : III

### 4.3 ASSESSMENT OF CHEMICAL, NUTRITIONAL, ORGANOLEPTIC AND SHELF STABILITY FEATURES OF THE SIMULATED PRODUCTS DEVELOPED FROM COCONUT MILK.

The simulated products namely coconut curds and coconut yoghurt were formulated from coconut milk, as a substitute for milk curd and milk yoghurt. Since coconut milk was low in lactic acid, and some of the nutrients, it was fortified with skim milk powder and soymilk. Two types of curds were standardised under the present investigation, one with coconut milk in combination with skim milk powder, and another with coconut milk in combination with soymilk. Similarly, two types of coconut yoghurt was standardised in the laboratory one with coconut milk in combination with skim milk powder and the other with coconut milk and soymilk.

#### 4.3.1 Chemical and Nutritional Characteristics of the Products Developed

The major components analysed in the simulated products were pH, acidity, total soluble solids, total sugar, reducing sugar, moisture, protein and fat and the minerals like calcium, phosphorus, iron, solid not fat and viscosity.

pH of the coconut curd was 4.66 in $P_1T_1$ and 5.38 in $P_1T_2$ where as in yoghurt pH was 7.57 and 5.04 respectively in $P_2T_1$ and $P_2T_2$. Acidity of the simulated products was 0.51 to 0.73 in coconut curds and 0.60 to 0.68 respectively in yoghurt.

TSS was 19.75 and 18.85 and total sugar was 12.04 and 10.71 respectively in coconut based curds ($P_1T_1$ and $P_1T_2$) where as in coconut yoghurt TSS was 19.64 and 19.72 respectively in $P_2T_1$ and $P_2T_2$. Total sugar was 12.44 in $P_2T_1$ as against 13.22 in $P_2T_2$. Reducing sugar ranged between 2.66 to 3.74 per cent in the simulated products formulated from the coconut milk. Moisture was almost similar in the two combinations of coconut curd and coconut yoghurt (75 per cent). With respect to nutrients, protein content of coconut curd and yoghurt in combination with soymilk was higher and similar (5.50 g) and that of curds was 3.56 in $P_1T_1$ and 4.33 in $P_2T_2$. Similarly fat content of the coconut curd and yoghurt was higher in soymilk blended combinations (4.0 and 4.55 respectively in $P_1T_2$and $P_2T_2$). Both the products and their combinations were found to be rich in minerals viz., calcium and phosphorous and ranged between 497 to 540 mg and 377 to 420 respectively. Iron content of the coconut curd was 1.54 as against 1.73 in coconut yoghurt. SNF of two products and their combinations ranged 14.25 to 16.34 and viscosity was 5.0 to 7.4.

Table 20. Chemical and nutritional characteristics of curds and yoghurt prepared from coconut milk

| Characteristics | Coconut curd | | Coconut yoghurt | | | |
|---|---|---|---|---|---|---|
| | $P_1T_1$ | $P_1T_2$ | $P_2T_1$ | $P_2T_2$ | $F_{80,4}$ | CD |
| pH | 4.66 | 5.38 | 7.57 | 5.04 | | NS |
| Acidity% | 0.51 | 0.73 | 0.60 | 0.68 | 17.07** | 0.011 |
| Total soluble solid °Brix | 19.75 | 18.85 | 19.64 | 19.72 | 24.38** | 0.152 |
| Total sugar% | 12.04 | 10.71 | 12.44 | 13.22 | 38.42** | 0.468 |
| Reducing sugar% | 2.66 | 3.54 | 2.98 | 3.74 | 895.25** | 0.017 |
| Moisture% | 75.16 | 75.78 | 75.16 | 75.78 | | NS |
| Protein mg | 3.56 | 5.50 | 4.33 | 5.50 | 54.89** | 0.771 |
| Fat g | 3.35 | 4.00 | 3.72 | 4.55 | | NS |
| Calcium mg | 540 | 497 | 525 | 513 | | NS |
| Phosphorous mg | 420 | 377 | 410 | 387 | 167.35** | 0.591 |
| Iron mg | 1.54 | 1.72 | 1.54 | 1.73 | 106.17** | 0.146 |
| Solid Not Fat | 16.34 | 14.25 | 15.82 | 16.29 | | |
| Viscosity | 5.0 | 7.40 | 4.48 | 8.49 | 21.55** | 0.122 |

**Significant at 1 per cent level.

$P_1T_1$ – curds with coconut milk – skim milk powder $P_1T_2$ – curds with coconut milk +soymilk $P_2T_1$ – yoghurt with coconut milk + skim milk powder $P_2T_2$– yoghurt with coconut milk + soymilk

When compared between the two curds, coconut curd with soymilk combination was having higher pH, acidity, reducing sugar and moisture. It was also to be rich in protein, fat, iron and viscosity when compared to coconut curd made from skim milk combination. Coconut curds with skim milk powder showed higher level of TSS and Total sugar. It was also rich in calcium, phosphorus and the solid not fat (SNF).

When two types of yoghurts were compared, coconut yoghurt with soy showed higher level of acidity, reducing sugar, total soluble solids, total sugar, and moisture. Nutrients like protein, fat, iron and constituents like solid not fat and viscosity were also recorded more in soya-enriched yoghurt. Coconut yoghurt with skim milk powder combination was found to have higher pH, calcium and phosphorus when compared with coconut yoghurt with soymilk.

### 4.3.2 Organoleptic Features in the Simulated Products from Coconut Milk

Table 21. Sensory attributes of curd and yoghurt

| Products | Mean score for sensory attributes | | | | | |
|---|---|---|---|---|---|---|
| | Appearance | Colour | Flavour | Taste | Consistency | Overall Acceptability |
| $P_1T_1$ | 4.4 | 4.5 | 4.5 | 4.6 | 4.5 | 4.4 |
| $P_1T_2$ | 4.2 | 3.8 | 3.9 | 4.0 | 4.1 | 4.0 |
| $P_2T_1$ | 4.4 | 4.5 | 4.0 | 4.4 | 4.4 | 4.4 |
| $P_2T_2$ | 4.4 | 4.3 | 4.1 | 4.2 | 4.4 | 4.2 |
| CD | - | - | 0.17 | - | - | - |
| $F_{80,4}$ | NS | NS | 15.45* | NS | NS | NS |
| *Significant at 5 per cent level. | | | | | | |

$P_1T_1$ – curds with coconut milk + skim milk powders $P_1T_2$ – curd with coconut milk + soymilk

$P_2T_1$ – yoghurt with coconut milk + skim milk powder $P_2T_2$– yoghurt with coconut milk + soymilk

Organoleptic evaluation of the simulated products indicates that the overall acceptability of the products ranged between 4.0 to 4.4 with a percentage acceptability of 80 to 88. When organoleptic attributes were analysed in detail, appearance of the products was almost similar (4.4 each) except for $P_1T_2$ which recorded comparatively lower score (4.2). Colour score was similar in coconut curd and yoghurt (4.5 each) in which skim milk was blended. Soymilk blended combination of coconut curds scored less (3.8) and that of yoghurt recorded better mean score of 4.3. Flavour profile indicated that coconut milk blended with skim milk scored highest score of 4.5 and soy blended scored the lowest (3.9). Mean flavour score of yoghurt was 4.0 and 4.1 respectively in $P_2T_1$ and $P_2T_2$. Taste attribute was best in coconut curd with skim milk blend (4.6) followed by coconut yoghurt (4.4) of same combination. Taste score was comparatively lower for yoghurt compared to curd. The consistency score of simulated products ranged between 4.1 to 4.5 respectively in coconut curd and coconut yoghurt. As indicated from CD value there was not much variation in the organoleptic features in different combination of coconut curds and coconut yoghurt except for flavour.

### 4.3.3 Changes in Chemical and Nutritional Characteristics of Simulated Products and Interaction with Products, Containers and Storage Periods

Curd and yoghurt are products of short shelf stability. These products when kept at room temperature, acidity increases and as a result, the products became unpalatable for the consumers. Hence products formulated in the present study was monitored daily up to 4 days after which it was unacceptable.

Changes in the constituents of the simulated products with storage in two different containers at ambient temperature was ascertained in detail and the results are presented in the following table.

Conspicuous changes were noted in constituents such as acidity, TSS and protein, while other constituents analysed remained unchanged.

Table 22. Changes in chemical and nutritional characteristics of simulated products with storage

| Constituents | Treatment | Mean scores at different storage periods (D) | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Acidity (%) | | Initial | 1days | 2days | 3 days | 4days | Mean | | |
| | $P_1T_1C_1$ | 0.34 | 0.35 | 0.35 | 0.35 | 0.44 | 0.36 | 0.52 | 0.62 |
| | $P_1T_1C_2$ | 0.40 | 0.66 | 0.66 | 0.81 | 0.87 | 0.68 | | |
| | $P_1T_2C_1$ | 0.41 | 0.52 | 0.75 | 0.75 | 0.77 | 0.64 | 0.73 | |
| | $P_1T_2C_2$ | 0.76 | 0.78 | 0.80 | 0.85 | 0.93 | 0.82 | | |
| | $P_2T_1C_1$ | 0.39 | 0.39 | 0.45 | 0.47 | 0.56 | 0.45 | 0.60 | 0.64 |
| | $P_2T_1C_2$ | 0.55 | 0.77 | 0.77 | 0.84 | 0.88 | 0.76 | | |
| | $P_2T_2C_1$ | 0.64 | 0.64 | 0.65 | 0.67 | 0.67 | 0.65 | 0.68 | |
| | $P_2T_2C_2$ | 0.68 | 0.70 | 0.73 | 0.73 | 0.75 | 0.72 | | |
| $F_{80,4}$ P 17.07**, PT 133.55**, PD 24.98**, PTD 34.22**, PTDC 6.15** <br> CD- P 0.011, PT 0.015, PD 0.24, PTD 0.035, PTDC 0.049 | | | | | | | | | |
| Total Soluble Solids°B | $P_1T_1C_1$ | 19.80 | 19.85 | 19.81 | 19.85 | 19.55 | 19.77 | 19.75 | 19.21 |
| | $P_1T_1C_2$ | 19.87 | 19.86 | 19.76 | 19.64 | 19.52 | 19.73 | | |
| | $P_1T_2C_1$ | 18.85 | 18.62 | 18.83 | 18.58 | 18.32 | 18.64 | 18.67 | |
| | $P_1T_2C_2$ | 18.83 | 18.83 | 18.66 | 18.62 | 18.61 | 18.71 | | |
| | $P_2T_1C_1$ | 19.84 | 19.82 | 19.69 | 19.72 | 19.68 | 19.75 | 19.48 | 19.6 |
| | $P_2T_1C_2$ | 20.06 | 19.81 | 18.77 | 18.86 | 18.60 | 19.22 | | |
| | $P_2T_2C_1$ | 19.84 | 19.82 | 19.72 | 19.81 | 19.66 | 19.77 | 19.72 | |
| | $P_2T_2C_2$ | 19.86 | 19.69 | 19.59 | 19.55 | 19.69 | 19.67 | | |
| $F_{80,4}$ P 24.38**, PT 41.63**, PD 3.53**, PTD 3.82**, PTDC 2.82* <br> CD- P 0.152,PT 0.215,PD 0.340,PTD 0.481, PTDC 0.680 | | | | | | | | | |
| Protein (g) | $P_1T_1C_1$ | 3.76 | 3.61 | 3.58 | 3.52 | 3.45 | 3.58 | 3.55 | 4.52 |
| | $P_1T_1C_2$ | 3.61 | 3.61 | 3.57 | 3.52 | 3.34 | 3.53 | | |
| | $P_1T_2C_1$ | 5.60 | 5.43 | 5.43 | 5.39 | 5.40 | 5.45 | 5.5 | |
| | $P_1T_2C_2$ | 5.68 | 5.58 | 5.60 | 5.50 | 5.42 | 5.55 | | |
| | $P_2T_1C_1$ | 4.45 | 4.32 | 4.32 | 4.32 | 4.29 | 4.34 | 4.32 | 4.91 |
| | $P_2T_1C_2$ | 4.32 | 4.32 | 4.29 | 4.29 | 4.28 | 4.3 | | |
| | $P_2T_2C_1$ | 5.60 | 5.56 | 5.42 | 5.42 | 5.41 | 5.48 | 5.5 | |
| | $P_2T_2C_2$ | 5.62 | 5.60 | 5.50 | 5.49 | 5.41 | 5.52 | | |
| $F_{80,4}$ – P 54.89**, PT 41.91**, PD 22.02**, PTD 18.80**, PTDC 1.56* <br> CD- P 0.771, PT 1.091, PD 1.72, PTD 2.43 PTDC 3.45 | | | | | | | | | |

P-Products,T–treatment (skimmilk and soymilk),D-Storage periods (4days) C - steel containers and plastic containers)

**Signification at 1 per cent level

Acidity of the simulated products was found to vary with storage media and storage periods. Mean scores obtained for acidity in simulated products viz. coconut curd ($P_1$) and coconut yoghurt ($P_2$) with respect to storage media and storage periods, were 0.62 and 0.64 respectively. $P_2$ scored better than $P_1$. As inferred from the CD values (0.011), significant difference was recorded between the simulated products standardized.

A significant difference in acidity was also recorded between the simulated products, with variations viz., with skim milk powder ($T_1$) and soymilk ($T_2$). As inferred from the CD values (0.015), the mean values for $P_1T_1$, $P_1T_2$, $P_2T_1$ and $P_2T_2$ were 0.52, 0.73, 0.60 and 0.68 respectively. Coconut curd in which soymilk was blended ($P_1T_2$), increase in the acidity (0.73) with storage was recorded and higher when compared with coconut curd with skim milk ($P_1T_1$) (0.52). Similarly in coconut yoghurt also, soymilk blended product recorded increased acidity (0.68) with storage when compared with coconut yoghurt with skim milk ($P_2T_1$),(0.60) (CD 0.035).

In coconut curd with skim milk ($P_1T_1$), the increase in acidity was observed more after 4th day in steel container, where as in plastic container increase in acidity was more conspicuous after 3rd day. In coconut curd with soymilk ($P_1T_2$) increase in acidity was seen after 2nd days irrespective of the containers. In coconut yoghurt with skim milk ($P_2T_1$) increase in acidity was seen after 3rd days in the plastic containers, where as in coconut yoghurt, with soymilk ($P_2T_2$), increase in acidity was steady irrespective of the containers (CD 0.049).

Mean scores obtained for Total soluble solids (TSS) of the simulated products viz., coconut curd ($P_1$) and coconut yoghurt ($P_2$) with respect to storage media and storage periods, were 19.21 and 19.67 in curds and yoghurt respectively. $P_2$ scored better than $P_1$. As inferred from the CD values (0.152), significant difference was recorded between the simulated products standardised.

Significant difference was also recorded between the simulated products with variations as inferred from the CD values (0.215). The mean value for Total soluble solids for $P_1T_1$, $P_1T_2$, $P_2T_1$ and $P_2T_2$ were 19.75, 18.67, 19.48 and 19.72 respectively. In coconut curd with soymilk blend ($P_1T_2$), the decrease in total soluble solids (18.67) with storage was recorded and higher when compared with coconut curd with skim milk ($P_1T_1$) (19.75) (CD 0.481).

In coconut yoghurt, with soymilk blend ($P_2T_2$) the decrease in the total soluble solids was 19.72 and in coconut curd with skim milk ($P_2T_1$) it was (19.63). In coconut curd and coconut yoghurt the decrease in total soluble solids was more conspicuous after second day, irrespective of the treatments and containers (appendix-VI)

Mean scores obtained for protein content of simulated products with respect to storage media and storage periods, were 4.52 and 4.91 respectively in curd and yoghurt. Coconut yoghurt was found to be better in protein content than coconut curd. As inferred from the CD values (0.77), significant variation in protein content was recorded between the curd and yoghurt standardised

In both coconut curd and coconut yoghurt, there was a gradual decrease in the protein content with storage, irrespective of treatments and storage containers (CD 1.09). In both coconut curd and yoghurt with soymilk blend, the decrease in protein was more prominent after second day in plastic container while coconut curd and yoghurt with skim milk; the decrease in protein was gradual irrespective of the containers (CD 2.43).

### 4.3.4 Changes in Organoleptic Features in the Simulated Products

Changes in organoleptic features of the developed products were analysed and following table depicts the results obtained.

No significant difference was observed in appearance of the products with storage. Treatments influenced the mean score of the appearance of the curds and yoghurt (CD 0.16). Coconut curd with skim milk scored better in appearance attributes when compared to other. Storage periods also influenced the appearance of the beverages (CD 0.26). With the passage of time, decrease in scores for appearance attribute was recorded in the products. Deterioration was more in coconut curd and coconut yoghurt with soymilk blend. Skim milk added simulated products from coconut milk scored better than soymilk-blended products.

The difference in appearance attribute was conspicuous after third day of storage irrespective of storage containers (CD 0.37). As far as storage containers are concerned, there was significant difference in appearance attributes was recorded (CD 0.16). Storage quality was better in steel container than in plastic containers in all the simulated products (CD 0.16). When coconut curd was taken into account, coconut curd with skim milk powder scored highest (4.4 – 3.6) in steel container when compared to plastic container.

Coconut curd with soymilk was not found much acceptable in plastic container. The mean score was 3.9 – 2.0. Coconut yoghurt with skim milk powder (4.4 – 2.1) scored better than coconut yoghurt with soymilk (4.4 – 2.0).

Table 23. Changes in organoleptic characteristics of simulated products with containers on Storage

| Quality attributes | Treatments | Mean scores at different storage periods (D) | | | | |
|---|---|---|---|---|---|---|
| | | 0 | 1 | 2 | 3 | 4 |
| Appearance | $P_1T_1C_1$ | 4.4 | 4.1 | 4.0 | 3.8 | 3.6 |
| | $P_1T_1C_2$ | 4.3 | 3.9 | 3.5 | 3.6 | 3.3 |
| | $P_1T_2C_1$ | 4.2 | 4.0 | 3.6 | 3.2 | 2.6 |
| | $P_1T_2C_2$ | 3.9 | 3.8 | 3.2 | 3.1 | 2.0 |
| | $P_2T_1C_1$ | 4.4 | 4.2 | 3.9 | 3.5 | 3.1 |
| | $P_2T_1C_2$ | 4.1 | 4.1 | 3.8 | 3.4 | 2.5 |
| | $P_2T_2C_1$ | 4.4 | 4.1 | 3.7 | 3.1 | 2.1 |
| | $P_2T_2C_2$ | 4.1 | 4.0 | 3.9 | 2.7 | 2.0 |
| $F_{80,4}$- D 38.93*, C 5.20*, PD 6.10*, TD 4.25*<br>CD- D 0.26, C 0.16, PD 0.37, TD 0.37 | | | | | | |
| Colour | $P_1T_1C_1$ | 4.5 | 3.9 | 3.9 | 3.8 | 2.6 |
| | $P_1T_1C_2$ | 4.3 | 3.8 | 3.5 | 3.1 | 2.3 |
| | $P_1T_2C_1$ | 3.8 | 3.8 | 3.6 | 3.5 | 3.4 |
| | $P_1T_2C_2$ | 3.8 | 3.7 | 3.5 | 3.2 | 3.2 |
| | $P_2T_1C_1$ | 4.5 | 4.4 | 4.0 | 3.6 | 3.0 |
| | $P_2T_1C_2$ | 4.2 | 4.0 | 3.9 | 3.3 | 2.3 |
| | $P_2T_2C_1$ | 4.4 | 4.0 | 4.0 | 3.7 | 2.5 |
| | $P_2T_2C_2$ | 4.3 | 3.8 | 3.6 | 3.1 | 1.9 |
| $F_{80,4}$- D 38.32*, C 9.75*<br>CD- D 0.27, C 0.17 | | | | | | |

$P_1$ – Curds, $P_2$ – Soymilk, $T_1$ – with skimmed milk powder, $T_2$ – with soymilk

$C_1$ – Steal container $C_2$ – Plastic container, *Significant at 5 per cent level

Table23.Continued

| Quality attributes | Treatments | Mean scores and storage periods in days(D) | | | | |
|---|---|---|---|---|---|---|
| | | 0 | 1 | 2 | 3 | 4 |
| Flavour | $P_1T_1C_1$ | 4.5 | 4.0 | 3.9 | 3.8 | 2.9 |
| | $P_1T_1C_2$ | 4.3 | 4.0 | 3.5 | 3.4 | 3.0 |
| | $P_1T_2C_1$ | 4.0 | 4.0 | 3.6 | 3.1 | 2.5 |
| | $P_1T_2C_2$ | 3.8 | 3.8 | 3.3 | 3.1 | 2.0 |
| | $P_2T_1C_1$ | 4.3 | 4.2 | 4.0 | 3.5 | 3.3 |
| | $P_2T_1C_2$ | 4.1 | 4.2 | 3.5 | 3.3 | 3.0 |
| | $P_2T_2C_1$ | 4.4 | 3.8 | 3.6 | 3.2 | 2.4 |
| | $P_2T_2C_2$ | 4.1 | 4.0 | 3.9 | 2.6 | 2.2 |
| $F_{80,4}$, D 47.01*, C-4.82*, CD D-0.27, C 0.17, TC 0.17 | | | | | | |
| Taste | $P_1T_1C_1$ | 4.0 | 4.1 | 3.8 | 3.8 | 3.3 |
| | $P_1T_1C_2$ | 4.0 | 3.9 | 3.3 | 3.4 | 3.3 |
| | $P_1T_2C_1$ | 3.9 | 3.9 | 3.6 | 3.0 | 2.4 |
| | $P_1T_2C_2$ | 3.8 | 3.8 | 3.1 | 3.0 | 2.1 |
| | $P_2T_1C_1$ | 4.0 | 3.9 | 4.0 | 3.7 | 2.6 |
| | $P_2T_1C_2$ | 3.8 | 3.9 | 3.5 | 3.2 | 2.2 |
| | $P_2T_2C_1$ | 4.0 | 3.8 | 3.5 | 3.1 | 2.2 |
| | $P_2T_2C_2$ | 3.9 | 3.5 | 3.5 | 2.5 | 2.0 |
| $F_{80,4}$- D 39.54*, C 5.36*, PD 3.83*, TD 3.34*<br>CD- D 0.27, C-0.17, PD 0.38, TD 0.38 | | | | | | |

*Significant at 5 per cent level

Table 23. Continued

| Quality attributes | Treatments | Mean scores and storage periods in days(D) | | | | |
|---|---|---|---|---|---|---|
| | | 0 | 1 | 2 | 3 | 4 |
| Consistency | $P_1T_1C_1$ | 4.5 | 4.0 | 3.9 | 3.8 | 3.3 |
| | $P_1T_1C_2$ | 4.4 | 3.6 | 3.4 | 3.4 | 3.0 |
| | $P_1T_2C_1$ | 4.0 | 3.9 | 3.6 | 3.0 | 2.5 |
| | $P_1T_2C_2$ | 3.8 | 3.7 | 3.3 | 3.0 | 2.1 |
| | $P_2T_1C_1$ | 4.4 | 3.8 | 3.8 | 3.7 | 2.6 |
| | $P_2T_1C_2$ | 4.1 | 3.7 | 3.5 | 3.0 | 2.2 |
| | $P_2T_2C_1$ | 4.4 | 3.9 | 3.6 | 3.0 | 2.4 |
| | $P_2T_2C_2$ | 3.9 | 3.6 | 3.7 | 2.5 | 2.1 |
| $F_{80,4}$- D 44.77*, C-8.69*, PD 2.25*, CD- D 0.26, C 0.17, PD 0.37 | | | | | | |

$P_1$ – Curds, $P_2$ – Soymilk, $T_1$ – with skimmed milk powder, $T_2$ – with soymilk

$C_1$ – Steal container $C_2$ – Plastic container

*Significant at 5 per cent level

Table 24. Changes in overall acceptability characteristic of simulated products with storage

| Quality attributes | Treatments | Mean scores and storage periods in days(D) | | | | |
|---|---|---|---|---|---|---|
| | | 0 | 1 | 2 | 3 | 4 |
| Overall acceptability | $P_1T_1C_1$ | 4.44 | 4.34 | 3.9 | 3.8 | 3.14 |
| | $P_1T_1C_2$ | 4.36 | 3.8 | 3.44 | 3.38 | 2.92 |
| | $P_1T_2C_1$ | 4.0 | 3.92 | 3.6 | 3.26 | 2.68 |
| | $P_1T_2C_2$ | 4.0 | 3.82 | 3.28 | 3.08 | 2.28 |
| | $P_2T_1C_1$ | 4.38 | 4.04 | 3.92 | 3.62 | 2.82 |
| | $P_2T_1C_2$ | 4.1 | 3.88 | 3.58 | 3.2 | 2.36 |
| | $P_2T_2C_1$ | 4.4 | 3.9 | 3.8 | 3.2 | 2.4 |
| | $P_2T_2C_2$ | 4.0 | 3.78 | 3.74 | 2.72 | 2.12 |

$P_1$ – Curds, $P_2$ – Soymilk, $T_1$ – with skimmed milk powder, $T_2$ – with soymilk

$C_1$ – Steal container $C_2$ – Plastic container

* Significant at 5 per cent level

When colour of simulated products were taken into consideration, the mean score for colour attribute was appreciable (3.8 4.5). No significant difference was observed in colour between the products. Though the treatments influenced the mean score of the colour of the treated products to some extend, the influence was not significant. Storage periods also influenced the mean score of the colour of the beverages (CD 0.27). With duration of storage there was decrease in scores for colour in the products. Higher deterioration was seen in coconut curd and coconut yoghurt in which soymilk was blended. Skim milk added simulated products from coconut milk scored better for colour than soymilk blended products. When colour of the product was accounted coconut curd with skim milk scored better both in steel and plastic containers followed by coconut yoghurt in steel container and then coconut curd with soymilk.

The difference was conspicuous after third day of storage irrespective of storage containers (CD 0.37). As far as storage containers are concerned there was significant difference in colour attribute (CD 0.17). Storage quality was better in steel container than plastic containers in all the simulated products.

Coconut curd with skim milk powder scored highest (4.5 – 3.8) in steel container for colour when compared to curd stored in plastic container. Coconut curd with soymilk was not much acceptable in plastic container. Coconut yoghurt with skim milk powder (4.5 – 3.0) scored better than coconut yoghurt with soymilk (4.4 – 2.5) for colour attributes.

The mean score for flavour attribute was better irrespective of the products (3.8-4.5). No significant difference was observed in flavour attributes between the products. Storage periods influenced the mean score of the flavour of the simulated products (CD 0.27). With the passage of time, there was a decrease in scores for flavour in the products. Highest deterioration was seen in coconut curd and yoghurt with soymilk. Simulated products from coconut milk scored better than soymilk blended products in flavour. The difference in flavour attribute was conspicuous after third day of storage irrespective of storage containers (CD 0.17).

Storage quality of all the simulated products was better in steel container compared to plastic container in all the simulated products (CD 0.17). Coconut curd with skim milk powder scored better (4.5 – 2.9) in steel container for flavour when compared to plastic containers. Coconut curd with soymilk was not much acceptable in plastic container. The mean score was (3.8 – 2.0). In case of coconut yoghurt with skim milk powder, the scores were 4.3 – 3.3 as against 4.0 – 2.2 in coconut yoghurt with soymilk.

The mean score for taste attribute was found to be ranged between 3.3-4.1 and no significant differences were observed in taste of the products standardised. However, treatments influenced the mean score of taste of the simulated products (CD 0.17). Coconut curd with skim milk scored better in taste attribute (4.0) when compared to others. Storage periods also influenced the mean score of the taste of the simulated products (CD 0.27). With duration of storage there was decrease in scores for taste in the products. Decrease in taste score was observed in coconut curd with soymilk followed by the coconut yoghurt with soymilk. Skim milk added simulated products from coconut milk scored better than soymilk added products in taste attribute.

The difference in the taste scores was conspicuous after third day of storage irrespective of storage containers (CD 0.38). As far as storage containers are concerned there was significant difference in taste attributes (CD 0.17).

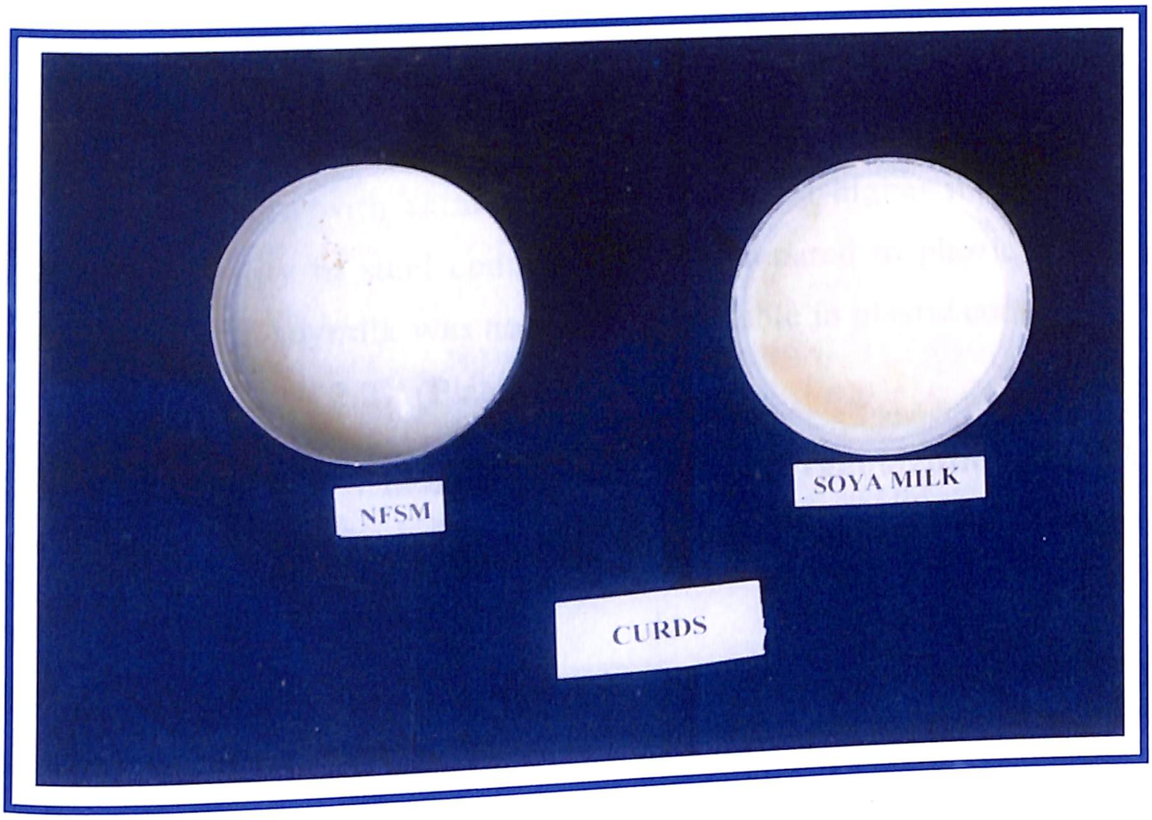
The scores were 4.0 – 2.6 in coconut curd with skim milk in steel container. Coconut curd with skim milk powder scored better for taste in steel container when compared to plastic container. Taste of coconut curd with soymilk was not much acceptable in plastic container. Coconut yoghurt with skim milk powder (4.0 – 2.6) scored better than coconut yoghurt with soymilk (4.0– 2.2) in taste attribute.

No significant difference was observed in consistency attribute between the products with storage and scores ranged between 3.0 - 4.5 with good acceptance. Treatments influenced the mean score of consistency of the simulated products (CD-0.17). Coconut curd with skim milk scored better in consistency attributes when compared to others. Storage periods also influenced the mean score of the consistency of the beverages (CD-0.26). With duration of storage there was a decrease in scores for consistency in the products. Deteriorative change was more in coconut curd with soymilk followed by the coconut yoghurt with soymilk. Skim milk added simulated products from coconut milk scored better than soymilk added products in consistency character.

Coconut curd with skim milk powder scored better (4.5 – 3.3) in steel container for consistency when compared to plastic container (4.4-3.0). Similarly, coconut yoghurt with skim milk powder scored better mean score for consistency in steel container when compared to plastic container.

The mean score for overall acceptability of coconut curd were found to be good in all the products (2.0-4.5) and no significant difference was observed in overall acceptability between the products with storage. Coconut curd with skim milk adjusted to be the best in overall acceptability attribute when compared to others. With duration of storage there was decrease in scores for overall acceptability in the products. As in the case of other attributes, deteriorative changes were more in coconut curd with soymilk followed by the coconut yoghurt with soymilk. Skim milk blended simulated products from coconut milk scored better than soymilk added products. When

## SIMULATED DAIRY MILK PRODUCTS



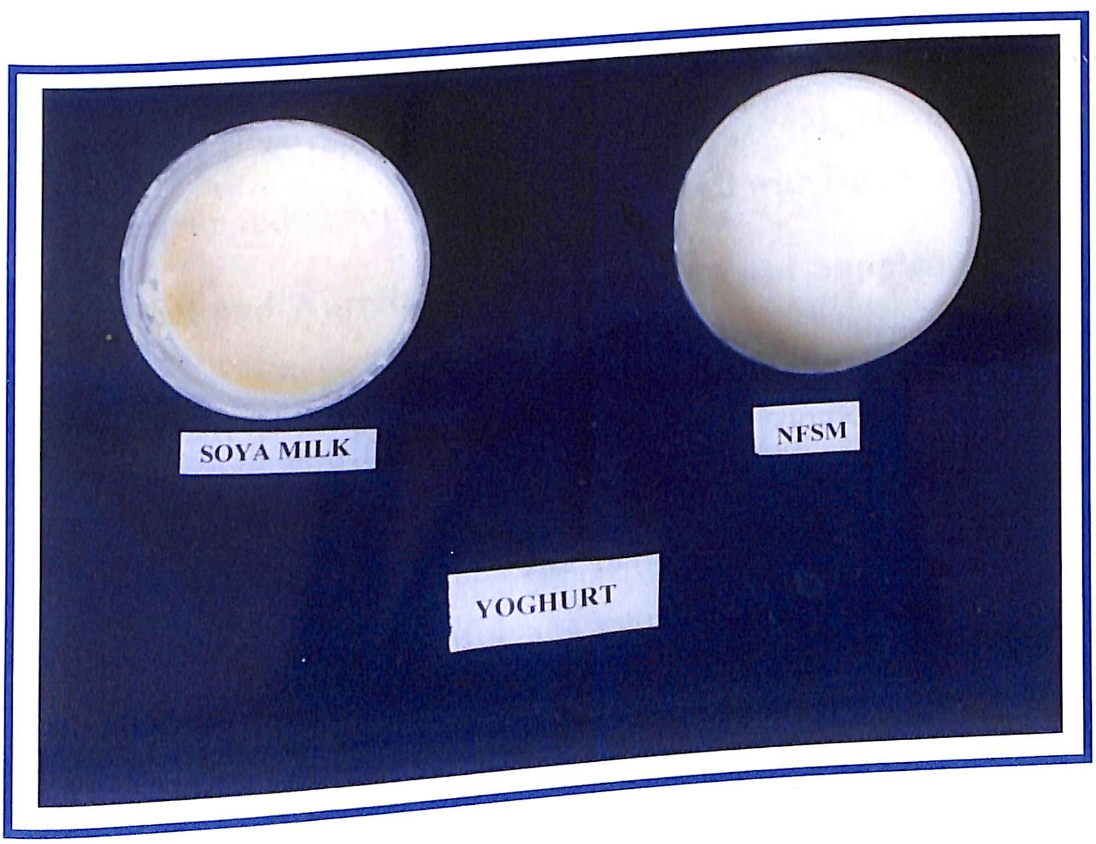




**Plate: IV**

overall acceptability of the product was considered, coconut curd with skim milk scored better in both plastic and steel container followed by coconut yoghurt in steel container and then coconut curd with soymilk.

Coconut curd with skim milk powder scored higher mean score for overall acceptability in steel container when compared to plastic container. Coconut curd with soymilk was not much acceptable in plastic container. The mean score was (4.0 – 2.2). (Plate IV)

### 4.4.1 Assessment of Chemical, Nutritional, Organoleptic and Shelf Stability Features of the Protein Enriched Supplements Developed from Coconut

In our country commercially available supplementary foods are expensive and so are out of reach to a large majority of the population who belong to the lower socio-economic strata. The major drawback detected in the commercial as well as the traditional supplementary foods is that, they have a high dietary bulk and hence low in calorie density becoming nutritionally inadequate as has been reported by Malleshi *et al.*(1986). Therefore there is a need to develop an indigenous supplementary food with simple technology.

### 4.4.1 Chemical and Nutritional Characteristics of Supplementary Base Mix.

Chemical and nutritional characteristics of supplementary base mix developed from coconut were analysed with respect to moisture, protein, calories, fat, fibre, free fatty acid and peroxide values and minerals like calcium, phosphorus and iron. Moisture content was recorded as 13.42 per cent, while that of protein was 13.80 g. Energy and fat content of the base mix was found to be 341 kcal and 15.21g. Fibre 1.58 per cent, Free fatty acid and peroxides were reported to be 0.67 per cent and 0.66 meq respectively. Minerals viz., calcium, phosphorous and iron were recorded as 363 mg, 335.67 mg and 3.13 mg respectively.

Table 25. Chemical and nutritional composition of base mix developed from coconut

| Nutritional/chemical composition of base mix | Nutrients per 100g |
|---|---|
| Moisture% | 13.42 |
| Protein g | 13.80 |
| Energy g | 341.00 |
| Fat g | 15.21 |
| Fibre % | 1.58 |
| Calcium mg | 363.30 |
| Phosphorus mg | 335.70 |
| Iron mg | 3.13 |
| Free Fatty acid % | 0.67 |
| Peroxide meq | 0.66 |

**Organoleptic characteristics of supplementary base mix**

With respect to organoleptic quality of the supplementary base mix, it was indicated that overall acceptability was recorded 3.8 out of 5 with 76 per cent acceptability among the panel judges. Appearance attribute was scored as 4.0 and that of colour score was 4.1. Flavour and taste were recorded as 3.7 each and texture of the base mix appeared good with a score of 3.9.

Supplementary base mix was stored in laminated and polypropylene covers and analysed for shelf stability for a period of 60 days, during which periodic monitoring was carried out.

### 4.4.2 Changes in Chemical and Nutritional Characteristic of Supplementary Base Mix

Table 26 shows the changes in chemical and nutritional characteristic of supplementary base mix and its interaction between, containers and storage periods. Changes in moisture, free fatty acid and peroxide was recorded in the base mix with storage. Other characteristics remain unchanged in the base mix with storage

Moisture content of supplementary base mix as was found to vary significantly with storage periods (CD 0.08). Moisture content increased from 13.04 per cent to 14.07 per cent when stored for 2 months. Significant difference was also observed in the products in different storage containers (CD 0.05). The moisture level of the base mix was steady till one month of storage and after which there was gradual increase was noticed. When stored in polyethylene pouches the moisture level increased considerably to a higher level when compared to laminated pouches at the end of two months

Table 26.Changes in chemical and nutritional characteristic of supplementary product and its interaction between containers and storage period

| Characteristics | Mean scores at different storage periods(P) | | | | | | |
|---|---|---|---|---|---|---|---|
| | Product | Container | Initial | 15days | 30days | 45 days | 60days |
| Moisture | T | $C_1$ | 13.04 | 13.03 | 13.30 | 13.59 | 13.62 |
| | | $C_2$ | 13.07 | 13.20 | 13.56 | 13.74 | 14.07 |
| $F_{20}$- P 159.44**, C 75.53**, PC 8.55** CD-P 0.08, C 0.05, PC 0.11 | | | | | | | |
| Free Fatty acid | T | $C_1$ | 0.10 | 0.22 | 0.82 | 0.92 | 1.03 |
| | | $C_2$ | 0.13 | 0.51 | 091 | 1.02 | 1.05 |
| $F_{20}$- P 179.91** C 20.34** CD- P 0.08 C 0.05 | | | | | | | |
| Peroxide | T | $C_1$ | 0.15 | 0.34 | 0.70 | 0.82 | 1.02 |
| | | $C_2$ | 0.22 | 0.52 | 084 | 0.91 | 1.08 |
| $F_{20}$- P 170**, C 13.11**, PC 3.15** CD- P 0.09, C 0.06, PC 0.13 | | | | | | | |
| Significant at 1 per cent level | | | | | | | |

C1- Poly propylene cover $C_2$- Laminated pouches, **Significant at 1 per cent level

With respect to free fatty content of supplementary base mix, significant difference was noted with storage period (CD 0.09). Storage containers also influenced the free fatty acid content of the base mix (CD 0.05). Free fatty content of the supplementary base mix was 0.10 to 1.03 per cent and 0.13 to 1.05 per cent respectively in laminated pouches and polyethylene pouches. Changes were significant after 15 days, in the products stored in polyethylene pouches (0.51 per cent) as against one month in laminated pouches (0.82 per cent).

Peroxide content of supplementary base mix also found to change significantly with storage periods (CD 0.09). Significant increase was observed after one month of storage in both the containers. A significant difference was also recorded in storage containers (CD 0.06). The level of peroxide value was high when stored in polypropylene covers when compared to storage in laminated pouches.

Peroxide value of supplementary base mix in polyethylene pouches increased from 0.22 to 1.08 mg whereas the increase was from 0.15 to 1.02 mg in laminated pouches.

Table 27. Changes in organoleptic characteristics of supplementary base mix and its interaction between containers and storage periods

| Attributes | Container | Mean scores at different storage periods(P) | | | | |
|---|---|---|---|---|---|---|
| | | Initial | 15days | 30days | 45 days | 60days |
| Appearance | $C_1$ | 4.0 | 4.0 | 4.0 | 3.9 | 3.4 |
| | $C_2$ | 3.9 | 3.6 | 3.7 | 3.1 | 3.0 |
| $F_{90,4}$- P 4.95*, C 14.68* P 0.51, C 0.32 | | | | | | |
| Colour | $C_1$ | 4.1 | 3.9 | 4.0 | 3.8 | 3.5 |
| | $C_2$ | 4.1 | 3.9 | 3.6 | 3.6 | 2.8 |
| $F_{90,4}$- P 7.83*, C 3.51*, PC 2.73* CD- P 0.47, C 0.30, PC 0.66 | | | | | | |
| Flavour | $C_1$ | 3.9 | 3.8 | 3.7 | 3.8 | 3.6 |
| | $C_2$ | 3.9 | 3.8 | 3.5 | 3.0 | 2.4 |
| $F_{90,4}$- P 7.08*, C 14.52*, PC 4.92* CD- P 0.36, C 0.23, PC 0.51 | | | | | | |
| Taste | $C_1$ | 3.8 | 3.6 | 3.8 | 3.6 | 3.7 |
| | $C_2$ | 3.8 | 3.8 | 3.2 | 3.6 | 2.4 |
| $F_{90,4}$- P 3.89*, C 6.36*, PC 4.94* CD- P 0.40, C 0.25, PC 0.56 | | | | | | |
| Consistency | $C_1$ | 3.9 | 3.8 | 3.8 | 3.5 | 3.2 |
| | $C_2$ | 3.7 | 3.7 | 3.3 | 2.8 | 2.2 |
| CD- P 0.39, C 0.24, PC 0.54 $F_{90,4}$ P –11.4*, C 16.69*, PC 1.80* | | | | | | |
| Overall acc. | $C_1$ | 3.88 | 3.82 | 3.9 | 3.72 | 3.48 |
| | $C_2$ | 3.84 | 3.76 | 3.58 | 3.06 | 2.72 |

C1- Poly propylene cover $C_2$- Laminated pouches, D – Storage period

* Significant at 5 per cent level

### 4.4.3 Changes in Organoleptic Characteristics of Supplementary Base Mix with Storage

When appearance attribute in supplementary base mix was taken into account, the mean score for appearance attribute varied from (4.0 – 3.0). A significant difference was observed in mean score of appearance with storage (CD 0.51). Storage containers also affected the mean score of the appearance of the products (CD 0.32). A decrease in freshness of the product with storage period was observed. Laminated pouches maintained the freshness for a longer period when compared with polypropylene covers.

When colour attribute of coconut base Supplementary base mix was taken into account, the mean score decreased from 4.1 –2.8, and a significant difference was observed in mean score of colour with storage (CD 0.47). Storage containers found to influence the mean score of the colour of the product (CD 0.30). Laminated pouches maintained the colour for a longer period when compared with polypropylene covers.

A significant difference in flavour attribute was also recorded in base mix with storage period (CD 0.36). Reduction of flavour was also observed with storage. Storage containers found to influence the mean score of the colour of the product (CD 0.23).

Similarly the mean score of the taste attribute of the supplement base mix decreased from 3.8 – 2.4. A significant difference was observed in mean score of taste with storage (CD 0.40). Slight rancid taste developed with storage. Storage containers also influenced the mean score of the taste of the product (CD 0.25).

A significant difference was observed in mean score of consistency with storage in the base mix (CD 0.39). The crispness of the supplementary mix decreased with storage. Storage containers affected the crispness of the product (CD 0.24).

Storage periods and containers also influenced the mean score of the overall acceptability of the supplementary base mix. Product stored in polythene cover displayed poor sensory qualities when compared to product stored in laminated pouches. The overall acceptability of the product showed that the product could be stored for a period of one month in polythene cover and above one month in laminated pouches.

### 4.5.2 Assessment of Chemical, Nutritional and Shelf Stability Features of the Health Drinks Standardised Using Coconut Milk Powder

According to Naram (2000) Food and medicine form a potential combination to fight disease. The fundamentals of good medicine lay in the diet. Consumers view diet as a component not only for achieving good health but also for its maintenance and possible improvement. The attention at present has been focused towards manufacturing food formulations in a variety of forms, to cater to diverse situations. Health foods, when taken as supplements, are able to compensate for dietary deficiencies.

The coconut milk powder easily dissolves in water to form a milky-white liquid with the flavour and texture of coconut milk. It is now flourishing in the Indian market but not much work has been done on the utilization of it in culinary purpose. In the present study, two types of health drinks therapeutic mix and malted health drink were standardized by using coconut milk powder as a base.

Table 28 Chemical and nutritional characteristics of Health Drinks mixes

| Characteristics | Products | | $F_{40,4}$ | CD |
|---|---|---|---|---|
| | $T_1$ | $T_2$ | | |
| Moisture (%) | 7.68 | 9.09 | 1552.75** | 0.07 |
| Protein (g) | 9.12 | 15.66 | 2568** | 0.71 |
| Energy (kcal) | 335 | 323 | | NS |
| Fat (g) | 1.87 | 2.90 | 1089** | 0.06 |
| Fibre (%) | 1.39 | 1.62 | 317.43** | 0.03 |
| Calcium (mg) | 430.33 | 566.37 | 5181** | 3.82 |
| Phosphorus (mg) | 222.77 | 219.32 | 47.39** | 1.01 |
| Iron (mg) | 1.76 | 1.95 | 203.69** | 0.03 |
| Free Fatty acid (%) | 0.23 | 0.32 | 84.30** | 0.02 |
| Peroxide (meq) | 0.39 | 0.54 | 1022** | 0.03 |

$T_1$ – Therapeutic health drink mix $T_2$– Malted health drink mix

** Significant at 1 per cent level

### *4.4.2.1 Chemical and Nutritional Characteristics of Health Drinks Powder*

Table 28 explains the chemical and nutritional characteristic of health drink mixes from coconut milk powder. The therapeutic health drink was prepared by adding condiments and coconut jaggery, while Malted health drink was prepared from malted cereals. In the standardized products, the moisture content was 8.58 in therapeutic health drink and that in malted drink was 9.09 per cent. Calorie content of health drink II was 323 as against 335 in therapeutic mix. Protein content of the mixes was 9.12 g and 15.66 respectively per 100g in mix I and mix II. Mineral content in the mixes viz., calcium, phosphorus and iron were 432, 223 and 1.76 mg in respectively mix I and 566 mg, 219 mg and 1.95 mg in mix II. Free fatty acids and peroxide were 0.23 to 0.32 per cent and 0.39 to 0.54meq respectively in mix I and II. Chemical and nutritional constituents present in the mixes developed vary significantly with each other except for energy. The health drink II had high level of moisture, protein, fat, fiber, calcium, free fatty acids and peroxide value when compared to health drink 1. The energy level was on par.

### 4.4.2.2Organoleptic Characteristics of Health Drinks

Table 29 Organoleptic features of Health Drinks

| Sl. No | Products | Mean score for sensory attributes | | | | | |
|---|---|---|---|---|---|---|---|
| | | Appearance | Colour | Flavour | Taste | Consistency | OA |
| 1 | $T_1$ | 3.5 | 3.3 | 3.9 | 4.0 | 2.8 | 3.5 |
| 2 | $T_2$ | 3.8 | 3.6 | 3.5 | 3.2 | 3.0 | 3.42 |
| | $F_{180,4}$ | | | 41.16 | 10.51 | | |
| | CD | NS | NS | 0.21* | 0.19* | NS | NS |
| | * Significant at 5 per cent level | | | | | | |

T1- therapeutic health drink, T2 – malted health drink

Average mean score obtained by the judges indicated that the overall acceptability was above 70 per cent in both the health drink mixes developed. Taste parameter scored 4.0 in therapeutic mix as against 3.2 in malted mix. Flavour scores were also in favour of therapeutic mix. 3.9 and 3.5 respectively in mix I and mix II whereas mean score was for appearance and colour was better appreciated in malted mix. As obtained by the CD value sensory features with respect to texture, flavour and taste vary significantly in products standardised.

### 4.4.2.3 Changes in the Chemical and Nutritional Characteristic of Health Drink mixes with Storage

Table 30 shows the chemical and nutritional characteristic of health drink powder and its interaction between products, containers and storage periods. The health drink powder was stored in polythene bags and laminated pouches for six months.

Moisture content of health drink mix when considered there was found to vary significantly with storage periods (CD-0.07). Moisture content increased from 7.72-7.89 when stored for 6months in therapeutic health drink and 8.13 –10.57 in malted health drinks respectively.

Moisture content also vary in the products with respect to storage containers (CD-0.05). When stored in polyethylene pouches, increase in moisture level was conspicuous (7.89) after 2 months, where as in laminated pouches, there was not much rise in moisture (7.62) content. In laminated pouches, the moisture level was steady till two and half months of storage but after two and half month there was increase in moisture content. When compared, the products in polyethylene covers depleted high level of moisture content within one month of storage.

With respect to free fatty content of Health drink mix, significant difference was noted with storage period (CD 0.09). Free fatty content of the Health drink mix ranged from 0.17 to 0.47 per cent and 0.28 to 0.51 per cent in laminated pouches and polyethylene pouches respectively. Storage containers also influenced the free fatty acid content of the Health drink mix (CD 0.05). Changes was significant after three months in products stored in polyethylene pouches (0.52 per cent) where as in laminated pouches (0.47 per cent) after one month of storage.

Peroxide content of Health drink mix also found to change significantly with storage periods (CD 0.09). Significant increase was observed after one month of storage in both the containers. A significant difference was also recorded with storage containers (CD 0.06). When peroxide value of the product was compared, when stored in polyethylene pouches the peroxide value increased from 0.3 to 1.06 mg and in laminated pouches it increased from 0.22 to 0.91mg. The level of peroxide value was seen high when stored in polyethylene covers than in laminated pouches. Significant increase was seen after the product was analysed after 1 month of storage in both the containers. At the initial stage no free fatty acid and peroxide value were indicated in the products.

When data was pooled together, statistically it was seen that there was significant difference in moisture content and free fatty acid level of the products with storage period and storage media whereas there was no significant difference in peroxide value with respect to storage period and storage container.

***4.4.2.4 Changes in the Organoleptic features of Health Drinks with storage***

Table 31 Sensory Attributes of Health drinks powders from coconut milk powder

| Attributes | Products | Containers | Duration (months) | | | | |
|---|---|---|---|---|---|---|---|
| | | | 0 | 1 | 2 | 3 | 4 |
| Appearance | T1 | C1 | 4.0 | 4.0 | 4.0 | 4.0 | 4.0 |
| | T1 | C2 | 4.0 | 3.9 | 3.5 | 3.5 | 3.0 |
| | T2 | C1 | 3.5 | 3.5 | 3.5 | 3.4 | 3.1 |
| | T2 | C2 | 3.1 | 3.1 | 2.3 | 2.2 | 2.2 |
| $F_{180,4}$- T 44.72*, P 4.89*, C 35.57* TP 5.52*<br>**CD**- T 0.22, P 0.34, C 0.22 TC 0.31 PC – ns, | | | | | | | |
| Colour | T1 | C1 | 4.1 | 4.1 | 4.1 | 3.9 | 3.8 |
| | T1 | C2 | 4.1 | 4.1 | 3.7 | 3.7 | 3.2 |
| | T2 | C1 | 4.1 | 4.0 | 3.4 | 3.3 | 3.2 |
| | T2 | C2 | 3.6 | 3.6 | 2.4 | 2.4 | 2.2 |
| $F_{180,4}$- T 41.12*, P 5.99*, C -28.93* TC 5.12* PC 5.90*<br>**CD**- T 0.21, P 0.33, C 0.21 TC 0.29 PC 0.46, | | | | | | | |
| Flavour | T1 | C1 | 3.9 | 3.9 | 3.9 | 3.9 | 3.7 |
| | T1 | C2 | 3.9 | 3.8 | 3.5 | 3.5 | 3.0 |
| | T2 | C1 | 3.9 | 3.5 | 3.1 | 3.0 | 3.0 |
| | T2 | C2 | 3.2 | 3.0 | 2.6 | 2.5 | 2.3 |
| $F_{180,4}$- T –41.16*, P – 4.29*, C -17.51*<br>**CD**- T – 0.21, P – 0.33, C - 0.21 | | | | | | | |
| Taste | T1 | C1 | 4.0 | 3.9 | 3.7 | 3.7 | 3.6 |
| | T1 | C2 | 3.9 | 3.6 | 3.4 | 3.2 | 3.2 |
| | T2 | C1 | 3.7 | 3.5 | 3.5 | 3.4 | 3.2 |
| | T2 | C2 | 3.7 | 3.5 | 3.5 | 3.3 | 2.3 |
| $F_{180,4}$- T 10.51*, P 4.84*, C 5.78*<br>**CD**- T 0.19, P 0.30, C 0.19 | | | | | | | |
| Consistency | T1 | C1 | 3.9 | 3.9 | 3.6 | 3.5 | 3.5 |
| | T1 | C2 | 4.0 | 3.5 | 3.4 | 3.3 | 2.8 |
| | T2 | C1 | 3.7 | 2.9 | 2.8 | 2.8 | 2.7 |
| | T2 | C2 | 3.0 | 2.8 | 2.7 | 2.7 | 2.0 |
| $F_{180,4}$- T 10.19*, C 4.53*,<br>**CD**- T 0.63, C 4.53 | | | | | | | |
| Overall acceptability | T1 | C1 | 3.9 | 3.9 | 3.8 | 3.8 | 3.8 |
| | T1 | C2 | 3.9 | 3.8 | 3.4 | 3.4 | 3.0 |
| | T2 | C1 | 3.8 | 3.2 | 3.2 | 3.2 | 2.7 |
| | T2 | C2 | 3.2 | 3.2 | 2.7 | 2.7 | 2.2 |

*Significant at 5 per cent level

T1- therapeutic health drink, T2 – malted health drink C1- Laminated pouches $C_2$- Poly propylene cover

The health drink mixes were kept for a period of 6 months, in polythene and laminated pouches. and tested periodically among the judges by mixing the mixes in hot water.

When appearance attribute in health drink mixes was taken into account, the mean score for appearance attribute varied from (4.0 – 3.1). A significant difference in the 'appearance' attribute was recorded between the two health drinks (CD - 0.22), and with the storage periods (CD- 0.34). The appearance score decreased and change was observed after 90 days. Containers also affected the appearance of the products (CD-0.31). The product appeared better in laminated pouches than in polypropylene covers.

When colour attribute of coconut base health drink mixes was taken into account, the mean score decreased from 4.1 –3.3. Colour attribute also depicted significant difference between the therapeutic health drinks and malted health drink (CD-0.21) so also with the storage periods (CD-0.33). Containers also influenced the colour of the products (CD-0.29). The product appeared better in laminated pouches than in polypropylene covers.

A significant difference in flavour attribute was seen between the products (CD- 0.21). But flavour variation was observed with the storage periods (CD - 0.33). The flavour score decreased and change was seen after 90 days in both the products. Containers also affected the flavour of the products (CD-0.21). Flavour was retained well in laminated pouches than in polypropylene covers.

Similarly the mean score of the taste attribute of the health drink mixes decreased from 4.0 – 3.2. A significant difference in taste attribute was observed between the health drinks (CD- 0.19), and also during the storage periods (CD - 0.30). The taste score decreased and change was noticed after 90 days in both the products. Containers were found to influence the taste of

# PROTEIN ENRICHED PRODUCTS



Plate: V

the products (CD-0.19). The products retained its fresh taste in laminated pouches than in polypropylene covers

Consistency was found to vary with the products and the storage period influenced the consistency attribute (CD - 0.63). The consistency score decreased and changes appeared after 90 days. However, containers do not affect the consistency of the products (CD-4.53). When overall acceptability of the products was considered, therapeutic health drinks scored better for attribute flavour and taste while malted health drinks scored better for appearance and colour.

After analysing each quality attribute, the score for over all acceptability was determined for the mixes. Both the health drink mixes remained better in laminated pouches than in polypropylene pouches.

From the above findings it could be concluded that, organoleptic features of the two health drink mixes and he supplementary base mix developed from the coconut found to remain stable till six month after which decrease in the sensory score and chemical qualities were observed. Laminated pouches were outstandingly superior for storing the health drink mixes and base mix as the chemical, sensory features are less affected in laminated pouches. (Plate V)

## 4.5 ASSESSMENT OF CHEMICAL, NUTRITIONAL, ORGANOLEPTIC AND SHELF STABILITY FEATURES OF THE BAKERY AND PRESERVED PRODUCTS DEVELOPED FROM COCONUT

According to Sharma *et al.* (1995), bakery industry is progressing at a very fast rate in India, because of changes in attitude of the growing population towards convenient foods. Under present investigation, bakery products developed from coconut by partial substitution of media with coconut grating, coconut milk, and coconut honey which would be profitable for the coconut growers, entrepreneurs and consumers.

### 4.5.1 Bakery Products

#### *4.5.1.1 Chemical and Nutritional Characteristics of the Bakery Products*

Table 28 Shows the chemical and nutritional characteristics of the bakery products standardised viz. coconut cookies and coconut biscuits incorporating coconut. Moisture content of coconut cookies ($T_2$) was 10.27 per cent while that of coconut biscuits was 8.28 per cent. Energy content of the cookies ($T_2$) and biscuits ($T_1$) was found to be 356 and 390 kcal per 100g. Protein content of the biscuit was 5.15g as against 3.08g in cookies. Fat content was 25.67 g and 20.55 g respectively in biscuits and cookies. Fibre content was negligible in both the products. Minerals namely calcium, phosphorus and iron were found to be 60.33 mg 242.33 mg and 1.70 mg in cookies as against 70.63 mg 282.63 mg and 1.59 g respectively in biscuits. Free fatty acid and peroxide present in the products were also accounted as these factors influence the keeping quality of the bakery products. Free fatty level was 0.41 per cent and 0.8 per cent respectively in cookies and biscuits while that of peroxide value were recorded as 0.65 meq and 0.77 meq respectively. Analysis of the data indicated differences in the nutritional and chemical constituents in the cookies and biscuits developed incorporating coconut significantly vary with each other.

Table 32. Chemical and nutritional characteristics of bakery products prepared from coconut

| Characteristics | Coconut cookies | Coconut biscuits | $F_{40,4}$ | CD |
|---|---|---|---|---|
| Moisture % | 10.27 | 8. 28 | 3708** | 0.02 |
| Energy kcal | 356 | 390 | 57.74 ** | 9.13 |
| Protein g | 3.08 | 5.15 | NS | |
| Fat g | 20.55 | 25.67 | 3411** | 0.28 |
| Fibre% | 1.70 | 1.59 | NS | |
| Calcium mg | 60.33 | 70.63 | 10521 ** | 0.347 |
| Phosphorus mg | 242.33 | 282.63 | 1110 ** | 0.393 |
| Iron mg | 1.57 | 1.43 | 1250 ** | 0.01 |
| Free Fatty acid % | 0.41 | 0.8 | 456.1** | 0.04 |
| Peroxide meq | 0.65 | 0.77 | 83.44** | 0.03 |

**Significant at 1 per cent level

#### *4.5.1.2 Organoleptic Features of Bakery Products*

Table 33 depicts the organoleptic features of bakery products. Sensory evaluation ascertained for cookies and biscuits indicated that coconut cookies scored best for appearance (4.5), colour (4.0), flavour (3.9) and doneness (4.4) whereas biscuit scored best for taste (3.8) attribute. Overall acceptability score was 4.1 in cookies as against 3.9 in coconut biscuits. Percentage acceptability ranged 78 to 82 indicating good acceptance of products among the judges. Overall acceptability of the bakery products when taken into account, coconut cookies adjudged to be best compared to biscuits. As inferred from the CD values sensory parameters like appearance colour, taste and doneness evaluated were found to vary significantly with each other whereas flavour and overall acceptability appeared to be similar in the products.

Table 33. Organoleptic characteristics of bakery products

| Attributes | Mean scores | | $F_{180,4}$ | CD |
|---|---|---|---|---|
| | $T_1$ | $T_2$ | | |
| Appearance | 4.1 | 4.5 | 13.57* | 0.22 |
| Colour | 3.8 | 4.0 | 12.37* | 0.22 |
| Flavour | 3.5 | 3.9 | NS | |
| Taste | 3.9 | 3.7 | 8.91* | 0.21 |
| Doneness | 4.0 | 4.4 | 19.75* | 0.21 |
| Overall acceptability | 3.86 | 4.1 | | NS |

$T_1$- Biscuits $T_2$- Cookies

*Significant at 5 per cent level , NS : Non significant

Table 34. Changes in chemical and nutritional characteristics of bakery products and its interaction between products, containers and storage periods

| Characteristics | Products | Containers | Mean scores at different storage periods (P) | | | | |
|---|---|---|---|---|---|---|---|
| | | | Initial | 15days | 30days | 45 days | 60days |
| Moisture% | $T_1$ | $C_0$ | 8.09 | 8.02 | 8.01 | 8.26 | 8.33 |
| | | $C_1$ | 8.09 | 8.33 | 8.50 | 8.61 | 8.62 |
| | $T_2$ | $C_0$ | 10.22 | 10.20 | 10.22 | 10.24 | 10.27 |
| | | $C_1$ | 10.22 | 10.21 | 10.34 | 10.36 | 10.35 |
| $F_{40,4}$- T 37081**, P 84.54**, C 300.92**, TP 29.92**, TC 113.23** | | | | | | | |
| CD- T 0.020, P 0.0329, C 0.020, TP 0.0465 TC 0.029, | | | | | | | |
| Free fatty acid% | $T_1$ | $C_0$ | 0.10 | 0.23 | 0.28 | 0.51 | 0.73 |
| | | $C_1$ | 0.10 | 3.03 | 0.503 | 0.62 | 0.71 |
| | $T_2$ | $C_0$ | 0.13 | 0.61 | 0.89 | 0.99 | 1.05 |
| | | $C_1$ | 0.33 | 0.87 | 0.97 | 1.03 | 1.05 |
| $F_{40,4}$- T 456.1**, P – ns, C 28.46**, TP 15.72** | | | | | | | |
| CD- T 0.036, C 0.365, TP 0.081 | | | | | | | |
| Peroxide meq | $T_1$ | $C_0$ | 0.10 | 0.34 | 0.71 | 0.82 | 1.01 |
| | | $C_1$ | 0.19 | 0.52 | 0.83 | 0.91 | 1.04 |
| | $T_2$ | $C_0$ | 0.22 | 0.52 | 0.84 | 0.91 | 1.11 |
| | | $C_1$ | 0.34 | 0.70 | 0.82 | 1.1 | 1.18 |
| $F_{40,4}$- T 83.55**, P 513.55**, C 59.77** | | | | | | | |
| CD- T 0.027, P 0.043, C 0.027 | | | | | | | |
| Significant at 1per cent level | | | | | | | |

$T_1$- Biscuits $T_2$- Cookies C1- Poly propylene cover $C_2$- Laminated pouches,
P – Storage periods

**Significant at 1 per cent level

### *4.5.1.3 Changes in Chemical and Nutritional Characteristics of Bakery with Storage*

Table 34 depicts the changes in the chemical and nutritional characteristics of the bakery products

Bakery products standardised were packed in laminated and polypropylene covers and studied for shelf stability. The products were analysed periodically for changes in the chemical constituents as well as organoleptic features. Results indicated that with the passage of time of coconut biscuits and coconut cookies depicted gradual changes in moisture, free fatty acid and peroxide content.

Coconut cookies had significantly higher moisture content than coconut biscuits (CD 0.02). A significant increase in moisture in coconut cookies and coconut biscuits was seen with storage periods (CD 0.0465) and storage containers (CD 0.029). Increase in moisture content was found significant only after one month of storage. Changes in moisture were more in polypropylene pouches when compared to laminated pouches during storage.

Similarly, Coconut cookies had significantly higher free fatty acid content than coconut biscuits (CD 0.036). A significant increase in free fatty acid content in coconut cookies and coconut biscuits was seen with storage periods (CD 0.081), but not much variation was recorded with storage containers. Increase in free fatty acid content was significant only after one month of storage. The free fatty acid content of the products was seemed to be increasing both in laminated pouches ($C_0$) and polypropylene with the storage periods.

A significant increase in peroxide content of coconut cookies and coconut biscuits was also recorded with storage periods (CD 0.043) and storage containers (CD 0.027). Increase in peroxide content was significant only after one month of storage. Changes in peroxide content were more in polypropylene pouches when compared to laminated pouches during storage.

The difference in moisture, free fatty acid and peroxide with storage period appeared after 15 days in polypropylene covers whereas in laminated pouches difference recorded after 30 days.

#### *4.5.1.4 Changes in organoleptic attributes of coconut cookies and coconut biscuits*

Table 35 depicts the changes in organoleptic attributes of coconut cookies and coconut biscuits and its interaction between products, containers and storage periods.

When sensory attributes of the coconut cookies and coconut biscuit were compared with respect to the storage periods, there was a significant difference in sensory attributes with the storage periods. There was a gradual decrease in all the attributes with the storage periods. The change was prominent after one months storage in polypropylene covers and after two months in laminated pouches. The products remained crisp and better in laminated pouches than in polypropylene covers.

Table 35. Changes in organoleptic characteristic of bakery products from coconut with storage

| Attributes | Products (T) | Container (C) | Mean scores at different storage periods( P) | | | | |
|---|---|---|---|---|---|---|---|
| | | | 0 | 15days | 30days | 45days | 60days |
| Appearance | $T_1$ | $C_1$ | 4.5 | 4.4 | 3.9 | 3.2 | 2.8 |
| | | $C_2$ | 3.9 | 3.9 | 3.9 | 2.2 | 2.1 |
| | $T_2$ | $C_1$ | 4.1 | 3.8 | 3.2 | 3.0 | 2.9 |
| | | $C_2$ | 3.2 | 2.7 | 2.7 | 2.5 | 2.5 |
| $F_{180,4}$- T 13.57*, P 21.41*, C 27.69* TP 5.09* CD- T 0.22, , P 0.35, C 0.22 TP 0.50 PC – ns | | | | | | | |
| Colour | $T_1$ | $C_1$ | 4.0 | 4.0 | 3.6 | 3.2 | 2.7 |
| | | $C_2$ | 3.8 | 3.7 | 3.6 | 1.9 | 1.9 |
| | $T_2$ | $C_1$ | 3.8 | 3.6 | 3.6 | 2.6 | 2.8 |
| | | $C_2$ | 3.3 | 2.2 | 3.5 | 2.1 | 2.2 |
| $F_{180,4}$ T 12.37* , P 29.89*, C 28.30* TP 7.51* CD- T 0.22, , P 0.34, C 0.22 TP 0.47 | | | | | | | |
| Flavour | $T_1$ | $C_1$ | 3.9 | 3.9 | 3.5 | 2.7 | 2.9 |
| | | $C_2$ | 3.4 | 3.5 | 2.8 | 2.0 | 2.0 |
| | $T_2$ | $C_1$ | 3.5 | 3.5 | 3.7 | 3.3 | 2.9 |
| | | $C_2$ | 3.7 | 3.5 | 3.5 | 2.7 | 2.0 |
| $F_{180,4}$- P 20.56*, C 21.04* CD- T –ns , , P 0.33, C 0.21, | | | | | | | |
| Taste | $T_1$ | $C_1$ | 3.7 | 3.7 | 3.8 | 2.8 | 2.0 |
| | | $C_2$ | 3.7 | 3.7 | 2.7 | 2.7 | 2.0 |
| | $T_2$ | $C_1$ | 3.9 | 3.8 | 3.8 | 3.5 | 2.8 |
| | | $C_2$ | 3.8 | 3.7 | 2.8 | 2.0 | 2.3 |
| $F_{180,4}$- T 8.91* , P 33.955*, C 15.35 *TP 2.,69** PC 3.39* CD- T 0.21, ; P 0.33, C 0.47 TP 0.21 PC 0.47 | | | | | | | |
| Doneness | $T_1$ | $C_1$ | 4.4 | 4.1 | 3.6 | 3.4 | 3.6 |
| | | $C_2$ | 4.0 | 4.0 | 3.5 | 4.0 | 4.0 |
| | $T_2$ | $C_1$ | 4.0 | 3.8 | 3.8 | 3.4 | 3.2 |
| | | $C_2$ | 3.3 | 2.8 | 3.3 | 3.8 | 3.3 |
| $F_{180,4}$- T 19.75*, P 2.56*, C - ns TP 3.08* PC 4.20* CD- T 0.21, P 0.33, C -ns TP 0.41 PC 0.47 | | | | | | | |
| Overall acceptability | $A_1$ | $C_1$ | 4.1 | 4.1 | 3.7 | 3.1 | 2.8 |
| | | | | | 3.3 | 2.6 | 2.4 |
| | | $C_2$ | 3.8 | 3.8 | 3.6 | 3.2 | 2.9 |
| | $A_2$ | $C_1$ | 3.9 | 3.7 | 3.2 | 2.6 | 2.5 |
| | | $C_2$ | 3.5 | 2.9 | | | |

*Significant at 5 per cent level
$T_1$- Cookies $T_2$ - Biscuits C1 - poly propylene cover C2 - Laminated pouches
P – Storage period

# BAKERY PRODUCTS FROM COCONUT

Coconut Biscuits

Coconut cookies

**Plate: VI**

A significant difference in the 'appearance' attribute was recorded between the products (CD 0.22), and with the storage periods (CD 0.35). The appearance score decreased and change was observed after 30 days. Containers also affected the appearance of the products (CD 0.22). The product appeared better in laminated pouches than in polyprolylene covers.

Colour attribute was also depicted significant difference between the products (CD 0.22) so also with the storage periods (CD 0.34). Containers also influenced the colour of the products (CD 0.22). The product appeared better in laminated pouches than in polyprolylene covers.

However, no significant difference in flavour attribute was seen between the products. But flavour variation was observed with the storage periods (CD 0.33). The flavour score decreased and change was seen after 30 days in both the products. Containers also affected the flavour of the products (CD 0.21). Flavour was retained well in laminated pouches than in polyprolylene covers.

A significant difference in taste attribute was observed between cookies and biscuits (CD 0.21), and also during the storage periods (CD 0.33). The taste score decreased and change was noticed after 30 days in both the products. Containers were found to influence the taste of the products (CD 0.47). The products retained its fresh taste in laminated pouches than in polyprolylene covers

Doneness of the product was found to vary with the products and the storage period influenced the doneness attribute (CD 0.33). The doneness score decreased and changes appeared after 30 days. However, Containers does not affect the doneness of the products (CD-ns). When overall acceptability of the products was considered, both coconut biscuit and coconut cookies scored high however cookies excelled. (Plate VI)

### 4.5.2 Preserved Products

Preservation of food in sugar syrup is an age-old practice. Different Preserves or candies are prepared by altering the sugar concentration. Tender coconut kernel forms a good base for the formulation of different types of candies. Crystallised candy and glazed candy was successfully standardized from coconut kernel under the present investigation.

#### *4.5.2.1 Chemical and Nutritional, Features of the Preserved Products Developed from Coconut*

Moisture content of crystallized candy was 17.73 per cent while that in glazed candy it was 20.87 per cent. Total soluble solids, total sugar and reducing sugar were 69.68, 75.01 and 28.03 per cent respectively in crystallized candy whereas it was 66.36, 65.66 and 26.70 per cent respectively in glazed candy.

Table 36. Chemical and nutritional characteristics of preserves

| Characteristics | Products | | $F_{40,4}$ | CD |
|---|---|---|---|---|
| | Crystallized candy | Glazed candy | | |
| Moisture % | 17.73 | 20.87 | 1022 | 0.294** |
| Total soluble solids $^0$B | 69.68 | 66.36 | 2736 | 0.046** |
| Total sugar % | 75.01 | 65.66 | 27953 | 2.17* |
| Reducing sugar% | 28.03 | 26.70 | 5318 | 0.020** |
| Calories kcal | 352 | 249.37 | 3329 | 12.12** |
| Protein g | 0.93 | 0.91 | | NS |
| Fat g | 5.21 | 5.22 | | NS |
| Fibre % | 3.08 | 2.55 | 193.91 | 0.065 |

** Significant at 1 per cent level, * Significant at 5 per cent level

Among the nutritional characteristics calorie content was found to be rather high and recorded 352 kcal in crystallized candy as against 249 in glazed candy. Protein content was recorded negligible and was comparable in both the products (0.93 g each). Fat content of the crystallized and glazed candy was found to be similar and recorded as 5 g per 100 g. In both the products, fiber content was more and it was 3.08 in crystallized candy and as against 2.5 in glazed candy. As inferred from the CD values, characteristics such as moisture, TSS, TS, reducing sugar and calories vary significantly with the products, whereas other constituents such as protein and fat found to be alike.

Table37. Organoleptic features of crystallized candy and glazed candy

| Products | Mean score for sensory attributes | | | | | |
|---|---|---|---|---|---|---|
| | Appearance | Colour | Flavour | Taste | Texture | OA |
| Crystallized candy | 4.0 | 3.9 | 4.1 | 4.1 | 4.3 | 4.08 |
| Glazed candy | 3.5 | 3.9 | 4.0 | 4.1 | 4.2 | 3.94 |
| $F_{40,4}$ | 7.99** | 13.18** | 18.01** | 45.46** | 27.24** | |
| CD | 0.18 | 0.15 | 0.18 | 0.16 | 0.18 | |

**Significant at 1 per cent level.

### 4.5.2.2 *Organoleptic Features of the Preserved Products Developed from Coconut*

Organoleptic evaluation conducted in preserves developed revealed that overall acceptability scores ranged between 3.94 to 4.08 indicating 78 to 80 per cent acceptance among the judges. Appearance attribute was better in crystallized candy (4.0) when compared to glazed candy (3.9). For flavour and taste, cystallized candy scored equally (4.1) as against (4.0 and 4.1) each in glazed candy. Taste score (4.0) was alike in crystallized candy and glazed candy.

Crystallised candy adjudged to be superior to glazed candy as ndicated from the scores. Appearance of crystallized candy was 4.0 as against 3.5 in glazed candy. In colour attribute, both the products recorded similar mean score (3.9 each). Mean score recorded for flavour and taste attribute was 4.1 each for crystallized candy where as it was 4.0 and 4.1 in glazed candy. Both the characters were scored comparatively better by the panel judges. Texture was found to be excellent in crystallized candy as indicated from the score of 4.3 out of 5 and it was similar in glazed candy (4.2). As inferred from the CD value, the organoleptic characteristics in crystallized and glazed candy were significantly different with respect to sensory.

### 4.5.2.3 *Changes in Chemical and Nutritional Characteristic of Preserves with Storage*

Preserves were stored in polypropylene and laminated pouches for a period of two months during which chemical and nutritional characteristics were analysed periodically. It is encouraging to record that there were no changes in the nutrient contents in the preserved products with storage. However, chemical constituents such as moisture, TSS, TS and reducing sugar found to alter with storage, the data of which is given in Table 38.

When moisture content of the two products viz., crystallized candy and glazed candy was compared there was a significant difference between the products (CD 0.294) and with storage (17.73 per cent and 20.87 per cent). Storage period found to influence the moisture content of the crystallized candy and glazed candy (CD 0.380). Moisture content was 17.73 and 21.08 respectively in crystallized candy and glazed candy when stored in polypropylene covers and at the end of the storage period it was 17.62 and 22.45 respectively.

An increase in moisture level was noticed after 30 days of storage. The type of containers (laminated pouches and polypropylene covers) does not influence moisture of the products.

Taking into account of the total soluble solids, there was a significant difference observed between the products (CD 0.046). The total soluble solid content decreased with the storage period (CD 0.059). The initial value recorded for total soluble solids was 68.71 per cent and 66.23 per cent respectively in crystallized candy stored in polypropylene covers and at the end of storage period it was 66.50 and 62.21 respectively. Decrease in total soluble solids was noticed after 30 days of storage with respect to storage containers. The type of containers (laminated pouches and polypropylene covers) also influenced total soluble solids content of the product.

When reducing sugar of the products was compared, there was a significant difference was observed between the products (CD 0.02). The reducing sugar increased with the storage period (CD 0.026). The initial value for reducing sugar content in crystallized candy and glazed candy stored in polypropylene covers were 27.23and 26.41 respectively and at the end storage period it was27.64 and 26.63 respectively. Conspicuous increase was recorded in both products (27.72 in crystallized candy and 26.67 in glazed candy). A significant increase in reducing sugar was seen after 45 days of storage in laminated pouches in both the products. But in polypropylene covers the increase in reducing sugar was found earlier (after 30days). The type of containers (laminated pouches and polypropylene covers) does not influence reducing sugar content of the product.

Table 38. Changes in chemical and nutritional characteristic of preserves and its interaction between products, containers and storage periods

| Characteristics | | Mean scores at different storage periods (P) | | | | |
|---|---|---|---|---|---|---|
| | Stage | Initial | 15days | 30days | 45 days | 60days |
| Moisture % | $T_1 C_1$ | 17.59 | 17.62 | 17.55 | 17.59 | 17.62 |
| | $T_1C_2$ | 17.73 | 17.75 | 17.87 | 17.93 | 18.03 |
| | $T_2C_1$ | 20.02 | 20.05 | 20.03 | 20.23 | 20.53 |
| | $T_2C_2$ | 21.08 | 20.85 | 21.69 | 21.71 | 22.45 |
| $F_{40,4}$- T 1022**, P 40.98**, C -ns, TP 104**, TC 3.46*, PC 4.26**, TPC 5.46**<br>CD- T 0.294, P 0.380, TP 0.658 TC 0.416 PC 0.537, TPC 0.93 | | | | | | |
| Total soluble solids $^0$B | $T_1 C_1$ | 68.72 | 68.65 | 67.84 | 67.11 | 67.01 |
| | $T_1C_2$ | 68.71 | 68.52 | 67.20 | 67.09 | 66.5 |
| | $T_2C_1$ | 66.48 | 66.21 | 65.83 | 65.63 | 65.61 |
| | $T_2C_2$ | 66.23 | 63.21 | 62.59 | 62.37 | 62.21 |
| $F_{40,4}$- T 2736**, P 73.29**, C 159.51**, TP 3.29**, TC 3.41* , PC 15.73**, TPC 2.26*<br>CD- T 0.046, P 0.0597C 0.037, TP 0.1033 TC 0.065 PC 0.084, TPC 0.146 | | | | | | |
| Reducing sugar % | $T_1 C_1$ | 27.26 | 27.68 | 27.69 | 27.72 | 27.85 |
| | $T_1C_2$ | 27.23 | 27.21 | 27.34 | 27.56 | 27.64 |
| | $T_2C_1$ | 26.39 | 26.46 | 26.53 | 26.56 | 26.63 |
| | $T_2C_2$ | 26.41 | 26.48 | 26.55 | 26.67 | 26.67 |
| $F_{40,4}$- T 5318**, P 21.15**, C -ns, TP 4.84**<br>CD- T 0.020, P 0.026, TP 0.045 | | | | | | |
| **Significant at 1 per cent level, *Significant at 5 per cent level | | | | | | |

$T_1$ - crystallized candy $T_2$- glazed candy P- storage periods $C_1$-laminated pouches

$C_2$ – polypropylene covers

### *4.5.2.4 Changes in the Organoleptic Qualities of the Preserves from Tender Coconut with Storage*

Table 39 Changes in the organoleptic qualities of the preserves from tender coconut with storage. The organoleptic qualities of the preserves (crystallised candy and glazed candy) were assessed for a period of two months, details of which are discussed below.

When appearance attribute of coconut preserve (crystallised candy and glazed candy) were taken into account, the mean score obtained ranged 3.38-3.69 between the products. A significant difference was observed in appearance quality of the products standardised (CD 0.18). Storage periods and storage containers do not influence the mean score of the appearance in the preserves developed.

Colour of coconut preserves which is assured to be an important quality character (crystallized candy and glazed candy), the mean score for colour attribute ranged between 3.80-3.42. A significant difference was observed in colour attributes between the products (CD 0.15). Storage periods (CD 0.20) and storage containers (CD 0.12) were found to influence colour of the preserves standardised. In crystallised candy the difference in colour with storage periods was noticeable only in the products stored in polypropylene covers. A change in colour attribute was seen in glazed candy after one month of storage. The preserves stayed better in laminated pouches than in polypropylene covers.

The mean score for flavour attribute ranged between 4.1- 4.6 and a significant difference was observed in flavour of the products standardised (CD 0.18). With storage, flavour scores in the products reduced significantly (CD 0.24). Storage containers do not significantly affect the flavour of the products.

Table 39. Changes in organoleptic characteristics of preserved products and its interaction between products, containers and storage periods

| Characteristics | Products | Mean scores at different storage periods (P) | | | | |
|---|---|---|---|---|---|---|
| | | 0 | 1 | 2 | 3 | 4 |
| Appearance | $T_1C_1$ | 4.0 | 4.0 | 3.7 | 3.8 | 3.4 |
| | $T_1C_2$ | 3.9 | 3.2 | 3.6 | 3.7 | 3.6 |
| | $T_2C_1$ | 3.5 | 3.7 | 3.9 | 3.6 | 3.4 |
| | $T_2C_2$ | 3.8 | 3.7 | 3.9 | 3.8 | 3.6 |
| $F_{40,1}$- T 7.99*, P –NS C -NS TP – NS<br>CD- T 0.18, | | | | | | |
| Colour | $T_1C_1$ | 3.9 | 3.9 | 4.0 | 3.8 | 4.0 |
| | $T_1C_2$ | 3.8 | 3.8 | 3.9 | 3.4 | 3.5 |
| | $T_2C_1$ | 3.9 | 4.0 | 4.0 | 4.0 | 3.3 |
| | $T_2C_2$ | 3.7 | 3.8 | 3.6 | 3.4 | 3.5 |
| CD - NS | | | | | | |
| Flavour | $T_1C_1$ | 4.1 | 3.9 | 4.0 | 3.9 | 3.6 |
| | $T_1C_2$ | 4.0 | 4.0 | 4.0 | 3.8 | 3.7 |
| | $T_2C_1$ | 4.0 | 4.0 | 3.9 | 3.8 | 3.2 |
| | $T_2C_2$ | 3.9 | 3.9 | 4.0 | 4.0 | 2.8 |
| CD - NS | | | | | | |
| Taste | $T_1C_1$ | 4.1 | 4.2 | 4.0 | 4.1 | 3.8 |
| | $T_1C_2$ | 4.1 | 4.1 | 4.0 | 3.7 | 3.1 |
| | $T_2C_1$ | 4.1 | 4.1 | 4.1 | 4.1 | 3.0 |
| | $T_2C_2$ | 4.1 | 4.1 | 4.2 | 3.9 | 2.4 |
| CD - NS | | | | | | |
| Texture | $T_1C_1$ | 4.3 | 4.3 | 4.1 | 4.0 | 4.2 |
| | $T_1C_2$ | 4.0 | 3.9 | 4.1 | 4.2 | 2.9 |
| | $T_2C_1$ | 4.2 | 4.1 | 3.9 | 4.2 | 3.3 |
| | $T_2C_2$ | 4.1 | 4.1 | 3.9 | 4.1 | 2.6 |
| $F_{40,1}$- T 27.24*, P 22.26*, C 28.22*TP 5.95* TC 3.46*<br>CD- T 0.18, P 0.23, C 0.15,TP 0.40. TC 0.26 | | | | | | |
| Overall acc | $T_1C_1$ | 3.94 | 3.98 | 3.96 | 3.94 | 3.24 |
| | $T_1C_2$ | 3.92 | 3.88 | 3.92 | 3.84 | 2.98 |
| | $T_2C_1$ | 3.7 | 3.58 | 3.62 | 3.24 | 3.28 |
| | $T_2C_2$ | 3.84 | 3.74 | 3.22 | 2.82 | 2.36 |

*Significant at 5 per cent level, NS : Non significant

$T_1$- Crystallized candy $T_2$- Glazed candy P- Storage periods $C_1$-Laminated pouches

$C_2$ – Polypropylene covers

Mean score for taste attribute was found to be rather high in all the products (3.92-3.19) during storage. A significant difference was observed in taste of the products between the crystallized and glazed candy (CD 0.16). Storage periods significantly reduced the mean score of the taste of the preserves (CD 0.21). Containers also profoundly influence the taste of the products (CD 0.13). The taste of product stored in laminated pouches was found to be better than stored in polypropylene covers. On interaction between the products and storage periods was considered there was difference in attributes taste (CD 0.36). Interaction effect between containers and storage periods was also found significant (CD 0.30).

When texture of coconut preserves was taken into consideration, the mean score for texture attribute ranged between 4.0-3.35. A significant difference was observed in texture of the products (CD 0.18) standardised. Storage period and storage container significantly influenced the texture of the preserves developed (CD 0.23 and CD 0.15 respectively).

Overall acceptability of the preserves ranged between 3.7-3.9 which indicate good acceptance of the products among judges during storage. As the days of storage increased, mean score for overall acceptability decreased to a significant level. In crystallised candy, the decrease was seen after 2 months of storage, where as in glazed candy the overall quality decreased after one month. Containers in which products were stored also significantly influenced the overall acceptability of the products.In laminated covers both the candies remained better than in polypropylene covers. (PlateVII)

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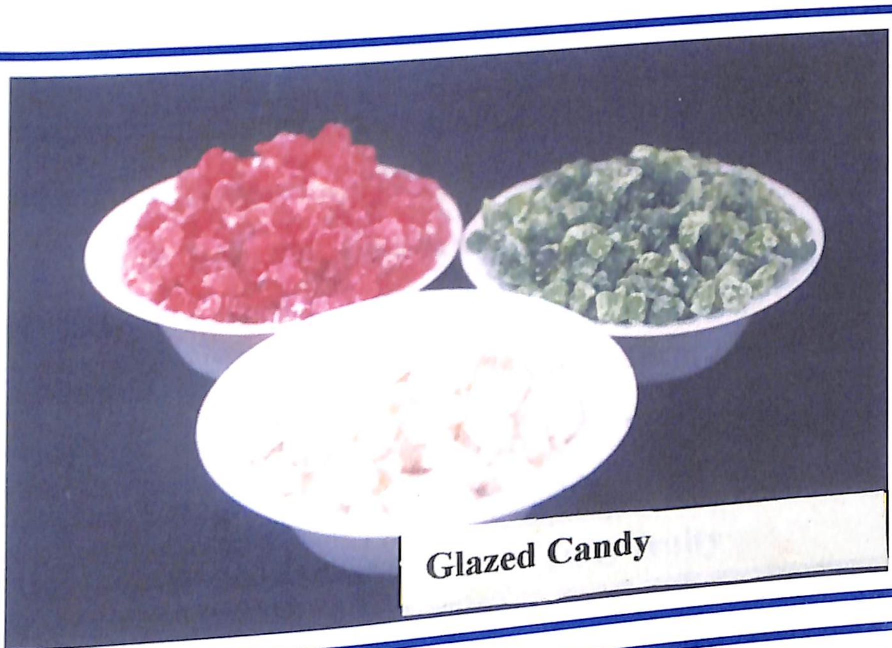
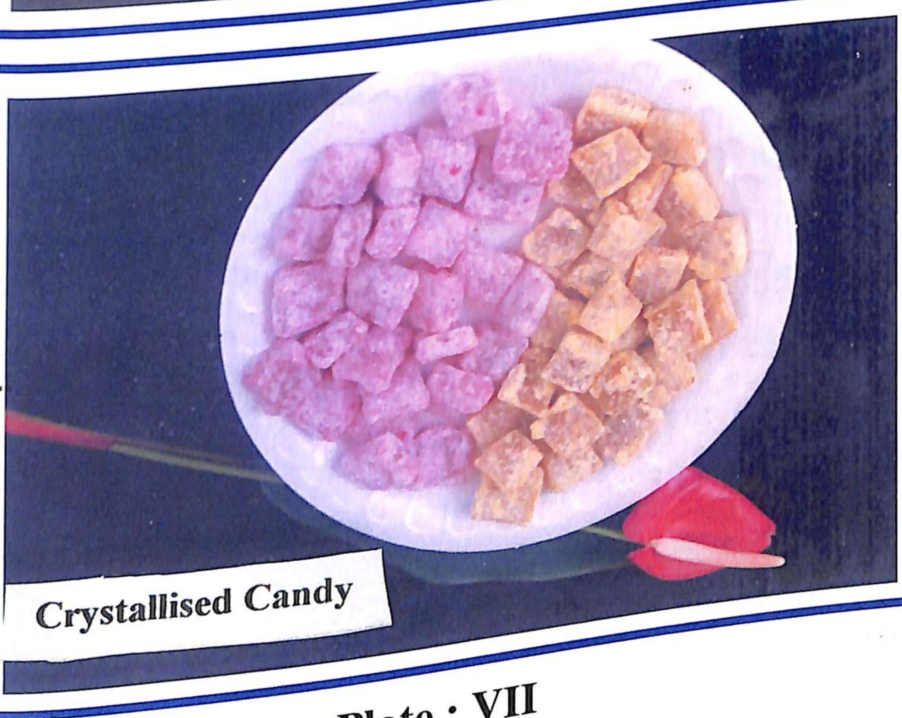
When texture of coconut preserves was taken into consideration, the mean score for texture attribute ranged between 4.0-3.35. A significant difference was observed in texture of the products (CD 0.18) standardised. Storage period and storage container significantly influenced the texture of the preserves developed (CD 0.23 and CD 0.15 respectively).

Overall acceptability of the preserves ranged between 3.7-3.9 which indicate good acceptance of the products among judges during storage. As the days of storage increased, mean score for overall acceptability decreased to a significant level. In crystallised candy, the decrease was seen after 2 months of storage, where as in glazed candy the overall quality decreased after one month. Containers in which products were stored also significantly influenced the overall acceptability of the products.In laminated covers both the candies remained better than in polypropylene covers. (PlateVII)

# PRESERVES FROM TENDERNUT



Glazed Candy



Crystallised Candy

Plate : VII

### 4.5.3 Standardisation of Coconut Honey from Coconut Milk

Coconut honey is a translucent, free flowing liquid with characteristic creamy, and nutty flavour. It is made from coconut milk and serves as an excellent base for soft drinks (Gonzalez, 1990). It can be used as a topping for the bakery products and waffles and can be used as a flavour enhances in desserts, ice-cream etc. Coconut honey can be diluted in water and used in cooking rice cakes and other delicacies. It is a low cost technology, which can be taken up as a cottage industry with very less investment. Two types of coconut honeys namely coconut honeys white ($T_1$) coconut honeys brown ($T_2$) were formulated. Physiochemical characteristics of Coconut honey analysed under the study as moisture pH, acidity, reducing sugar, total soluble solids, total sugar and nutritional characteristics were protein, calories, fat, and minerals like calcium, phosphorus and iron.

#### *4.5.3.1 Chemical and Nutritional Characteristics of Coconut Honeys*

Moisture content of brown honey was 38.63 while that in white honey was 40.22. pH and acidity were 6.30 and 0.37 in white honey as against 5.83 and 0.22 in brown honey. Total soluble solids, total sugar and reducing sugar were 50.39 °brix, 58.92 and 2.83 per cent respectively in brown honey and 55.45 °brix, 59.85 and 3.42 per cent respectively in brown honey. Calorie content was found to be 325 and 319 respectively per 100 g in brown and white coconut honey. Protein and fat content was 5.35 and 13.67 g per 100 g. respectively in brown honey while it was 5.09 and 12.65 respectively in white honey. Mineral content was also recorded higher level in brown honey. Calcium 27.67 mg, phosphorus 139.33 mg and iron 1.83 mg as against 24 mg, 135.33 mg, 1.71 in white honey. Statistical analysis of the data indicated that all chemical and nutritional characteristics were significantly different in both the products.

Table 40. Chemical and nutritional characteristics of coconut honeys

| Characteristics | Product | | $F_{20,4}$ | CD |
|---|---|---|---|---|
| | $T_1$ | $T_2$ | | |
| Moisture% | 40.22 | 38.63 | 30.53 | 0.24** |
| PH | 5.83 | 6.30 | 20 | 0.11** |
| Acidity% | 0.22 | 0.37 | NS | NS |
| Reducing sugar% | 2.83 | 3.42 | 137.58 | 0.08** |
| Total soluble solids $^{o}$ B | 50.39 | 55.45 | 1350.96 | 0.27** |
| Total sugar% | 58.92 | 59.85 | 184.49 | 0.29** |
| Protein g | 5.09 | 5.35 | 945.98 | 0.03** |
| Calories kcal | 319 | 325 | 42.66 | 2.81** |
| Fat g | 12.65 | 13.67 | 15.87 | 1.36** |
| Calcium mg | 24 | 27.67 | 9.45 | 2.48* |
| Phosphorous mg | 135.33 | 139.33 | 5.76 | 3.47** |
| Iron mg | 1.71 | 1.83 | 185.19 | 0.01** |
| ** Significant at 1 per cent level | | | | |

$T_1$- Coconut Honey white, $T_2$ - Coconut honey brown

#### 4.5.3.2 *Organoleptic Characteristics of Coconut Honey*

Table 41 gives the organoleptic characteristic of the coconut honey developed. Organoleptic evaluation conducted in honey revealed that overall acceptability scores ranged between 70 to 76 per cent and the mean score for brown honey (3.8) was higher than the white honey (3.5). Other sensory parameters such as appearance and colour (4.2) were also in favour of brown honey. For colour and flavour brown honey scored 4.2 each as against 3.8 each in white honey. Taste score was4.0 in brown honey as against 3.7 in white honey whereas consistency was comparatively better in white honey 3.1 than in brown honey 3.0 respectively.

Table 41. Organoleptic characteristics of coconut honey

| Attributes | Product | | $F_{90,4}$ | CD |
|---|---|---|---|---|
| | $T_1$ | $T_2$ | | NS |
| Appearance | 4.1 | 3.7 | 0.36 | NS |
| Colour | 4.2 | 3.8 | 6.95 | 0.35* |
| Flavour | 4.2 | 3.8 | 12.19 | 0.33* |
| Taste | 4.0 | 3.7 | 11.84 | 0.32* |
| Texture | 3.3 | 3.1 | 2.18 | NS |
| Consistency | 3.0 | 3.1 | 1.65 | NS |
| Overall acceptability | 3.8 | 3.5 | | |

*Significant at 5 per cent level

$T_1$- Coconut honey brown, $T_2$ - Coconut Honey white

#### 4.5.3.3 *Changes in Chemical and Nutritional Characteristics of Coconut Honey and its Interaction between Products, Containers and Storage Periods* (Table 42)

There was a significant variation in total sugar in between the two honey (CD 0.29). A variation was also seen in total sugar with storage periods (CD 0.460). An increase in total sugar with storage period was conspicuous after 30 days of storage. A significant difference was seen in between the products, coconut white honey was having high moisture content when compared to brown honey (CD 0.24). The moisture content decreases with storage (CD 0.379). Change was more after one month of storage.

Table 42. Changes in chemical and nutritional characteristics of coconut honey and its interaction between products, containers and storage periods

| Nutrient | Products | Mean scores at different storage periods (P) | | | | |
|---|---|---|---|---|---|---|
| | | Initial | 15days | 30days | 45 days | 60days |
| pH | $T_1$ | 5.83 | 5.87 | 5.85 | 5.58 | 5.53 |
| | $T_2$ | 6.30 | 6.30 | 6.31 | 6.31 | 6.31 |
| $F_{20,4}$-T 120** P 2.95*<br>CD- T 0.116 P 0.184 | | | | | | |
| Total sugars | $T_1$ | 58.92 | 58.99 | 60.12 | 62.04 | 64.89 |
| | $T_2$ | 59.85 | 60.00 | 63.38 | 65.00 | 65.59 |
| $F_{20,4}$ T 184.49** P 250.13** TP 13.70**<br>CD T 0.291 P 0.460 TP 0.651 | | | | | | |
| Moisture | $T_1$ | 40.22 | 40.22 | 38.63 | 38.50 | 38.50 |
| | $T_2$ | 38.63 | 38.6 | 38.00 | 38.00 | 36.00 |
| $F_{20,4}$ T 30.53** P 11.44** TP 11.44**<br>CD T 0.24 P 0.379 TP 0.537 | | | | | | |
| **Significant at 1 per cent level, * Significant at 5 per cent level | | | | | | |

$T_1$- Coconut Honey white, $T_2$ -Coconut honey brown

Table 43. Changes in organoleptic attributes of coconut honey and its interaction between products, containers and storage periods

| Attributes | Products | Mean scores at different storage periods (P) | | | | |
|---|---|---|---|---|---|---|
| | | 0 | 1 | 2 | 3 | 4 |
| Appearance | $T_1$ | 4.1 | 3.3 | 3.4 | 3.4 | 3 |
| | $T_2$ | 3.7 | 3.2 | 2.8 | 3.3 | 2.9 |
| $F_{20,4}$ P 5.73* CD P 0.53 | | | | | | |
| Colour | $T_1$ | 4.2 | 3.5 | 3.6 | 3.3 | 2.8 |
| | $T_2$ | 3.8 | 3.3 | 2.8 | 2.9 | 2.7 |
| $F_{20,4}$ T 6.95* P 5.24* CD T 0.35 P 0.52 | | | | | | |
| Flavour | $T_1$ | 4.2 | 3.6 | 3.4 | 3. 0 | 2.8 |
| | $T_2$ | 3.8 | 3.1 | 2.8 | 2.8 | 2.6 |
| $F_{20,4}$ T 12.19* P 5.16* CD T 0.33 P 0.52 | | | | | | |
| Taste | $T_1$ | 4.0 | 3.7 | 3.2 | 2.9 | 2.8 |
| | $T_2$ | 3.7 | 3.0 | 2.8 | 2.8 | 2.7 |
| $F_{20,4}$ T 11.84* P 3.45* CD T 0.32 P 0.51 | | | | | | |
| Texture | $T_1$ | 3.3 | 3.1 | 3.1 | 2.9 | 2.7 |
| | $T_2$ | 3.1 | 3.0 | 2.8 | 2.8 | 2.6 |
| NS | | | | | | |
| Consistency | $T_1$ | 3.0 | 3.1 | 2.9 | 2.9 | 2.7 |
| | $T_2$ | 3.1 | 3.2 | 2.8 | 2.9 | 2.7 |
| NS | | | | | | |
| Overall acceptability | $T_1$ | 3.8 | 3.4 | 3.2 | 3.1 | 2.8 |
| | $T_2$ | 3.5 | 3.1 | 2.8 | 2.9 | 2.7 |

*Significant at 5 per cent level

$T_1$- Coconut honey brown, $T_2$ - Coconut Honey white, P – Storage period

### *4.5.3.4 Changes in Organoleptic Attributes of Coconut Honey with Storage*

Table 43 depicts the changes in organoleptic attributes of coconut honey and its interaction between products, and storage periods.

A significant difference in attribute appearance was seen in between the products. (CD 0.53), but no significant difference was seen with the storage periods.

A significant difference in attribute colour was seen in between the products (CD 0.35). A significant difference was also seen with the storage periods (CD 0.52).

A significant difference in attribute flavour was seen in between the products (CD 0.33) and also with the storage periods (CD 0.52). A significant difference in attribute taste was seen in between the products (CD 0.32), but no significant difference was seen with the storage periods (CD 0.51).

No significant difference in attribute texture and consistency was seen in between the products and in between the storage periods. When the interaction between the product and storage period were considered there was no significant differences in both the attributes.

When organoleptic attributes of two coconut honeys as a whole are taken in consideration there was a significant difference in attributes colour flavour and taste with storage periods, where as no much effect was there on change of appearance, texture or consistency.

Overall acceptability showed coconut honey brown scored better (3.8) than coconut honey white (3.5).(PlateVIII)

## Honey from coconut

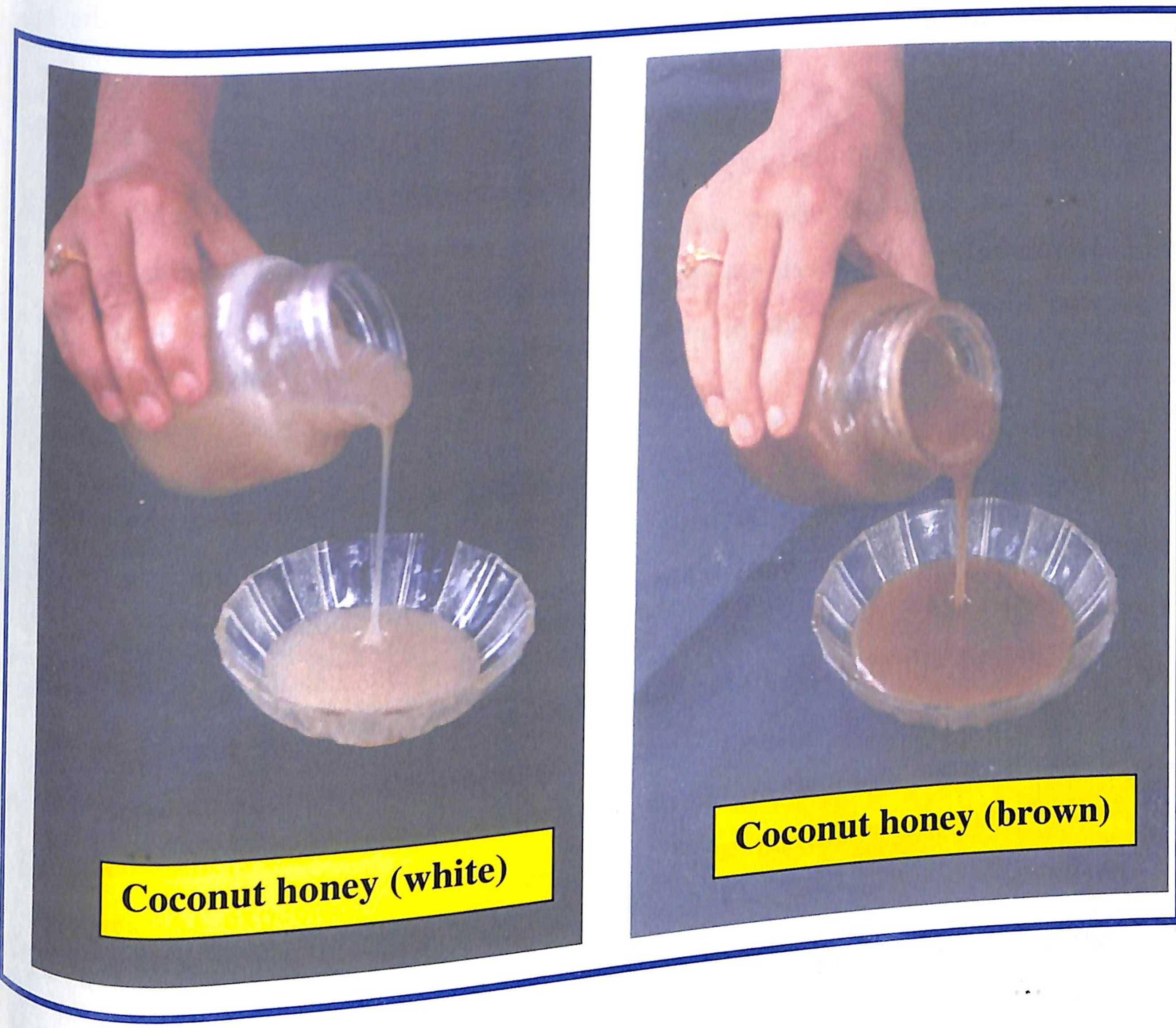



Plate : VIII

## 4.6 ASSESSMENT OF MICROBIAL PROFILE OF THE PRODUCTS DEVELOPED FROM COCONUT WITH STORAGE

Microbial population in the processed foods is an important factor, which determines the quality and safety of the product. The population of fungi and bacteria in the products developed from coconut was hence ascertained. Processing methods and addition of additives were assumed to reduce the microbial load, which would enhance the keeping quality of the products.

When foods are processed, there are chances of contamination through various means and during the storage of the products, these microbes multiply and cause spoilage of the products. Hence assessment of microbial infestation in the products is an essential step in the development of new products.

The microbial contamination in the various food products developed from coconut was assessed at different periods of storage in different containers. In the coconut beverages, microbial load showed an increasing trend when analysed at two months of storage (Table 44). However, microbial load was found to be within the permissible limit. Among the different containers used for storage, it was found that beverages stored in glass containers showed higher microbial population than that stored in retort pouches. As expected, development of spoilage microbes was less in the beverages stored under refrigerated condition.

The data on microbial load of bioprocessed products revealed that the mean score of microbes differed among the products and the score was having highest in nata de soya (51 nos). Nata de soya products had highest microbial load than the nata produced from other treatments. The development of spoilage microorganisms was less in the products stored in cans when compared to that in glass containers.

Table 44. Changes in total counts of bacteria in the beverages developed from tender coconut with storage

| Products $10^{-2}$ | Viable count $\times 10^{2}$ cfu/ml | |
|---|---|---|
| Beverages | Initial | 60days |
| $T_1R_1C_1$ | 1 | 3 |
| $T_1R_1C_2$ | 2 | 4.0 |
| $T_1R_2C_1$ | 1 | 4.0 |
| $T_1R_2C_2$ | 1 | 5.5 |
| $T_2R_1C_1$ | 0 | 3 |
| $T_2R_1C_2$ | 1 | 5.3 |
| $T_2R_2C_1$ | 1 | 5 |
| $T_2R_2C_2$ | 1 | 6.1 |
| $T_3R_1C_1$ | 0 | 3 |
| $T_3R_1C_2$ | 2 | 6.0 |
| $T_3R_2C_1$ | 0 | 3.0 |
| $T_3R_2C_2$ | 0 | 4.7 |

$T_1$-Acidulant added, $T_2$ –Pineapple blended, $T_3$ –Lemon blended, $R_0$ -Ambient temperature, $R_1$ - Refrigerated condition, $C_1$- Retort pouches, $C_2$ -Bottle

Nata de soya recorded highest microbial load of 40 - 51 $\times 10^{2}$ cfu/g followed by nata de pine 20 – 43 cfu/g and nata de coco 18 – 39.67 cfu/g at 60 days of storage. The nata products stored in cans show less microbial load than that stored in glass bottles. Among the various products developed, microbial load was high rather in bioprocessed products when compared to the other products, though it was within the permissible limit. Shelf stability of simulated products was monitored stored for a period of four days at ambient condition and daily analysis of the products for microbial quality indicated that the microbial density increased with the increase in the period of storage (Table 45).

Table 45. Effect of storage period and containers on microbial population in simulated products

| Type of products | Viable counts X $10^5$ cfu/ml | | |
|---|---|---|---|
| Simulated products | Container | Initial | Storage periods (4 days) |
| Curd + Skim milk powder | Plastics | 1.33 | 25.45 |
| | Steel | 1.67 | 23.3 |
| Curd + Soya milk | Plastics | 2.0 | 26.76 |
| | Steel | 2.33 | 24.54 |
| Yoghurt + Skim milk powder | Plastics | 1.67 | 23.01 |
| | Steel | 1.33 | 20.89 |
| Yoghurt + Soya milk | Plastics | 2.67 | 24.0 |
| | Steel | 1.67 | 25.09 |

Protein enriched supplements recorded very low population of microbes in the initial periods of storage but showed slight increase during storage period of two months. There was negligible microbial development in therapeutic health drink mix, when stored for two months whereas in malted health drink microbial loads of 3 $\times 10^2$ cfu/g at one month of storage period. However, the microbial counts recorded in these products were within the permissible limits.

Among the various bakery products, microbial contamination was comparatively very less (7.67 – 14.33 $\times 10^2$ cfu/g) at five months of storage. Biscuits and cookies remained stable without any significant microbial development in the two containers used for storing. When compared to other products, both biscuits and cookies could be stored safely in both the containers.

Preserve products such as glazed candy and crystallized candy microbial load was to the tune of $2.7\times 10^2$ cfu/g. In glazed candy the load was very high when compared to crystallized candy. The counts of microbial groups increased with storage periods. The glazed candy could be stored for one month without significant development of storage micro-organisms.

In coconut honey the microbial count ranged from 11.67 and 11.33 $\times 10^2$ cfu/g. The counts were higher in white honey when compared to that in brown honey. The microbial count increased with increase in storage period.

Among the various products developed from coconut, microbial load was found to be relatively more in bioprocessed products and simulated products while products like therapeutic health drinks, crystallised candy, protein enriched supplementary mix and bakery products were found to be less susceptible to microbial attack (Table 46).

Table 46. Effect of storage period and containers on microbial population in coconut products

| | Characteristic | Bacteria x $10^2$ cfu/g | | |
|---|---|---|---|---|
| | | Container | Initial | Storage period (60days) |
| Bioprocessed products | Nata de coco | Can | 20.0 (60days) | 25.0 |
| | | Glass | 18.00 | 39.67 |
| | Nata de pine | Can | 20.0 | 28.0 |
| | | Glass | 27.21 | 43.0 |
| | Nata de soya | Can | 39.0 | 37.0 |
| | | Glass | 40.0 | 51.0 |
| Protein enriched supplements | Supplementary snacks food | Laminated pouches | 0 | 6.67( 30day) |
| | | Polypropylene | 0 | 11.67 |
| | Therapeutic health drink mix | Laminated pouches | 0 | 2.0 (5months) |
| | | Polypropylene | 0 | 3.0 |
| | Malted health drink mix | Laminated pouches | 0 | 5.7 (5months |
| | | Polypropylene | 0 | 6.0 |
| Bakery and Preserved Products | Biscuits | Laminated pouches | 0 | 9.0 (5months) |
| | | Polypropylene | 0 | 14.33 (5months) |
| | Cookies | Laminated pouches | 0 | 7.67(5months) |
| | | Polypropylene | 0 | 9.67 |
| | Crystallised candy | Laminated pouches | 0 | 1.5 (60days) |
| | | Polypropylene | 0 | 2.7 |
| | Glazed candy | Laminated pouches | 0 | 5.0 (60days) |
| | | Polypropylene | 0 | 4.67 |
| | Brown honey | Bottle | 0 | 11.67(60days) |
| | White honey | Bottle | 0 | 1133(60days) |

The predominant bacterial and fungal cultures were isolated from various food products and prepared slant cultures in the respective media. They were purified and identified to the generic level based on morphological, cultural and biochemical characteristics.

The assessment of the microbial load revealed that all the coconut products had microbial count below the permissible limit.

Identification of microbial cultures isolated from coconut beverages revealed the presence of *Acetobacter*, *Sacchromyces* (yeast), *Candida and Aspergilus* whereas in nata products the predominant ones included bacteria *viz*., *Acetobacter* and fungi *Pencillium* (Table 47).

In simulated products standardised viz., coconut curd and coconut yoghurt, *Lactobacillus and Acetobacter* were predominant organisms.

*Pencillium and Mucor* was the predominant spoilage organisms in therapeutic health drinks and malted health drink. In bakery products bacteria like *Streptococcus, Bacillus,* Fungi like *Aspergilus* and *Rhizo-pus* were identified.

In glazed candy, *Serratia* organisium was seen along with *pencillium* whereas coconut honey was attacked by the fungus, *Cunninghamella.*

The food products were also analysed to detect the presence of coliforms by MPN method using brilliant green lactose bile broth. Observation of the culture tubes after the required incubation period did not show the presence of coliform, important spoilage micro-organisms in foods. The analysis of food products by dilution plate method using Baird and Parkers medium did not reveal the presence of *staphylococcus aureus*, the most commonly occurring food poisoning bacteria, (enterotoxins) producing in any of the food products prepared from coconut.

Table 47 Test for bacteria in coconut products.

| **Morphological test** | Characters | | | | |
|---|---|---|---|---|---|
| Gram test | -ve | -ve | +ve | +ve | +ve |
| Shape | Rod | Rod | Rod | Sphere | Elliptical |
| Size | 0.6-0.4 | 0.5 x 1.2 | 0.7 x 1.7 | 0.9 | 1 x 2.5 |
| Pigment | Pink pigment | Brown pigment | Non pigment | Yellowpigment | Red pigment |
| | | | | | |
| **Biochemical test** | | | | | |
| Catalase | + | + | - | + | + |
| Oxidase | - | - | - | - | - |
| gas from glucose | - | + | - | - | - |
| Nitrate reduced | + | - | - | + | + |
| CarbohydrateLactose | | | | | |
| Glucose | - | - | - | + | - |
| Ethanol | - | + | - | - | - |
| Lactose | - | + | + | + | - |
| Maltose | + | - | + | + | - |
| mannotol | + | - | - | + | - |
| Sucrose | + | - | + | - | - |
| Sorbitol | - | - | - | - | - |
| Hexoses | - | + | - | + | - |
| Related citrate source | | | | | |
| citrate | + | + | - | - | + |
| Gluconate | + | - | - | - | - |
| MR | - | - | - | - | - |
| VP | + | - | - | - | - |
| Protein reaction | - | - | - | - | - |
| Tryosine | - | - | - | - | + |
| arginine | - | - | - | - | - |
| Gelatin hydrolysis | + | - | - | - | + |
| H2S from TSI | - | - | - | + | - |
| Indole | - | - | - | - | - |
| Urea hydrolysis | - | - | - | - | - |
| | | | | | |
| Shape | Rod | Rod | Rod | Sphere | Elliptical |
| Size | 0.6-0.4 | 0.5 x 1.2 | 0.7 x 1.7 | 0.9 | 1 x 2.5 |
| Pigment | Pink pigment | Brown pigment | Non pigment | Yellowpigment | Red pigment |
| Bacteria identified | *Serratia* | *Acetobacter* | *Lactobacillus* | *Staphylococus* | *Bacillus* |

Table. 48 Consumer acceptance of coconut products

| Beverages | Appearance | Colour | Flavour | Taste | Clarity | Overall acceptability |
|---|---|---|---|---|---|---|
| Acidulant blended | 3.52 | 3.48 | 3.04 | 2.92 | 3.04 | 3.2 |
| Pineapple blended | 3.8 | 3.92 | 3.44 | 3.6 | 3.52 | 3.66 |
| Lemon blended | 3.52 | 3.52 | 3.56 | 3.52 | 2.44 | 3.3 |
| CD | 0.36 | 0.39 | 0.49 | 0.56 | 0.49 | 0.42 |

| Bioprocessed products | Appearance | Colour | Flavour | Taste | Texture | Overall acceptability |
|---|---|---|---|---|---|---|
| Nata de coco | 3.32 | 3.08 | 3.0 | 3.44 | 3.44 | 3.26 |
| Nata de pine | 3.56 | 3.12 | 3.0 | 3.48 | 3.4 | 3.31 |
| Nata de soya | 3.2 | 2.12 | 3.12 | 3.0 | 3.16 | 2.92 |
| CD | 0.47 | 0.59 | 0.66 | 0.60 | 0.57 | 0.42 |

| Simulated products | Appearance | Colour | Flavour | Taste | Consistency | Overall acceptability |
|---|---|---|---|---|---|---|
| Curd 1 | 3.6 | 3.12 | 3.16 | 2.52 | 2.96 | 3.07 |
| Curd 2 | 3.08 | 2.52 | 3.0 | 3.12 | 3.16 | 2.90 |
| Yoghurt1 | 3.6 | 3.12 | 3.16 | 2.52 | 2.96 | 3.07 |
| Yoghurt2 | 3.08 | 2.52 | 3.0 | 3.12 | 3.16 | 2.98 |
| CD | 0.61 | 0.56 | 0.56 | 0.55 | 0.53 | 0.34 |

| Bakery products | Appearance | Colour | Flavour | Taste | Donness | Overall acceptability |
|---|---|---|---|---|---|---|
| Cookies | 4.0 | 4.0 | 3.8 | 4.0 | 4.0 | 3.96 |
| Biscuits | 3.48 | 3.32 | 3.04 | 3.96 | 3.92 | 3.54 |
| CD | 0.36 | 0.39 | 0.49 | 0.56 | 0.49 | 0.34 |

| Preserves | Appearance | Colour | Flavour | Taste | Texture | Overall acceptability |
|---|---|---|---|---|---|---|
| Crystallised candy | 3.56 | 3.44 | 3.4 | 3.52 | 3.04 | 3.39 |
| Glazed candy | 3.4 | 3.56 | 3.04 | 3.44 | 3.0 | 3.29 |
| CD | 0.35 | 0.41 | 0.52 | 0.43 | 0.63 | 0.42 |

| Honey | Appearance | Colour | Flavour | Taste | Texture | Overall acceptability |
|---|---|---|---|---|---|---|
| Brown | 4.44 | 4.44 | 3.08 | 3.4 | 3.44 | 3.76 |
| White | 2.92 | 4.52 | 3.56 | 3.68 | 3.0 | 3.54 |
| CD | 0.53 | 0.42 | 0.47 | 0.55 | 0.63 | 0.34 |

| Protein mix | Appearance | Colour | Flavour | Taste | Texture | Overall acceptability |
|---|---|---|---|---|---|---|
| Supplementary base mix | 3.92 | 3.84 | 3.52 | 3.44 | 2.92 | 3.53 |
| Therapeutic health drink | 3.44 | 2.96 | 3.6 | 3.4 | 3.44 | 3.41 |
| Malted health drink | 3.48 | 3.44 | 3.08 | 3.44 | 3.44 | 3.38 |
| CD | 0.31 | 0.55 | 0.44 | 0.44 | 0.53 | 0.42 |

Table. 48 Consumer acceptance of coconut products

| Beverages | Appearance | Colour | Flavour | Taste | Clarity | Overall acceptability |
|---|---|---|---|---|---|---|
| Acidulant blended | 3.52 | 3.48 | 3.04 | 2.92 | 3.04 | 3.2 |
| Pineapple blended | 3.8 | 3.92 | 3.44 | 3.6 | 3.52 | 3.66 |
| Lemon blended | 3.52 | 3.52 | 3.56 | 3.52 | 2.44 | 3.3 |
| CD | 0.36 | 0.39 | 0.49 | 0.56 | 0.49 | 0.42 |

| Bioprocessed products | Appearance | Colour | Flavour | Taste | Texture | Overall acceptability |
|---|---|---|---|---|---|---|
| Nata de coco | 3.32 | 3.08 | 3.0 | 3.44 | 3.44 | 3.26 |
| Nata de pine | 3.56 | 3.12 | 3.0 | 3.48 | 3.4 | 3.31 |
| Nata de soya | 3.2 | 2.12 | 3.12 | 3.0 | 3.16 | 2.92 |
| CD | 0.47 | 0.59 | 0.66 | 0.60 | 0.57 | 0.42 |

| Simulated products | Appearance | Colour | Flavour | Taste | Consistency | Overall acceptability |
|---|---|---|---|---|---|---|
| Curd 1 | 3.6 | 3.12 | 3.16 | 2.52 | 2.96 | 3.07 |
| Curd 2 | 3.08 | 2.52 | 3.0 | 3.12 | 3.16 | 2.90 |
| Yoghurt1 | 3.6 | 3.12 | 3.16 | 2.52 | 2.96 | 3.07 |
| Yoghurt2 | 3.08 | 2.52 | 3.0 | 3.12 | 3.16 | 2.98 |
| CD | 0.61 | 0.56 | 0.56 | 0.55 | 0.53 | 0.34 |

| Bakery products | Appearance | Colour | Flavour | Taste | Donness | Overall acceptability |
|---|---|---|---|---|---|---|
| Cookies | 4.0 | 4.0 | 3.8 | 4.0 | 4.0 | 3.96 |
| Biscuits | 3.48 | 3.32 | 3.04 | 3.96 | 3.92 | 3.54 |
| CD | 0.36 | 0.39 | 0.49 | 0.56 | 0.49 | 0.34 |

| Preserves | Appearance | Colour | Flavour | Taste | Texture | Overall acceptability |
|---|---|---|---|---|---|---|
| Crystallised candy | 3.56 | 3.44 | 3.4 | 3.52 | 3.04 | 3.39 |
| Glazed candy | 3.4 | 3.56 | 3.04 | 3.44 | 3.0 | 3.29 |
| CD | 0.35 | 0.41 | 0.52 | 0.43 | 0.63 | 0.42 |

| Honey | Appearance | Colour | Flavour | Taste | Texture | Overall acceptability |
|---|---|---|---|---|---|---|
| Brown | 4.44 | 4.44 | 3.08 | 3.4 | 3.44 | 3.76 |
| White | 2.92 | 4.52 | 3.56 | 3.68 | 3.0 | 3.54 |
| CD | 0.53 | 0.42 | 0.47 | 0.55 | 0.63 | 0.34 |

| Protein mix | Appearance | Colour | Flavour | Taste | Texture | Overall acceptability |
|---|---|---|---|---|---|---|
| Supplementary base mix | 3.92 | 3.84 | 3.52 | 3.44 | 2.92 | 3.53 |
| Therapeutic health drink | 3.44 | 2.96 | 3.6 | 3.4 | 3.44 | 3.41 |
| Malted health drink | 3.48 | 3.44 | 3.08 | 3.44 | 3.44 | 3.38 |
| CD | 0.31 | 0.55 | 0.44 | 0.44 | 0.53 | 0.42 |

## Consumer acceptance of coconut products

Today consumers have increased concern regarding food safety and sensory qualities. Sharma (1995) stated that consumer testing of the processed products is equally important to understand the acceptability of products. Hence the acceptance of the developed products among the consumers was assessed.

Assessment of consumer acceptability of different types of products developed was tested among 50 consumers at random. Freshly prepared products were distributed to the consumers

Among various beverages standardized with tender coconut water, pineapple blended beverage scored the best based on the beverages acceptability score followed by lemon blended beverage. Both the beverages were superior to control beverage.

With respect to bioprocessed products nata de pine secured highest mean score for overall acceptability followed by nata de coco. Nata de soya was less acceptable to the consumers.

Among the simulated dairy products, coconut curd as well as coconut yoghurt was found to be less acceptable product among consumers, compared to other products developed in the study. In both categories of products coconut milk supplemented with skim milk products scored better than those supplemented with soymilk.

As expected consumers in general were in favour of the baked products and in the present study both cookies and biscuits standardized incorporating coconut was found to be very acceptable to the consumers. Among the various products developed cookies scored outstanding.

Consumers found to welcome glazed candy and cryatallised candy standardized and both the products were acceptable to them with higher inclination towards glazed candy. Similarly coconut milk honey standardized was also outstandingly acceptable to the consumers with a greater liking towards brown honey. Among the various products standardised brown honey scored next to cookies in acceptance among the consumers.

Among the protein enriched supplements, and the health drink mixes developed also found to score better in overall acceptability.

The above results, indicate the well acceptance of different products among consumers, as the consumers preference differs in taste and variety of the products and hence these products needs to be promoted for market, which we find good potential in the domestic as well as in the export market.

Table 49.Consumer preference of the products developed based on hedonic scale

| | | Rating Scale | | | | | |
|---|---|---|---|---|---|---|---|
| Classification of products | Products | Like extremely | Like very much | Like moderately | Like slightly | Neither like nor dislike | Dislike slightly |
| Beverages | Acidulant blended RTS | 8 | 31 | 35 | 12 | 8 | 6 |
| | Pineapple blended RTS | 25 | 71 | 4 | 0 | 0 | 0 |
| | Lemon blended RTS | 10 | 61 | 18 | 6 | 4 | 1 |
| Bioprocessed products | Nata de coco | 11 | 53 | 20 | 6 | 6 | 4 |
| | Nata de pine | 12 | 65 | 15 | 3 | 4 | 1 |
| | Nata de soya | 9 | 49 | 22 | 7 | 8 | 5 |
| Simulated products | Curdswith SKM | 6 | 29 | 36 | 14 | 8 | 7 |
| | Curds SYM | 6 | 25 | 37 | 15 | 10 | 7 |
| | YoghurtSKM | 7 | 46 | 25 | 8 | 8 | 6 |
| | YoghurtSYM | 5 | 22 | 34 | 14 | 16 | 9 |
| Protein enriched food | Supplementary base mix | 10 | 51 | 21 | 6 | 7 | 5 |
| | Therapeutic Health mix | 7 | 30 | 35 | 14 | 8 | 6 |
| | Malted health mix | 8 | 48 | 23 | 8 | 7 | 6 |
| Bakery and confectionery | Cookies | 24 | 72 | 4 | 0 | 0 | 0 |
| | Biscuit2 | 8 | 46 | 24 | 8 | 8 | 6 |
| | Crystallised candy | 20 | 72 | 4 | 3 | 1 | 0 |
| | Glazed candy | 8 | 47 | 24 | 8 | 7 | 6 |
| | Honey brown | 15 | 70 | 7 | 3 | 4 | 1 |
| | Honey white | 9 | 50 | 22 | 7 | 7 | 5 |

**Consumer Preference of the products developed under study**

According to Anvita (1993) most of the consumers have fairly fixed ideas and know what to expect in terms of sensory quality of a given processed food. During the development of new food products or the reformation of existing products the identification of changes caused by processing method or storage or by the use of new ingredients, their acceptability could be assessed by conducting preference test on a large number of consumers (Watts *et al.* 1989). Preference studies are designed to determine consumers subjective reactions to external phenomena and their reasons for having them.

Consumer's reaction towards a new product is of great importance in the product development, which would help in market promotion of the products. In the present study, hundred consumers were selected at random from the participants attended Kisan Mela/exhibitions/training programmes conducted at CPCRI, Kasaragod over a period of one year. Food products were prepared and distributed among the selected consumers, and asked to record there likings in the hedonic rating scale developed for the purpose. Hedonic rating scale, ranged from like extremely to dislike extremely. Hedonic scale administered is given in Appendix IV.

During processing of the data, since none of the products developed were found to be disliked by the consumers, the extreme negative ratings (1, 2 and 3) have been discarded.

Preference study was conducted for all the 19 products developed. Acidulant blended RTS was found to be 'liked extremely' by 8 percent consumers, while, 31 percent and 35 per cent consumers respectively recorded the rating as 'liked very much' and 'liked moderately', 12 percent 'liked slightly', 8 percent 'neither liked nor disliked', 6 percent 'liked slightly'.

Consumer preference for pineapple blended RTS depicted extreme likeness by 25 percent consumers whereas 71 percent recorded 'like very much' rating. Lemon blended RTS was rated 'liked very much' by 61 percent consumers, whereas 10 percent 'liked it extremely' and 18 percent 'liked it moderately'.

With regard to bioprocessed products 53 percent recorded 'like very much' rating whereas 20 percent recorded 'like moderately' rating. Whereas 12 percent liked Nata de pine extremely, 65 percent liked it very much and 15 percent liked it moderately. Nata de soya was assessed 'liked extremely' by only 9 percent while 49 percent 'liked it very much' and 22 percent 'liked it moderately'.

When simulated products were analysed curd with skim milk powder was liked extremely by only six percent. 29 percent of the consumers recorded 'liked very much' and 36 percent liked it moderately. In the case of curd with soymilk only 6 percent liked it extremely, 25 percent liked very much, 37 percent rated liked moderately and 15 percent liked slightly.

Curds with skim milk and soya milk were rated 'liked very much' by 29 and 25 percent consumers and 'liked moderately' by 36 and 37 percent consumers. Preference for yoghurt with skim milk and soya milk was 46 percent and 22 percent for the rating 'liked very much', it was moderately liked by 25 percent and 34 percent consumers.

Protein enriched products when analysed, it was found that supplementary base mix scored 10 percent for 'like extremely' rating, half of the consumers (51 percent) liked it very much and 21 percent liked it moderately.

Therapeutic health drink was analysed 'liked extremely' by 8 percent consumers whereas 48 percent and 23 percent respectively recorded 'liked very much' and 'liked moderately'.

Seven percent of the consumers rated malted health drink as 'like extremely' while 30 percent 'liked it very much', 35 percent 'liked it moderately' and 14 percent 'liked slightly'. Preference for bakery products indicated that coconut cookies were 'liked extremely' by 24 percent, 'liked very much' by 72 percent whereas coconut biscuits were rated liked extremely by 8 percent, liked very much by 46 percent, liked moderately by 24 percent consumers.

Preserves with coconut (crystallized candy) were rated 'liked extremely' by 25 percent, liked very much by 72 percent.

For glazed candy 8 percent consumers rated as 'liked extremely', 47 percent gave 'like very much' and 24 percent 'liked moderately' and 8 percent liked slightly.

With respect to coconut honey, brown honey rated 15 percent for 'like extremely', 70 percent for 'liked very much' where as white honey was scored 9 percent for like extremely, 50 percent by 'liked very much' and 22 percent 'liked moderately'.

Table 50. Preference scores of the products developed with respect to the 'rank order'

| Classification of products | Products | Percentage score | Rank order |
|---|---|---|---|
| Beverages | Acidulant blended RTS | 77.9 | 15 |
| | Pineapple blended RTS | 91.2 | 1 |
| | Lemon blended RTS | 84.8 | 6 |
| Bioprocessed products | Nata de coco | 82.8 | 7 |
| | Nata de pine | 86.1 | 5 |
| | Nata de soya | 81.0 | 10 |
| Simulated products | Curdswith SKM | 76.7 | 17 |
| | Curds SYM | 75.7 | 18 |
| | Yoghurt SKM | 79.8 | 14 |
| | Yoghurt SYM | 73.2 | 19 |
| Protein enriched foods | Supplementary snack mix | 81.8 | 8 |
| | Therapeutic Health mix | 80.4 | 11 |
| | Malted healthdrink | 77.3 | 16 |
| Bakery and confectionery | Coconut cookies | 91.1 | 2 |
| | Coconut Biscuit | 80.0 | 13 |
| | Crystallised candy | 89.7 | 3 |
| | Glazed candy | 80.3 | 12 |
| | Honey brown | 87.3 | 4 |
| | Honey white | 81.3 | 9 |

Based on the consumers' likeness, the products developed under the present investigation who ranked. Percent score is the ratio of the aggregate score given by 100 consumers to the maximum score of 900. Table. 49 also gives the rank order of the products based on the consumers percentage score.

Out of three beverages, consumers preferred pineapple blended RTS as the best (91.2), followed by Lemon blended RTS (84.8) and Acidulant blended RTS (70.9). It was also found that pineapple blended RTS was the most preferred among all the products standardised ($1^{st}$).

Among bioprocessed foods, Nata de pine was found more preferred with a percent score of 86.1. Among all the products standardized it was also ranked fifth. As per priority order Nata de pine (86.1), Nata de coco (82.8) and nata de soya (81.0) are preferred by the consumers.

When simulated products when considered, it was found that the consumer was not found to prefer them very much compared to other products, being the individual rankings were between 14 to 19.

When the percent score of the protein-enriched foods were considered, it was found that supplementary snack mix (81.8) was found preferred than the other two. Therapeutic Health mix and health malted drink were preferred in order ($11^{th}$ and $16^{th}$ rank order respectively).

Coconut cookies were the most preferred among the bakery and confectionery foods (91.1) and also raked second among all the products standardized. Crystallised candy (89.7) and honey brown (87.3) also ranked third and fourth among all the products developed.

## 4.8 ASSESSMENT OF THE PRODUCTS FOR FPO STANDARDS

According to Kapoor (1993), food laws are essential for food safety. Day by day consumers are becoming quality conscious about food, not only about appearance but also about food free of contamination. The Bureau of Indian Standard (BIS) has specified certain type tests for various products to maintain quality of processing and marketing.

The type tests pertaining to the product were carried out using standard techniques. The coconut based value added products developed in the present study were analysed for specifications prescribed by BIS.

FPO standards prescribe a minimum of 10 per cent total soluble solids in the final product of RTS beverage. Total soluble solids of Pineapple blended RTS was found to have a TSS of 12.45 followed by the TSS of Lemon blended RTS beverage 14.64. Total soluble sugar of the fruit blended products prepared in the present studies was found to be in line with the minimum TSS percentage prescribed by FPO. Products confirm with FPO standard whereas when acidulant alone was added minimum TSS prescribed is not attained. Plain tender coconut water has a TSS of only 5.0. In this context, it can be pointed out that tender coconut water differs from fruit juices in different aspects, and separate standards were not fixed for tender coconut RTS beverages.

The minimum percentage of fruit juice content prescribed by FPO in the final product is 10. The percentage of fruit juice content present in Pineapple blended RTS beverage, Lemon blended RTS beverage and acidulant added RTS was well above FPO value. Since the RTS's were prepared from tender coconut water without dilution with water. Therefore the minimum percentage of fruit juice in the final product is also well above the FPO specification.

Standards for 'nata' products are not available, hence no comparison could be made in the products developed. Since it is a fermented products, microbial load was ascertained and was with the prescribed and given in the microbial study of the coconut products.

According to F.A.O. (1970), yoghurt must contain a minimum of 0.5% fat and minimum of 8.5% milk solids-not fat In coconut curd and coconut yoghurt developed in t this study revealed that it contain fat 3.35-4.0 and 3.75- 4.55 percent respectively and solid not fat of 16.34 to 14.25 and 15.83-16.29 respectively.

According to Devadas (1998), Food nutritionist, a supplementary food should provide 300calories and 10-12 g protein per 100g. The present study also provides 347 calories and 13.80g proteins per 100 gm of the nutrimix.

As per the ISI type test administered for biscuit and cookies (IS: 1011 -1981), the estimated value of the moisture of cookies and biscuit was approximate reaching the ISI specification. The ISI specification for moisture content of biscuits was minimum 6.0 percent, where as in the formulated products the moisture contents of cookies and biscuits was10.27 and 8.28 respectively.

Taking into account of the preserved products FPO standards prescribe a minimum of per cent total sugar in the final product of preserved is 70. Total sugar of Crystallized candy standardized in the studies was found to have a 75 percent whereas in glazed candy it was 71 percent. Thus the total sugar of the preserve prepared in the present study was found to be in line with the minimum total sugar percentage prescribed by FPO.

The minimum percentage of reducing sugar prescribed by FPO in the final product of preserve is 25. The percentage of reducing sugar present in crystallized candy and glazed candy were 28.03 and 26.70 respectively. Therefore the minimum percentage of reducing sugar in the final product is also well above the FPO specification.

The comparative value obtained gives the indication that the recipes were properly adjusted for its essential content according to the standards. The above data indicate that the products developed almost satisfy the FPO and BIS standards. Thus it could be concluded that in this experiment recipes for coconut based beverages, have been properly formulated and procedures were well adjusted during their standardisation process in order to meet the specified requirement. The scientific steps followed in preparation of the products have favoured the products to meet the standards.

## Product yield ratio of the coconut products standardized

The factors that determine the cost of the final product is the turn over of the finished product obtained from the raw materials used. Knowledge of the product yield of any product developed is essential in deciding the economic feasibility of that particular product. Hence product yield ratio of each of the product standardised under the present investigation was determined. Results are presented in Table 51.

Table 51 Product yield ratio of coconut products developed.

| Classification of products | Name of the products | Wt before processing | Wt after processing | Yield |
|---|---|---|---|---|
| Beverages | Acidulant blended RTS | 1litre | 950 | 1:0.95 |
| | Pineapple blended RTS | 1litre | 900 | 1:0.90 |
| | Lemon blended RTS | 1litre | 950 | 1:0.95 |
| Bioprocessed products | Nata de coco | 1Kg | 450 | 1:0.45 |
| | Nata de pine | 1Kg | 550 | 1:0.55 |
| | Nata de soya | 1Kg | 500 | 1:0.50 |
| Simulated products | Curdswith SKM | 1Kg | 1100 | 1:1.10 |
| | Curds SYM | 1Kg | 1120 | 1:1.12 |
| | Yoghurt SKM | 1Kg | 1005 | 1:1.01 |
| | Yoghurt SYM | 1Kg | 1100 | 1:1.11 |
| Protein enriched foods | Supplementary snack mix | 1Kg | 900 | 1:0.90 |
| | Therapeutic Health mix | 1Kg | 900 | 1:0.90 |
| | Health malted drink | 1Kg | 850 | 1:0.85 |
| Bakery and Confectionery | Coconut cookies | 1Kg | 790 | 1:0.79 |
| | Coconut Biscuit | 1Kg | 825 | 1:0.83 |
| | Crystallised candy | 1Kg | 875 | 1:0.88 |
| | Glazed candy | 1Kg | 825 | 1:0.83 |
| | Honey brown | 1Kg | 500 | 1:0.5 |
| | Honey white | 1Kg | 500 | 1: 0.50 |

Raw material used for obtaining the finished products is taken into account while ascertaining the product yield of the products developed from the coconut. Assessment of product yield of the coconut products developed indicated that simulated products recorded better yield than other products developed since the atio was more than one. Bioprocessed products as well as coconut honey ecorded comparatively lower yield since finished products reached only nearly ialf the quantity of the raw materials taken. Next to simulated products beverages ecorded good product yield followed by bakery products, confectionary products nd health drinks. Product yield recorded low for coconut cookies.

**ost effectiveness of the products standardised**

able 52 Cost of production of coconut products developed

| Classification of products | Name of the product | Quantity of finished product | Cost including 10% overhead charges (Rs.) |
|---|---|---|---|
| everages | Acidulant blended RTS | 1litre | 19.8 |
| | Pineapple blended RTS | 1litre | 27.5 |
| | Lemon blended RTS | 1litre | 22.0 |
| ioprocessed products | Nata de coco | 1Kg | 27.5 |
| | Nata de pine | 1Kg | 44.0 |
| | Nata de soya | 1Kg | 34.1 |
| mulated products | Curdswith SKM | 1 litre | 12.1 |
| | Curds with SYM | 1 litre | 9.9 |
| | Yoghurt with SKM | 1 litre | 13.1 |
| | Yoghurt with SYM | 1 litre | 11.0 |
| otein enriched foods | Supplementary snack mix | 1Kg | 50.38 |
| | Therapeutic Health mix | 1Kg | 242.0. |
| | Health malted drink mix | 1Kg | 231.0 |
| ikery and nfectionery | Coconut cookies | 1Kg | 44.0 |
| | Coconut Biscuit | 1Kg | 38.5 |
| | Crystallised candy | 1Kg | 22.0 |
| | Glazed candy | 1Kg | 19.8 |
| | Honey brown | 1 litre | 40.0 |
| | Honey white | 1 litre | 48.0 |

Table 52 gives the details of the cost of production of the products for one kilogram or one litre. The cost of production of 1litre of beverages was found to be Rs. 19.80 to Rs. 27.5 being highest for pine apple blended RTS and lowest for acidulant blended RTS. Among the bioprocessed products Nata de pine was found to cost Rs. 44.0 /kg, while nata de coco cost the lowest Rs.27.5.Comparatively cost of production was found to be low for simulated products and it ranged between Rs. 9.9 to Rs. 12.1per liter in curds, Rs. 11 to Rs. 13.1per liter in yoghurt. Protein enriched supplements/health drinks were found to be very expensive as the cost ranged Rs 242 to Rs. 231 in health drinks and Rs 50.38 for supplementary base mix. Bakery products developed incorporating·coconut was found to cost Rs 38 to Rs 44/- while it was Rs 40 to Rs. 48 for two types of coconut milk honey.

# Discussion

# 5. DISCUSSION

Results of the present investigation entitled "Developing diversified and value added products from coconut (*Cocos nucifera,* L.) are discussed in this chapter under the following sections.

5.1 Assessment of chemical, nutritional, organoleptic and shelf stability features of the **Beverages** developed with tender coconut water.

5.2 Assessment of chemical, nutritional, organoleptic and shelf stability features of the **Bioprocessed products** developed from coconut.

5.3 Assessment of chemical, nutritional, organoleptic and shelf stability features of the **Simulated products** developed from coconut.

5.4 Assessment of chemical, nutritional, organoleptic and shelf stability features of the **Protein enriched supplements** developed from coconut.

5.5 Assessment of chemical, nutritional, organoleptic and shelf stability features of the **Bakery and preserved products** developed from coconut.

5.6 Assessment of **Microbial profile** of the products developed from coconut with storage.

5.7 Assessment of **Consumer acceptance and preference** of the products.

5.8 Confirmation of **FPO/ ISI standard.**

5.9 Assessment of **Product yield and Cost effectiveness.**

## 5.1 ASSESSMENT OF THE CHEMICAL AND NUTRITIONAL CHARACTERISTICS OF THE TENDER COCONUT WATER BEVERAGE

### 5.1.1 Standardisation of Coconut Water Beverages

Kaur and Khurdiya (1993) pointed out that fruit beverages are becoming increasingly popular in the market with growing consciousness of people with respect to health point of view. Bosco (1998) remarked that the tender coconut water is a sweet, delicious and refreshing natural drink and most sterile of all the naturally occurring drinks, with life saving electrolytes. However preserving the tender nuts in their natural form is difficult due to its bulk and short shelf stability. This necessitates an alternative strategy to be looked into for preserving tender nut water.

Thus in the present study, tender coconut water was utilised for the formulation of beverages, with intention of more popularity, longer shelf life, lesser cost and better nutritional quality.

According to Deka *et al.* (2003), blending of fruit juices was found to be beneficial in the development of new products, which offer economic advantages apart from nutrients and organoleptic qualities. Many fruit juices are too acidic or too strongly flavoured to become pleasant beverages without diluting or blending or both.

In the present study, tender coconut water was blended with acidulants, lime and pine apple juice in order to improve taste, flavour and nutritional qualities.

Under the present investigation beverages standardized with tender coconut water by blending pineapple juice/lemon juice and acidulants yielded better quality beverages. In the formulation of pineapple and lemon blended coconut beverages the ideal proportion obtained with consumer appeal was 1:0.25 and 1:0.08 respectively. In acidulant blended coconut beverage, coconut water was supplemented with 0.2 percent acidulants in order to enhance its quality parameters. Earlier researchers had successfully formulated beverages by blending with other fruit juices.

Rao and Reddy (1979) standardized a beverage by blending Rangapur lime and acid lime. He found that the beverage was acceptable when they were in the ratio of 5:10 and 20:5. Verma *et al.* (1988) successfully standardised pineapple and mango pulp mixture in the ratio of 25:75, 50: 50 and 75:25 for squash.

Chakraborty *et al.* (1993) reported that watermelon juice blended with limejuice or pineapple juice yielded RTS beverage of acceptable quality.

As pointed out by Swaminathan (1980) preservation techniques like pasteurisation and carbonation of drinks improves the quality of the products. Tender coconut water beverages standardised under the study were pasteurised and carbonated. Khurdiya (1985) reported that carbonation increases the shelf life of the products. He was also of the opinion that carbonated drinks can obviate the need for the addition of synthetic colouring, flavouring and thickening agent. Khurdiya (1989) found that a drink containing 3% juice, 10° brix and 0.2 % acidity with carbonation adjudged to be the best among the other drinks formulated.

Rosario and Rubico (1979) developed a non-carbonated beverage from mature coconut water, which was found to have a shelf life of three months under ambient condition. Gonzalez (1990) supported acidulant blending undertaken in the present investigation by pointing out the use of sodium citric acid mixture for minimizing the biting taste in the formulated beverage.

Satyavati (1995) succeeded in upgrading the mature coconut water to the level of tender coconut water, by supplementing with permitted chemicals and sugar along with heat-pasteurization.

In the present study, mature coconut water beverages standardized were not found to have longer shelf life and consumer appeal and hence further investigations were not carried out with mature coconut water beverages.

Investigations carried out at Defence Food Regional Laboratory, Mysore by Srivatsa and Arya (1998) indicated that the flavour of tender coconut water is due to a group delta lactones which easily get destroyed when the temperature is above 100° C. In the present investigation pasteurization was carried out at 62° C to 65° C in order to preserve the characteristic flavour of the tender coconut water.

Thus in the present study, pasteurisation, carbonation and chemical preservation were attempted to attain good quality beverages with tender coconut water. In this context, the formulated beverages from tender coconut water, applying hurdle technology was a success.

### 5.1.2 Chemical characteristics of the tender coconut water blended beverages (RTS)

Analysis of chemical characteristics of the tender coconut water blended beverages (RTS) indicated that blending with fruit juices improved the nutritional and sensory qualities of the beverages standardised.

Krawger *et al.* (1992) standardized pineapple juice in which TSS was 11.2 – 16.2 g and acidity 0.46–1.2 g. According to Annapurna (1997) the physico-chemical characteristics of RTS passion fruit beverage was 6.0 °Brix, pH 3.5 and acidity 0. 7 per cent.

The formulated beverages under investigation were found to have pH between 3.38 to 4.52 and acidity from 0.16 to 0.29 percent. TSS of the beverages was enhanced when blended with fruit juices, which in a way improve the taste of the beverage. Total soluble solids of tender coconut water was found to be 5.42° Brix and that of total sugar and reducing sugar were 5.80 and 4.69% respectively, where as in the formulated blended beverages total soluble solids ranged between 6.43 to 14.64, total sugar ranged between 7.37 to 14.42 and that of reducing sugar between 5.28 to 9.16 percent. As expected pH level was lowest for lemon blended RTS (3.38) and highest for plain tender coconut water (4.52). Blending with acidic fruit, resulting in lowering of pH, which is needed for a better keeping quality. According to Okoli and Ezenweke (1990) , papaya juice at pH 3.9 was found to be highly acceptable.

Highest acidity (0.16 %) was recorded in plain RTS, followed by acidulant blended (0.17 %) and lemon blended RTS (0.20 %).

According to Satyavati, (1995), the total reducing sugar content of tender coconut water is 5.15g/100ml, while blending with other fruit juices reducing sugar content of the beverages increased, highest for lemon blended RTS followed by pineapple blended RTS.

Total soluble solids recorded highest in pineapple blended RTS (12.4 %), followed by lemon blended RTS (14.64 %), and acidulant blended RTS (6.4 %). Passion fruit RTS standardised by Diju (1995) reported a TSS of 14 %, 12.45 % and 18.65 % respectively for plain, pineapple and lemon blended RTS. The total sugar of coconut water RTS standardised was 5.8, 12.1 and 14.4 percent respectively for plain, pineapple and lemon blended RTS.

Tender coconut water contains less vitamin C and hence blending it with fruit juices enhanced its vitamin C content. Verma and Sastry (1960 ) was of the opinion that lime is a rich source of vitamin C, which could be used widely in sherbet and soft drinks. Vitamin C content of the prepared RTS ranged from 2.58 to 10.63 mg and lemon blended coconut beverage found to have higher vitamin C content, followed by pine apple blended beverage. In addition, the antioxidant properties of fruit juices further improved the quality of the standardised beverages from tender coconut. Minerals such as calcium and phosphorus level also in favour of lemon blended RTS (51.7 mg and 60.7 mg respectively) followed by pineapple blended RTS. Calcium content was 23.3 to 51.7 mg, phosphorus 11.8 to 60.6 mg, iron 0.11 to 2.4mg, sodium 29 mg to 46.5 mg and potassium from 251.7mg to 346.7mg.

Iron and sodium content was found to be highest for pineapple blended RTS, (2.4 mg and 46.5 mg respectively) as against lowest value of 0.11 mg and 45.5 mg respectively for plain tender coconut RTS. While potassium level was on par with plain tender coconut water (288.2 mg). Sodium level was found to be similar in beverages (45 mg – 46.5 mg) except for lemon blended RTS (39 mg). Potassium level was recorded highest in lemon blended RTS (346 mg). According to Punzalen and Gonzelez (1988) among the individual minerals, potassium accounts for more than 50 percent in coconut water. Unlike the other fruit beverages, tender coconut water contains appreciable amounts of minerals, and when it has been utilized for beverage industry added benefit is thus derived. In this context, formulation of beverages using tender coconut water stands distinct and sound.

### 5.1.3 Organoleptic Quality of Beverages from Tender Coconut Water

The organoleptically assessed samples form a true representative of the products developed and organoleptic assessment stands essential for the further development of the products. As the consumer preference to appearance is one of the major factors leading to the increasing demand of the product, it is very important to keep the appearance and colour of the product quite attractive (Christen, 1985). According to Potter (1986), food colour determines quality and also function as a common index of spoilage. According to Kramer and Twigg (1970), flavour is the unique character of colour and taste and flavour is the quality attribute, which stands next to taste. Brich *et al.* (1988) has also stated that flavour is unitary experience of sensation produced by a material taken in the mouth perceived principally by the senses of basic smell and by the other cutaneous sensations in the mouth. Clarity of the beverages gives the freshness of the beverages.

On assessing the sensory attributes of RTS beverages formulated, it was found that overall acceptability score of standardized RTS ranged between 3.9 – 4.4 out of 5 indicating 78 - 88 percent acceptability among the panel members. Irene (1997) reported that the overall acceptability score of fresh RTS beverage prepared from Neelum mango was 3.8.

Pineapple blended RTS and lemon blended RTS scored better for colour, appearance, flavour and taste compared to acidulant added beverage and control. For appearance and colour highest mean score was recorded by pineapple and lemon added beverages and the lowest for acidulant added RTS. For clarity attribute pineapple RTS scored superior to others (mean score 4.4 followed by Plain RTS 4.3).

The highest mean score for colour was recorded for pineapple beverage, because of the coloured appearance when compared to other RTS from coconut water. The colour of the product after processing was light yellow for pineapple blended RTS, transparent appearance for lemon blended RTS and crystal clear for acidulant added products and slightly cloudy appearance for control sample.

However, all the products scored better for attributes viz., appearance and colour despite of the difference in colour in the products.

According to Teotia *et al.* (1991), the RTS beverage made from muskmelon-mango blend resumed attractive appearance upon shaking the bottle prior to serving. All the products were carbonated, out of which half were kept under refrigerated condition. So chilled and bubbling effect due to $CO_2$ might have enhanced the appearance of the products. Rokade *et al.* (2001) reported that the carbonated beverage was superior in organoleptic properties than the non-carbonated beverages. He has also found that in the coconut beverages formulated from two different cultivars, carbonated beverage with 0.3 % acidity and 14° brix scored maximum for organoleptic properties.

For the flavour attribute, the blended beverages like lemon and pineapple scored maximum when compared to control and acidulant blended coconut beverages. This may be due to the fact that flavour of pineapple and lemon blends well with less flavoured coconut water and produced a flavour intense beverage with consumer appeal. According to Potter (1986), loss of flavour volatiles progress with storage. Thorner and Herzaberg (1978) are of the opinion that regardless of the storage temperature, off-flavour will develop eventually and mere absence of oxygen cannot retard off-flavour development.

Pineapple blended beverages bagged the highest score for taste (4.4) followed by lemon blended (4.3), Control (4.3), and lastly by acidulant added beverages (3.9). Siddappa and Tandon (1986) pointed out that oxygen of the air adversely affect the taste and aroma of the products.

The Clarity attribute was highest for pineapple-blended beverage (3.9), followed by lemon blended (3.8), Control (3.7), and acidulant blended beverages (3.6). Shamel and Zoghbi (1993) are of the opinion that the cloudy appearance is important properties of soft drinks like orange-lime and lemon juice since it give natural appeal to the fruit drink. When acidulants were added to the product, the clarity is masked and imparted less appeal to the product moreover pineapple and lemon juice blended harmoniously with tender coconut water and gave a clear and uniform RTS.

### 5.1.4 Changes in the Chemical Constituents of the Formulated Beverages with Storage

Data on the changes in the chemical constituents in formulated beverages indicated that there was a significant difference in pH, TSS, reducing sugar and TS, where as no variation was observed in acidity with storage periods. PH and TSS were found to decrease with storage periods whereas acidity, reducing sugar and total sugar increased. Over a period of 60 days the pH level of the formulated beverages decreased irrespective of the storage conditions, containers and storage periods. The beverages stored at refrigerated condition were found to depict the changes in pH slowly when compared to beverages stored at ambient condition.

In acidulant blended beverage there was a sudden increase in pH after 15 days of storage and then lowered considerably in the following weeks. This can be explained by the inversion of sugars in the product. Low pH of the product in the initial period was conducive to the inversion of sucrose, which is present in high amounts in acidulant added beverage. As pointed out by Potter (1996) partial inversion of sucrose resulted in a sucrose-invert sugar mixture that has greater solubility in water than sucrose alone.

Joshi *et al.* (1993) reported that the addition of spices to the plum squash reduced the acidity of the product by 3.37 - 5.15 percent. Deka (2000) found that the acidity of the RTS beverages prepared from lime-alone, mango-pineapple, guava-mango blends decreased with addition of spice to the beverages and also during storage of six months under different storage conditions.

With respect to acidity, a control as well as formulated beverages depicted an increasing trend with storage of 45 days except in Acidulant blended beverages. Sethi (1994) noticed an increase of 2.08 percent in titrable acidity in tomato concentrate stored for 8 months. However, a decreasing trend in acidity was reported by Sharma *et al.* (1991) in apple juices. Kalra *et al.* (1991) supported the above. Containers in which the beverages were stored viz., retort pouches and glass found to influence the acidity of the beverages.

Hicks (1990) noted a decrease of titrable acidity in lemon juices and squashes. Metha and Bajaj (1983) found out that the loss of acidity ranged between 13.83 – 51.70 percent in citrus juices stored for 8 months at room temperature. Tripathi *et al.* (1989) reported that the acidity of RTS beverages prepared from pineapple-guava blend (90:10) was found to decrease (0.40 to 0.36%) throughout the storage period of three months at ambient temperature. Kalra *et al.* (1991) noticed that beverages made from the blend of commercial mango cultivars and papaya blends showed negligible changes in titrable acidity.

In the present study total soluble sugar content of the beverages was found to decrease with the storage periods. The finding was in line with Thirumaran and Sreelatha (1990) who had reported a decrease in TSS up to 3.6 percent in tomato concentrates stored in glass bottles. Chakraborthy *et al.* (1993) also reported a decrease in TSS up to 15 to14.5 percent in watermelon RTS stored for 5 months. As against to the above findings Deka (2000) found an increasing trend in TSS lime-alone and mango-pineapple spiced RTS beverages during storage at ambient and low temperatures in. However, the rate of increase was more at ambient temperature when compared to low temperature. This was found true in the case of TSS level of beverages stored at the ambient condition in the present study.

Guava pulp stored at different temperature showed an increasing trend in total soluble solids within forty-five days of storage (Kalra and Revath, 1981). Mehta and Bajaj (1983) also observed increase in total soluble solids in citrus juice during storage at room temperature. Sethi (1985) reported that Litchi juice stored at room temperature and low temperature showed a rise in total soluble solids.

Khurdiya (1989) reported negligible change in TSS in phalsa beverage during storage at different temperatures. Khurdiya and Roy (1984) also observed similar results in the TSS of jamun beverage and watermelon juice standardised.

The decrease in TSS was rather less in formulated beverages stored at refrigerated condition. The TSS level of the beverages was observed to be decreasing over the periods of storage for all the beverages prepared irrespective of the refrigerated condition and irrespective of the containers in which it was stored.

In contrast Chakraborty *et al.* (1993) reported a decrease in total sugar in the RTS beverage prepared from watermelon. Total sugar content of the beverages standardized in the present study was found to enhance with the storage. According to Jain *et al.* (1988), the increase in total sugar could be attributed to the gradual inversion of non reducing sugar. Mean while Khurdiya (1989) stated that not much change in total sugar was observed in phalsa beverage. Change in total sugar was more prominent in the beverages stored under ambient condition as against a gradual increase in beverages stored at refrigerated condition. Total sugar content was not found to vary with respect to the types of containers (viz., glass bottles and retort pouches) used for the study. This observation was in accordance with the study done in pear juice by Saini and Agrawal (1995). Bawa and Saini (1987) also reported decline in total sugar by 0.14 percent in carrot juice when stored at room temperature.

It should also be noted that the extent of increase in the TSS content coincides with the corresponding increase observed in the total sugar content.

With respect to reducing sugar, increasing trend with storage were observed in the beverages formulated, except for acidulant blended RTS. In lemon blended RTS increase in reducing sugar level was fast after 30 days, in both storage conditions as against gradual increase in reducing sugar in other beverages. Type of containers also profoundly influences the reducing sugar level of the beverages standardised.

In support of the above findings Metha and Bajaj (1983) observed an increase in total sugar in the range of 5.89 – 12.11 percent in citrus juices stored for 8 months at room temperature. Palaniswami and Muthukrishnan (1980) also reported an increase in total sugar content during 7 months of storage of lemon juice.

In all the beverages, standardised with tender coconut water under present study, storage containers (glass and retort pouches) and storage conditions (refrigerated and non refrigerated) influenced the chemical constituents of the products during storage. Pineapple and lemon blended beverages stayed well both in glass and retort pouches whereas acidulant and control beverage stored better in retort pouches. All the beverages prepared from tender coconut water under study stayed well in refrigerated conditions. According to Rajasekhar *et al.* (1991) concluded from their studies that there was no significant difference in moisture, ash, pH and acidity in banana puree and ivy gourd when packed in retort pouches. Ghosh (1991) studied those corrosives products like banana and tomato puree could be safely packed in glass bottles.

### 5.1.5 Changes in Sensory Attributes of Coconut Beverages with Storage

The organoleptic qualities of the products assumed to change during storage. Assessment of organoleptic qualities of the beverages indicated that there was a significant difference in flavour, taste and clarity attributes in beverages formulated with storage. According to Sreeja (1996) the score obtained for appearance increased over a period of six months in cashew apple clarified juice (3.5 to 4.0), Taste and flavour decreased from 3.8 to 2.4 and 3.6 to 2.3 respectively.

Storage conditions influenced the mean score of all the sensory attributes of the beverages. (CD-0.12). Refrigerated beverages scored better when compared to beverages kept at room temperature. Raju *et al.* (2003) reported that water beverages keep well at refrigerated (5-10° C) and room temperature (28-30° C). Storage at controlled temperature of 37° C does not alter much of the acceptability of the products, except for a mild discolouration. (Raju 1998). Storage periods also influenced the mean score of the all the sensory attributes of the beverages (CD-0.23) formulated under the present study. Changes in the organoleptic qualities were more conspicuous during the later period of storage.

Hema (1997) found that Jamun RTS showed a reduction in score values in organoleptic characters except for clarity. According to Ranote *et al.* (1992), colour scores of kinnow RTS declined during storage. The decline was more pronounced for products packed in flexible pouches, which can be attributed to the catalytic effect of light on deterioration, as the pouches were transparent.

In line with the above finding colour attribute in the beverages formulated decreased with storage. In the present study colour of the pineapple and lemon blended beverages appeared more appealing in glass containers. More over colour of the product appears to be better when stored under refrigerated condition.

As Ashurst (1986) reported that colour pigments particularly carotenoids are susceptible to oxidation both initially and during storage. Ranote *et al.* (1993) explained that formulation of brown pigments in the stored RTS is attributed to the degradation of the products of sugar, ascorbic acid and protein.

Bawa (2003) remarked that preservation of tender coconut water in pouches/cans offers enormous scope as a natural beverage without any artificial colour and flavour. In the formulated beverages no artificial colour and flavour was added and thus stands outstanding with natural ingredients.

The taste attribute scores of the formulated beverage was found to decline during storage bringing undesirable taste towards the end of shelf life. This may be due to the fact that the fruit drinks are inherently susceptible to spoilage by fermentative microorganisms during storage, which bring out deteriorative changes in the taste attribute.

Clarity of the beverage decreased with storage irrespective of the storage condition and storage container and also with passage of time. However clarity attribute observed to be unchanged in acidulant added beverage with storage.

Flavour scores of the beverages also decreased with storage. Storage condition was also found to influence the flavour attribute of the beverages. Refrigerated storage condition retained the flavour of the beverages to a greater extent. However, storage media was not found to influence the flavour attribute of the beverages.

With duration of storage there was decrease in scores for all the sensory attributes in the products except for clarity in acidulant beverages. This might be due to the preservative effect of acidulant added to the beverage and also because of carbonation. The difference was conspicuous after one month of storage irrespective of storage containers (CD 0.19). As far as storage containers are concerned there was significant difference in all the sensory attributes. Acidulant blended beverage stayed better in retort pouches than in glass containers but in pineapple and lemon blended beverages remained better in glass containers. Glass containers revealed only slight changes in appearance and colour of the product.

Taking into account of the overall acceptability of the beverages, Pineapple blended coconut beverage adjudged to be the best with respect to sensory attributes, while lowest acceptability was recorded for acidulant blended coconut beverage.

Organoleptic scores decreased considerably and the changes were more conspicuous after one month of storage. Storage conditions influenced the overall acceptability scores of the beverages. Changes were more detectable in the beverages stored at ambient conditions. However, storage containers were not found to influence the overall acceptability scores of the products. Acidulant and lemon-blended beverage were seemed to be less influenced by the storage period than the pineapple blended beverage.

Sharma *et al.* (1993) developed an RTS with apricot pulp, which had acceptable sensory attributes, and 9 months shelf life. Jyothi (1997) prepared mango RTS drink and nectar, which remained acceptable for 3 and 4 months respectively.

Taking onto account of all the changes in chemical constituents and organoleptic factors the beverages formulated with tender coconut water was found to have a shelf stability of 60 days when stored at refrigerated condition (Fig. 4).

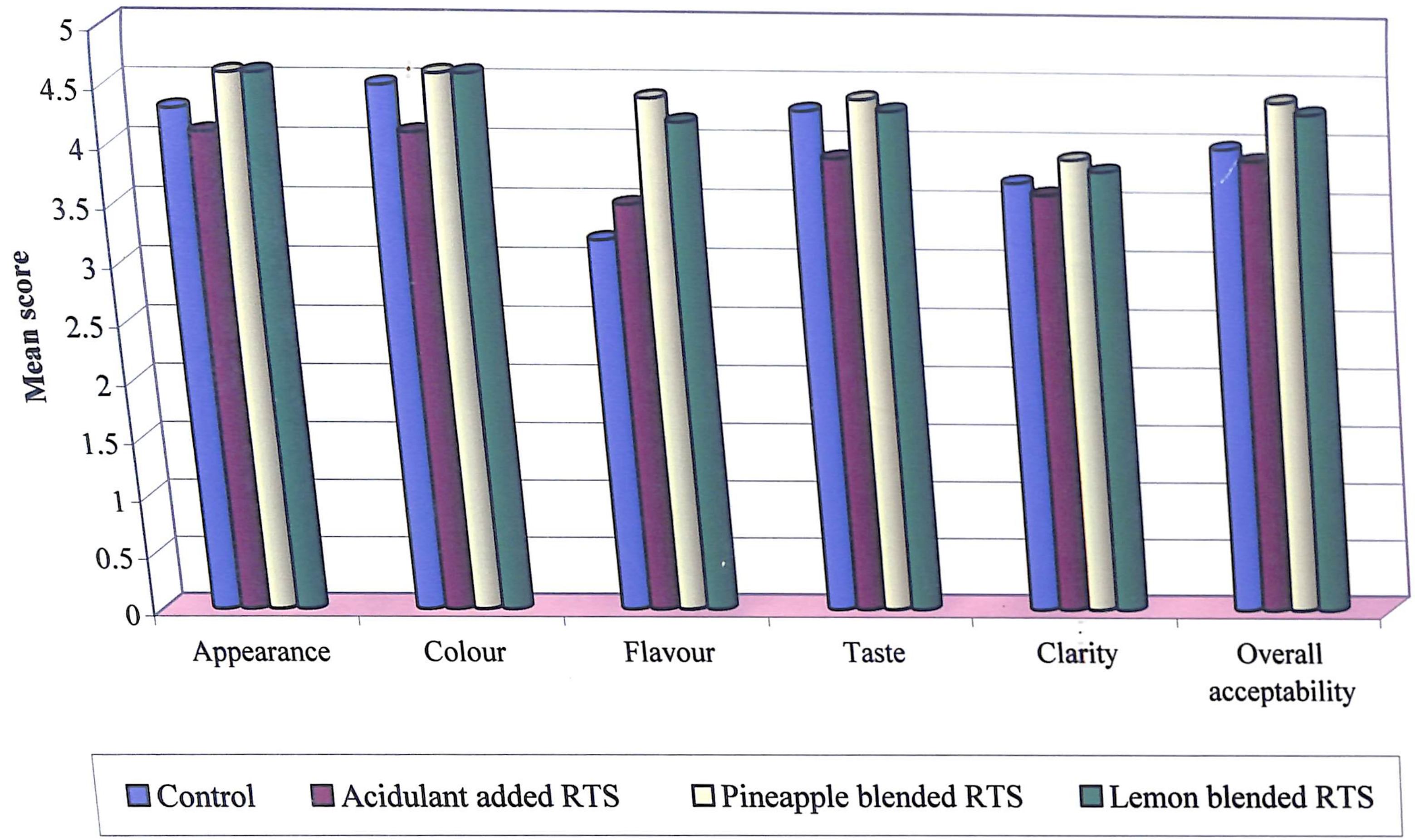



**Fig.4 Organoleptic characteristics of RTS beverages from tender coconut water**

## 5.2 ASSESSMENT OF CHEMICAL, NUTRITIONAL, ORGANOLEPTIC AND SHELF STABILITY FEATURES OF THE BIOPROCESSED PRODUCTS DEVELOPED FROM COCONUT.

### 5.2.1 Standardisation of Bioprocessed Products

A large quantity of coconut water is obtained as a by-product from desiccated coconut, chips or copra-based industries creating huge food loss and environmental pollution. Satyavati (1995) viewed that coconut water thus wasted can be used for making bioprocessed product. In the present study an attempt has been made to utilise the coconut water thus wasted for the formulations of value added bioprocessed product, which will have consumer appeal and market potential.

Sanchez (1990) stated that Nata-de-coco is a traditional dessert delicacy of Philippines and a commercial food product exported to Japan, Korea and Middle East earning considerable foreign exchange.

According to Hegde (1997) the bacterium Acetobactor xylenium Gel-strain in capable of bioconverting pineapple juice and coconut water into gels in the preparation of bio-sweet. He was also of the opinion that bio-sweet prepared out of Nata-de-pine is unique in taste, texture and flavour.

Technology of production of nata using three different substrates viz., plain coconut water, coconut water with pineapple extract and coconut water with soya milk was carried out successfully under the present investigation. The proportion identified for active growth of the nata were plain coconut water, 30 percent replacement of coconut water by pineapple extract and 20 percent replacement of coconut water with soya milk subsequently to produce 'nata de pine' and 'nata de soya'. Pineapple extract and soyamilk replacement with coconut water expected to improve the nutritional quality of nata, besides taste and flavour.

According to Thomas *et al.* (1987) Coconut water contains growth-promoting factors. The pineapple fruit contains 80-85% water, 12.15% sugars, 0.6% acid and 0.4% protein. It is a good source of vitamins A and B, fairly rich in vitamin C and minerals like calcium, magnesium and iron. Soy milk was prepared by the method suggested by Nsofar and cuwkur (1992).

According to Thomas *et al.* (1987) coconut water possesses growth-promoting factors and is a good media for microorganisms. Bernardo *et al.* (1998), isolated and characterized cellulose-producing bacteria namely *Acetobacter xylinus* and *A. hansenii* for nata de coco production in the Philippines.

Palo *et al.* (1989) studied the effect of vinegar as a substitute for glacial acid on nata production using coconut water. Lopez (1990) studied the possibility of using leftover fermented juice of nata de coco as the raw materials for producing canned nata products viz., nata pickle in flavoured vinegar, nata pickle in miso, nata in syrup and beverage.

### 5.2.2 Chemical and Nutritional Characteristics of 'Nata' Products

Comparative analysis of the data revealed that the moisture content was on par in the three types of nata formulated. Lowest pH value was seen in nata-de-pine and highest for 'nata de soya'. This may be due to acidic nature of pineapple when compared to coconut water and soya milk. However there was not much difference in acidity in the three products developed. Total soluble solids were found to be highest in 'nata de soya' and the lowest for 'nata-de-coco'. Nata-de pine recorded the highest value for total sugar followed by 'nata de soya' and 'nata-de pine'.

Among the nutritional characterisitics, protein content of the 'nata' was found to vary from 1.84 to 2.02g and fiber 1.09 to 1.25 percent. Nata-de-soya recorded higher value for protein, as expected while nata de pine the lowest. Significant difference was observed in the chemical and nutritional characteristics analysed in the products.

### 5.2.3 Organoleptic Features of Bioprocessed Nata Products

Appearance score of the 'nata' ranged between 2.3 to 3.0 being the highest in nata de pine (3.0) and lowest in nata de coco (2.6). Pineapple gave a strong flavour and taste to the media and the product developed. Colour, flavour and taste scores were also found to be best in 'nata de pine' 3.3 each for colour and flavour and 3.5 for taste. Flavour was the lowest in 'nata de soya' (3.0). In this context Sanchez (1990) reported that the addition of different flavouring extracts (almond, banana, lemon, strawberry, and vanilla) could improve the acceptability of nata produced.

Taste score was 3.4 and 3.3 respectively in nata de coco and 'nata de soya'. Texture attribute was similar in nata de pine and 'nata de soya', however scores were lesser than that nata de coco. Overall acceptability of the product ranged between 58-64 percent, nata de pine being most preferred by the judges. Overall acceptability seems to the best in nata de pine followed by 'nata de coco'(3.1). Significant difference was noted in the 'nata' products with respect to colour, flavour, taste and texture, however not much variation could be seen in overall acceptability of the products. When compared to other products overall acceptability score was not very much appreciable, for nata products however considering the sources from which it has been formulated the acceptance of the product is to be valued. Moreover, the product is not very much familiar to the judges, which may in turn influence the acceptability of the product.

### 5.2.4 Changes in the Chemical, Nutritional Constituents of 'Nata' with Storage

The preserved nata was stored for a period of six months during which periodical evaluation of shelf stability was carried out. With storage, TSS and pH level in the stored nata declined whereas reducing sugar and total sugar increased. The mean pH value was lowest for nata de pine and highest for nata de soya.

In all the products there was significant decrease in pH when stored in glass containers than in cans. According to Hubeis *et al.* (1996) the bacteria *Acetobacter acetic xylinium* is grown on the surface of sugar enriched matured coconut water; multiply fast in glass jars and stainless steel vessels at ambient temperature of 28 to 30oC.

There was significant increase in reducing sugar with storage periods. The level of reducing sugar was more in nata de coco, followed by nata de pine and nata de soya with storage, but there was not much difference in reducing sugar when stored in cans and glass bottles.

There was no significant difference in total soluble solids in the three products with storage media and storage periods. The highest mean score for total sugar was seen for nata de pine, and lowest for nata de coco. There was not much change in total sugar in storage media irrespective of storage periods, but significant increase in total sugar was seen in nata de pine with storage periods.

**5.2.5 Changes in the Organoleptic Qualities of the Nata Products with Storage**

The organoleptic qualities were found to change during storage. The organoleptic qualities of the 'nata'was assessed till the end of shelf life, details of which are discussed below. The mean score for appearance attribute of 'nata' products varied from 2.31-2.74. A significant difference was observed in appearance, colour, flavour, taste and texture attributes in the products with storage. However the changes was seen only after a period of six months.

Difference in colour with storage periods was noticeable in the nata products, which were stored in cans for six months. There was slight darkening in the nata products after storage in cans when compared to glass containers. Acidic nature of the products might have reacted with metals of the cans causing darkening. The nata stayed better in glass containers than in cans. Changes in flavour, taste and texture attributes were detectable with the passage of time among the 'nata' product standardised (Fig.5)

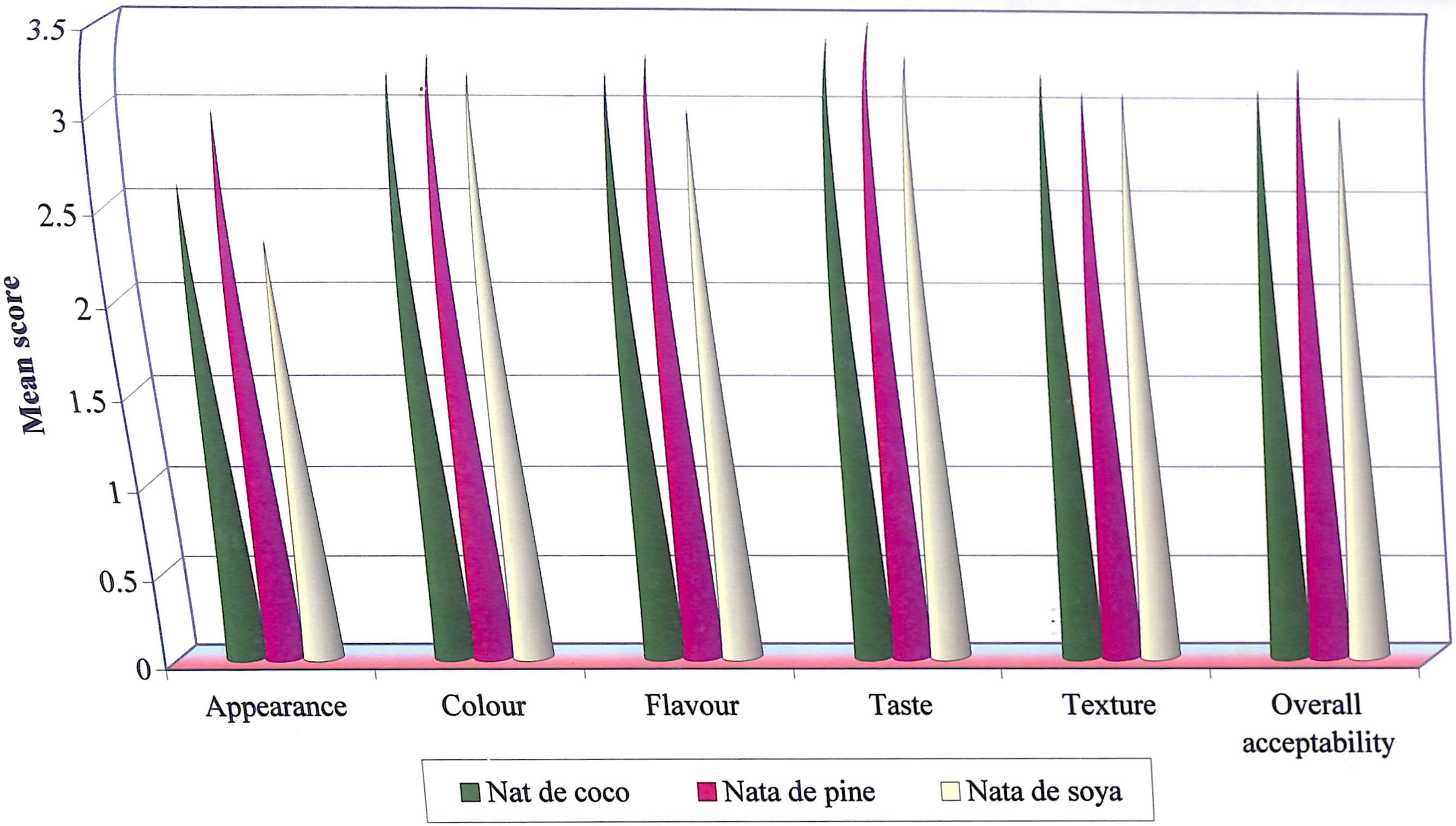



**FIg.5 Organoleptic characteristics of bioprocessed products**

## 5.3 ASSESSMENT OF CHEMICAL, NUTRITIONAL, ORGANOLEPTIC AND SHELF STABILITY FEATURES OF THE SIMULATED PRODUCTS DEVELOPED FROM COCONUT.

### 5.3.1 Standardisation of Simulated Products

Curd or Dahi preferred as a fermented product in the dietary habits of Indians whereas Yoghurt is a fermented dairy product, which is the western equivalent of Indian Dahi. As per F.A.O. (1970), yoghurt contains a minimum of 0.5% fat and 8.5% milk solids-not fat.

Yoghurt is most appreciated these days as a nutritious delight and attributes to benefit such as longevity, improving immune response and aid in digestion. In the present investigation an attempt has been made to utilise coconut milk to prepare curd and yoghurt by partially replacing with skim milk or soymilk. Banzon (1978) explained the use of coconut skim milk in the preparation of cultured milk in which high protein component of coconut milk is made use of after extracting fat from coconut milk through wet processing. According to Sanchez (1998) cultured milk differs from the type of organisms used, nature of fermentation and also in taste. The taste improvement in coconut milk yoghurt could be enhanced by the addition of 10 percent sucrose before adding starter inoculum.

In the present study, the proportions found feasible for the preparation of coconut milk based curd and yoghurt with skim milk powder was 5:1 and coconut milk based curd and yoghurt with soya milk was 6:3:1 respectively. According to Gupta and Jayaram (1995) adding 4% sucrose to the base formulation enhance soya milk yoghurt. He has also of the opinion that inclusion of citrate or acetate improves the soya yoghurt base by enhancing diacetyl production. Soymilk has great sale potentials as it can replace milk for lactose intolerants (Sinha *et al.*, 1993). Hence in the present study soymilk substitution in combination with coconut milk yield better quality yoghurt and curds, this can be used even for lactose intolerant subjects. Lee *et al.* (1990) formulated milk-based yogurt and soymilk-based yogurt were in which activated carbon treated-soymilk containing

3-5% (w/w) added whey protein concentrate (WPC) or nonfat dry milk (NFDM) was used.

Vijayananda *et al.* (1989) reported that the use of a different starter inoculum, *Lactobacillus casei* is responsible for improved citrate utilization resulting in enhanced flavour. Gupta and Jayaram (1995) observed that good quality yoghurt of typical flavour could be obtained where the mixture culture contains equal proportion of *S. Thermophilus* and *L. Bulgaricus* during coagulation. Sachdeva *et al.* (1982) observed that the combination of *S. Thermophilus* and *L. Bulgaricus* in the ratio 1:2 and *S. Thermophilus 489* and *L. Bulgaricus* (W) in the ratio of 1:1 gave the best product.

In the present study coconut milk was enriched with 2 to 10 percent skim milk powder, which yielded good quality curd and yoghurt. In the preparation of basematerial skim milk powder was added at various levels ranging from 2 to 10 per cent to the diluted milk before homogenization. It was found that less than 6 percent skim milk powder in the formulation did not provide sufficient body. The protein and fat contents of the coconut milk containing 6 percent skim milk powder were 2.34 and 3.8 percent, respectively.

Chopra *et al.* (1984) has the opinion that low non-fat solids present in coconut milk (10%) compared with that in the skim milk (97.0%) lower the yield of the product.

Coconut skim milk is a solution of the soluble components of coconut after the cream is separated in a cream separator. Non-fat-dry milk is often added to milk base for yoghurt making to increase total solids, improve flavour, and ensure optimum acid production by lactic starter culture in soy yoghurt.

Sandeep *et al.* (1997) reported that yoghurt made with 22 % soy solids that corresponded to the use of 275g of soybean for base formulation, containing 0.02 % $CaCl_2$ yielded acceptable quality (Nsofor and Chukwu, 1992). Hruskar *et al.* (2000) reported that addition of skim milk to soymilk up to 30 per cent enhanced acid production by lactic cultures. The changes in pH were in conformity with acid production by the culture.

The coconut milk has an added effect as it act itself as an emulsifying or stabilising agent. The type of stabiliser was found to have significant impact on the quality parameters such as viscosity, sensory smoothness and appearance. In the present study no artificial stabilizer was used, thus improving the quality of product made.

Lee *et al.* (1990) reported that adding two percent corn starch to the base formulation produce a desirable body/texture in yoghurt. Yoghurt made with pectin gave better consistency and sensory properties.

### 5.3.2 Chemical Characteristics of the Simulated Product from Coconuts Milk

The major components analysed in the simulated products were pH, acidity, total soluble solids, total sugar, reducing sugar, moisture, protein and fat and the minerals like calcium, phosphorus, iron, solid not fat and viscosity.

pH of the coconut curd was 4.66 in $P_1T_1$ and 5.38 in $P_1T_2$ where as in yoghurt pH was 7.57 and 5.64 respectively in $P_2T_1$ and $P_2T_2$. pH of the coconut milk curd was comparatively low as with its counterpart whereas in coconut milk based yoghurt pH was towards neutral side. As reported by Krishnaswamy *et al.* (1971) high quality yoghurt is reported to have pH of 4.5 - 7.5. Acidity of the simulated products under study ranged between 0.51 and 0.73 in coconut curds and 0.60 to 0.68 in yoghurt. As reported by Gupta *et al.* (1997) acidity of the yoghurt is 0.8 – 0.9 percent. Hruskar *et al.* (2000) pointed out that the titratable acidity of yoghurt ranged from 1.0 to 1.8 per cent. Acidity of coconut milk curd and yoghurt formulated in the present study was found to be less acidic. In the formulation of a conventional plain yoghurt, the standard chemical composition was found to be 3.2 - 3.5 percent fat, 10 – 15 percent solid-not-fat (SNF), and 3.5 percent protein (Nalawade, *et al.* 1998).

The composition of commercial plain yoghurt is as follows: fat, 1.66, total solids 10.98; total protein 3.45; carbohydrates, 5.15 and ash, 0.75. Typical flavored yoghurt, on the other hand,, has 1.5% fat, 3-5% lactose, 3-5% added solid, 0.3-0.5% stabilizer, and 17.21% total solids (Davida *et al.*, 1993). The coco yoghurt contains 77.40% moisture, 2.58% fat, 14.02% SNF, 2.73% protein 0.86% acidity, and 11.29% total sugar. It has a pH of 4.50. The composition is almost similar to the plain yoghurt made from 100% dairy milk (Chopra *et al.*, 1984).

TSS of the formulated product was 18.85 to 19.75 in coconut based curds in $P_1T_1$ and $P_1T_2$ where as in coconut yoghurt TSS was 19.64 and 19.72 respectively in $P_2T_1$ and $P_2T_2$. Krishnaswamy *et al.* (1971) reported 4 per cent loss in total solids after 24 hours and 6.6 percent loss after seven days of storage at 37°C in curd prepared from raw cow's milk.

Total sugar was 12.44 in $P_2T_1$ in coconut yoghurt as against 13.22 in $P_2T_2$. Total sugar was observed to be less in coconut curd. Reducing sugar content ranged between 2.66 to 3.74 percent in the simulated products formulated from the coconut milk.

Gonzalez (1991) formulated NIYOGURT, nutritious, containing 4.36% total protein, 1.07% total minerals (ash), 1.90% fat, 23.99% total solids, and 1.386% titratable acidity with pH 3.92. Its fat, protein, and titratable acidity contents resembled those of the commercial brand yogurt; however, the latter had a significantly higher total solids (30.64%) but lower pH (3.67) and minerals (0.86%). None of the pathogens survived in dahi/yoghurt stored at 37°C for more than 25 hours. Moisture was also similar in the combination of coconut curds and coconut yoghurt (75%).

With respect to nutrients, protein content of coconut curd and yoghurt in combination with soymilk was higher and similar (5.50 g) and that of curds was 3.56 in $P_1T_1$ and 4.33 in $P_2T_2$. The protein and fat contents of the coconut milk containing 6 per cent S.M.P were 2.34 and 3.8 per cent, respectively (Davide *et al.*, 1999). According to Kohk *et al.* (1977) there was a reduction in total nitrogen when fermentation of milk was prolonged.

Similarly, fat content of the coconut curd and yoghurt was higher in soymilk blended combination 4 and 4.55 respectively in $P_1T_2$ and $P_2T_2$. The fat was found to be the important component influencing body and texture. As reported by Nalawada *et al.* (1998) increase in fat content significantly influenced ($p < 0.03$) the body and texture scores of the product. The lactose content also had a positive impact.

### 5.3.3 Organoleptic Qualities of Simulated Products from Coconut Milk

Organoleptic evaluation of the simulated products indicated that the overall acceptability of the products ranged between 4.0 to 4.5 with a percentage acceptability of 80 to 88 percent. Appearance and colour attributes of the products were almost alike, except in soya milk enriched coconut curd. Soya milk imparted slightly white tinge to the product, which was not liked by the judge panel.

Yogurt made from milk with 8 % sugar and addition of mango pulp upto 4 % marginally improved the flavour characteristics, while addition of mango pulp higher than 4% affected the delicate yoghurt flavour and also the body and texture characteristics. However, addition of Mango pulp increased the softness and syneresis of yoghurt (Balasubramanyam and Kulkarni, 1991). Flavour profile was appreciated in the simulated products in which skim milk was blended. Taste of the coconut curd was more appreciated than the coconut yoghurt. Unfamiliarity of the yoghurt, might have contributed to the less appreciation of the product. Coconut curd with skim milk scored better in all sensory attributes when compared to others.

### 5.3.4 Changes in the Chemical, Nutritional of Simulated Products with Storage

When compared between the two curds, coconut curd with soymilk was having higher pH, acidity, reducing sugar and moisture. It was also rich in protein, fat, iron and viscosity was more when compared to coconut curd made from skim milk powder. Coconut curds with skim milk powder showed high level of TSS and Total sugar. It was also rich in calcium, phosphorus and the solid not fat (SNF) value was high in coconut curd. When yoghurt was compared, coconut yoghurt with soya showed high level of acidity, reducing sugar, total soluble solids, total sugar, and moisture. Nutrients like protein, fat, iron and characteristics like solid not fat and viscosity were also recorded more in soya-enriched yoghurt. Coconut yoghurt in which skim milk powder was substituted observed to have higher level of pH, calcium and phosphorus when compared with coconut yoghurt with soymilk.

A significant difference in chemical and nutritional constituents like acidity, total soluble solids and protein was recorded between the simulated products viz., coconut curd and coconut yoghurt standardised.

There was an increase in acidity, decrease in TSS and protein irrespective of storage periods and storage containers. A significant difference was also recorded between the simulated products with various treatments viz., with skim milk powder ($T_1$) and soy milk ($T_2$). In coconut curd and coconut yoghurt with soy milk supplement ($P_1T_2$, $P_2T_2$), the increase in the acidity with storage were higher when compared with coconut curd and coconut yoghurt with skim milk ($P_1T_1$, $P_2T_1$).

In coconut curd and coconut yoghurt, with soymilk supplement ($P_1T_2$ and $P_2T_2$), the decrease in TSS and protein was more when compared to coconut curd and coconut yoghurt with skim milk ($P_1T_1$, $P_2T_1$). In coconut curd and coconut yoghurt the changes in acidity, TSS and protein was more after 2nd day irrespective of containers it is stored. Interaction effect of the treatment on the formulated simulated products as whole indicated that there was no significant variation in TSS and protein, but a significant difference was seen in acidity with respect of its treatment, storage media and storage period.

### 5.3.5 Changes in the Organoleptic Qualities of Simulated Products from Coconut Milk with Storage

Simulated products from coconut milk were studied for four days at ambient temperature by storing in two containers steel and plastic with lid. When coconut curd was taken into consideration, coconut curd with skim milk powder scored highest (4.4 – 3.6) in steel container when compared to plastic container. Coconut curd with skim milk powder scored highest mean score for all the sensory attributes in steel container when compared to plastic container. Coconut curd with soymilk was not much acceptable in plastic container. The mean score was (3.9 – 2.0). With duration of storage there was decrease in scores for all the sensory attributes, but significant difference were seen in attribute appearance, taste and consistency of the products. The difference was conspicuous after third days of storage irrespective of storage containers (CD-0.38).

Storage quality in steel container was much better than plastic container in all the simulated products. Highest deterioration was seen in coconut curd with soya milk followed by the coconut yoghurt with soya milk. Skim milk added simulated products from coconut milk scored better than soya milk added products. When overall acceptability of the product was accounted coconut curd with skim milk scored high in both plastic and steel container followed by coconut yoghurt in steel container and then coconut curd with soya milk (Fig. 6).

## 5.4 ASSESSMENT OF CHEMICAL, NUTRITIONAL, ORGANOLEPTIC AND SHELF STABILITY FEATURES OF THE PROTEIN ENRICHED SUPPLEMENTS DEVELOPED FROM COCONUTS.

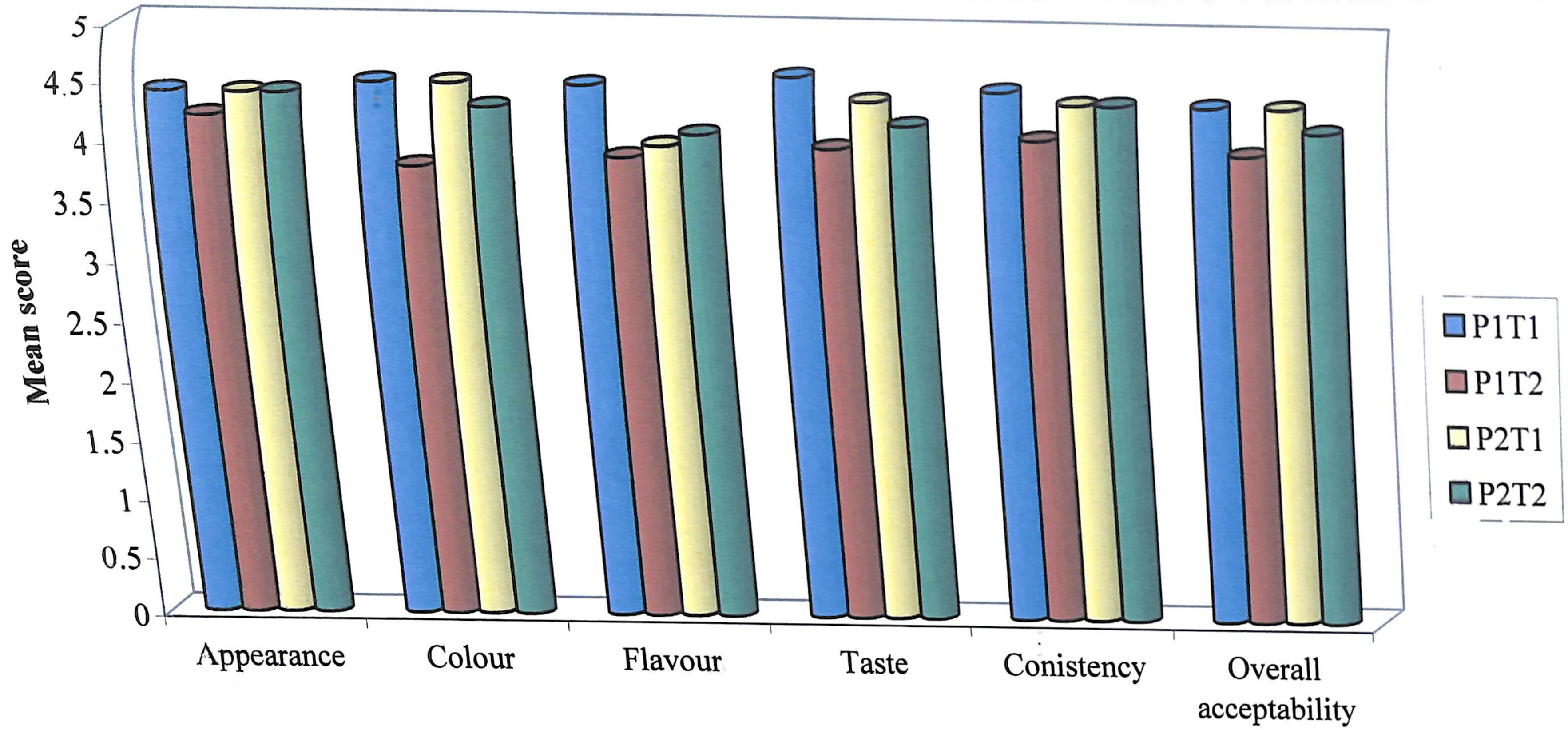
### 5.4.1 Standardisation of Protein Enriched Supplements

In recognition of the world wide need for more dietary proteins particularly for low income people, there have been extensive efforts to develop low cost protein food by blending certain cereal and milk powder in such proportion as to minimize the deficiency of amino acids and to have a nutritive value superior to that of the ingredients from which it has been made

Devadas (1998), an authority on nutrition in India, has stated that development of complementary food should be governed by six major principles namely; high nutritional value good supplementary value, (i.e., high energy value and NPU of 60-65), acceptability, ease of preparation, low cost, shelf life (4-6 months), and local availability of ingredients.

Functional food has a positive impact on an individual's health, physical performance or state of mind, in addition to its nutritive value (Varshney, 2001).

According to Varshney (2001), theoretically a health food has to be 100 percent natural i.e., free from any additives such as synthetic colour or flavour or




P1T1 – Curds with coconut milk + skim milk powder
P1T2 – Curds with coconut milk + soya milk
P2T1– yoghurt with coconut milk + skim milk powder
P2T2– yoghurt with coconut milk + soya milk

**Fig. 6 Organoleptic characteristics of simulated products**

any type of preservatives. Broadly it can say that it assists the therapeutic process of the body towards the substitution of medicines. It fit the consumer for enduring health in a convenient and natural way. Srilakshmi (2003) remarked that health foods assist the consumers in attaining enduring health in a convenient and natural way.

The most promising additional sources of proteins available for improving diets in the less developed countries are various edible oilseeds and nuts and their meals. Surveys have shown that oilseeds and nuts and their meals can provide about 10g additional protein daily/capita if used fully for human consumption (Swaminathan, 1995).

Thus in the present study, the supplementary base mix was prepared with the combination of, coconut grating 30 percent, soya flour 10 percent, groundnuts 10 percent, rice 15 percent and coconut jaggery 35 percent. Srivastav (1992) opined that the beneficial effects of combining cereals and pulses have long been recognised by the nutritionists. Maximal food utilization can be achieved for nutritious formulations by blending cereals with oilseed proteins in a manner that would provide the requisite balance of available amino acids, minerals, vitamins and calories (Srilakshmi, 2003).

It is therefore, become imperative to make best use of locally available protein rich resources which includes cereals like wheat, rice, soybean etc. for manufacturing low cost nutrients protein supplements. Rice as the staple food of Keralities from ancient times has many diverse uses and is consumed in many forms (Munday *et al.*, 1989).

Apart from the base mix, two types of health drinks were also developed with ingredients such as malted wheat flour, barley, coconut milk powder and adding condiments for flavour and taste.

Health drink considered under the functional food, is basically a food derived from naturally occurring raw materials that is taken as a part of daily diet. The functionality can include such things as prevention and recovery from a specific disease, enhancement of immunity, control of physical and mental state and slowing down of the ageing process.

Gonzales (1983) investigated the effect of fortifying two snack items with dessicated coconut and soyaflour. He found that the products were highly acceptable and suggested as an ideal vehicle for fortification.

In the formulation of therapeutic health drink mix, ingredients used were
Coconut milk powder 30 per cent, Skim milk powder (cow's) 15 percent,
Coconut palm jaggery 20 percent, Coriander powder 10 percent, Pepper
5percent, Dried ginger percent5, Cardamom 2.5 percent, Cumin seeds
percent5, Tulsi powder 1 percent, Fenugreek-1.5 percent.

Malted health drink was standardized using the ingredients viz.
Coconut milk powder 40 percent, Skim milk powder (cow's) 15 percent,
Malted wheat flour 20 percent, Malted barley powder 8 percent, Defatted soya
flour 5 percent, Glucose 4 percent, Arrowroot powder 4 percent, Cocopowder
4 per cent Sorbitol (as preservative) 0.5 percent

Barley malt has gained importance because of its utility in bakery and
processed foods and in vinegar and syrup making (Rosado *et al.* 2000). The malt
quality and nutritive value are dependent upon its chemical constituents. When
barley starts germinating, various hydrolytic enzymes are either synthesized *de*
*novo* or activated from the pre-existing inactive forms, which results in hydrolytic
cleavage of the reserves.

Pioneering work has been done in this area at CFTRI, Mysore and it was
reported that addition of 5% malted barley flour reduced the viscosity of 15% hot
paste slurry of the commercial supplementary foods (Desikachar, 1982).

Whitley (1970) reported that 5 percent coconut flour can replace
proportionate amounts of wheat flour and non-fat dry milk powder used in school
nutrition programmes without affecting baking qualities and food value.

Spices and condiments are important ingredients of our daily diet although
are used in small quantities. Spices in foods are primarily used for their flavour

and stability in storage and have natural antioxidant and antimicrobial properties apart from having carminative effect and also aid digestion through the stimulation of appetite (Fellow, 2002). Spiced beverages in the form of fruit drinks/squashes/ appetizers/health drinks etc are gaining importance in the market (Griffin, 1992). The spiced can be added successfully to supplementary foods to improve its flavour and aroma. In the present study, condiments such as cumin seeds, fenugreek seed, dry coriander seed, cardamom, pepper, tulsi etc were used in the formation of health drink, which was found to be well acceptable to the consumers.

According to Srilakshmi (2003) malted beverages are also known as Amylase rich food (ARF). Malted food is inexpensive. It can be made at household, community level and even at commercial level.

Dahiya and Kapoor (1994) revealed that malting used in the formation of the supplements significantly reduced hot paste viscosity of all 4 supplements and increased their nutrient density per unit volume.

Neeraja *et al.* (1991) observed that the amount of nutrients increased due to roasting and was attributed to lower moisture content of material, causing concentration effect. Roasting reduces moisture content thereby concentrating the food value. It also enhances in vitro protein digestibility (Srivastav 1992) and acceptability by imparting a popular nutty flavour to the food without causing any appreciable reduction in various amino acids. Roasting and grinding processes rendered the whole pulses and grains highly digestible without significant loss of any nutritious components. Thus in the formation health drink mix roasting of condiments improve the quality and shelf life stability.

Krishnakumari and Geervani (1996) formulated supplementary foods in the powder and biscuit forms, using wheat, soya and sugar with a proportion of 70:10:20, by employing the processing techniques, such as popping, roasting and baking. Products, named pushti, have calorie content 377 with a protein content of 13 gm while biscuits were found to have 456 kcal and 9 g of protein per 100 g, respectively in pushti powder and biscuits.

### 5.4.2 Chemical and Nutritional Characteristics of Protein Enriched Supplements from Coconut

**Supplementary snack food**

Supplementary food base mix developed using coconut was found to have moisture content as 13.42 percent, while that of protein was 13.80 g. Energy and fat content of the base mix was found to be 341 kcal 15.21g respectively with a fibre content of 1.5 percent. Free fatty acid and peroxides were observed to be 0.67 percent and 0.66 meq respectively. Appreciable amount of minerals viz., calcium, phosphorous and iron were also recorded in the base mix.

Supplementary food developed by Naikare and Mabesa (1993) for infants and children consisting of flours of processed brown rice, germinated munge, sesame, and carrot blend at 50:50:5:5 ratio, was reported to contain 7.30percent,protein, 65.50 percent carbohydrate, 4.90 percent, fat, 2.50 percent minerals, 346 mg / 100g B-carotene and 518 K cal. of energy per 100g.Supplement mixes developed by Dahiya and Kapoor (1994) using whole wheat, pearl millet, bengal gram, green gram grain and amaranth leaves using roasting and malting found to meet one third of the requirements for protein, energy, iron and calcium for young children.

While Gahlawat and Sehgal (1994) developed a weaning food with roasted rice (70g), roasted green gram (30g) and jaggery (25g) provided 300 K cal of energy, 6-9 protein and 6.5 mg iron per day. Sailakshmi (1995) formulated soya based supplementary food with parboiled rice, defatted soya flour and groundnut flour in the proportion 85:10:5. The supplement food provided 11.20 g protein and 368.50 kcal / 100 g.

According to Nirmala (2002), supplementary food formulated with parboiled rice, defatted soyaflour and groundnut flour contained 11.20g of protein and 368.50 kcals per100g .She also pointed out that calcium, iron and phosphorus was found to be 32.80mg, 1.00mg and 200mg respectively.

Amirtham developed by Sri Avinashlingam University, Coimbatore has calorific 391 Kcal value, protein 16.14, fat 5.44, carbohydrates 69.37, calcium191.23 mg, iron 8.9 mg, crude fibre 1.05 and moisture 5.78 (Anon, 2000). A weaning food developed by Sailaxmi(1995) containing parboiled rice : defatted soya flour : ground nut flour in the proportion 85 : 10 : 15 contained 369 K cal, 11.2 g protein and 2.7 mg iron.

Thus, base mix developed from coconut under the present study, also found to be excellent in nutritional quality and comparable with products developed by other researchers. Base mix developed can be used for making consumer acceptable snacks for the vulnerable groups as well as others.

**Health Drink Mix**

Two types of health drink mixes standardised in the present investigation recorded the moisture content was 8.58 percent in therapeutic health drink and 9.09 percent in malted drink. Calorie content of health drink II was 323 as against 335 in therapeutic mix I. Protein content of the mixes was 9.12 g and 15.66 respectively per 100g in mix I and mix II. Mineral content in the mixes viz., calcium, phosphorus and iron were 432, 223 and 1.76 mg in respectively mix I and 566 mg, 219 mg and 1.95 mg in mix II. Free fatty acids and peroxide were 0.23 to 0.32 percent and 0.39 to 0.54 meq respectively in mix I and II. Chemical and nutritional constituents present in the mixes developed significantly with each other except for energy. The health drink II had higher level of protein, fat, fiber and calcium. The energy level was on par in the two products.

Chellammal (1995) reported that addition of skim milk powder to the product increase its calcium content. Thus two health drink mixes developed under the present study were found to be nutritionally superior in its quality.

## 5.4.3 Organoleptic Characteristics of Protein Enriched Foods

With respect to organoleptic quality of the supplementary base mix, it was indicated that overall acceptability was recorded 3.8 as out of 5 with 76 % acceptability among the panel judges. Appearance attribute was scored as 4.0

and that of colour score was 4.1. Flavour and taste were recorded as 3.7 each and texture of the base mix appeared good with a score of 3.9.

Supplementary base mix was stored in laminated and polypropylene covers and analysed for shelf stability for a period of 60 days, during which periodic monitoring was carried out. Jacob (1997) developed a supplementary food with rice flour 615 g, soya flour 154 g, amaranthus 77 g and skim milk powder 154 g was very well excepted organoleptically.

For health drink mix the average mean score obtained by the judges indicated that the overall acceptability was above 70 percent in both the health drink mixes developed.

Taste parameter scored in therapeutic mix was 4.0 as against 3.2 in malted mix. Flavour scores were also in favour of therapeutic mix. 3.9 and 3.5 respectively in mix I and mix II whereas mean score was for appearance and colour was better appreciated in malted mix. . Flavour in therapeutic mix is due to the right combinations of condiments like cardamom, cuminseed, corianderseed, and coconut jaggery. As obtained by the CD value sensory features with respect to texture, flavour and taste were found to vary significantly in the products standardised.

## 5.4.4 Changes Chemical and Nutritional Characteristics of Protein Enriched Supplements with Storage

### *5.4.4.1* Changes Chemical and Nutritional Characteristics of Supplementary Basemix with Storage

Changes with storage in the supplementary basemix was studied and found that moisture content of supplementary snack mix enhanced from 13.04% to 14.07% when stored for 2 months. Significant difference was also seen in the products stored in different containers. When stored in polyethylene pouches the moisture level increased considerably to a higher level at the end of two months, whereas in laminated pouches increase were less, that too after one month of storage. The moisture level was steady till one month of storage and after that there was gradual increase was noticed. Sankar (1992) opined that most of the stored products are considered to be safe at particular moisture content, low moisture is highly important for longer storage period. Variation in the moisture content was found to be lowest in laminated containers followed by polythene containers. The same trend could be observed throughout the storage period.

Storage containers also influenced the free fatty acid content and peroxide value of the base mix (CD 0.05), (CD 0.06) .Free fatty content of the supplementary base mix ranged from 0.10 to 1.03% and 0.13 to 1.05% respectively in laminated pouches and polyethylene pouches respectively. Changes were significant after 15 days in the products stored in polyproylene pouches (0.51%) as against one month in laminated pouches (0.82 %).

Peroxide value of the base mix stored in polyproylene pouches increased from 0.22 to 1.08 mg whereas it increased from 0.15 to 1.02 mg in laminated pouches.

Inamdar (1980), reported an increase from 10 – 14.70 percent for RTE mix after a storage period of 28 days. Solanki (1986) reported as an increase from 5.16 to 5.39 percent in the developed RTE mixes after a storage period of 28 days. The increase in the moisture content of flaked rice-based wafers has been reported by Kulkarni *et al.* (1992).

### 5.4.4.2 Changes in Chemical and Nutritional Characteristic of Health Drink Mix with Storage

Moisture content of health drink mix was found to vary significantly with storage periods (CD 0.08). Moisture content increased from 7.72-7.89 when stored for 6months in therapeutic health drink and 8.13 –10.57 in malted health drinks respectively. In a study conducted by Malleshi *et al.* (1984) a malted weaning food with 11 % moisture was tested for its storage stability. The food packed in polythene pouches and stored at ambient storage conditions remained acceptable up to five months.

It was also seen in the products stored in different storage containers vary in moisture content (CD-0.05). When stored in polyethylene pouches change in moisture content was conspicuous after 2 months, where as in laminated pouches, changes in moisture level was less and steady till two and half months of storage The moisture level was unchanged only till one month of storage in polyethylene pouches after which a gradual increase was noticed.

With respect to Free fatty acid content of Health drink mix significant difference was noted with storage period (CD- 0.09). Free fatty content of the Health drink mix ranged from 0.1 to 0.47% and 0.23 to 0.52% in laminated pouches and polyethylene pouches respectively. Storage containers also influenced the free fatty acid content of the Health drink mix (CD-0.05). Changes were significant after 2months in products stored in polyethylene pouches (0.52%) where as in laminated pouches (0.47%) after one month of storage.

Peroxide content of Health drink mix also found to change significantly with storage periods (CD 0.09). Significant increase was observed after one month of storage in both the containers. A significant difference was also recorded with storage containers (CD 0.06). The level of peroxide value was recorded high when stored in polyethylene covers than in laminated pouches. Significant increase was observed after one month of storage in both the containers. In a product (sevian) prepared from colocasia mash admixed with besan found that the peroxide value changed from nil to 1.07 meq when stored for one month. (Banerjee and Tripathi 2000)

Dahiya and Kapoor (1994) reported that supplements stored in 3 packings namely, polythene bags, tins with lids, glass bottle with lids remained stable with respect to moisture, peroxide value, fat, acidity and alcoholic acidity for one month. The moisture, peroxide value, fat acidity was within the range of prescribed specifications.

Banerjee and Tripathi (2000) the product made form 80:20 blends of colocasia and besan had an excellent sensory quality appeal with respect to colour, texture, taste and overall acceptability. The product was found acceptable only up to 30 days storage at ambient temperature (30-35°C, RH 30-65%) when packed in120-guage polypropylene. Fig 7

## 5.4.5 Changes Organoleptic Characteristics of Protein Enriched Supplements with Storage

### 5.4.5.1 Changes in Organoleptic Characteristics of Supplementary Product and its Interaction between, Containers and Storage Periods

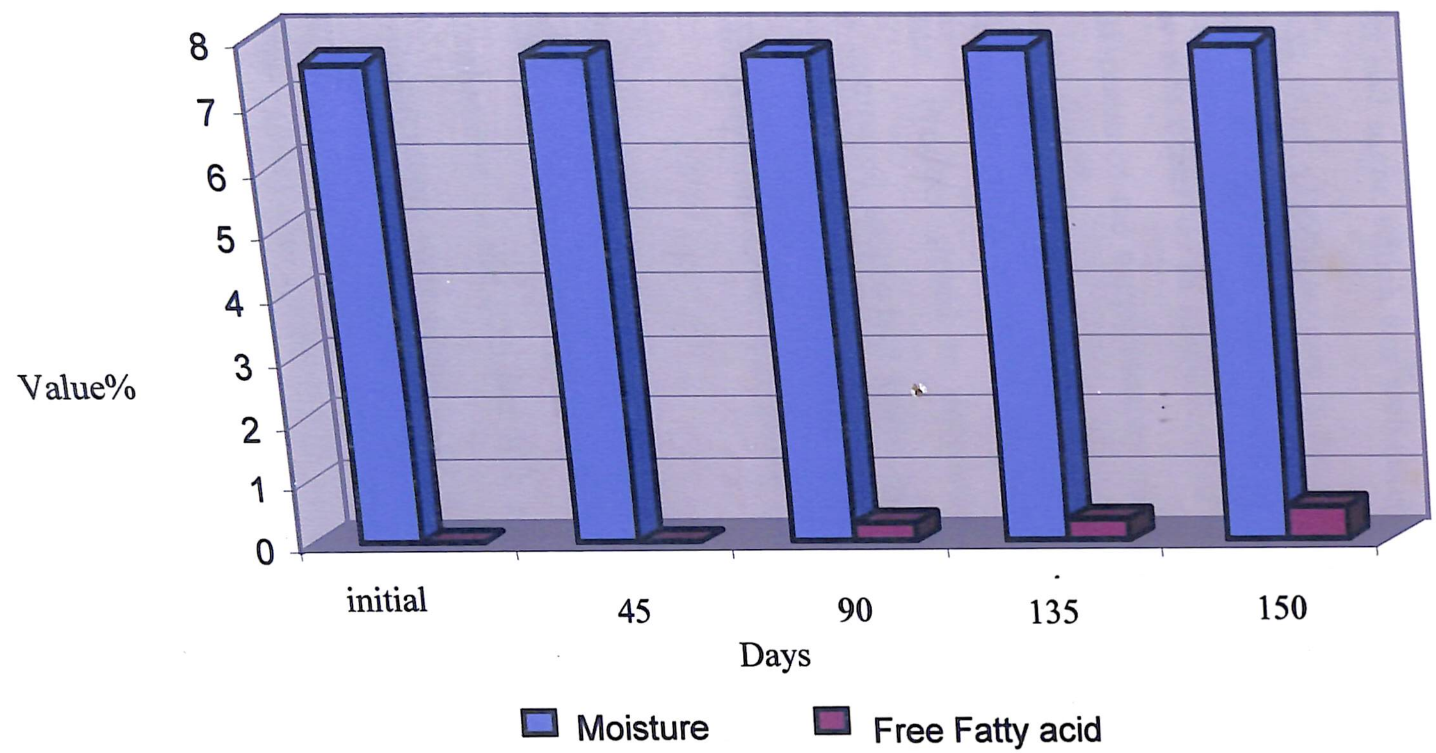
As the consumer preference to appearance is one of the major factors leading to the increasing demand of the product, it is very essential to keep the appearance of the product quite attractive (Anvita 1993). The result revealed that the developed Mix had obtained a score of five for appearance. When appearance attribute in supplementary base mix was taken into account, the mean score for appearance attribute varied from (4.0 – 3.0). A decrease in freshness of the product with storage period was observed. Laminated pouches maintained the freshness for a longer period when compared with polypropylene covers.

When colour attribute of coconut base supplementary base mix was taken into account, the mean score decreased from 3.9 –2.8 and a significant difference were observed in mean score of colour with storage. Storage containers found to influence the mean score of the colour of the product Laminated pouches maintained the colour for a longer period when compared with polypropylene covers. When ranked for colour the combinations containing raw rice emerged as the best .The colour of all combinations was dull due to the addition of soya flour, which imparts a dull yellowish brown to dark brown colour.

Similarly the mean score of the taste attribute of the supplement base mix decreased from 3.8 – 2.4. A significant difference was observed in the mean score of taste with storage. Slight rancid taste developed with storage. Storage containers also influenced the mean score of the taste of the product.

When compared to quality attributes of taste the formulations containing raw rice and puffed rice were found to better than that made from parboiled rice and flaked rice. (Rosita *et al.* 1997). According to Rolls et al (1981) in the various

Fig. 7 CHANGES IN MOISTURE AND FFA WITH STORAGE



quality attributes tests, the first preference goes to taste followed by flavour, appearance texture and colour. In this study the developed Mix has got an average score of 4.8 for taste. This is because of the reason that, since the quality of the ingredients used has got direct impact on taste the score percentage is found to be high. The use of milk powder in the Mix also helps to improve the taste of the product. Susan (1992) developed a weaning food with banana, sesame, horse gram, skim milk powder and sugar, which was well accepted among children.

According to Ject *et al.* (1995) texture is the property of food, which is associated with the sense of feel or touch experienced by the fingers or the mouth A significant difference was observed in mean score of consistency with storage in the base mix. The crispness of the supplementary mix decreased with storage. The score secured by the Mix for consistency was 4.0. Storage periods and containers also influenced the mean score of the overall acceptability of the supplementary base mix. Product stored in polythene cover displayed poor sensory qualities when compared to product stored in laminated pouches. The overall acceptability of the product showed that the product could be stored for a period of one month in polythene cover and above one month in laminated pouches.

According to Dahiya and Kapoor (1994) Storage of supplements for 30 days resulted in non-significant changes in organoleptic traits except for taste and aroma of bajra based supplements on the 20th and 30th day of storage. In spite of these variations, all the supplements were found to be acceptable till 30th day of storage.

Dahiya and Kapoor (1994) also conducted an organoleptic trials on rural mothers (from Haryana, India) revealed that taste, texture, colour, aroma, appearance and overall acceptability of all 4 supplements were excellent with mean scores of overall acceptability (9.77, 9.33, 9.11 and 8.75) for supplements I, II, III and IV, respectively. Children did not develop any gastrointestinal disorders after consuming the products.

### 5.4.5.2Changes in the Organoleptic characteristics of Health drink mixes with storage

The health drink mixes were kept for a period of 6 months, in polythene and laminated pouches and tested periodically among the judges by mixing the mixes in hot water.

A significant difference in the 'appearance' attribute was recorded between the two health drinks (CD - 0.22), and with the storage periods (CD- 0.34). The appearance score decreased and change was observed after 30 days. Containers also affected the appearance of the products (CD-0.31). The product appeared better in laminated pouches than in polypropylene covers.

Colour attribute also depicted significant difference between the therapeutic health drinks and malted health drink (CD- 0.21) so also with the storage periods (CD-0.33). Containers also influenced the colour of the products (CD-0.29). The product appeared better in laminated pouches than in polypropylene covers.

A significant difference in flavour attribute was seen between the products (CD- 0.21). But flavour variation was observed with the storage periods (CD - 0.33). The flavour score decreased and change was seen after 30 days in both the products. Containers also affected the flavour of the products (CD-0.21). Flavour was retained well in laminated pouches than in polypropylene covers.

According to Nimmy (1996) the overall acceptability depends on the concentration or amount of particular components, the nutritional and other hidden attributes of a food and its palatability or sensory quality. After analysing each quality attribute, the score of over all acceptability was determined for the mixes. A score of 3.5 and 3.4was attained by the Mix I and Mix II respectively for overall acceptability.

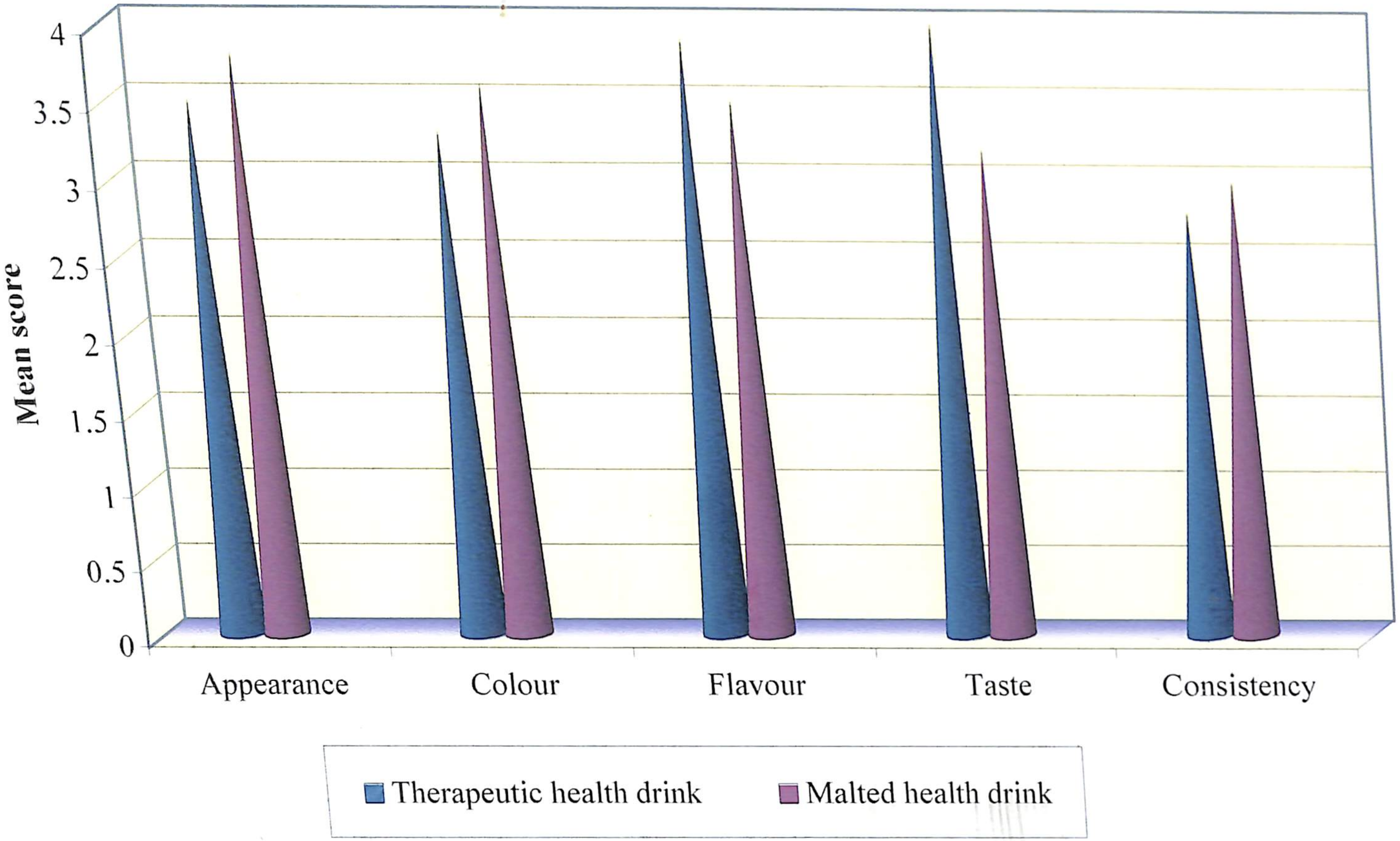



**Fig. 8 Organoleptic characteristics of health drinks**

In the present study above-mentioned coconut constituents were used for standardizing bakery products. Whitley (1970) found that desiccated coconut can be added at different levels from 10-65 percent without affecting the quality of the baked product. He has also reported that 5 percent desiccated coconut could replace proportionate amounts of wheat flour and non-fat dry milk powder without affecting baking qualities and food value. Tsen *et al.* (1973) viewed that soya flour (defatted and full fat) and protein isolates are suitable fortifiers to improve the nutritional value of cookies by raising their protein content and balancing their amino acid.

In the formulation of two-bakery products viz., Coconut Biscuits and Cookies basic ingredients used were desiccated coconut and roasted coconut gratings.

### *5.5.1.2* Chemical Characteristics of the Bakery Products from Coconut

Chemical and nutritional characteristics of the bakery products were studied, in order to understand the quality of the product. Moisture content, one of the prime parameters determining the shelf stability, of baked products when analysed was found that coconut biscuits contain less moisture, and remains less than 10 percent.

Formulated coconut based bakery products were found to have a calorie content of 356 and 390 kcal respectively in cookies and biscuits. Protein content of biscuits was 5.15 g as against 3.08 in cookies. Elizabeth, (1999), reported that protein content of the cookies and biscuits developed from sweet potato flour was found to be 9.66 g and 6.83 g respectively. Fat content was 25.67 and 20.55 g respectively in biscuits and cookies. Free fatty acid and peroxide content present in the products were also accounted as these factors influence the keeping quality of the bakery products. Free fatty acid level was 0.41and 0.8 respectively in cookies and biscuits while that of peroxide value was recorded as 0.65 and 0.77 respectively.

Mc Watters (1980) reported that protein content of biscuit developed was 6 g, while Semwal *et al.* (1996) developed biscuits with protein content 5.4 -

6.9%. Study conducted by Krishnakumari and Geervani (1996), revealed that the protein content of the 'Pushti' powder and biscuit formulated from soya was 13.0 and 9.0 g respectively. Coconut biscuits developed were higher in protein and fat content when compared to cookies.

Semwal, *et al.* (1996) reported that total fat content in various biscuits developed ranged between 1 and 24.6%, while total energy values ranged between 365 and 501 kcal which could be compared to some commercially available biscuits.

Both the products developed contain appreciable amount of fibre. With respect to minerals namely calcium, phosphorus and iron was found to be 60.3mg 242.3mg and iron 1.7mg in cookies as against 70.6mg 282.6mg and 1.5g respectively in biscuits. According to Semwal, *et al.* (1996), in commercially available biscuits, the concentrations of sodium, potassium, iron and calcium ranged between 800- 4950 mg/kg, 450-1720 mg/ kg, 38-230 mg/kg and 120-1800 mg/kg respectively. In this context, the developed coconut cookies and biscuits are ideal, nutrient dense and comparable with proprietary products available in the market. Significant difference in the nutritional and chemical constituents was detected in the bakery products developed incorporating coconut constituents.

### *5.5.1.3* Organoleptic Quality of Bakery Products from Coconut

Sensory evaluation carried out in the bakery products indicated that organoleptic features such as colour, flavour and doneness were high in favour of cookies while taste character was rated maximum in biscuits. Pande (2002) viewed that millard reaction is important for the production of brown hues on the surface of the baked products. Coconut cookies and biscuits developed vary significantly in sensory attributes with each other, except for flavour. Since the coconut has its own flavour, additional flavours are not needed. Moreover, in coconut biscuits, coconut honey was added for flavour and smoothness. It was also used for obtaining the desired golden brown crust colour in short dough biscuits. Based on the individual parameters overall acceptability accounted to be excellent in cookies, closely followed by biscuits indicating well acceptance of both products.

### *5.5.1.4* Changes in the Chemical and Nutritional Qualities of Bakery Products with Storage

Bakery products formulated under the present investigation was subjected to shelf stability assessment. The products were stored in laminated and propylene covers and analysed periodically up to two months. Results indicated that during storage coconut biscuits and coconut cookies depicted gradual changes in moisture, free fatty acid and peroxide values.

Pande (2002) reported that most of the stored products are considered to be safe when stored at particular moisture content, low moisture content is highly important for longer storage period.

In the present study, changes with respect to moisture, free fatty acid and peroxide were found after 15 days in the products stored in polypropylene covers whereas in laminated pouches changes appeared after 30 days thus indicating better shelf life stability in the laminated pouches.

Considering the moisture content of the developed baked products, it could be observed that there was an increase in moisture content through out the storage period up to four weeks. Moisture content was found to be more in coconut cookies after the storage when compared to coconut biscuits. Inamdar (1980) found an increase in moisture from 10 – 14.70 percent for RTE mix after a storage period of 28 days. Solanki (1986) reported an increase of moisture content from 5.16 to 5.39 percent in the developed RTE mixes after a storage period of 28 days. An increase in the moisture content of flaked rice-based wafers has been reported by Kulkarni *et al.* (1992).

Peroxide value was high in coconut biscuits on storage. Though there was gradual increase in free fatty acid with the storage periods, there was not much difference between the products stored in polypropylene and laminated pouches.

### 5.5.1.5 Changes in Organoleptic Qualities of Bakery Products with Storage

When sensory attributes of the coconut cookies and coconut biscuit were compared, coconut cookies ($A_1$) scored better for attributes like appearance, colour, flavour and doneness. The shape and colour of the biscuit was very attractive than other products, and that might have contributed to the highest score. Ranganna (1984) stated that flavour is an important factor, which enriches the consumers' preference to a particular product.

Doneness was ascertained by pressing the crumb with fingers to see whether sticky or not. For doneness, the highest mean score was secured by biscuit, which may be due to the fibre present that helped for proper doneness of biscuit. Diwan *et al.* (1982) reported that biscuit had longer shelf life, than soft biscuit. Study done by Elizabeth (1999) revealed that the shelf life of biscuit and cookies. nancutts was only 4 weeks. When overall acceptability of the products was considered, both coconut biscuit and coconut cookies scored high however cookies excelled.

The quality of a food is a combination of the attributes that determine the degree of acceptability of the product. These include nutritional value and microbiological qualities. For an average consumer, the concept of food quality consists in those related to sensory characteristics which may be classified in accordance with the human senses of perception as appearance, kinesthetic (texture), odour and taste (Sethi and Malani 1989).

As the consumers' preference to appearance is one of the major factors leading to the increasing demands of the product, it is very essential to keep the appearance of the product quite attractive (Vatsala and Haridas 1991). The appearance of baked products was assessed and the result revealed highest mean score for biscuit and the lowest score for cookies. The shape and colour of the biscuit was very attractive than cookies, and that might have contributed to the highest score.

Both the products scored the excellent mean value for flavour. The addition of egg and coconut to the two products influenced the flavour of the products. However cookies scored the highest mean value in taste attribute than biscuits. The highest score of the cookies was due to its ingredients such as coconut and milk powder.

Texture constitutes a physical property of foodstuffs apprehended by the eye, the skin and muscle sense located in the mouth. The surface area of biscuit was smooth and texture was very crisp and this quality must have contributed for the highest score.

The highest mean score for doneness in biscuit was due to the fibre, which help the proper doneness of the biscuit.

Overall acceptability depends on the concentration or amount of particular components, the nutritional and other hidden attributes of a food and its palatability or sensory quality. Henu (1996) found that acceptable cookies can be prepared from wheat flour fortified with 12-15 per cent of soya products.

Features of baked products were analysed periodically, in order to understand qualitative changes occurring. It was indicated that there was a significant difference in the sensory attributes with the storage. There was a gradual decrease in all the attributes viz., colour, flavour and texture with the storage. The change in organoleptic characteristics was conspicuous after one month in the products stored in polypropylene covers and after two months in the laminated pouches. The products remained crisp and excellent in laminated pouches. However, significant difference in flavour attribute was recorded between the products with storage, though flavour scores also decreased with passage of time

No significant difference was observed with respect to overall acceptability of the products with storage. The present study indicate well acceptance of the baked products from coconut among the consumers (Fig.9).

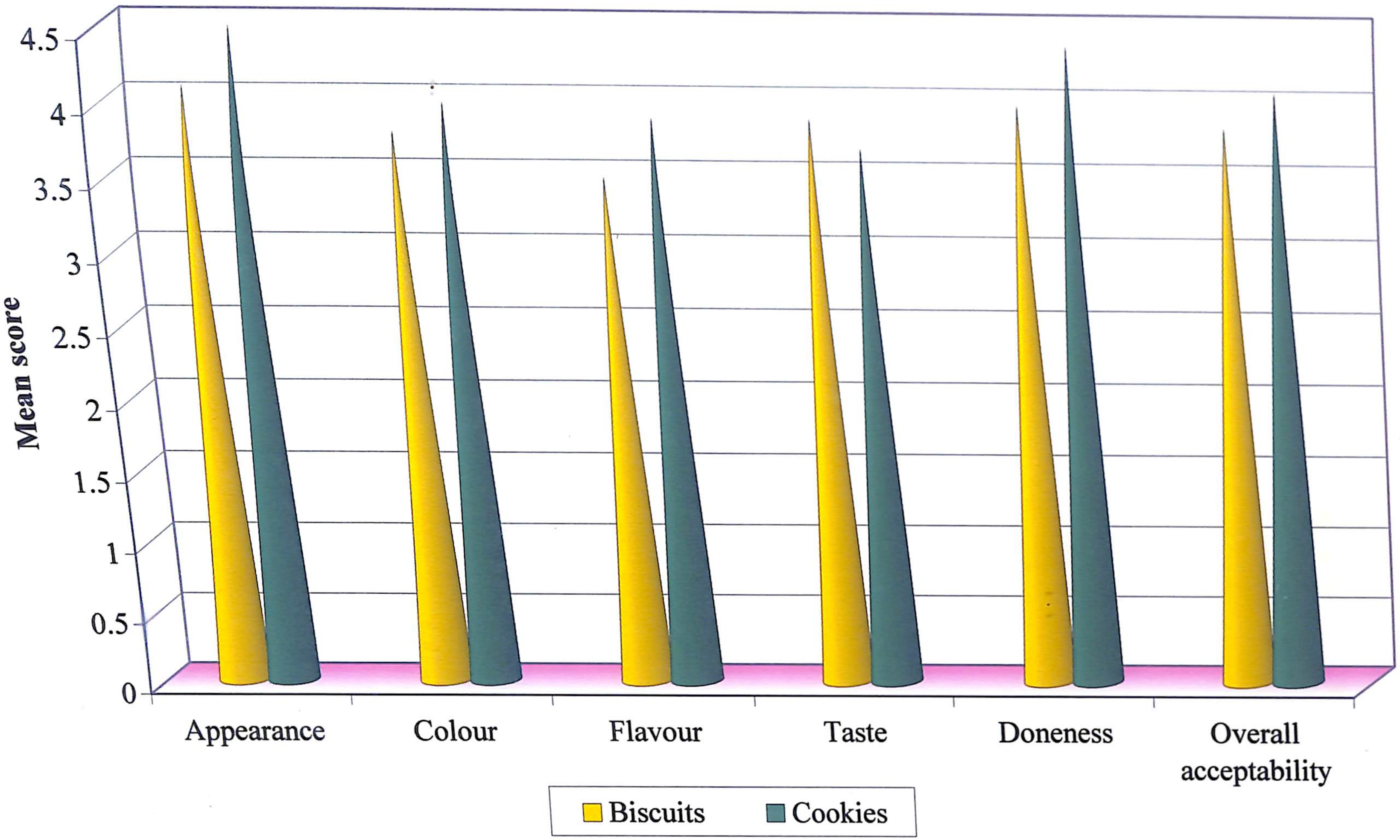



**Fig.9 Organoleptic characteristics of bakery products**

## 5.5.2 Preserved Products

### *5.5.2.1* Standardisation of Preserves Products

Bosco (1998) reported that more than 0.2 billion nuts are harvested and consumed in India alone in the tender stage mainly in cities and tourist places. The kernel of the tender coconut is sometimes eaten or else thrown away, as it is difficult to remove from the shell. Under the present investigation, tender kernel thus wasted, was utilised to prepare preserved products such as crystallized candy and glazed candy. Neelofar *et al.* (2002) found that from one nut about 250 g of kernel is available which is a good source of carbohydrate, fiber and other nutrients.

Punzalan and Gonzalez (1988) reported that young tender coconut kernel could be processed in the form of sweetened dehydrated or dried "buko" or dried as buko chips. These young coconut kernel products are ideal for dessert or snack food. It can also be used as a filling for the pies (Wazir, 1995).

Arancon (1998). The proximate composition of sweetened dried "buko" is moisture 4.7%, crude protein 3.6% crude fat 17.7% and carbohydrates 61.6%.

### 5.5.2.2 Chemical Characteristics of the Preserve Products from Coconut

Chemical and nutritional characteristics of the products analysed revealed that moisture content of crystallized candy was 17.73 per cent while that in glazed candy was 20.87 percent. In support of the above Chavan *et al.* (1991) reported moisture content of 17.94% in tutti- fruity prepared from beer fruit.

Total soluble solids, total sugar and reducing sugar were $69.68^0$B, 75.01 and 28.03 percent respectively in crystallized candy as against $66.36^0$B, 65.66 and 26.70 percent respectively in glazed candy. Chavan *et al.* (1991) found the TSS content of the tutti-fruity prepared from beer fruit was $69^o$ Brix. Sheeja (1994) developed candy from papaya which contain 0.05 percent acidity, $71.0^o$B total sugar and 21.27 percent reducing sugar. Sheeja ( 1995) developed karonda candy with pH of 3.35-3.55 total soluble solids of70 $^o$B , and total sugar70.50 percent.

Sreeja (1996) reported total soluble solids of 10.30 – 12.00 $^{o}$B and reducing sugar of 14.04-15.54 percent in cashew apple candy.

Dabhade and Khedkar (1982) reported TSS in the tutti-fruity prepared from raw bits of papaya as 68$^{0}$ Brix.

Among the nutritional characteristics calorie content was found to be rather high and recorded 352 kcal in crystallized candy as against 249 in glazed candy. Protein content was recorded negligible and was comparable in both the products (0.93g each).

The fat content of the crystallized and glazed candy was found to be alike and recorded as 5 g per 100 g. In both the products, fiber content was more and it was 3.08 in crystallized candy and as against 2.5 in glazed candy. As inferred from the CD values, characteristics such as moisture, TSS, TS, reducing sugar and calories vary significantly with the products, whereas other constituents such as protein and fat found to be similar.

Babar, *et al.* (1998) reported that the tutti-fruity prepared from bottle gourd by different methods contained 20.23 moisture, 68$^{0}$ to 69$^{0}$ Brix TSS and 6.25 to 7.01 mig/100g ascorbic acid

### *5.5.2.3* Organoleptic Qualities of the Preserves from Tender Coconut Kernal

Organoleptic evaluation conducted in the preserves developed revealed that overall acceptability scores ranged from 4.08 to 3.94 indicating 78 to 80 percent acceptance among the judges. Beerch and Rama (1983) standardized a method for preparing candy from pear fruit, which had good colour, taste and acceptability. Singh and Singh (2000) reported that papaya and jackfruit candy were rated high in appearance, flavour and texture

Appearance of crystallized candy was 4.0 as against 3.5 in glazed candy. In colour attribute, both the products recorded similar mean score (3.9 each). Mean score recorded for flavour and taste attribute was 4.1 each for crystallized candy where as it was 4.0 and 4.1 in glazed candy. Both the characters were scored comparatively better by the panel judges. Texture was found to be excellent in crystallized candy as indicated from the score of 4.3 out of 5 and it was similar in glazed candy (4.2). As inferred from the CD value, the organoleptic characteristics in crystallized and glazed candy were significantly different in all the attributes and crystallised candy adjudged to be superior to glazed candy as indicated from the scores. Sheeja (1995) standardized karonda candy with sensory attributes value between 5.00- 4.70. Bal *et al.* (1978) reported that the freshly prepared ber candy had an average score of 8.89 for overall acceptability. The overall acceptability scores of tutti-fruity from bottle gourd prepared by different methods ranged from 8.3 to 9.0 (Babar *et al.* 1998).

### *5.5.2.4* Changes in the Chemical, Nutritional of Preserves with Storage

Coconut kernel preserves developed were stored in polypropylene and laminated pouches for a period of two months during which chemical and nutritional characteristics were analysed periodically. Results indicated that chemical constituents such as moisture, TSS, TS and reducing sugar found to alter with storage.

With respect to moisture, a significant difference was noted between the products (CD-0.294) with storage. Storage period also found to influence the moisture content of the crystallized candy and glazed candy (CD-0.380).

An increase in moisture level was noticed after 30 days of storage. The type of containers (laminated pouches and polypropylene covers) was not found to influence the moisture content of the products. Moisture content was found to be more in candies stored in polyethylene pouches. Rani and Bhatta (1985) who observed a decrease in moisture content in pear and date candies. Gupta (1992) also observed gradual fall in moisture during storage in ber candies.

The total soluble solid content of the preserve decreased with the storage (CD-0.059). Decrease in total soluble solids was noticed after 30 days of storage, and type of containers (laminated pouches and polypropylene covers) also influenced the total soluble solid content of the products. TSS of fresh candies prepared by slow and fast methods by Unde *et al.* (1998) found to increase after 3 months storage. The reason for increase in TSS during storage was attributed to decrease in moisture content and inhibition of sugar by the process of osmosis.(Sagar and Khurdiya, 1996).

When reducing sugar content of the products was compared, a significant difference was recorded in between the products (CD-0.02). The reducing sugar increased with the storage period (CD -0.026). The initial value for reducing sugar content in crystallized candy and glazed candy stored in polypropylene covers were 7.23and 6.41 respectively and at the end storage period it was7.64 and 6.63 respectively. Conspicuous increase was recorded in both the products 7.72 in crystallized candy and 6.67 in glazed candy. Saini and Dharmpal ( 1997) opined that the increase in reducing sugar was due to the inversion of monosugar. A significant increase in reducing sugar was seen after 45 days of storage in laminated pouches in both the products. But in polypropylene covers the increase in reducing sugar was found at an early period (after 30days). The type of containers (laminated pouches and polypropylene covers) does not influence the reducing sugar content of the products.

### 5.5.2.5 Changes in the Organoleptic Qualities of the Preserves from Tender Coconut water with Storage

The organoleptic qualities of the preserves (crystallized candy and glazed candy) was assessed for a period of two months, details of which are discussed below. ..

When appearance attribute of coconut preserve (crystallized candy and glazed candy) was taken into account, mean score ranged between 3.38 - 3.69. Significant difference was observed in appearance of the products. (CD-0.18) standardised. Storage periods and storage containers do not influence the mean score of the appearance in the preserves developed. Kerterz (1980) from his studies concluded the appearance of pear candy decrease as the storage period advanced.

A similar work was done by Sharma *et al.* (1991) in apple candies revealed that the method of preparation, packaging materials, storage temperature and storage time had negligible effect on colour and flavour of the candied apples.

It was also observed that the score for flavour of candies improved during three months storage and then decreased slightly.

According to Angela *et al* (1987) dehydrated blue berry products have a good texture, flavour and overall acceptability and had a shelf life of 16-64 months. Sreeja (1996) reported that flavour of cashew apple candy maintained at the maximum level up to 3 month of storage.

The mean score for colour attribute ranged between 3.80-3.42. A significant difference was observed in the colour of the products. (CD-0.15). Storage periods (CD-0.20) and storage containers (CD-0.12) were found to influence colour of the preserves. Karim and Taufik (1992) reported similar reduction in colour in chikku leather during storage. In crystallised candy the difference in colour with storage periods was noticeable only in poypropylene covers. In glazed candy the changes in colour was seen after one month of storage. The fading of colour on storage was due to the oxidation resulting in bleaching of colour pigments. Studies conducted by Kalra (1990) had revealed that heat application might stabilize the colour and texture and also helps to remove the raw taste.

The preserves stayed better in laminated pouches than in polypropylene covers. Dabhada and Khadkar (1982) reported that the apple candies could also be safely packed in polyethylene pouches for 6 months.

The mean score for flavour attribute ranged between 4.1- 4.6 and a significant difference was observed in flavour of the products standardised (CD- 0.18). With storage, flavour scores in the products significantly reduced (CD- 0.24). Sharma *et al.* (1991) reported that flavour character of apple candies improved after storage of three months and then decreased. Storage containers do not significantly affect the flavour of the products. Mean score for taste attribute was found to be high in the products under study (3.92 - 3.19) during storage. However, a significant difference was observed in taste of the products between the crystallized and glazed candy (CD - 0.16). Storage periods significantly reduced the mean score of the taste of the preserves (CD - 0.21). Containers also profoundly influence the taste of the products (CD - 0.13). The taste of product was better in laminated pouches than in polypropylene covers.

When mean texture score of coconut preserves was taken into account, it ranged between 4.0-3.35. A significant difference was observed in texture of the products (CD-0.18) standardised. Storage period and storage container significantly influenced the texture of the preserves (CD-0.23 and CD-0.15 respectively).

Overall acceptability of the preserves ranged between 3.7-3.9 with storage. As the days of storage increased, mean score for overall acceptability decreased to a significant level 2.36 to 3.28. In crystallised candy, the decrease was seen after 2 months of storage, where as in glazed candy the overall quality decrease was recorded after 1month. Tripathi *et al.* (1989) also supported the above finding. He found that organoleptic evaluation of stored amla candy and dehydrated amla depicted decrease in acceptability with storage.

Sheeja (1994) and Sreeja (1996) revealed that acceptability of papaya candy and cashew apple candy decreases with storage.

As against Sheeja (1995) reported that Karonda candy maintained good quality under ambient conditions of storage.

Containers also significantly influenced the overall acceptability of the products. In laminated covers both the candies remained better than in polypropylene covers (Fig. 10).

### 5.5.3 Assessment of Chemical, Nutritional, Organoleptic and Shelf Stability Features of the Coconut Milk Honey Developed

#### *5.5.3.1 Standardisation of Coconut Milk Honey*

Honey has been used for more than thousand years before cane sugar or beet sugar came into existence and as reported by Ghazali and Singh (1986) honey possesses prophylatic and curative properties.

In the present investigation, coconut milk honey was simulated from coconut milk, which resembles natural honey that can be used as a base for soft

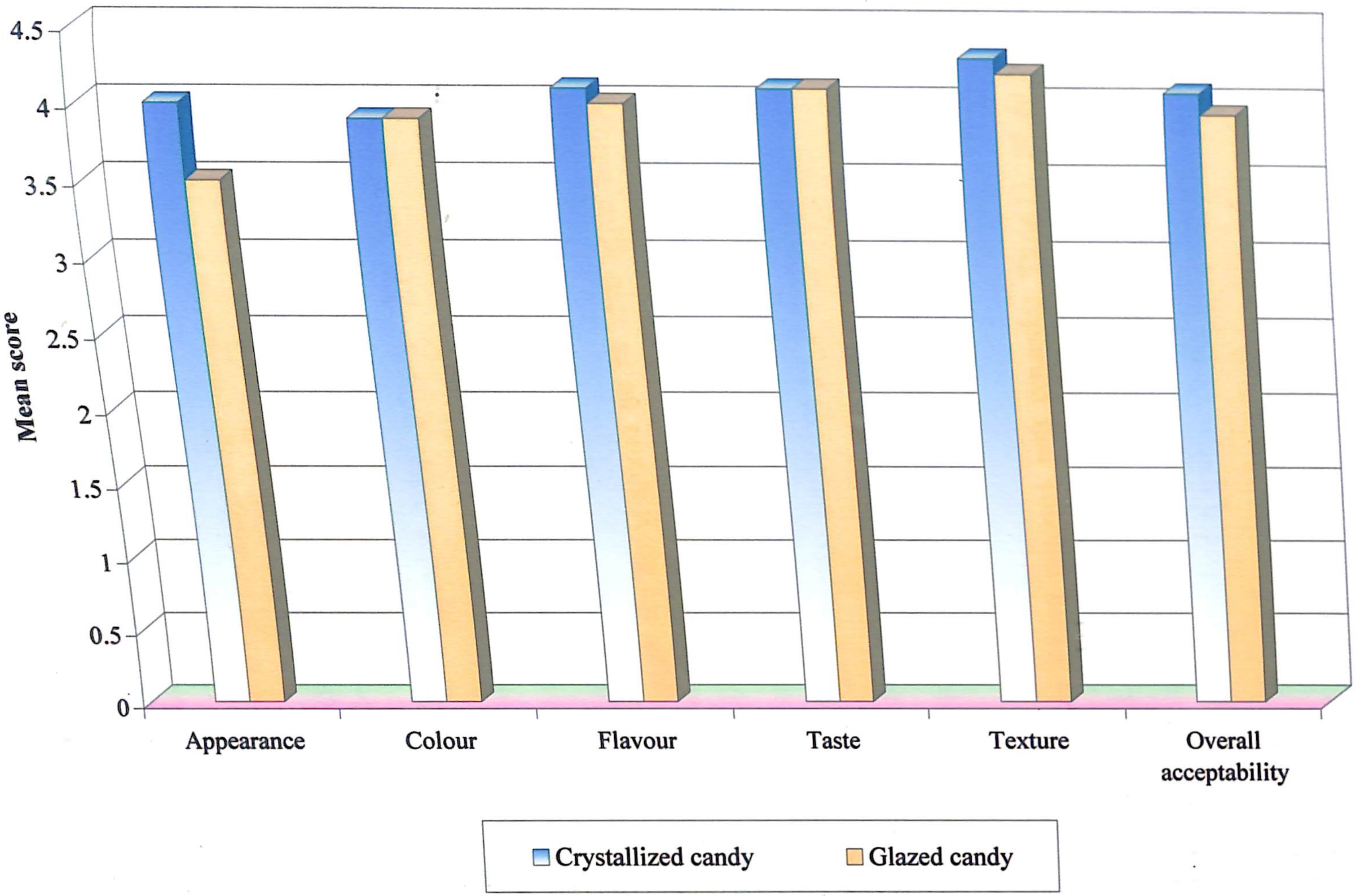



**Fig.10 Organoleptic characteristics of preserved foods**

drinks and serves as toppings for pastries, desserts and ice creams. The standardized coconut milk honey appeared as a free flowing liquid with characteristic coconut flavour.

Some similar products were attempted by earlier workers. Mabesa (1979) prepared coco spread from 2 parts coconut milk, along with one part brown sugar acidified with 1 % citric acid, which was enriched with legume flour. Sanchez (1991) developed coconut syrup, which is prepared by cooking coconut milk with an equal amount of refined sugar and di-sodium phosphate equivalent to 0.25% of the volume of the milk, until the mixture attains a TSS content of 68-70 %. Srivatsa *et al.* (1998), reported that coconut honey can be made from mature coconut water.

Davida *et al.* (1985) were of the opinion that the extracted coconut milk will not stay for more than five hours even at refrigerator condition. This necessitates the processing of extracted coconut milk immediately for making honey. The formulated honey was found to have moisture content up to 40 percent, with pH between 5.83 to 6.30 and an acidity 0.22 to 0.37 percent.

Coconut milk acts as an emulsifying (or stabilising) agent.and hence as reported by Sanchez and Rasco (1984) very little quantity of stabilizer is needed while preparing products. During standardisation, skim milk was used because the undiluted coconut milk coagulates, on heating to a temperature of about 80°C. The undiluted milk also showed phase separation on standing. Hence it was necessary to stabilize the emulsion.

### 5.5.3.2 Chemical and Nutritional Characteristics of Coconut Honey

Chemical and nutritional characteristics of coconut honeys analysed under the present study were moisture pH, acidity, reducing sugar, total soluble solids, total sugar, and nutrients such as protein, calories, fat, and minerals.

Acidity and pH were 0.37 and 6.30 in white honey as against 0.22 and 5.83 in brown honey. Total sugar and reducing sugar were 58.92 and 2.83 percent respectively in white honey and 59.85 and 3.42 percent respectively in brown honey. Sanchez *et al.* (1996) reported that coconut syrup a similar product like coconut honey from coconut milk consists of 27.80 % moisture, 3.11% fat 6.24 % protein and TSS 64.50 %. Moisture content of simulated coconut honey was high as 40 percent as against 17 percent in natural honey.

Coconut syrup a similar product like coconut honey prepared from coconut milk was reported to have moisture content of 27.8 percent (Sanchez *et al.* 1996).

Due to the higher content of sugar, honey is an energy giving food, par excellence. Calorie content was found to be 325 and 319 respectively per 100 g in brown and white coconut honey. Protein and fat content was found to be 5.35 and 13.67 g per 100 g respectively in brown honey while it was 5.09 and 12.65 respectively in white honey.

Sanchez (1998) reported that a TSS of coconut syrup prepared from coconut milk was 64.5-50.39, while that of formulated honey under present investigation was found to have a TSS of 55.45 ° Brix .

Mann et al. (1970) reported that acidity of natural honey is 0.065 – 0.25 and the acidity of formulated honey was 0.22 and 0.37 respectively in white and brown honeys. Total sugar content of the honey standardised from coconut milk was found to be 59 percent as against 83 percent in natural honey as reported by Swaminathan (1995).

Mineral contents of the honey simulated from coconut milk was recorded high, and compared to white honey brown honey stands superior. It can also serve as a source of iron as indicated by the iron content (1.71 in white honey and 1.83 in brown honey).

Protein content of the natural honey is as low as 0.1, in this context, coconut honey standardized stands distinct and superior. Apart from protein fat content of coconut honey also recorded as high as 12, and 13 percent, which could serve as a quick source of energy.

All nutritional characteristics were found to be higher in brown honey, when compared to white honey and both the products can serve as a source of nutrients. Thus coconut honey standardized from coconut milk is highly ideal and can be promoted as a product of good nutritional quality.

### *5.5.3.3* Organoleptic Characteristics of the Coconut Honey

Organoleptic evaluation conducted in honey revealed that overall acceptability scores ranged between 70 to 76 percent and brown honey stands outstanding with better sensory parameters. All the sensory parameters such as appearance, colour, flavour and taste were in favour of brown honey compared to white honey; however, consistency of honey was preferred in white honey. The better score for colour in the honey was achieved through the addition of caramelised sugar and coconut jaggery that made it look like natural honey. When coconut jaggery was added, taste of the brown honey was enhanced. With its unique flavour brown honey excelled white honey in taste attribute. The caramelised sugar and coconut jaggery added were found to interfer the consistency, and texture of the brown honey and that is why white honey achieved better score for consistency.

### *5.5.3.4* Changes in Chemical and Nutritional Characteristics of Coconut Honey with Storage

Chemical and nutritional characteristics of coconut honey were analysed after storing in glass bottles for a periods of two months. It is very much encouraging to record that there were no prominent changes in the chemical constituents except for pH, total sugar and moisture with the storage in both the honeys. Total sugar, pH and moisture were found to vary significantly between the products and decreased with the storage period. Changes in pH, total sugar and moisture were observed only after 30 days of storage in both the honeys. According to Kaushik and Nath (1994) the acidity increased from 2.47 – 3.05 %

during the 4 months storage of natural honey. They also reported that heating at 60 °C, addition of KMS and storage temperature do not affect the TSS, pH and acidity of natural honey while an increase in TSS was recorded.

When the interaction effect between the product and storage period was considered there was significant difference in total sugar and moisture, but no significant variation in pH level was observed in the products standardized with storage. The above factors account for the stability of the coconut honey standardised.

### *5.5.3.5* Changes in Organoleptic Attributes of Coconut Honey with Storage

A significant variation was observed in the coconut honey with respect to colour; flavour and taste attributes with storage while other sensory parameters such as appearance, texture and consistency remain unchanged in the products. In the present study, coconut honey was stored at ambient temperature and a change in colour attribute was noticed with the storage two months. This observation is in line with the findings reported by Gupta *et al.* (1992) who has noticed colour darkening of honey with storage temperature and period. He has also reported that the addition of KMS reduces the darkening effect of honey at room temperature. Heat treatment also reduced the darkening of honey and prevented granulation both at room temperature and 5°C for 60 and 90 days, respectively. However, no such treatment was applied in the present study. Palak and Soumy (2003) reported that the various treatments and storage period employed affected the sensory qualities of honey to a varying extent. Studies showed that natural honey stored at 40°C was not liked due to perceivable after taste. Storage of honey at 40°C resulted in deterioration of colour, increase in colloidal contents and complete inhibition of granulation. In sensory qualities, unheated honey stored at 5°C was found to be the best (Sanchez and Rasco, 1984). There was a decrease in flavour of the honey after one month of storage in the present study. The changes in sensory characteristics in brown honey were recorded after 45 days of storage while the changes appeared after 30days in white honey. When overall acceptability was taken into account, 20 – 25 % decrease in overall acceptability was recorded. However the products were acceptable to the consumers for a period of 30 days (Fig. 11).

## 5.6 ASSESSMENT OF MICROBIAL PROFILE OF THE PRODUCTS DEVELOPED FROM COCONUT WITH STORAGE

Very little work has been done in India on the microbiological aspects of product diversification of the coconut particularly with emphasis on food and beverage processing. Thomas *et al.* (1987)

Today's consumers are very much concerned about the food safety and quality of food products. Hence assessment of microbial quality of the products standardised from coconut become an essential prerequisite in the study.

The development and type of spoilage depends on several factors such as physical state of the food products, its colloidal nature, types of preparation, treatments, chemical composition, nature of containers etc. Microbiological quality assessment of beverages developed from tender and mature coconut water revealed very low counts of spoilage microorganisms, which are within the prescribed limits for food products (50,000/g).

Irene (1997) detected colonies of *Pencillium* in the RTS beverage prepared from Neelam mangoes after 4 weeks of storage. She also found that fermented test was found to be positive in the fresh RTS beverage prepared from Neelam.

On evaluation of the microbial quality of beverages from coconut under present study, beverages stored in glass containers showed higher microbial population than that stored in retort pouches and beverages stored under refrigerated condition depicted less spoilage of organisms.

In the present study, bioprocessed and simulated products, which were developed by different fermentative processes and recorded higher microbial load. However, identification of the representative bacteria isolated from the food items revealed the presence of organisms such as *Acetobacter*, *Lactobacillus* etc. which are involved in the fermentative process and not the spoilage microorganisms. Nata de soya recorded highest microbial load of 40 - 51 $\times 10^2$ cfu/g followed by

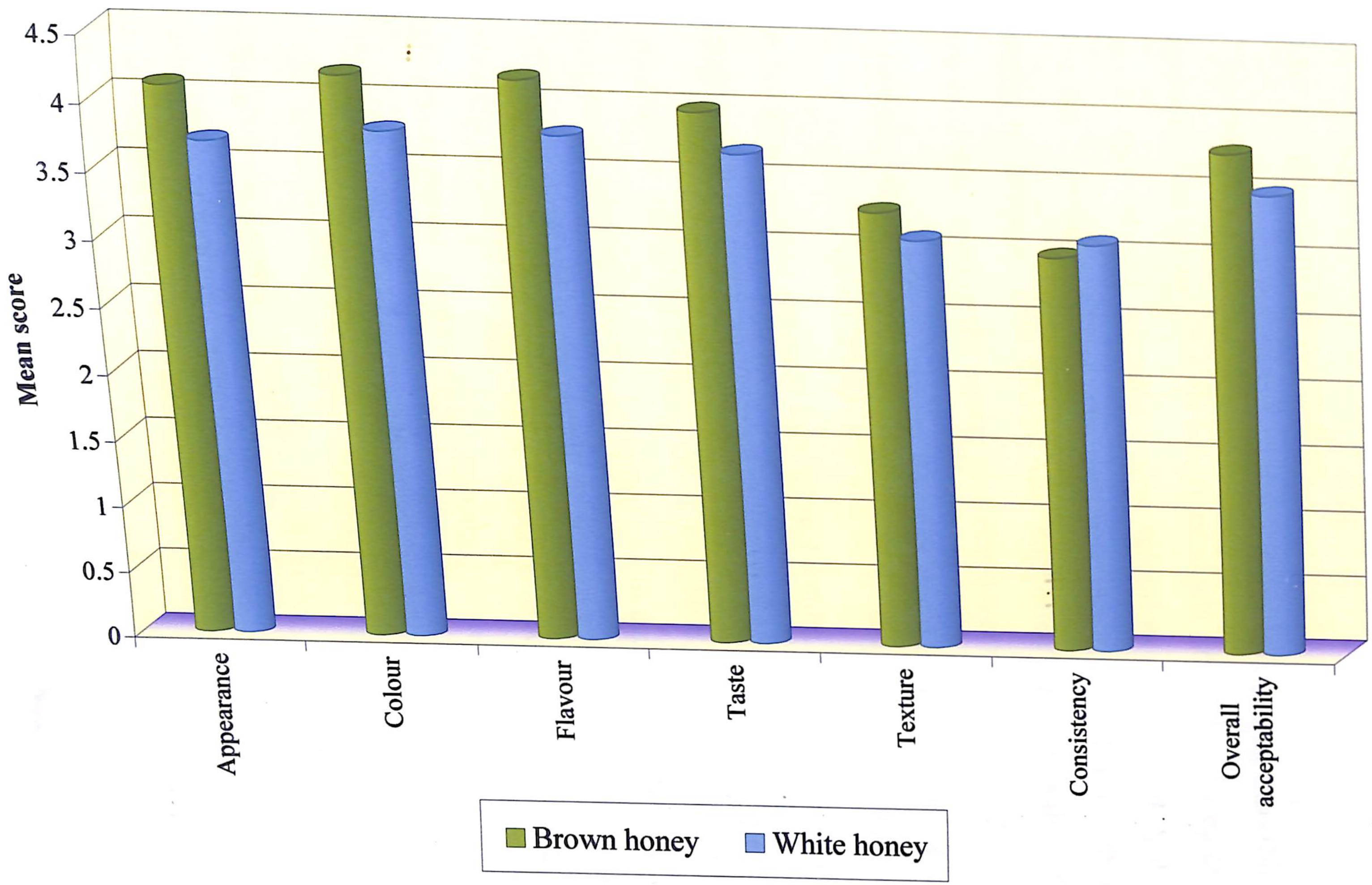



**Fig.16 Organoleptic characteristics of coconut milk honeys**

nata de pine 20 – 43 cfu/g and nata de coco 18 – 39.67 cfu/g during 60 days of storage. The nata products stored in cans showed less microbial loads than that stored in glass bottles. Pangahas (1999) pointed out that coconut milk, with its high fat content, along with protein and carbohydrate constituents, presents a rich medium for the growth of microorganism.

The moisture content is an important factor influencing microbial growth in the products. Among the various bakery products formulated based on coconut viz., biscuits and cookies recorded lowest microbial load due to low moisture content in the finished products. The load was less (7.67 – 14.33 $\times 10^2$ cfu/g) at five months of storage. This finding was supported by Elizebeth (1999) who found low microbial load in the biscuit products developed from soya.

Harrigan. and McCanu (1966) reported that *Monilia, Aspergellus, Mucor, Rhizopus, Pencillium sporoterihus* are common contaminants found in bakery items. Alien *et al.* (1986) reported that spore forming *Bacilli* is the most relevant one among the Bacilli species identified in the food products.

Negligible microbial contamination was seen in therapeutic health drink mix, when stored for two months. In malted health drink mixes microbial loads of 3 $\times 10^2$ cfu/g was detected at one month of storage period. This may be attributed to the changes occurred during milling process. However, the microbial counts recorded in these products were within the permissible limits

Coconut milk honey standardised in the present study, was not found to support the development of spoilage microbes due to the high sugar content and acidity. So also the candies developed from tender coconut kernel, which have high sugar and low moisture content. Sheeja (1995) reported absence of micro-oganism in karonda candy, jelly, canned karonda and wine during storage.

According to ISI specification stated in SP18 Part XI 1981 (ISI 1981), prescribed bacterial count per gram should not exceed 50000 and the count for yeast and mold should not exceed 10/g. (Nimmy 1996). In the present investigation, none of the products developed from coconut exceeded the above prescribed limits.

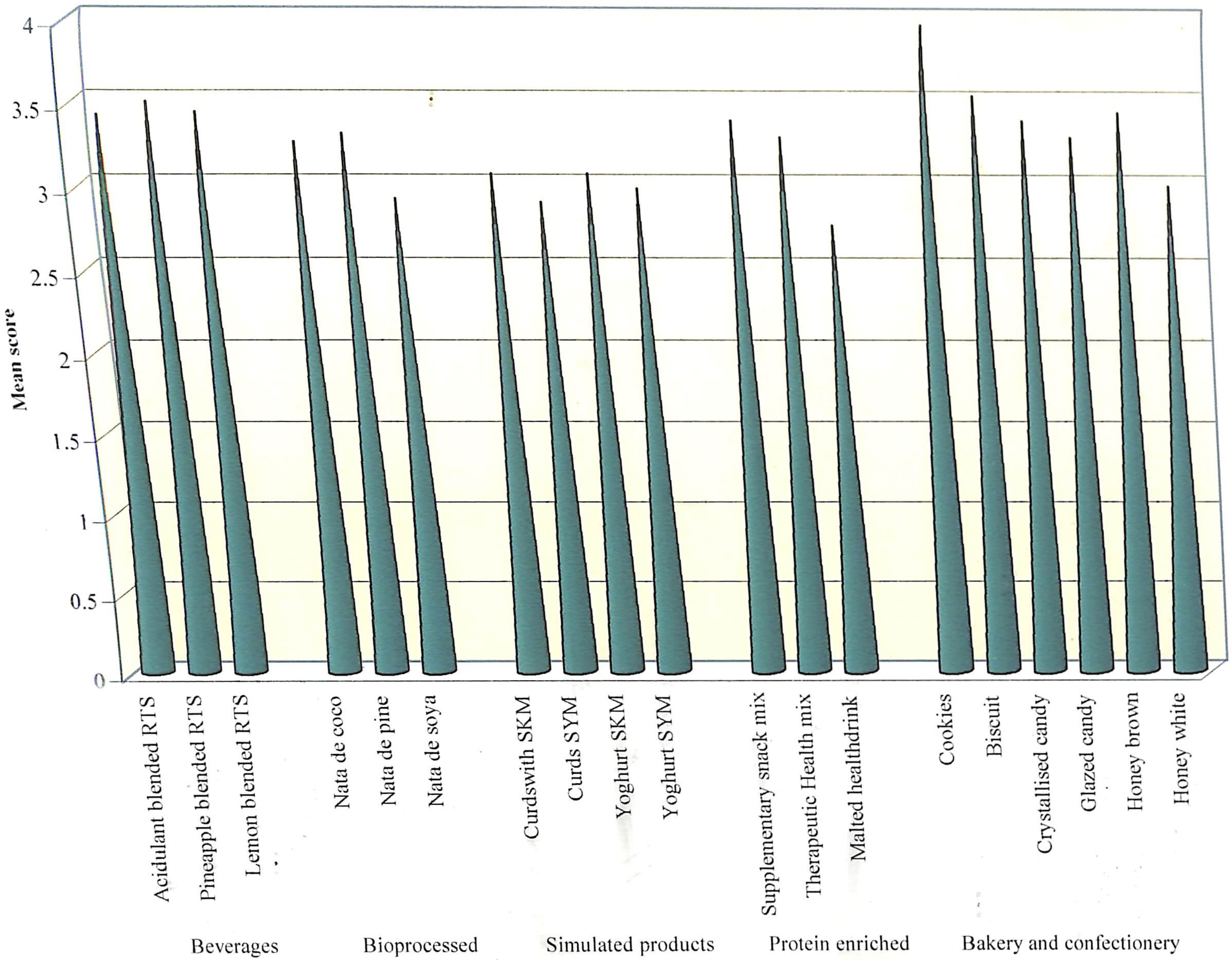



**Fig.12 Consumer acceptance score**

blended beverage. Both the beverages were superior to control beverage. Blending with other fruits with tender coconut water imparted special colour, flavour and taste of the RTS formulated, and was found to be successful. Pineapple and lemon are available throughout the year, and are cheap and hence form an ideal blend in the formulation of beverages.

With respect to bioprocessed products, nata de pine secured highest mean score for overall acceptability followed by nata de coco. The flavour of pineapple helped to retain the flavour even after processing. Nata de soya was less acceptable to the consumers. This may be due to the beany taste of the soya, which gave lower score.

Coconut curd as well as coconut yoghurt was found to be less acceptable among the consumers when compared to other products developed in the study. In both categories of products, coconut milk supplemented with skim milk products scored better than those supplemented with soymilk.

As expected consumers in general were in favour of the baked products and in the present study both cookies and biscuits standardised incorporating coconut was found to be very much acceptable to the consumers.

Consumers found to welcome glazed candy and crystallised candy standardised and both the products were acceptable to them with higher inclination towards glazed candy. Similarly coconut milk honey standardised was also outstandingly acceptable to the consumers with a greater liking towards brown honey.

Protein enriched supplements, and the health drink mixes developed also found to score better consumer appeal (Fig. 12).

Consumer preference of 19 products standardised from coconut was evaluated among 100 consumers, result indicated that out of three beverages, consumers preferred pineapple blended RTS as the best (91.2), followed by Lemon blended RTS (84.8) and Acidulant blended RTS (70.9). It was also found

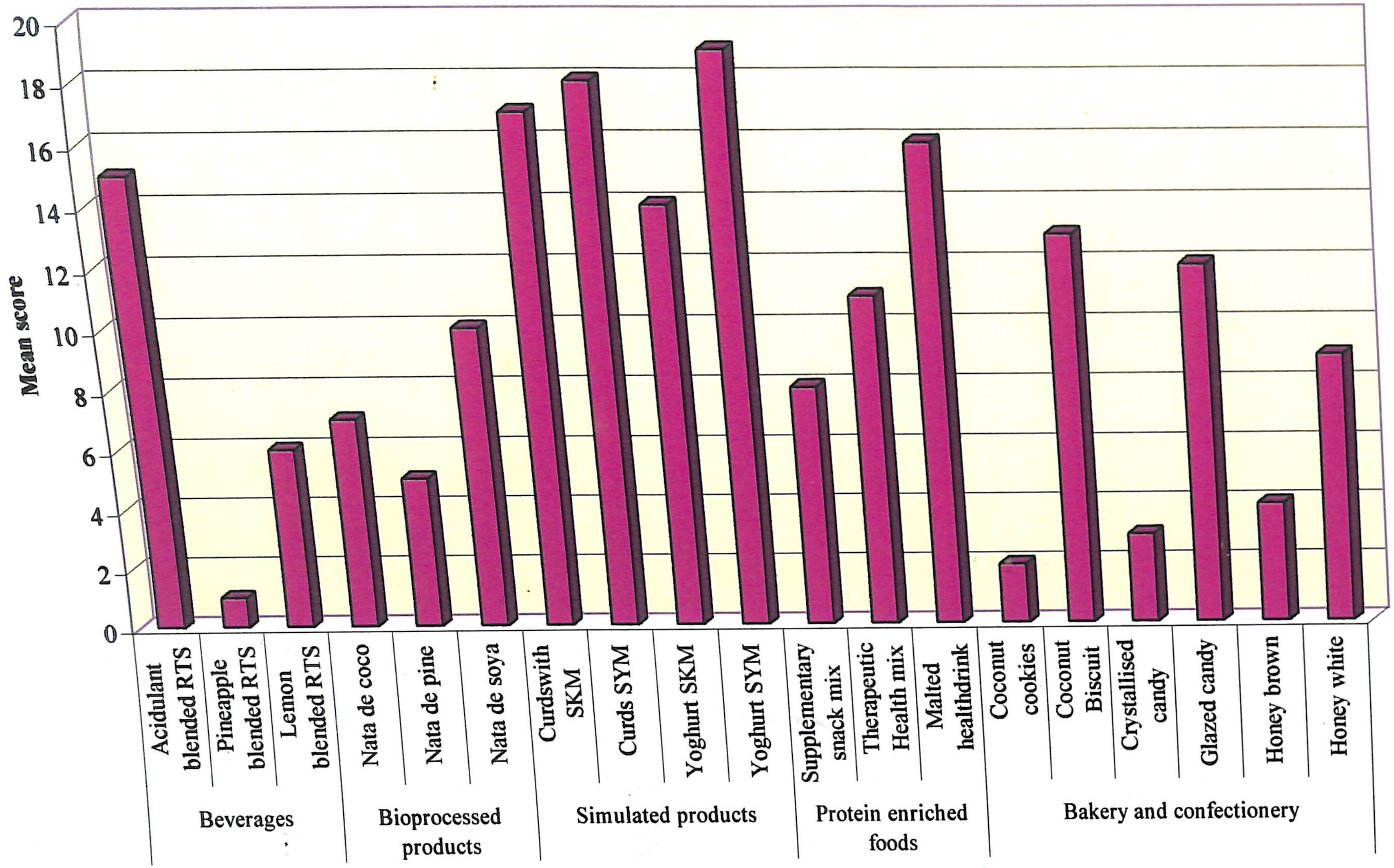



**Fig.13 Rank order of preference scores**

that pineapple blended RTS was the most preferred among all the products standardised as per the rank order.

Bakery and confectionery products were the next consumer preferred items developed from coconut. Percentage score for cookies was 91.1 and ranked second among the products. Crystallised and brown honey scored 89.7 and 87.3 respectively with the rank orders third and fourth.

Among bioprocessed foods, Nata de pine was found more preferred with a percent score of 86.1. Among all the products standardized nata de pine ranked fifth.

Consumer preference score of the protein-enriched foods indicated that supplementary snack mix (81.8) was preferred over the other two. Therapeutic Health mix and health malted drink were preferred in order of 11$^{th}$ and 16$^{th}$ rank respectively.

Simulated products were found to be less preferred as the individual rankings were between 14 to 19 (Fig. 13).

5. 8 CONFIRMATION WITH FPO/ IS STANDARDS

The coconut based value added products developed in the present study were analysed for specifications prescribed by BIS.

FPO standards prescribe a minimum of 10 per cent total soluble solids in the final product of RTS beverage. Products confirm with FPO standard whereas when acidulant alone was added minimum TSS prescribed is not attained. Plain tender coconut water has a TSS of only 5.0. In this context, it can be pointed out that tender coconut water differs from fruit juices in different aspects, and separate standards have not being fixed for tender coconut RTS beverages.

The minimum percentage of fruit juice content prescribed by FPO in the final product is 10. The percentage of fruit juice content present in pineapple blended, lemon blended and acidulant blended RTS was well above FPO standards. Since the RTS's were prepared from tender coconut water without dilution with water. Therefore the minimum percentage of fruit juice in the final product is also well above the FPO specification.

Coconut yoghurt and coconut curds developed in the study found to have a fat content percent and solid not fat and acidity was as stated in different studies.

The supplementary mix developed based on coconut satisfies the limits prescribed by ICDS. It provides 347 calories and 13.80g proteins per 100 gm.

As per the ISI type test administered for biscuit and cookies (IS:1667-1981), the estimated value of the moisture content of cookies and biscuit was approximately reaching the ISI specification.

FPO prescribe a minimum total sugar and reducing sugar of 70 and 55 percent in the preserved products. The minimum percentage of total sugar and reducing sugar in the final preserved product is also well above the FPO specification.

Standards for 'nata' products and coconut honey was not available, hence no comparison could be made in the products developed.

## 5.9 ASSESSMENT OF AND PRODUCT YIELD AND COST EFFECTIVENESS

### 5.9.1 Product Yield Ratio of the Coconut Products Standardised

Raw material cost per kg of the finished product is another important aspect to be considered while developing new products. Hence in the present investigation products standardised form the coconut was assessed in terms of product yield.

Assessment of product yield of the coconut products developed indicated that simulated products recorded higher yield than other products developed since the ratio of raw materials to the finished products was more than one.

Next to simulated products, beverages recorded good yield potential followed by bakery products, confectionary products and health drinks. According to Mehta *et al.* (2002) in the preparation of juice concentrate, the solid content and yield of juice are equality important.

Nirmala (2002) remarked that the weight loss during processing should be minimum in order to facilitate maximum output.

Bioprocessed products as well as coconut honey recorded comparatively lower yield since finished products reached only nearly half the quantity of the raw materials. Product yield recorded was also found to be low for coconut cookies.

### 5.9.2 Cost Effectiveness

Economic feasibility is an important factor in the development of any new product.

Kumbhar and Singh (1991), the cost of processed product depends on the purchase of the raw material, cost involved in processing, packaging and marketing and profit margin set by the industry.

Amla (1993) opined that while developing new food products the cost is to be kept at minimum. Nagarjan (1993) remarked that the strategy for the development of the food products is to be based on affordable price and cost effectiveness.

Cost benefit analysis was carried out to assess the expenses incurred for obtaining different finished products from coconut.

The cost of production of one liter of beverage was found to be Rs. 19.80 to Rs. 27.5 being highest for pineapple blended RTS and lowest for acidulant blended RTS. Among the bioprocessed products Nata de pine was found to cost Rs. 44.0 /kg, while nata de coco cost the lowest (Rs.27.5).

Cost of production was found to be comparatively low for simulated products and ranged between Rs. 9.9 to Rs. 12.1/litre in curds and Rs. 11 to Rs. 13.1 in yoghurt. The major raw material used was coconut which at the level of study was at its minimum.

Prema (1999) suggested that the supplementary foods for the young children meant for low-income strata of the society must necessarily be low in cost. Supplementary base mix formulated in the present study was only Rs. 50.38/kg. When five supplementary foods developed by Kerala Agricultural University were evaluated, it was found that rice based mix was the cheapest (Rs. 20/kg) and banana based mix (Rs 75/kg) was found to be the costliest. Ashlesha and Vali (1997) have developed wheat germ based supplementary food formulation with wheat germ, green gram and ragi with relatively low cost of Rs 3.92 to Rs 4.43 per 100g when compared to other market samples.

Protein enriched health drink powders developed from coconut were found to be very expensive as the cost ranged Rs 231 to Rs. 242 per kg. Base materials used were coconut milk powder, skim milk powder and condiments which are comparatively expensive. According to Desikachar (1982), addition of milk solids could increase the nutritive value of supplementary foods and make them nutritionally complete. Dijkhuizen (2000) has of the view that the addition of skim milk powder increases the cost but greatly improves the flavour.

Bakery products developed incorporating coconut was found to cost Rs 38 to Rs 44/kg while coconut milk honey was found to cost Rs 40 to Rs. 48 per litre.

In this context, it is pertinent to record that the cost of production of all the products developed under the present investigation will be less with bulk production and also at commercial level.

# Summary

# 6. SUMMARY

The present study entitled "Developing diversified and value added products from coconut (*Cocos nucifera. L*)," is aimed at developing beverages, bioprocessed products, simulated dairy milk products, protein enriched products, bakery and confectionary products by utilising coconut water (tender as well as mature), coconut milk, coconut kernel (tender as well as mature) as well as with desiccated coconut and coconut powder. The products developed were studied for its chemical, nutritional, organoleptic and shelf-life qualities along with packaging, consumer acceptance preference and cost effectiveness.

In the present study, tender coconut water was utilised for the formulation of beverages, with and intention of more popularity longer shelf life, lesser cost and better nutritional quality.

Tender coconut water was blended with acidulants, lime and pine apple juices in order to obtain different varieties of beverages with better sensory features and nutritional characteristics.

Acidulant added RTS had better shelf life,while pineapple blended beverage was organoleptically superior and both lemon and pineapple blended RTS were nutritionally sound. Pineapple blended RTS and lemon blended RTS scored better for colour, appearance, flavour and taste compared to acidulant added beverage and control. Flavour attribute was also in favour of blended beverages. When acidulants were added to the product, the clarity was masked and imparted less appeal to the product moreover pineapple and lemon juice blended well with tender coconut water and gave a clear and uniform RTS. Overall acceptability score of standardized coconut water beverages ranged between 3.9 – 4.4 indicating 78 - 88 % acceptability.

Data on the changes in the chemical constituents in formulated beverages indicated that there was a significant difference in pH, TSS, reducing sugar and

TS, whereas no variation was seen in acidity with storage periods. pH and TSS were found to decrease with storage periods were as acidity, reducing sugar and total sugar increased. Over a period of 60 days, the pH level of the formulated beverages decreased irrespective of the storage conditions, containers and storage periods. The beverages stored at refrigerated condition were found to depict the changes slowly when compared to beverages stored at ambient condition.

In all the beverages, storage containers (glass and retort pouches) and storage conditions (refrigerated and non-refrigerated) were found to show an impact on the chemical constituents of the products. Blended beverages stayed well both in glass and retort pouches whereas acidulant and control beverage stored better in retort pouches. All the beverages prepared from tender coconut water under study stayed well in refrigerated condition.

Assessment of changes in organoleptic qualities of the beverages indicated that there was a significant difference in flavour, taste and clarity attributes in beverages formulated with storage. Storage conditions influenced the mean score of all the sensory attributes of the beverages.

With duration of storage there was a decrease in scores for all the sensory attributes in the products except for clarity in acidulant beverages. The changes were conspicuous after one month of storage irrespective of storage containers (CD-0.19). As far as storage containers are concerned there was significant difference in all the sensory attributes. Organoleptic qualities of acidulant blended beverages were better retained in retort pouches than in glass containers whereas pineapple and lemon blended beverages remained well in glass containers.

Taking into account of the overall acceptability of the beverages, Pineapple blended coconut beverage adjudged to be the best even with storage. Lowest acceptability was recorded for acidulant blended coconut beverage.

Based on the findings it could be concluded that coconut blended beverages were excellent and found to have a shelf life stability of 60 days.

Simple technology of production of 'nata' which is a bioprocessed product was standardised under Indian climatic condition in the present study where three different substrates namely, coconut water, coconut water with pineapple extracts and coconut water with soya milk using *Acetobacter aceti subsp. Xylinium* as starter culture. Physico-chemical characteristics of the three types of nata products standardised indicated that pH ranged from 2.9 to 3.8, acidity 0.4, total soluble solid 9.2 to 9.3° Brix, total sugar 8.5 to 11.7 percent, reducing sugar 3 to 3.8 percent, and fiber from 1.09 to 1.25 percent. Product yield of 'nata' was found to be 40-55 percent. Highest organoleptic score was attained for 'nata de pine' and the lowest for 'nata de soya'. Overall acceptability score of the products indicated well acceptance of the product among the consumers.

The products were stored in cans and glass containers for a period of 6 months. TSS and pH in the stored nata declined with storage where as acidity, reducing sugar and total sugar enhanced. Coconut water with soya milk substrate gave higher yield, followed by coconut water with pineapple extract and plain coconut water. Shelf stability of the product was found to be six months both in glass bottles and cans. However a slight change in colour was noted in nata stored in cans.

Two types of simulated products viz., coconut curd and coconut yoghurt were standardised from coconut milk in the present study.

When compared between the two curds, coconut curd with soya milk combination was found to have higher pH, acidity, reducing sugar and moisture. It was also found rich in protein, fat and iron. Viscosity which gives the body of the product was found to be in favour of coconut curd made from skim milk combination. Coconut curds with skim milk powder showed higher level of TSS and total sugar and in minerals when compared to its counterpart.

Among the two types of yoghurt, coconut yoghurt with soya depicted high value for acidity, reducing sugar, total soluble solids, total sugar, and moisture. Nutrients like protein, fat, iron and constituents like solid not fat and viscosity was also recorded more in soya-enriched yoghurt.

Organoleptic evaluation of the simulated products indicated that the overall acceptability of the products ranged between 4.0 to 4.5 with a percentage acceptability of 80 to 88.

Conspicuous changes were noted in the constituents such as acidity, TSS and protein where as other constituents remained unchanged.

Products were stored in steel and plastic containers and assessed periodically up to 4 days. Storage quality was found to be better in steel container than in the plastic containers for both the simulated products.

No significant difference was observed in overall acceptability between the products with storage. When overall acceptability of the product was considered, coconut curd with skim milk scored better in both plastic and steel containers.

Assessment of chemical, nutritional, organoleptic and shelf stability features of the protein enriched supplements developed from coconut was carried out. Moisture content was recorded as 13.42 percent, while that of protein was 13.80 g. Energy and fat content of the base mix was found to be 341 kcal and 15.21g. Fibre, free fatty acid and peroxides were reported to be 1.5 percent, 0.67 percent and 0.66 meq respectively. Minerals viz., calcium, phosphorous and iron was recorded as 363 mg, 335.67 mg and 3.13 mg respectively.

With respect to organoleptic quality of the supplementary base mix, it was indicated that overall acceptability was recorded 3.8 out of 5.0 with 76 % acceptability among the panel judges.

Supplementary base mix was stored in laminated and polypropylene covers and analysed for shelf stability for a period of 30 days, during which periodic monitoring was carried out.

Moisture content increased from 13.04% to 14.07% when stored for 30 days. When base mix was stored in polyethylene pouches, the moisture level increased considerably towards the end of two months, whereas in laminated pouches increase was less. The moisture level was steady till one month of storage and after which a gradual increase was noticed.

With respect to free fatty content and peroxide value of supplementary base mix, free fatty acid content of the base mix increased with storage periods. Other chemical components remained unchanged in the base mix till the end of storage period of two months.

A decrease in freshness of the product with storage period was observed in the base mix. Laminated pouches maintained the freshness for a longer period when compared with polypropylene covers. Changes were seen in all the attributes with the storage.

A significant difference was observed in mean score of consistency with storage in the base mix. (CD-0.39). The crispness of the supplementary mix decreased with storage. Storage containers affected the crispness of the product (CD-0.24).

Storage periods and containers also influenced the mean score of the overall acceptability of the supplementary base mix. Product stored in polypropylene cover displayed poor sensory qualities when compared to product stored in laminated pouches. The overall acceptability of the product showed that the product could be stored for a period of one month in polypropylene cover and more than one month in laminated pouches.

Two health drink mixes were standardized from coconut milk powder in the present investigation. Therapeutic health drink was prepared by adding condiments and coconut jaggery, while Malted health drink was prepared from malted cereals. Moisture content was 8.58 in therapeutic health drink and 9.09 percent in malted drink. The health drink II had higher level of moisture, protein, fat, fibre, calcium, free fatty acids and peroxide value when compared to health drink I. The energy level was on par.

Average mean score obtained by the judges indicated that the overall acceptability was above 70 percent in both the health drink mixes developed. Taste parameter scored 4.0 in therapeutic mix as against 3.2 in malted mix. Flavour scores were also in favour of therapeutic mix (3.9 and 3.5 respectively in mix I and mix II) whereas for appearance and colour was better appreciated in malted mix. As obtained by the CD value sensory features with respect to texture, flavour and taste vary significantly in the products standardised. Overall performance of therapeutic mix was higher compared to malted health mix.

Moisture content increased from 7.72-7.89 in therapeutic health drink mix when stored for 6months and while enhanced from 8.13 –10.57 in malted health drinks respectively.

Free fatty content of the Health drink mix ranged from 0.1 to 0.47% and 0.23 to 0.52% respectively in laminated pouches and polypropylene pouches respectively. Change were significant after 2months in the products stored in polypropylene pouches (0.52%) where as in laminated pouches changes appeared after six months of storage.

Peroxide value increased from 0.3 to 1.06mg in polypropylene covers, whereas it increases from 0.22 to 0.91mg in laminated pouches.

When data was pooled together, it was seen that there was significant difference in moisture content and free fatty acid level in the product with storage period and storage media.

Two bakery products viz., coconut biscuits and cookies basic ingredients selected were standardized under the present investigation.

Moisture content of coconut cookies was higher than the coconut biscuits. Formulated bakery products were found to be nutrient dense, with 356 and 390 kcal respectively in cookies and biscuits. Protein and fat contents was also recorded more in biscuits. Both the products developed contain appreciable amount of fibre. Minerals namely calcium, Phosphorus and iron was found to be 60.33mg 242.33mg and iron 1.70mg in cookies as against 70.63mg 282.63mg and 1.59g respectively in biscuits. Free fatty acid and peroxide content present in the products were also accounted as these factors influence the keeping quality of the bakery products. Free fatty level was 0.41and 0.8 respectively in cookies and biscuits while that of peroxide value was recorded as 0.65 and 0.77 respectively.

Significant difference in the nutritional and chemical constituents was detected in the bakery products developed incorporating coconut constituents.

Sensory evaluation carried out in the bakery products indicated that organoleptic features such as colour, flavour and doneness were highly in favour of cookies while taste character was rated maximum in biscuits. Based on the individual parameters overall acceptability accounted to be excellent in cookies, closely followed by biscuits indicating well acceptance of both products. Since the coconut has its own flavour additional flavours are not needed.

During storage, coconut biscuits and coconut cookies depicted gradual changes in moisture, free fatty acid and peroxide values. Low moisture content is highly important for longer storage period.

Changes with respect to moisture, free fatty acid and peroxide were monitored and changes were found after 15 days in the products stored in polypropylene covers whereas in laminated pouches changes appeared after 30 days thus indicating better shelf life stability in the laminated pouches. Moisture content was found to be more in coconut cookies ($T_1$) after the storage when compared to coconut biscuits ($T_0$). Peroxide value was high in coconut biscuits on storage. Though there was gradual increase in free fatty acid with the storage periods, there was not much difference between the products stored in polypropylene and laminated pouches.

Coconut cookies ($A_1$) scored better for attributes like appearance, colour, flavour and doneness. When overall acceptability of the products was considered, both coconut biscuit and coconut cookies scored high however cookies excelled.

The change in organoleptic characteristics was conspicuous after one month of storage in polypropylene covers and after two months in the laminated pouches. The products remained crisp and excellent in laminated pouches. However significant difference in flavour attribute was recorded between the products with storage. Though flavour scores also decreased with passage of time.

Tender coconut kernel forms a good base for the formulation of different types of candies. Crystallised candy and glazed candy were successfully standardized from coconut kernel.

Moisture content of crystallized candy was 17.73 per cent as compared to 20.87 percent in glazed candy.

Total soluble solids, total sugar and reducing sugar were 69.68, 75.01 and 8.03 percent respectively in crystallized candy whereas it was 66.36, 65.66 and 6.70 percent respectively in glazed candy.

Among the nutritional characteristics calorie content was found to be rather high and recorded 352 kcal in crystallized candy as against 249 in glazed candy. The fat content of the crystallized and glazed candy was found to be similar and recorded as 5 g per 100 g. In both the products, fiber content was more and it was 3.08 in crystallized candy and as against 2.5 in glazed candy. As inferred from the CD values, characteristics such as moisture, TSS, TS, reducing sugar and calories vary significantly with the products, whereas other constituents such as protein and fat were found to be similar.

Organoleptic evaluation conducted in preserves developed revealed that overall acceptability scores ranged 4.08 to 3.94 indicates 78 to 80 percent acceptance among the judges.

Crystallised candy adjudged to be superior to glazed candy as indicated from the scores. As inferred from the CD value, the organoleptic characteristics in crystallized and glazed candy were significantly different in all the attributes.

Preserves were stored in polypropylene and laminated pouches for a period of two months during which chemical and nutritional characteristics were analysed periodically, chemical constituents such as moisture, TSS, TS and reducing sugar were found to alter with storage.

An increase in moisture level was noticed after 30 days of storage. The type of containers (laminated pouches and polypropylene covers) does not influence moisture of the products. The total soluble solid content decreased with the storage period. Higher moisture content was found in candies stored in polyethylene pouches.

Duration of storage had a profound effect on moisture content of the candies, which decreased with increase in storage time.

Decrease in total soluble solids was noticed after 30 days of storage in candies. The type of containers (laminated pouches and polypropylene covers) also influenced total soluble solids content of the product. While the reducing sugar increased with the storage period (CD - 0.026). Conspicuous increase was recorded in both products. Significant increase in reducing sugar was seen after 45 days of storage in laminated pouches in both the products. But in polypropylene covers the increase in reducing sugar was found at an early period (after 30days).

Overall acceptability of the preserves ranged between 3.7-3.9. As the days of storage increased, mean score for overall acceptability decreased to a significant level. In crystallised candy, the decrease was seen after 2 months of storage, where as in glazed candy the overall quality decreased after 1 month. Containers were also significantly influenced the overall acceptability of the products. Laminated covers were recommended for the storage.

Two types of coonut milk honey were standardized under the present investigation. The formulated honey was found to have a moisture content upto 40 percent, with a pH between 5.83 to 6.30 and an acidity 0.22 to 0.37 percent.

Protein content of the natural honey is as low as 0.1, in this context, coconut honey standardized stands distinct and superior with higher protein content (5.09 - 5.35). Apart from protein fat content of coconut honey also recorded as high as 12, and 13 percent, which could serve as a quick source of energy.

All nutritional characteristics were found to be higher in brown honey, when compared to white honey and both the products can serve as a source of nutrients. Thus coconut honey standardized from coconut milk is highly ideal and can be promoted as a product of good nutritional quality.

Organoleptic evaluation conducted in honey revealed that overall acceptability scores ranged between 70 to 76 percent and brown honey stands outstanding with better sensory parameters. All the sensory parameters such as appearance, colour, flavour and taste were in favour of brown honey compared to white honey; however, consistency of honey was preferred in white honey. The better score for colour in the honey was achieved through the addition of caramelised sugar and coconut jaggery which made it look like natural honey

Chemical and nutritional characteristics of coconut honey were analysed after storing in glass bottles for a periods of two months. It is very much encouraging to record that there were no prominent changes in the chemical constituents except for pH, total sugar and moisture with the storage in both the honeys. Total sugar, pH and moisture were found to vary significantly between the products and decreased with the storage period. Changes in pH, total sugar and moisture were observed only after 30 days of storage in both the honeys.

Significant variation was observed in the coconut honey with respect to colour, flavour and taste attributes with storage while parameters such as appearance, texture and consistency remain unchanged in the products.

The changes in sensory characteristics in brown honey were seen after 45 days of storage while changes appeared after 30days in white honey. When overall acceptability was taken into account, 20 – 25 % decrease in overall acceptability was recorded. However the products were acceptable to the consumers for a period of 40 days.

## Microbial evaluation of all the products

The microbial counts were within the permissible limit. Bioprocessed and simulated products, which are developed by different fermentative processes recorded higher microbial load. Identification of the representative bacteria isolated form the food items revealed the presence of organisms such as *acetobacter, lactobacillus* which are not harmful microorganisms.

When consumer preference was taken into consideration, the pineapple blended RTS was preferred as the best among all the products while youghurt with soya milk was the least preferred.

Products developed were compared with the ISI type tests and FPO standards and found that the products exhibited prescribed quality and were incomparable with the specifications.

Cost of production of the 19 products developed under the present investigation ranged from Rs. 9.02 to Rs 242.0, being coconut curd with soya milk the cheapest and therapeutic health drinks the most expensive.

When assessment of the product yield of the product developed indicated that simulated product recorded best yield, while bioprocesssed product as well as coconut honey recorded comparatively lower yield.

Based on the in depth investigations carried out in the present study the following recommendations have been brought out.

- Technologies developed need to be transferred and popularised.
- Upscaling or refinement of some of the products is needed.
- Product diversification achieved should be taken up for alleviation of unemployment problems in the country.
- Mass production will bring down the cost further. Hence small scale and cottage industries must be encouraged to take up the production and sales.

There is an excellent possibility for the value added diversification of the coconut products. Analysis of the data of consumer acceptance indicates that there is a bright future for the diversification of coconut products in India. The works in that direction will considerably mitigate the apprehensions of the coconut growers and unemployment problem. The ever increasing demand for food, drinks, nutrition, medicine, and ecofriendly aethetic products substantiate the need of diversification.

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# *Appendices*

**Appendix – I**

# PROCEDURE FOR MAKING COCONUT PRODUCTS

## Formulation of supplementary base mix

| **Ingredients** | |
|---|---|
| Coconut gratings (Roasted and powdered) | 30 per cent |
| Soyabeans (malted and powdered) | 10 per cent |
| Groundnuts (roasted and powdered) | 10 per cent |
| Rice (puffed and powdered) | 15 per cent |
| Coconut jaggery | 35 per cent |

**Method of preparation**

1. Coconut gratings are roasted over a medium flame till golden brown.
2. Groundnuts are roasted and deshelled.
3. Puffed rice, malted soyflour and powdered jaggery are added to the above and pulverized to a fine powder.

## Formulation of therapeutic drink mix

| Ingredients | |
|---|---|
| Coconut milk powder | 35 per cent |
| Skim milk powder (cow's) | 15 per cent |
| Coconut palm jaggery | 20 per cent |
| Coriander powder | 10 per cent |
| Pepper | 5 per cent |
| Dried ginger | 5 per cent |
| Cardamom | 2.5 per cent |
| Cumin seeds | 5 per cent |
| Tulsi powder | 1.0 per cent |
| Fenugreek | 1.5 per cent |

**Methods of preparation**

1. All the condiments are roasted, powdered and sieved separately.
2. Coconut skim milk powder and poswdered coconut jaggery are added to the above powder and stored in polythene and laminated covers.
3. Wheat and barley are malted and powdered.
4. Roasted soyaflour, arrowroot powder, glucose, coco powder are added to the coconut milk powder to the coconut milk powder and skim milk powder and stored in laminated and polythene pouches.

## Composition of malted health drink mix

| Ingredients | |
|---|---|
| Coconut milk powder | 40 per cent |
| Skim milk powder (cow's) | 15 per cent |
| Malted wheat flour | 20 per cent |
| Malted barley powder | 8 per cent |
| Defatted soya flour | 5 per cent |
| Glucose | 4 per cent |
| Arrowroot powder | 4 per cent |
| Coco powder | 4 per cent |
| Sorbitol | 0.5 per cent |

## Composition of coconut biscuit

| Ingredients | |
|---|---|
| Refined flour | 120g |
| Desiccated coconut | 60g |
| Fat | 120 gm |
| Powdered sugar | 120 gm |
| Lemon juice | 3 tsp |
| Coconut Honey | 1 tbsp. |

**Method of preparation**

1. Cream butter and sugar until fluffy
2. Add in this order sifted maida, desiccated coconut, honey and lemon juice to the above mixture
3. Mix gently to get a light batter
4. Pre-heat oven at 350°F for 10 minutes
5. Take a spoonful of batter and place it on the greased tray leaving gap in between and
6. Bake approximately for 12 min or until lightly golden on top.

## Composition of the coconut cookies

| Ingredients | |
|---|---|
| Refined flour | 500 g |
| Fat | 250 g |
| Sugar | 250 g |
| Roasted coconut gratings | 400 gm |
| Granulated sugar | 150 gm |
| Milk for mixing. | |

**Method**

1. Sift flour twice.
2. Mix all the ingredients together with milk to form a homogenous dough.
3. Break the dough into small pieces; give round shape and place it over the baking sheet an inch apart.
4. Bake at 350° F for 15-20 minutes.

# Appendix – II

## Evaluation card for triangle test

In the triangle test three sets of sugar solution of different concentration were used. Of the three sets two solutions were of identical concentrations and the members were asked to identify the third sample which is of different concentration.

Name of the product:

Note: Two of the three samples are identical identify the odd sample

| Sl. No. | Code No. of Samples | Code No of identical samples | Code No. of the odd samples |
|---|---|---|---|
| 1. | XYZ | | |
| 2. | ABC | | |

## Appendix – II

### Evaluation card for triangle test

In the triangle test three sets of sugar solution of different concentration were used. Of the three sets two solutions were of identical concentrations and the members were asked to identify the third sample which is of different concentration.

Name of the product:

Note: Two of the three samples are identical identify the odd sample

| Sl. No. | Code No. of Samples | Code No of identical samples | Code No. of the odd samples |
|---|---|---|---|
| 1. | XYZ | | |
| 2. | ABC | | |

## Appendix – III

# SCORE CARDS ADMINISTERED

## Score Card for Beverages from Coconut Water

Product:............

Dated:..............

| | Criteria | Score | A | B | C |
|---|---|---|---|---|---|
| 1. | **Appearance** | | | | |
| | Very good | 5 | | | |
| | Good | 4 | | | |
| | Fair | 3 | | | |
| | Poor | 2 | | | |
| | Very poor | 1 | | | |
| 2 | **Colour** | | | | |
| | Very acceptable | 5 | | | |
| | Acceptable | 4 | | | |
| | Slightly acceptable | 3 | | | |
| | Neither acceptable nor unacceptable | 2 | | | |
| | Unacceptable | 1 | | | |
| 3 | **Flavour** | | | | |
| | Very pleasant | 5 | | | |
| | Pleasant | 4 | | | |
| | Neither pleasant nor unpleasant | 3 | | | |
| | Unpleasant | 2 | | | |
| | | 1 | | | |
| 4 | **Taste** | | | | |
| | Excellent | 5 | | | |
| | Very good | 4 | | | |
| | Good | 3 | | | |
| | Fair | 2 | | | |
| | Poor | 1 | | | |
| 5 | **Clarity** | | | | |
| | Sparkling clear | 5 | | | |
| | Clear | 4 | | | |
| | Slightly clear | 3 | | | |
| | Slightly cloudy | 2 | | | |
| | Very cloudy | 1 | | | |
| 6 | **Overall acceptability** | | | | |
| | Like extremely | 5 | | | |
| | Like very much | 4 | | | |
| | Likes moderately | 3 | | | |
| | Dislike slightly | 2 | | | |
| | ... extremely | 1 | | | |

Tested by Name & Designation

Signature

Age

## SCORE CARD FOR BIOPROCESSED PRODUCTS

Product:............

Dated:..............

| Criteria | | A | B | C |
|---|---|---|---|---|
| 1. **Appearance** | 5 | | | |
| Excellent | 4 | | | |
| Good | 3 | | | |
| Fair | 2 | | | |
| Poor | 1 | | | |
| Very poor | | | | |
| 2. **Colour** | 5 | | | |
| Highly acceptable | 4 | | | |
| Acceptable | 3 | | | |
| Fairly acceptable | 2 | | | |
| Less acceptable | 1 | | | |
| Not acceptable | | | | |
| 3 **Flavour** | 5 | | | |
| Highly acceptable | 4 | | | |
| Acceptable | 3 | | | |
| Fairly acceptable | 2 | | | |
| Less acceptable | 1 | | | |
| Not acceptable | | | | |
| 4 **Taste** | 5 | | | |
| Excellent | 4 | | | |
| Good | 3 | | | |
| Fair | 2 | | | |
| Poor | 1 | | | |
| Very poor | | | | |
| 5. **Texture** | 5 | | | |
| Excellent | 4 | | | |
| Good | 3 | | | |
| Fair | 2 | | | |
| Poor | 1 | | | |
| Very poor | | | | |
| 6 **Overall acceptability** | 5 | | | |
| Like extremely | 4 | | | |
| Like very much | 3 | | | |
| Likes moderately | 2 | | | |
| Dislike slightly | 1 | | | |
| Dislike extremely | | | | |

Tested by Name & Designation

Age

Signature

# SCORE CARD FOR SIMULATED PRODUCTS

Product: ............
Dated: ..............

| Criteria | | A | B | C |
|---|---|---|---|---|
| 1. **Appearance** | 5 | | | |
| Excellent | 4 | | | |
| Good | 3 | | | |
| Fair | 2 | | | |
| Poor | 1 | | | |
| Very poor | | | | |
| 2. **Colour** | 5 | | | |
| Highly acceptable | 4 | | | |
| Acceptable | 3 | | | |
| Fairly acceptable | 2 | | | |
| Less acceptable | 1 | | | |
| Not acceptable | | | | |
| 3. **Flavour** | 5 | | | |
| Highly acceptable | 4 | | | |
| Acceptable | 3 | | | |
| Fairly acceptable | 2 | | | |
| Less acceptable | 1 | | | |
| Not acceptable | | | | |
| **5 Taste** | 5 | | | |
| Excellent | 4 | | | |
| Good | 3 | | | |
| Fair | 2 | | | |
| Poor | 1 | | | |
| Very poor | | | | |
| **6. Constitency** | 5 | | | |
| Firm | 4 | | | |
| Viscous | 3 | | | |
| Free flowing | 2 | | | |
| Slight watery | 1 | | | |
| Watery | | | | |
| **7. Overall acceptability** | 5 | | | |
| Like extremely | 4 | | | |
| Like very much | 3 | | | |
| Likes moderately | 2 | | | |
| Dislike slightly | 1 | | | |
| Dislike extremely | | | | |

Tested by Name & Designation
Age
Signature

## SCORE CARD FOR SUPPLEMENTARY BASE MIX

Product:............

Dated:..............

| Criteria | | A | B | C |
|---|---|---|---|---|
| **1 Appearance** | 5 | | | |
| Excellent | 4 | | | |
| Good | 3 | | | |
| Fair | 2 | | | |
| Poor | 1 | | | |
| Very poor | | | | |
| **2 Colour** | 5 | | | |
| Highly acceptable | 4 | | | |
| Acceptable | 3 | | | |
| Fairly acceptable | 2 | | | |
| Less acceptable | 1 | | | |
| Not acceptable | | | | |
| **3 Flavour** | 5 | | | |
| Highly acceptable | 4 | | | |
| Acceptable | 3 | | | |
| Fairly acceptable | 2 | | | |
| Less acceptable | 1 | | | |
| Not acceptable | | | | |
| **4 Taste** | 5 | | | |
| Very good | 4 | | | |
| Good | 3 | | | |
| Fair | 2 | | | |
| Poor | 1 | | | |
| Very poor | | | | |
| **5 Texture** | 5 | | | |
| Smooth | 4 | | | |
| Soft | 3 | | | |
| Fibrous | 2 | | | |
| Hard | 1 | | | |
| Tough | | | | |
| **6. Overall acceptability** | 5 | | | |
| Like extremely | 4 | | | |
| Like very much | 3 | | | |
| Likes moderately | 2 | | | |
| Dislike slightly | | | | |
| Dislike extremely | | | | |

Tested by Name & Designation

Age

Signature

# SCORE CARD FOR HEALTH DRINK MIXES

Product :............

Dated :..............

| Criteria | | A | B | C |
|---|---|---|---|---|
| **1. Appearance** | 5 | | | |
| Excellent | 4 | | | |
| Good | 3 | | | |
| Fair | 2 | | | |
| Poor | 1 | | | |
| Very poor | | | | |
| **2. Colour** | 5 | | | |
| Highly acceptable | 4 | | | |
| Acceptable | 3 | | | |
| Fairly acceptable | 2 | | | |
| Less acceptable | 1 | | | |
| Not acceptable | | | | |
| **3. Flavour** | 5 | | | |
| Highly acceptable | 4 | | | |
| Acceptable | 3 | | | |
| Fairly acceptable | 2 | | | |
| Less acceptable | 1 | | | |
| Not acceptable | | | | |
| **4. Taste** | 5 | | | |
| Very good | 4 | | | |
| Good | 3 | | | |
| Fair | 2 | | | |
| Poor | 1 | | | |
| Very poor | | | | |
| **5. Texture** | 5 | | | |
| Smooth | 4 | | | |
| Soft | 3 | | | |
| Fibrous | 2 | | | |
| Hard | 1 | | | |
| Tough | | | | |
| **6. Overall acceptability** | 5 | | | |
| Like extremely | 4 | | | |
| Like very much | 3 | | | |
| Likes moderately | 2 | | | |
| Dislike slightly | 1 | | | |
| Dislike extremely | | | | |

Tested by Name & Designation

Age

Signature

## SCORE CARD FOR BAKERY PRODUCTS

Product :............
Dated :..............

| Criteria | | A | B | C |
|---|---|---|---|---|
| **1 Appearance** | 5 | | | |
| Excellent | 4 | | | |
| Good | 3 | | | |
| Fair | 2 | | | |
| Poor | 1 | | | |
| Very poor | | | | |
| **2 Colour** | 5 | | | |
| Highly acceptable | 4 | | | |
| Acceptable | 3 | | | |
| Fairly acceptable | 2 | | | |
| Less acceptable | 1 | | | |
| Not acceptable | | | | |
| **3 Flavour** | 5 | | | |
| Highly acceptable | 4 | | | |
| Acceptable | 3 | | | |
| Fairly acceptable | 2 | | | |
| Less acceptable | 1 | | | |
| Not acceptable | | | | |
| | 5 | | | |
| **4. Taste** | 4 | | | |
| Excellent | 3 | | | |
| Good | 2 | | | |
| Fair | 1 | | | |
| Poor | | | | |
| Very poor | | | | |
| | 5 | | | |
| **5. Doneness** | 4 | | | |
| Well cooked | 3 | | | |
| Cooked | 2 | | | |
| Slightly cooked | 1 | | | |
| Moderately cooked | | | | |
| Uncooked | | | | |

Tested by Name & Designation
Age
Signature

# SCORE CARD FOR PRESEVED FOOD FROM TENDER COCONUT

Product :............

Dated :..............

| | Criteria | | A | B | C |
|---|---|---|---|---|---|
| 1 | **Appearance** | | | | |
| | Excellent | 5 | | | |
| | Good | 4 | | | |
| | Fair | 3 | | | |
| | Poor | 2 | | | |
| | Very poor | 1 | | | |
| 2 | **Colour** | | | | |
| | Highly acceptable | 5 | | | |
| | Acceptable | 4 | | | |
| | Fairly acceptable | 3 | | | |
| | Less acceptable | 2 | | | |
| | Not acceptable | 1 | | | |
| 3 | **Flavour** | | | | |
| | Highly acceptable | 5 | | | |
| | Acceptable | 4 | | | |
| | Fairly acceptable | 3 | | | |
| | Less acceptable | 2 | | | |
| | Not acceptable | 1 | | | |
| 4. | **Taste** | | | | |
| | Excellent | 5 | | | |
| | Good | 4 | | | |
| | Fair | 3 | | | |
| | Poor | 2 | | | |
| | Very poor | 1 | | | |
| 5. | **Texture** | | | | |
| | Very good | 5 | | | |
| | Good | 4 | | | |
| | Fair | 3 | | | |
| | Poor | 2 | | | |
| | Very poor | 1 | | | |
| 6. | **Overall acceptability** | | | | |
| | Like extremely | 5 | | | |
| | Like very much | 4 | | | |
| | Likes moderately | 3 | | | |
| | Dislike slightly | 2 | | | |
| | Dislike extremely | 1 | | | |

Tested by Name & Designation

Age

Signature

# SCORE CARD FOR COCONUT MILK HONEY

Product :............

Dated :..............

| Criteria | | A | B | C |
|---|---|---|---|---|
| **1 Appearance** | | | | |
| Excellent | 5 | | | |
| Good | 4 | | | |
| Fair | 3 | | | |
| Poor | 2 | | | |
| Very poor | 1 | | | |
| **2 Colour** | | | | |
| Highly acceptable | 5 | | | |
| Acceptable | 4 | | | |
| Fairly acceptable | 3 | | | |
| Less acceptable | 2 | | | |
| Not acceptable | 1 | | | |
| **3 Flavour** | | | | |
| Highly acceptable | 5 | | | |
| Acceptable | 4 | | | |
| Fairly acceptable | 3 | | | |
| Less acceptable | 2 | | | |
| Not acceptable | 1 | | | |
| **4. Taste** | | | | |
| Very good | 5 | | | |
| Good | 4 | | | |
| Fair | 3 | | | |
| Poor | 2 | | | |
| Very poor | 1 | | | |
| **5. Texture** | | | | |
| Very good | 5 | | | |
| Good | 4 | | | |
| Fair | 3 | | | |
| Poor | 2 | | | |
| Very poor | 1 | | | |
| **6. Consistency** | | | | |
| Firm | 5 | | | |
| Viscous | 4 | | | |
| Free flowing | 3 | | | |
| Slight watery | 2 | | | |
| Watery | 1 | | | |
| **7. Overall acceptability** | | | | |
| Like extremely | 5 | | | |
| Like very much | 4 | | | |
| Likes moderately | 3 | | | |
| Dislike slightly | 2 | | | |
| Dislike extremely | 1 | | | |

Tested by: Name & Designation

Age

Signature

## Appendix – IV

# HEDONIC SCALE FOR PREFERENCE TEST

Name and signature:

Product :

| | |
|---|---|
| Like extremely | 9 |
| Like very much | 8 |
| Like moderately | 7 |
| Like slightly | 6 |
| Neither likes nor dislikes | 5 |
| Dislike slightly | 4 |
| Dislike moderately | 3 |
| Dislike very much | 2 |
| Dislike extremely | 1 |

Appendix V. Changes in nutritional characteristics in RTS from tender coconut water with storage

Changes in pH of RTS and its interaction between products, containers and storage periods

| Characteristics | Storage periods( P) | | | | | |
|---|---|---|---|---|---|---|
| | Initial | 15days | 30days | 45 days | 60days | Mean |
| T0R0C0 | 4.92 | 4.55 | 4.53 | 4.34 | 4.02 | 4.47 |
| T0R0C1 | 4.92 | 4.52 | 4.54 | 4.33 | 4.03 | 4.47 |
| T0R0 | 4.92 | 4.53 | 4.53 | 4.33 | 4.03 | 4.51 |
| T0RC0 | 4.96 | 4.90 | 4.49 | 4.39 | 4.25 | 4.60 |
| T0R1C1 | 4.94 | 4.75 | 4.56 | 4.22 | 4.25 | 4.54 |
| T0R1 | 4.95 | 4.83 | 4.53 | 4.31 | 4.25 | 4.57 |
| T0 | 4.93 | 4.68 | 4.52 | 4.32 | 4.13 | 4.52 |
| T1R0C0 | 4.54 | 4.55 | 4.53 | 4.26 | 3.93 | 4.36 |
| T1R0 C1 | 4.53 | 4.52 | 4.43 | 4.07 | 3.72 | 4.25 |
| T1R0 | 4.53 | 4.53 | 4.48 | 4.01 | 3.83 | 4.30 |
| T1R1C0 | 4.50 | 4.74 | 4.64 | 4.62 | 4.45 | 4.59 |
| T1R1 C1 | 4.50 | 4.76 | 4.61 | 4.55 | 4.44 | 4.57 |
| T1R1 | 4.50 | 4.75 | 4.63 | 4.59 | 4.45 | 4.58 |
| T1 | 4.51 | 4.64 | 4.55 | 4.37 | 4.13 | 4.44 |
| T2R0C0 | 3.56 | 3.54 | 3.51 | 3.48 | 3.44 | 3.51 |
| T2R0 C1 | 3.56 | 3.36 | 3.36 | 3.32 | 3.26 | 3.37 |
| T2R0 | 3.56 | 3.45 | 3.44 | 3.40 | 3.35 | 3.44 |
| T2R1C0 | 3.51 | 3.52 | 3.51 | 3.48 | 3.26 | 3.46 |
| T2R1 C1 | 3.51 | 3.35 | 3.36 | 3.32 | 3.03 | 3.31 |
| T2R1 | 3.51 | 3.43 | 3.44 | 3.40 | 3.15 | 3.39 |
| T2 | 3.53 | 3.44 | 3.43 | 3.40 | 3.24 | 3.41 |
| T3R0C0 | 3.53 | 3.45 | 3.39 | 3.52 | 3.29 | 3.43 |
| T3R0 C1 | 3.42 | 3.49 | 3.36 | 3.33 | 3.25 | 3.37 |
| T3R0 | 3.47 | 3.47 | 3.37 | 3.43 | 3.27 | 3.4 |
| T3R1C0 | 3.43 | 3.35 | 3.29 | 3.26 | 3.26 | 3.32 |
| T3R1 C1 | 3.44 | 3.36 | 3.36 | 3.32 | 3.50 | 3.40 |
| T3R1 | 3.44 | 3.35 | 3.33 | 3.29 | 3.38 | 3.36 |
| T3 | 3.45 | 3.41 | 3.35 | 3.35 | 3.33 | 3.38 |

CD-T-0.08, TR-0.025, TC-0.02, TRP-0.036, TRC -0.056, TRCP - 0.018,

F-T 9405.14** , TR 141.60**, TC 23.32**, TRP 11.38**,TRC30.30**, TRCP 2.10**

Changes in acidity of RTS and its interaction between products, containers and storage periods

| Characteristics | Storage periods( P) | | | | | |
|---|---|---|---|---|---|---|
| | Initial | 15days | 30days | 45 days | 60days | Mean |
| T0R0C0 | 0.13 | 0.13 | 0.14 | 0.15 | 0.40 | 0.19 |
| T0R0C1 | 0.13 | 0.13 | 0.14 | 0.15 | 0.44 | 0.20 |
| T0R0 | 0.13 | 0.13 | 0.14 | 0.15 | 0.42 | 0.19 |
| T0R1C0 | 0.10 | 0.11 | 0.13 | 0.15 | 0.16 | 0.13 |
| T0R1C1 | 0.10 | 0.12 | 0.14 | 0.15 | 0.17 | 0.14 |
| T0R1 | 0.10 | 0.11 | 0.14 | 0.15 | 0.16 | 0.13 |
| T0 | 0.11 | 0.12 | 0.14 | 0.15 | 0.28 | 0.16 |
| T1R0C0 | 0.17 | 0.17 | 0.17 | 0.18 | 0.18 | 0.18 |
| T1R0 C1 | 0.17 | 0.17 | 0.17 | 0.18 | 0.18 | 0.16 |
| T1R0 | 0.17 | 0.17 | 0.17 | 0.18 | 0.18 | 0.16 |
| T1R1C0 | 0.15 | 0.15 | 0.16 | 0.15 | 0.16 | 0.15 |
| T1R1 C1 | 0.15 | 0.16 | 0.17 | 0.16 | 0.17 | 0.16 |
| T1R1 | 0.15 | 0.15 | 0.17 | 0.16 | 0.16 | 0.15 |
| T1 | 0.16 | 0.16 | 0.16 | 0.16 | 0.17 | 0.16 |
| T2R0C0 | 0.21 | 0.23 | 0.25 | 0.27 | 0.32 | 0.25 |
| T2R0 C1 | 0.21 | 0.27 | 0.38 | 0.42 | 0.46 | 0.35 |
| T2R0 | 0.21 | 0.25 | 0.32 | 0.34 | 0.39 | 0.30 |
| T2R1C0 | 0.22 | 0.23 | 0.25 | 0.27 | 0.32 | 0.26 |
| T2R1 C1 | 0.21 | 0.27 | 0.38 | 0.40 | 0.40 | 0.33 |
| T2R1 | 0.22 | 0.25 | 0.32 | 0.34 | 0.36 | 0.29 |
| T2 | 0.21 | 0.25 | 0.32 | 0.34 | 0.37 | 0.29 |
| T3R0C0 | 0.17 | 0.18 | 0.18 | 0.19 | 0.47 | 0.19 |
| T3R0 C1 | 0.18 | 0.18 | 0.19 | 0.19 | 0.24 | 0.24 |
| T3R0 | 0.17 | 0.18 | 0.18 | 0.19 | 0.36 | 0.22 |
| T3R1C0 | 0.17 | 0.17 | 0.18 | 0.18 | 0.19 | 0.18 |
| T3R1 C1 | 0.17 | 0.18 | 0.18 | 0.19 | 0.19 | 0.18 |
| T3R1 | 0.17 | 0.17 | 0.18 | 0.18 | 0.19 | 0.18 |
| T3 | 0.17 | 0.18 | 0.18 | 0.19 | 0.27 | 0.19 |
| CD-T-0.028, TR-0.039, TC-0.039, TRP-0.088 | | | | | | |
| F-T 39.10** , TR 4.13**, TC 4.99**, TRP 2.89** | | | | | | |

hanges in reducing sugar of RTS and its interaction between products, containers and orage periods

| Characteristics | Storage periods( P) | | | | | |
|---|---|---|---|---|---|---|
| | Initial | 15days | 30days | 45 days | 60days | Mean |
| T0R0C0 | 4.67 | 4.67 | 4.67 | 4.68 | 4.68 | 4.67 |
| T0R0C1 | 4.67 | 4.69 | 4.71 | 4.71 | 4.75 | 4.71 |
| T0R0 | 4.67 | 4.68 | 4.69 | 4.69 | 4.71 | 4.7 |
| T0RC0 | 4.67 | 4.67 | 4.67 | 4.67 | 4.70 | 4.68 |
| T0R1C1 | 4.67 | 4.68 | 4.70 | 4.72 | 4.72 | 4.70 |
| T0R1 | 4.67 | 4.68 | 4.69 | 4.70 | 4.71 | 4.68 |
| T0 | 4.67 | 4.678 | 4.688 | 4.688 | 4.712 | 4.69 |
| T1R0C0 | 5.25 | 5.24 | 5.25 | 5.25 | 5.25 | 5.25 |
| T1R0 C1 | 5.25 | 5.25 | 5.25 | 5.25 | 5.24 | 5.25 |
| T1R0 | 5.25 | 5.25 | 5.25 | 5.25 | 5.25 | 5.25 |
| T1R1C0 | 5.25 | 5.25 | 5.25 | 5.24 | 5.25 | 5.25 |
| T1R1 C1 | 5.25 | 5.25 | 5.25 | 5.25 | 5.91 | 5.38 |
| T1R1 | 5.25 | 5.25 | 5.25 | 5.25 | 5.58 | 5.31 |
| T1 | 5.25 | 5.25 | 5.25 | 5.25 | 5.41 | 5.28 |
| T2R0C0 | 6.26 | 6.26 | 6.26 | 6.27 | 6.30 | 6.27 |
| T2R0 C1 | 6.26 | 6.27 | 6.31 | 5.35 | 6.39 | 6.12 |
| T2R0 | 6.26 | 6.27 | 6.28 | 5.81 | 6.35 | 6.19 |
| T2R1C0 | 6.26 | 6.26 | 6.28 | 6.31 | 6.31 | 6.28 |
| T2R1 C1 | 6.26 | 6.27 | 6.27 | 6.28 | 6.33 | 5.28 |
| T2R1 | 6.26 | 5.27 | 6.28 | 6.29 | 6.32 | 6.28 |
| T2 | 6.26 | 6.265 | 6.28 | 6.052 | 6.33 | 6.24 |
| T3R0C0 | 8.82 | 8.66 | 8.84 | 9.24 | 9.29 | 8.97 |
| T3R0 C1 | 8.93 | 9.30 | 9.67 | 9.78 | 9.83 | 9.50 |
| T3R0 | 8.87 | 8.98 | 9.25 | 9.51 | 9.56 | 9.23 |
| T3R1C0 | 8.80 | 8.93 | 9.30 | 9.33 | 9.25 | 9.12 |
| T3R1 C1 | 8.82 | 8.66 | 8.84 | 9.49 | 9.50 | 9.06 |
| T3R1 | 8.81 | 8.79 | 9.07 | 9.41 | 9.38 | 9.09 |
| T3 | 8.84 | 8.88 | 9.16 | 9.46 | 9.46 | 9.16 |
| CD-T-0.077, TR-0.109, TC-0.109, TRC -0.155, TRCP - 0. .347 | | | | | | |
| F-T 5021.35** , TR 3.50**, TC 5.39**, TRC30.30**, TRCP 2.10** | | | | | | |

Changes in Total soluble solids of RTS and its interaction between products, containers and storage periods

| Characteristics | Storage periods( P) | | | | | |
|---|---|---|---|---|---|---|
| | Initial | 15days | 30days | 45 days | 60days | Mean |
| T0R0C0 | 5.45 | 5.45 | 5.39 | 5.39 | 5.27 | 5.39 |
| T0R0C1 | 5.47 | 5.42 | 5.39 | 5.42 | 5.22 | 5.38 |
| T0R0 | 5.46 | 5.44 | 5.39 | 5.4 | 5.25 | 5.38 |
| T0RC0 | 5.52 | 5.50 | 5.46 | 5.42 | 5.39 | 5.46 |
| T0R1C1 | 5.52 | 5.48 | 5.43 | 5.40 | 5.38 | 5.44 |
| T0R1 | 5.52 | 5.49 | 5.44 | 5.41 | 5.39 | 5.45 |
| T0 | 5.49 | 5.46 | 5.412 | 5.41 | 5.32 | 5.42 |
| T1R0C0 | 6.46 | 6.46 | 6.43 | 6.42 | 6.40 | 6.43 |
| T1R0 C1 | 6.46 | 6.44 | 6.44 | 6.40 | 6.38 | 6.43 |
| T1R0 | 6.46 | 6.45 | 6.44 | 6.41 | 6.39 | 6.43 |
| T1R1C0 | 6.46 | 6.44 | 6.44 | 6.42 | 6.41 | 6.44 |
| T1R1 C1 | 6.46 | 6.43 | 6.42 | 6.43 | 6.41 | 6.43 |
| T1R1 | 6.46 | 6.44 | 6.43 | 6.43 | 6.41 | 6.43 |
| T1 | 6.46 | 6.44 | 6.43 | 6.42 | 6.40 | 6.43 |
| T2R0C0 | 12.48 | 12.48 | 12.47 | 12.46 | 12.45 | 12.47 |
| T2R0 C1 | 12.47 | 12.46 | 12.44 | 12.39 | 12.39 | 12.43 |
| T2R0 | 12.48 | 12.47 | 12.45 | 12.43 | 12.42 | 12.44 |
| T2R1C0 | 12.48 | 12.49 | 12.48 | 12.45 | 12.45 | 12.47 |
| T2R1 C1 | 12.47 | 12.45 | 12.43 | 12.42 | 12.41 | 12.44 |
| T2R1 | 12.48 | 12.47 | 12.45 | 12.44 | 12.43 | 12.45 |
| T2 | 12.475 | 12.47 | 12.45 | 12.44 | 12.43 | 12.45 |
| T3R0C0 | 12.38 | 12.02 | 11.97 | 11.95 | 11.60 | 12.13 |
| T3R0 C1 | 12.42 | 12.57 | 12.44 | 11.60 | 11.60 | 11.98 |
| T3R0 | 12.40 | 12.29 | 12.21 | 11.78 | 11.60 | 12.05 |
| T3R1C0 | 12.95 | 12.60 | 12.57 | 12.44 | 11.60 | 12.43 |
| T3R1 C1 | 12.45 | 12.38 | 12.02 | 11.97 | 11.60 | 12.09 |
| T3R1 | 12.70 | 12.49 | 12.29 | 12.21 | 11.60 | 12.25 |
| T3 | 12.55 | 12.39 | 12.25 | 11.99 | 11.60 | 12.16 |

CD-T-0.022, TR-0.032, TP-0.05 TC-0.03, TRP-0.07, TRC -0.05, TRCP - 0.102

F-T -300** , TR 3.52**, TP-39.12** TC22.58**, TRP 8.85**,TRC4.80**, TRCP

Changes in Total sugar of RTS and its interaction between products, containers and storage periods

| Characteristics | Storage periods( P) | | | | | |
|---|---|---|---|---|---|---|
| | Initial | 15days | 30days | 45 days | 60days | Mean |
| T0R0C0 | 5.70 | 5.78 | 5.95 | 5.96 | 5.98 | 5.93 |
| T0R0C1 | 5.70 | 5.71 | 5.87 | 6.03 | 6.37 | 5.75 |
| T0R0 | 5.70 | 5.69 | 5.78 | 5.83 | 6.11 | 5.83 |
| T0RC0 | 5.70 | 5.70 | 5.71 | 5.87 | 6.03 | 5.80 |
| T0R1C1 | 5.70 | 5.68 | 5.70 | 5.70 | 6.02 | 5.76 |
| T0R1 | 5.70 | 5.69 | 5.70 | 5.78 | 6.02 | 5.78 |
| T0 | 5.73 | 5.74 | 5.74 | 5.82 | 6.07 | 5.8 |
| T1R0C0 | 7.01 | 7.47 | 7.58 | 7.96 | 8.33 | 7.67 |
| T1R0 C1 | 7.02 | 7.01 | 7.22 | 7.34 | 7.52 | 7.22 |
| T1R0 | 7.02 | 7.24 | 7.40 | 7.65 | 7.93 | 7.46 |
| T1R1C0 | 7.01 | 7.28 | 7.47 | 7.58 | 7.96 | 7.46 |
| T1R1 C1 | 7.02 | 7.05 | 7.01 | 7.22 | 7.34 | 7.13 |
| T1R1 | 7.02 | 7.16 | 7.24 | 7.40 | 7.65 | 7.29 |
| T1 | 7.02 | 7.20 | 7.32 | 7.53 | 7.79 | 7.37 |
| T2R0C0 | 13.76 | 13.76 | 14.50 | 14.97 | 15.30 | 14.46 |
| T2R0 C1 | 13.83 | 14.29 | 14.74 | 15.22 | 15.46 | 14.71 |
| T2R0 | 13.80 | 14.02 | 14.62 | 15.09 | 15.38 | 14.58 |
| T2R1C0 | 13.76 | 13.76 | 13.76 | 14.50 | 14.97 | 14.15 |
| T2R1 C1 | 13.83 | 13.83 | 14.29 | 14.74 | 15.10 | 14.36 |
| T2R1 | 13.80 | 13.80 | 14.02 | 14.62 | 15.03 | 14.25 |
| T2 | 13.80 | 13.91 | 14.32 | 14.86 | 15.21 | 14.42 |
| T3R0C0 | 14.37 | 14.76 | 14.76 | 14.90 | 14.90 | 14.74 |
| T3R0 C1 | 13.65 | 14.37 | 14.79 | 14.77 | 14.90 | 14.5 |
| T3R0 | 14.01 | 14.57 | 14.78 | 14.84 | 14.90 | 14.62 |
| T3R1C0 | 14.57 | 14.57 | 14.79 | 14.77 | 14.90 | 14.72 |
| T3R1 C1 | 14.38 | 14.40 | 14.65 | 14.76 | 14.90 | 14.62 |
| T3R1 | 14.48 | 14.49 | 14.72 | 14.77 | 14.90 | 14.66 |
| T3 | 14.24 | 14.53 | 14.75 | 14.80 | 14.90 | 14.64 |

CD-T-0.052, TR-0.075, TC-0.07, TRP-0.17, TRCP - 0.236

F-T-44652**, TR- 9.29**, TC- 10.90**, TRP- 2.37**. TRCP-2.50**

• $T_0$ – Plain Coconut water, $T_1$– Acidulant added, $T_2$– Pineapple blended, $T_3$ – Lemon blended, $R_1$ -Ambient temperature, $R_2$- Refrigerated condition, $C_1$ - Retort pouches, C -Glass bottle

Abstract

# DEVELOPING VALUE ADDED AND DIVERSIFIED PRODUCTS FROM COCONUT (*COCOS NUCIFERA* L.)

BY

NEELOFAR ILLIASKUTTY

ABSTRACT OF THE THESIS
SUBMITTED IN PARTIAL FULFILMENT OF THE REQUIREMENT
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# ABSTRACT

Coconut palm forms an important component in the socio-economic and cultural life of every Keralite. Lack of modern technologies within the country for large scale manufacture of value added products is one of the major lacunae that lead to retarded growth of coconut industry. Therefore, the need of the hour is to accomplish product diversification in coconut applying modern and indigenous technologies and to popularise the technologies developed so that the coconut based products and by products flourish in the domestic as well as export markets.

In this context, the present investigation entitled 'Developing value added and diversified food products from coconut (*Cocos nucifera L.*)' was undertaken to develop innovative products utilising coconut constituents and to study the chemical, nutritrional, organoleptic and shelf life qualities and consumer acceptance of the products. Products developed under the present investigation are beverages, bioprocessed products, simulated dairy milk products, protein enriched products and bakery and confectionary products.

In depth investigation was carried out with respect to standardisation procedure, chemical, nutritional and organoleptic features of the developed products using standard techniques. Shelf stability of the product in different storage containers and with different storage periods was studied in detail.

Consumer acceptance and consumer preference of the products along with cost effectiveness and product yield were the other criteria ascertained in the study.

Three types of coconut beverages standardised using tender coconut water in combination with acidulants, lemon and pineapple juices were found to be

consumer acceptable when stored in both retort pouches as well as in glass bottles for a period up to 60 days. Lemon juice blended beverage was found nutritionally sound whereas pineapple blended RTS was organolepticlly superior. Chemical and organoleptic characteristics were found to change with storage but the beverages remained acceptable till two months of storage.

Bioprocessed products viz., 'nata' could be successfully standardised with three different base materials such as plain coconut water, blends of coconut water with pineapple juice and blend of coconut water and soya milk. Since the product is formulated from the matured coconut water, which is at present being wasted, needs special mention. Nata products remain more stable in glass containers and for a period of six months. Nata de soya contains more protein while fibre content of the three products was similar. Nata de pine is adjudged to be the best organoleptically.

Simulated milk products viz., coco curd and coco yoghurt were standardised from coconut milk, were found to be comparatively low in acceptance on the whole. Coco curd and coco yoghurt prepared with coconut milk and non fat dry milk (NFDM) were more appealing organoleptically, but nutritionally soya based curd and yoghurt were better. Storability was better in steel containers and the products are of short shelf life (two days) at ambient condition.

Protein enriched coconut supplements viz., supplementary base mix and two health drinks could be standardised successfully from coconut constituents. All the three products were found to be nutritionally adequate and easy to formulate. With storage changes were noted in moisture, free fatty acid and peroxide content. Health drinks were more shelf stable than supplementary base mix in laminated containers for a period of five months.

Biscuits and cookies standardised from coconut were found to have good consumer appeal with shelf life of five months.

Confectionery products developed were found to have very good consumer appeal. Preserves viz., 'crystallised and glazed candy' were standardised from tender coconut kernel stayed stable for a month in laminated pouches under ambient temperature.

Preserved products developed namely, coconut honey standardised under present investigation also found to be nutritionally rich and organoleptically sound with superior consumer appeal. The product was stable in glass containers for a period of two months.

Majority of the products were acceptable to the consumers and the most preferred products were pineapple blended RTS from tender coconut water, coconut cookies, crystallized candy, coconut honey and nata de pine. Less acceptance was shown towards simulated milk products from coconut.

Products developed with coconut were compared with the available food standards prescribed and found in accordance with standards

Cost of production and product yield was worked out and found that costs of products are reasonable, except for health drinks. Product yield indicated that products could be made and marketed profitably.