DEVELOPMENT OF VALUE ADDED PRODUCTS FROM BANANA PEEL

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DECLARATION

I, hereby declare that this thesis entitled **"Development of value added products from banana peel"** is a bonafide record of research work done by me during the course of research and the thesis has not previously formed the basis for the award of any degree, diploma, associateship, fellowship or other similar title, of any other University or Society.

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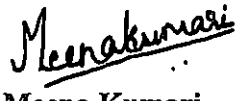

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MEGHA S. KARTHIKEYAN

DEDICATED TO MY FAMILY

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LIST OF ABBREVIATIONS

ISM	Instant soup mix
RTC	Ready to cook
OVQ	Overall visual quality
cfu/g	Colony forming unit per gram
Fig	Figure
Gm	Gram
gm/100gm	gram/100gram
mg/100gm	Milligram/100gram
Kcal/100gm	Kilocalories per 100gram
Min	Minute
Ml	Milliliter
et al.	and others
%	Per cent
i.e.	that is

INTRODUCTION

1. INTRODUCTION

Banana is a very important tropical fruit. Banana belongs to the family *Musaceae*. India is the second largest producer of banana (390000 T). Banana whether eaten raw or cooked, is a popular fruit consumed by all sections of people world wide. The annual production of bananas was reported to be over 145 MT in 2011. The main by-product of the banana processing industry is the peel, which represents approximately 40 per cent of the fruit. After consumption and processing, a significant amount of banana peel is being generated as waste. The fruit is protected by its peel which is discarded as waste after the inner fleshy portion is eaten. This by -product constitutes an environmental problem, because it contains large quantities of nitrogen and phosphorous. Besides its high water content makes it susceptible to attack by microorganisms.

Among bananas the variety, nendran ranks first in commercial value. The cultivators of the Agasthiamalai ranges call this variety as the "King of Bananas". The shelf-life of the fruits of nendran is more than that of others. So, the fruits of nendran are exported in huge amounts to the Arabian and European countries.

Banana peels have significant nutritional qualities. They are rich source of starch (3%), crude protein (6-9%), crude fat (3.8-11%), total dietary fibre (43.2-49.7%). They are also rich sources of polyunsaturated fatty acids particularly linoleic acids and alpha linolenic acid. It contains essential amino acids such as leucine, valine, phenyl alanine and threonine and also the micronutrients K, P, Ca, Mg, Fe and Zn. In the case of Zn and Fe they were found in higher concentrations in peels compared to pulp. Banana peels are also good sources of lignin (6-12%), pectin (10-21%), cellulose (7.6-9.6%), hemicelluloses (6.4-9.4%) and galactouronic acid.

Pectin extracted from banana peel also contain glucose, galactose, arabinose, rhamnose and xylose (Emaga *et al.*, 2007).

The total amount of phenolic compounds in banana peel ranges from 0.90 to 3.0 g/100 (g DW). Phenolic compounds are the secondary metabolites produced by the plants. It has multiple biological effects. Gallocatechin is identified at a concentration of 160 mg/100 g DW. Ripe banana peel also contains other compounds, such as the anthocyanins, delphinidin, cyanidin and catecholamines. Furthermore, carotenoids, such as beta-carotene, alpha-carotene. xanthophylls, have been identified in banana peels in the range of 300–400 mg lutein equivalents/100 gm. Sterols and triterpenes, such as b-sitosterol, stigmasterol, campesterol, cycloeucalenol, cycloartenol, and 24-methylene cycloartanol are also identified in banana peels. Potassium content is also found to be high in banana peel (78.10 mg/gm). This helps in the regulation of body fluids and maintain normal blood pressure. It will also help to control kidney failure, heart diseases and respiratory flaw (Nguyan *et al.*, 2003).

Food processing industry is of enormous significance in India's development because of the vital linkage and synergies that it promotes between the two pillars of the economy, namely industry and Agriculture (Maheshkumar, 2009). Convenience foods or processed foods are foods which are designed for convenience to women in the kitchen. It also reduces costs due to spoilage (Liaqat *et al.*, 2009).

Ray and Athwali (2000) reported that more and more people are going for processed foods and it is estimated that over 10 percent of total expenditure incurred in the households for food, is spent on processed foods. The trend in consumption of ready to eat food products is increasing due to increase in the number of working women in the population, concomitant with the increase in per capita income, urbanization, scarcity of household labour, lack of time and hectic schedules,

compelling the consumers to look for foods with convenience, which are easily available, culturally acceptable, nutritive and minimally processed with longer shelf life.

Fruit wastes, which are highly perishable, is a problem to the processing industries and pollution monitoring agencies. Suitable methods to utilize them for the conversion into value-added products would be useful for developing healthy foods. By-product recovery from fruit wastes can also improve the overall economics of processing units. Besides this, the problem of environmental pollution also can be reduced considerably.

Despite the nutritional, economic and medicinal importance of banana peel, they still remain neglected. Not much work has been done to develop banana peel based processed foods. In this context, the present investigation on 'Development of value added products from banana peel' was selected with the objective of developing value added products from banana peel and to evaluate their organoleptic, functional, nutritional and shelf life qualities.

REVIEW OF LITERATURE

2. REVIEW OF LITERATURE

The literature reviewed which is pertinent to the study entitled "Development of value added products banana peel" is presented under the following heads:

2.1 Importance of value addition of fruits and vegetables

2.2 Scope of value addition of fruit and vegetable waste in industries

2.3 Nutritional importance of banana peel

2.4 Health benefits of banana peel

2.5 Traditional knowledge on uses of banana peel

2.6 Scope of banana peel in food industry

2.7 Industrial application of banana peel

2.1 Importance of value addition of fruits and vegetables

Value addition is a term frequently mentioned in the context of the future profitability of agriculture. In general, adding value is the process of changing or transforming a product from its original state to a more valuable state (Brown, 2000).

The purpose of value addition is to maintain or enhance quality of the products and make it readily marketable. It is estimated that 10-15 per cent of horticultural crops such as vegetables and fruits perish due to lack of proper methods of processing and storing. Proper methods of processing, storage, packaging, transport and marketing are required for the export of crops such as jack, mango, banana, vegetables and spices (Abdullah *et al.*, 2010).

Value addition enterprises are aimed at giving value to the raw commodities that will be transformed into multiple products like fruit candies, jams, jellies,

marmalades, fruit nectars, juices, dehydrated products, semi-processed foods and many more. It provides convenient and safe foods to consumers and promotes diversification and commercialization of agriculture by providing effective linkage between consumers and farmers. Moreover, it will make farm produce more exportable (Picha *et al.*, 2007).

By adding value to farm products, the food processing sector plays a key role in rural growth, by enhancing farm income and also providing rural jobs. Value addition of farm products is successful in providing employment in the processing industry (Barkama and Drabenstott, 2001).

Importance of value addition lies in the fact that it has the capability to meet food requirements of the growing population by eliminating avoidable losses and making more nutritive food items from low grade raw commodities, by their processing and fortification (Rasheed *et al.*, 2008).

2.2 Scope of value addition of fruits and vegetables waste in industries

Foods are generally consumed for their nutritive value and exotic taste. Fruits and vegetables are considered as an important part of a good diet. Besides their delicious taste and flavor, they are known to reduce risk of several chronic diseases. They contain significant amounts of phytoconstituents which are proven to be negatively associated with the morbidity and mortality, especially from cerebrovascular, cardiovascular and certain types of cancers (Alesiani *et al.*, 2010).

Along with the consumption of fruits and vegetables, their wastes and by-products are formed in great amounts during industrial processing and hence represent a serious problem, as they exert harmful impact on environment. So they need to be managed or they need to be utilized (Duda and Tarko, 2007).

Infectious diseases are a leading cause of death in the world wide scenarios due to the prevalence of multidrug resistant strains of bacteria, reduced susceptibility to microbes and the increase in untreatable bacterial infections.

Ushimaru *et al.* (2007) have suggested that different fruits and vegetable peels have antimicrobial, antioxidant, antiproliferative, anti-inflammatory activities. Fruit and vegetable peels are thrown into the environment as agro waste, which can be utilized as a source of antimicrobics. If utilized this will be economically feasible, eco friendly and also reduce pollution to a great extent.

Zoreky (2009) reported that the antimicrobial activity of various extracts prepared from pomegranate fruit peels were evaluated using both *in-vitro* agar diffusion and *in-situ* methods against some food-borne pathogens. It was found that 80 per cent methanolic extract of peels was a potent inhibitor for *Yersinia enterocolitica, Listeria monocytogenes, Staphyllococcus aureus* and *Escherichia coli.*

M. indica L. peel, usually a waste product which is thrown into the environment has a very good antimicrobial potential. The demonstration of the broad spectrum of antibacterial activity by *M. indica* peels may help to discover a new chemical class of antibiotic substances that could serve as selective agents for infectious diseases. The free radical scavenging activities of mango flesh and peel extracts were evaluated by electron spin resonance and it was recorded that mango peel extract exhibited stronger free radical scavenging ability on 1, 1-diphenyl-2-picrylhydrazyl and alkyl radicals than plain mango flesh extract, without any relation to its ripeness (Kim *et al.*, 2010).

The antioxidant activities of the extracts obtained from fresh green and yellow banana peel fruits were evaluated by using the thiocyanate method and the fresh green and yellow banana peel fruits were treated with 70 per cent acetone. The water

soluble and ethylacetate fractions of green peel displayed high antimicrobial and antioxidant activity (González *et al.*, 2010).

Dhanavade *et al.* (2011) observed that lemon is an important medicinal plant of Rutaceae family. It is cultivated mainly for its alkaloids, which have anticancer activities. The citrus peel oils show strong antimicrobial activity against the microorganisms like *Pseudomonas aeruginosa.*

Nowadays, there is a growing interest in finding phytochemicals as an alternative to the synthetic substances, which are commonly used in the food, pharmaceutical and cosmetic industry. Several studies have shown that the content of phytochemical compounds is higher in peel and seeds with respect to the edible tissue.

Gorinstein *et al.* (2001) found that the total phenolic compounds in the peels of lemons, oranges, and grapefruits were 15 per cent higher than that of the pulp of these fruits. Peels from apples, peaches, pears, as well as yellow and white flesh nectarines were found to contain twice the amount of total phenolic compounds as that contained in fruit pulp. Apple peels were found to contain up to 3300 mg/100 gm of phenolic compounds in dry weight.

The peels and seeds of tomatoes are richer sources of phenolic compounds than the pulp of the tomatoes.The tomato peel has significantly higher levels of total phenolic compounds, total flavonoids, lycopene, ascorbic acid, and antioxidant activity as compared with the pulp and seeds (George *et al.*, 2004).

Nasrin *et al.* (2008) reported that oil palm agro waste such as EFB (empty fruit bunches) has applications as fertilizer, fuel and is used in the synthesis of high

tensile composite materials for mechanical and pharmaceutical grade. This may be of great interest to the existing oil palm mills to operate as economic models.

Fertilizers are any organic or inorganic material of natural or synthetic origin that is added to the soil to supply one or more plant nutrients essential to the growth of the plants. Investigations made on the effect of different formulations of fruit peels, have revealed increased fertility of soil and soil micro organisms. Most of the fruit peels contain potassium, vitamins, minerals and some essential elements which enhance the growth of plants.

Tsay and Lin (2004) observed that the citrus peel powder extract increased the growth of plants and their yield. The leaves of the plants retained their green colour till harvesting. Additionally, growth of microorganisms also increased by the application of citrus peel powder and extract. In addition, citrus peel powder can be used for the preparation of tissue culture media and it was finally concluded that the chemical fertilizers can be replaced by the citrus peel powder and extracts to protect the soil from the infertility.

Characterization of lignocellulosic fruit waste as an alternative feed stock for bioethanol production was undertaken. This study observed that different fruit wastes can be utilized as the alternative of feed stock for ethanol production.

Orange peel (OP) and mango peel (MP) residues were found to have the potential in application as raw materials for bioethanol production because of their acceptable content of cellulose and hemicelluloses and low lignin content (Ajila *et al.*, 2007).

Galbe and Zacchi (2007) conducted a study on bioconversion of vegetable and fruits waste peels into commercially viable products. Four substrate were taken

for this viz. turnip, apple, papaya and banana. These peel extracts were prepared and used for ethanol and biomass production. Various analytical tests were performed to estimate total sugar, fermentable sugar, residual sugars, protein, fat, ash, moisture and nucleic acid content before and after fermentation. The kinetics of biomass production on different peel extracts were studied. The effect of time on alcohol production and biomass production were also studied. It was concluded that papaya contained maximum fermentable sugars and produced maximum amount of alcohol after 48 hours of incubation. The biomass was also maximum in papaya.

The bioconversion of fruit wastes into single cell protein (SCP) production has the potential to solve the worldwide food protein deficiency by obtaining an economical product for food and feed. The term SCP refers to dead, dry microbial cells or total proteins extracted from pure microbial cell culture and is produced using a number of different microorganisms including bacteria, fungi and algae. It is rich in certain essential amino acids like lysine and methionine which are limiting in most plant and animal foods. This protein can be used as an additive in diets instead of expensive sources such as soybean and fish (Ghasem *et al.*, 2007).

In a study conducted by Adoki (2007), cucumber and orange peels were evaluated for the production of single cell protein using *Saccharomyces cerevisiae* by submerged fermentation. Results showed that the tested fruit wastes were highly susceptible to hydrolysis. A comparative study of fruit wastes revealed that cucumber peel generated higher amount of protein followed by that of orange peel with 53.4 per cent and 30.5 per cent crude protein respectively per 100 gm of substrate used.

Yeoh *et al.* (2009) developed noodles, a value added product by incorporating banana peel powder as the main ingredient. Banana peel powder is rich in dietary fiber, amino acid, calcium, phosphorus and phyto-chemicals. Therefore, it helped to

improve the nutritional status of the population and thus decrease chances of nutrient deficiency diseases. They are found to be of low cost with reasonable price.

The new aspects concerning the use of wastes as by products for further exploitation in the production of food additives or supplements with high nutritional value have gained increasing interest, because their recovery was economically attractive. The by-products represent an important source of sugars, minerals, organic acid, dietary fibre and phenolics which have a wide range of action that includes anti-tumoral, antiviral, antibacterial, cardio protective and antimutagenic activities.

2.3 Nutritional importance of banana peel

Organic matter measures the nutritional profile of the plant material with tespect to carbohydrate, lipid and protein. Banana peel is a rich source of carbohydrate (59%), crude protein (6-9%), crude fat (3.8-11%), total dietary fibre (43.2-49.7%) and starch (3%). It is a rich source of polyunsaturated fatty acids particularly linoleic acids and alpha linolenic acid. It contains essential amino acids such as leucine, valine, phenyl alanine and threonine and also the micronutrients K, P, Ca, Mg, Fe and Zn. In the case of Zn and Fe they were found to be higher in concentration in the peels than the pulp. Banana peels are also good sources of lignin (6-12%), pectin (10-21%), cellulose (7.6-9.6%), hemicellulose (6.4-9.4%) and galactouronic acid. Pectin extracted from banana peel also contain glucose, galactose, arabinose, rhamnose and xylose (Emaga *et al.*, 2007).

Banana peel is rich in phytochemical compounds. Phyto chemicals are the chemical substances that naturally occur in plants, some are responsible for colour and others for organoleptic properties (Seymour *et al.*, 2003). The total amount of phenolic compounds in banana peel ranged from 0.90 to 3.0 gm/100 g DW. Phenolic compounds are the secondary metabolites produced by the plants. It has multiple biological effects. Among the antioxidant compounds present in banana peel, the

phenolic compounds have been intensively studied in the last two decades with regard to its effect on human health. These studies strongly support their role in the prevention of degenerative diseases, particularly cardiovascular diseases and cancers (Scalbert *et al.*, 2005).

Dietary fibre has shown beneficial effects in the prevention of several diseases, such as cardiovascular diseases, diverticulosis, constipation, irritable colon, colon cancer, and diabetes (Rodriguez *et al.*, 2006). The fruit fibre has better quality than other fibre sources due to its high total and soluble fibre content, water and oil holding capacities, colonic fermentability, as well as a lower phytic acid and caloric value content (Figuerola *et al.*, 2005).

banana peel is a good source of dietary fibre (50 gm/100 gm). Emaga *et al.* (2008) found that the maturation of banana fruits has an impact on dietary fibre composition of banana peels. The components of the insoluble dietary fibre fractions namely Cellulose, lignin, and hemicellulose varied from 7 to 12 gm/100 gm, 6.4 to 9.6 gm/100 gm and 6.4 to 8.4 gm/100 gm, respectively, whereas in the case of pectin, a component of the soluble dietary fibre, the amount ranged from 13.0 to 21.7 gm/100 gm.

The concentrations of hydrogen cyanide, and oxalate content in banana peels were found to be 1.33 mg/gm and 0.51 mg/gm, respectively, which is however falling within the safety limits (Anhwange, 2008). These results indicate that banana peels are safe and valuable functional ingredients for human consumption.

Someya *et al.* (2002) reported that gallocatechin is identified at a concentration of 160 mg/100 g DW. The banana peel extract, which contained more gallocatechin than the pulp, showed stronger antioxidant activity than the pulp extract. Bananas should be considered to be a good sources of natural antioxidants in

foods. Banana peel, which is usually discarded, should also be considered to be a functional food source against cancer and heart disease.

Ripe banana peel also contains other compounds, such as the anthocyanins, delphinidin, cyanidin and catecholamines. Furthermore, carotenoids, such as beta-carotene, alpha-carotene and xanthophylls, have also been identified in banana peel in the range of 300–400 mg lutein equivalents/100 gm. Similar levels for sterols and triterpenes, such as b-sitosterol, stigmasterol, campesterol, cycloeucalenol, cycloartenol, and 24-methylene cycloartanol have been reported too. Potassium content was found to be high in banana peel (78.10mg/gm). This would help in the regulation of body fluids and maintain normal blood pressure. It would also help to control kidney failure, heart diseases and respiratory flaw (Nguyan *et al.*, 2003).

Banana peel is rich in antioxidants. Anti oxidants are the compounds that are able to prevent or inhibit the oxidation reaction in human body and food products. It will help to prevent a wide range of chronic diseases such as diabetis, cancer, atherosclerosis, viral infections. They also have anti-ageing properties. They contain mainly poly phenols and carotenoids. Unripe banana peel have stronger antioxidant activity than ripe banana peel (Huang and Shen, 2012).

A study on anti-oxidant activity of three varieties in Mysore, revealed that higher radical scavenging activity (90%) was reported in "Nendranbale"(Syamal and Nicholas, 2011). Many synthetic antioxidants used in processed foods, such as butylated hydroxyanisole (BHA) and butylatedhydroxytoluene (BHT), may accumulate in the body, resulting in liver damage and carcinogenesis (Valentao *et al.*, 2002). For this reason, more attention has been paid to natural non-toxic antioxidants as an effort to protect the human body from free radicals and retard the progress of many chronic diseases (Sun *et al.*, 2011).

The antioxidant effect of banana peel extract and synthetic antioxidants BHT/BHA on lipid oxidation and chemical properties was investigated with meat balls stored for 9 days at 4°C. Banana peel extract revealed lower peroxide and thiobarbituric acid values compared to control (Diaz *et al.*,2013).

Non essential minerals were found to range between 0.21-0.02mg/100gm. Moisture content of the peel was reported to be 6.7 per cent, this implies that banana peel can be stored for a long time without attack of moulds.

Ash content of peels were found to 8.50 per cent. This indicates that banana peel is rich in minerals. Organic matter content was found to be 91.05 per cent. It is also found to be rich in beta carotene and vitamin B6 (Kaur and Kapoor, 2000).

2.4 Health benefits of banana peel

Many health benefits of banana peel have been pointed out by various scientists through research and scientific justification. Some of them are presented herewith.

Protection of cardio vascular system: Banana peel has a beneficial effect on the heart. Its high levels of soluble and insoluble fiber are very useful to reduce the level of bad cholesterol. It will help the the body to eliminate atherosclerosis by preventing cholesterol from sticking to the walls of the arteries (Subalgo *et al.*, 2001).

In a study conducted in Brawijaya University, in East Java, acid extracted dried pectin from banana peel lowered cholesterol level of mice fed on high fat diet (Schieber *et al.*, 2000).

Protection of red blood cells(RBC) : RBC helps in carrying oxygen to all parts of the body. Banana peel contains nutrients that protects RBC from breaking

down. Green banana peels were seen to be even more effective in protecting the body from free radicals (Manach *et al* ., 2004) .

Eye health : Banana peel contains beta carotene, which is associated with good eye sight. It is also rich in lutein, which is often referred to as the eye vitamin. It improves the eye health and night vision. This compound also protects the eyes from conditions like macular degeneration and cataract. Lutein is a powerful anti oxidant that protects the eyes from damage caused by the free radicals. It also protects the eyes from the harmful effects of UV rays of the sun.

Suparmi and Prasetya (2012) reported that banana peel extracts can avoid retinal destruction caused by light damage. Total carotenoid of yellow ambon banana peel was 6.203 ± 0.004 mg /gm of vitamin A and the carotenoid conversion was 124.06 ± 0.08 IU. β-Carotene from yellow ambon banana peel increased the blood serum retinol levels, as much as provitamin as potential.

Aid in weight loss and obesity: Barcia *et al.* (2010) reported that the high amount of fiber in banana peel gives the sensation of fullness, which prevents from over eating and snacking between the meals. It is low in calories and at the same time rich in nutrients. This makes it at a healthy and nutritious food for people trying to loss weight. It will also reduce the risk of heart attacks and the early onset of diabetes.

Presence of anti cancer agents : Banana peel contains powerful anti-carcinogenic compounds that helps to prevent cancer . They also contain cyto protective agents and anti mutagenic agents. This reduces the chance of yielding to cancer. At the same time it contains lots of carotenoids and poly phenols which help to keep the immune system healthy (Gonzalez *et al.*, 2010).

Cheung *et al.* (2014) observed that Banlet (banana lectin), the protein derived from the fully ripe darkened bananas could be developed into anti tumour agents.

Easing Depression: Banana peel contains the amino acid tryptophan which increases the level of serotonin in the body. Serotonin helps in improving our moods and makes us feel happy. A low level of serotonin has been considered to be one of the reasons of depression in people. Increase in the levels of serotonin helps in easing depression (Someya *et al.*, 2002).

Cure of Insomnia : Banana peel is rich in tryptophan, an essential amino acid that helps to sleep better. Therefore, it can be a curative for Insomnia (Aruoma, 2011).

Healthy bowel movements : Banana peel is rich a source of both soluble and insoluble dietary fibers. The intake of foods rich in fiber makes bowel movements regular and prevents constipation.

In a study on effect of resistant starch (RS) on reduction of diarrhea, it was observed that the results were significant when banana peel was used as the source of RS (Menezes *et al.*, 2011).

Aid for probiotic bacteria : Probiotic bacteria are the useful microorganisms which give beneficial effect to humans when it is consumed. High fiber content in the peel creates an ideal site for probiotic bacteria to grow in our colon. It creates a better immune system (Gonzalez *et al.*, 2010).

Skin health : Aruoma (2011) observed that the application of banana peel over the skin improves its appearance and glow. This may be due to the peel being a rich source of vitamin C and other antioxidants that promotes increased blood circulation and also stimulate the production of collagen

Control on skin ageing : Bloknina *et al.* (2003) points out that the antioxidants in banana peel controls the free radicals and prevent the oxidation stress on the cells of our body. This helps in slowing the ageing process and also reduces the signs of ageing.

Healing of acne : Acne is the inflammation of the skin usually seen during teenage . The high K content in banana peel destroys the bacteria and helps to heal blemishes at a faster rate. The antibacterial properties of banana peel are helpful in treating other kinds of skin infections too (Guo *et al.*, 2003).

Eczema and psoriasis : Eczema is the inflammation of the skin. Psoriasis is a common chronic immune mediated skin disease characterized by red patches and papules which is usually itchy. Due to the high antioxidant contents, the peel have excellent exfoliating properties which help in removing loose and flaky skin. The anti oxidant and other nutrients in banana peel provide the necessary nourishment to the skin. Banana peel has anti- inflammatory properties that help in reducing the inflammation associated with eczema and psoriasis (Emaga *et al.*, 2001).

Curing warts : Warts are small rough growth or solid blisters, which is commonly seen in human hands or feet. They are mostly caused by the viral infections, specifically by human papiloma virus. Banana peel has been found to be effective in removing warts and also preventing them from occuring again (Bennet *et al.*, 2010).

2.5 Traditional knowledge on uses of banana peel

Many health practices have been handed down from generations in different parts of the world.

Bug bite relief : Banana peel contains anti-histamines, which works by subduing and blocking histamines such that the effect of the histamines is undone. histamines are the chemical compounds released in body cells that cause allergic reactions. Hence it is applied on bug bites .The anti histamines in the banana peel sink in to the skin and prevent further swelling and cure itching (Saravanan and Aradhya, 2011).

Oral health : Williams (2007) reported that consumption of highly refined food products and caffeine products leave many of our peoples teeth stained. Banana peel is used as a very cheap and accessible way to whiten the teeth, because it contains minerals like K, Mg, Mn. These minerals are absorbed into the teeth making them white and stain free.

Meat tenderizer: Banana peel can be used as a meat tenderizer. Banana peel contains potent enzymes that can help to tenderize meat, it also makes the meat moist and juicy (Yang *et al.*, 2009).

Improving appearance of indoor plants: Leaves of the house plants which look dirty or dusty, when wiped with the inside of banana peel, appears more lustrous (Essien *et al.*, 2005).

Compost making: High nutritional content of banana peel helps to maintain the garden in a cheap, natural and effective way. Banana peel not only decomposes fast but also contain important minerals like potassium and phosphates which will help in the growth of healthy plants and flowers. It is the best way of putting the banana peels to use instead of throwing them off (Castro *et al.*, 2011).

2.6 Scope of banana peel in food industry

Food industry has also benefitted by this raw material in various ways.

Vinegar from starch of banana peels -

Vinegar is produced by fermentation of alcohols to acetic acid by bacteria. Generally, the acetic acid bacteria break down the sugars or starch in the food(substrate) converting it to alcohol and then further to acetic acid by membrane bound enzymes. This vinegar can be used in salad dressings, manufacture of useful medicines, preservation of food stuffs, provision of antioxidants or as an antibacterial agent. *matooke* peel was utilised for this purpose. Here banana peel extract was

fermented by adding wine yeast by surface culture acetification (Beed and Markham, 2008). Since *matooke* peel has about 2 per cent starch adhering to it after peeling, it was hypothesized that this can be further processed by fermentation into a valuable products such as vinegar. The production of vinegar from the *matooke* waste can be of great value to the country economically by providing locally made vinegar in the market which can create jobs and reduce seasonal losses of the fruits. It can also help by providing an avenue to utilize the vast waste produced in the form of peels (Tumutegyereize *et al* ., 2011)

Alcohol production-

The increasing demand of ethanol for various industrial purposes such as alternative source of energy, industrial solvents, cleansing agents and preservatives, has necessitated increased production of this alcohol. Ethanol production is usually accomplished by chemical synthesis of petrochemical substrates and microbial conversion of carbohydrates present in agricultural products.

Banana peels and beet waste are readily available agricultural waste, yet they seem to be under utilized as potential growth medium for local yeast strains, despite their rich carbohydrate content and other basic nutrients that can support yeast growth. A study by Hueth and Melkonyan (2004), indicated that indigenous yeast with good fermentation attributes, enhanced ethanol yield and minimized cost of production. Since ripe banana peels are available in abundance, they can serve as a readily available raw material for the production of ethanol.

Production of alcohol in the media containing dextrose was observed to be 3.07 per cent on the 12th day, while the maximum alcohol production from beet waste and banana peels was 2.15 per cent and 1.90 per cent on 4th day itself. Alcohol produced from dextrose within 4th day was found to be 2.05 per cent, which is

equivalent to ethanol produced from waste in lesser time period (Brooks, 2008). This result indicates that banana peel can effectively be used as the substitute for production of alcohol.

Source of antioxidant phenolic compounds-

Wastes of food industry should be considered as potential sources of bioactive compounds that are of importance both for the food industry and pharmaceuticals, due to its antioxidant capacity, low cost and easy availability. The content of phenolic compounds in banana peel is generally greater than that found in banana pulp. Gallocatechin was more abundant in peel (158 mg/100 g DW) than in pulp (29.6 mg/100 g DW) (Sulaiman *et al.*, 2011).

Kanazawa and Sakakibara (2000) reported that banana peel can be processed to obtain flour that is more easily stored for further use. The high phenolic content of extracts of banana peel flour is likely to be responsible for the very high antioxidant activity. The extracts of banana peel flour exhibited high phenolic content due to the occurrence of important amounts of flavonoid phenolics, mainly, highly polymerized proanthocyanidins.

Banana peel noodles was standardised by partial substitution of wheat flour with banana peel flour. The tensile strength of banana peel noodles was similar to control, but their elasticity was higher, glycemic index was also lower than control (Liorch *et al* ., 2002).

2.7 Industrial application of banana peel

Cellulose nanofiber- from banana peel-

The growing demand for environmental sustainability has encouraged research into biodegradable polymers, to minimize the environmental impact of

conventional polymers. Recently, cellulose has been used to produce rigid nano sized particles. Cellulose nanofibers (CNFs) offer many advantages: they are mechanically strong, stiff, and highly crystalline, so they find wide applications in the biomedical pharmaceutical and the paper industries. They can also function as reinforcing agents in polymer matrices. The addition of CNFs to polymer matrices culminates in composites with improved mechanical, thermal, and permeability properties, providing both economic and strategic benefits. Banana peel is a potential source of cellulosic fiber, a material that is essential to produce paper and clothing and which has recently found applications in the production of nanomaterials. For this bran was prepared from the peel of unripe plantain from the variety "Terra" (*Musa paradisiaca*). The fruit was obtained from the southeastern region of Brazil, from the crop harvested in March 2013, which was not subjected to many postharvest treatments. It was more appropriate to use the unripe banana peel instead of the ripe fruit. This was because the enzymatic reaction in the fruit occured during maturation, and this led to partial degradation of cellulose to monosaccharides. This indicates that banana peel can be effectively used for the production of cellulosic nano fibers (Elanthikkal *et al.*, 2010.

Conversion to biofertilizer-

During the past few years great emphasis has been laid on the biological conversion of plant wastes, especially agricultural wastes into value added products. Fungi are known organic waste decomposers and are generally capable of hydrolysing complex organic compounds as a major source of energy. This potential has been utilized for biomass production, organic waste disposal and its conversion into biofertilizers.

The peel of banana (*Musa sapientum*) is an organic waste that is rich in carbohydrate and other basic nutrients, that could support microbial growth. The potential economic benefits which may accrue from the use of this cheap nutrient material as a source of mycological research medium, and as a substrate for production of valuable micro fungal biomass have prompted the evaluation of the growth performance and biomass production of two mould species on banana peel substrates. The growth performance of moulds on banana peel substrates were found to be adequate when compared to their growth on malt extract based media (Boddy *et al.*, 1985).

There is an urgent need to explore organic materials as alternative sources of microbial growth medium. Banana peel offers a good option for it.

Stable production of biogas from banana peel substrates after 29th day was reported by Nirmala and Ramanathan (2006) . This was obtained after 40 per cent methane was produced .Cattle dung was replaced by chopped banana peel and banana peel powder. Pine apple waste was used as another substrate. Hyphomycetous (Aspergillus fumigatus) and Phycomycetous (Mucor hiemalis) moulds were cultivated in vitro at room temperature (28 ± 20° C) on waste banana peel agar (BPA) and commercial malt extract agar (MEA) as control. The moulds grew comparatively well on banana peel substrates (Stern and McCarer, 2004).

Eco friendly asbestos free brake pad using banana peel -

Brake pads are important parts of braking system for all types of vehicles that are equipped with disc brake. The brake pads generally consist of asbestos fibers embedded in polymeric matrix along with several other ingredients. The use of asbestos fibre has been avoided due to its carcinogenic nature.

A new brake pad was produced using banana peels waste to replace asbestos and Phenolic resin (phenol formaldehyde), as a binder. The proportion of resin varied from 5 to 30 per cent. Morphological, physical, mechanical and wear

properties of the brakepad were studied. The results showed that compressive strength, hardness and specific gravity of the produced samples were seen to be increasing with increase in resin addition. While the oil soak, water soak, wear rate and percentage charred decreased as resin increased. The samples,containing 25 wt per cent in un carbonized banana peels (BUNCp) and 30 carbonized(BCp) gave better properties in all (Akadike *et al.*, 2010).

The result of this research indicates that banana peels particles can be effectively used as a replacement for asbestos in brake pad manufacture.

Banana peel a green solution for metal removal from contaminated water-

Metal contamination is considered to be one of the most ubiquitous and complex environmental issues today. Accumulation of heavy metals in soils and water is of particular importance because it can impact upon human health through possible contamination of food . With the increasing demand for water in agricultural, domestic, industrial, and recreational purposes, remediation and reuse of contaminated waters is receiving prime attention globally.

Therefore, the search for economically affordable alternatives, remains one of the key priorities in research. In this context, agricultural waste materials have been recognized as a possible alternative adsorbent mainly due to the fact that they are easily available, cost-effective and highly efficient in the adsorbtion of different kinds of heavy metal ions (Anhwange, 2008).

Banana peel, which represents about 40 per cent of total weight of the fresh fruit . is generally considered to be a waste material. From production records, it is apparent that the banana industry produces more than 40 million tons of banana peel annually (peel represents about 40% of the total weight of fresh banana).

Exploring alternative uses of banana peel would thus bring an additional value to the industry. Fruit peels generally contain organic compounds such as cellulose, hemicellulose, pectin substances, chlorophyll pigments, and some other low molecular weight compounds. The pectin substances includes complex heteropolysaccharides containing galacturonic acid, arabinose, galactose, and rhamnose,that are found in fruit peels . Galacturonic acid with the carboxyl functions could make pectin substances a strong metal adsorbent in aqueous solutions (Saeed *et al.*, 2005).

According to Hossain *et al.* (2012), 1gm of banana peel can adsorb 28 mg of Cu^{2+} in a favourable condition, and thus provide with a potential alternative for Cu^{2+} removal from water. Moreover, it could adsorb 5.71 and 2.18 mg/gm of $Cd^{2+}$and Pb^{2+}, respectively. Thus, banana peel is recognized to be an economically viable and environmentally sound adsorbent for removal of heavy metals from contaminated waters.

The proven metal removal capacity of banana peel provides with a favorable platform to researchers to work on and come out with a sound technologies applicable in the removal and recovery of metals from water and waste waters. Such a green technology would not only address the much needed sustainable tool for cleaning contaminated waters, but of course bring an additional value to banana peel enhancing the fruit industry worldwide.

Banana peel as an bio-sorbent material for removal of 2-chlorophenol from water-

Water is one of the vital necessities for the survival of human beings. Waste water reclamation, recycling and reuse are vital to meet the water requirements for irrigation, industry and domestic use due to increasing population and related developments in many parts of the world. Industrial waste waters largely possess

organic and inorganic materials such as dyes, phenols, aromatic compounds, and heavy metals.

Phenols cause bad taste and odor to drinking water and can exert negative effects on different biological processes. Phenol and its derivatives also show mutagenic effects by unbinding of the DNA helix, inhibition of DNA synthesis in humans, induction of gene mutations, chromosome aberrations and neuploid formations (phenol, catechol).

Banana peel, was used to produce bio-adsorbents through easy and environmental friendly processes. This natural bio-sorbent was evaluated for the adsorptive removal of 2-chlorophenol compound from water. The characterization results showed that this bio-sorbent has very high specific surface area, potential binding sites and functional groups which could support the adsorption process (Cong *et al.*, 2012).

Banana peel was confirmed as a less expensive, economic and selective adsorbent and an alternative to expensive adsorbents for the removal of 2-chlorophenol from water. The adsorption process was very fast, and it reached equilibration after 1 hour. The equilibrium of the solid-phase extraction of chlorophenols decreased with increasing adsorbent concentration and it reached to a level of 0.2 gm of banana peel/10mL, for removal of 400 µg/L of 2-chlorophenol in 10 ml solution. Thus it can be affirmed that ,banana peel can be effectively used for the removal of 2-chlorophenol from water (Arunakumara *et al.*, 2013).

Organic deodorants and cleaning agents from banana peel –

Bansidhhi (2003) reported that the organic waste from the banana peels were fermented by microorganisms on molasses which was used as the fermented organic liquid. Phitasunulok municipality had utilized this liquid as a deodorizer and cleaning liquid. Furthermore this organic liquid was used as a fermented organic liquid fertilizer.

After the success of the product was ascertained, training courses were organised for the value addition of agricultural waste like banana peels to the local farmers, to increase the income of the farmers. Thus the project "Organic Farming for Good Health" was launched. The project aimed at reducing the use of chemical substances in agriculture. The outcome of the project not only reduced the cost of using chemical fertilizers but also increased the income and thus strengthened farmers of the Organic farming group (Udomporn, 2006).

Dye removal from aqueous solution using banana peel-

Dyes are chemicals, which on binding with a materials will give color to them. Colored dye in waste water arises as a direct result of the production of the dyes and because of its use in the textile and other industries. There are more than 100,000 commercially available dyes with over 7×10^5 of dyes being produced annually worldwide.

There is a need to enhance the adsorption process effectively by various means so as to bring down the values to permissible limits for waste water before discharging it to the environment (Shaobin *et al.*, 2005). The removal of color from aqueous solutions and wastewaters using activated carbon and three low cost

sorbent materials- orange peel, neem leaves and banana peels were studied by studying the effect of time, adsorbent dosage and pH.

Batch studies and column studies confirmed that these low cost materials could be used as a substitute for high cost adsorbent (Rasheed *et al.*, 2002).

Improved chick feed

Ripe banana peel and unripe banana peel were subjected to solid state fermentation using three types of fungal isolates. After 7 days all the three isolates increased the crude protein in the two substrates by 34,30.3 and 32.3 (Heruwatno *et al.*, 2000). This suggests that this can be used to increase the nutritive value of chick feed.

Banana peel, thus stands out from the huge mass of dumped waste of processing industry. Its applications in food industries and other industries needs to gain popularity. Most of all its role in detoxifying environmental hazards, needs to be exploited on a large scale.

MATERIALS AND METHODS

3. MATERIALS AND METHODS

The present study entitled "Development of value added products from banana peel is explained under the following heads:

3.1.Selection and collection of the raw material for the study

3.2. Standardization and product development

3.3. Packaging and storage

3.4. Quality assessment of the products

3.1. SELECTION AND COLLECTION OF THE RAW MATERIAL FOR THE STUDY

Banana belonging to the family *Musaceae* is the most important and popular fruit consumed worldwide by all sections of people. India is the second largest producer of banana (390000 T). Banana is consumed in different forms viz. fresh as well as processed forms like chips, puree or pulp, powder, jams, juice, bars, biscuits, wine and many more forms. Whatever be the form of consuming, 30-40 per cent of banana peel is generated as waste. Banana peels are the thick ropey-textured green to yellow coloured skin. This by -product is also known to cause an environmental problem, because it contains large quantities of nitrogen and phosphorous. Besides the high water content in it, makes it susceptible to attack by microorganisms. At present these peels are not used for any other use, but dumped (Robards *et al.*, 2009).

Studies report that banana peel is a rich source of starch (3%), crude protein (6-9%), crude fat (3.8-11%) and total dietary fibre (43.2-49.7%). It also comprises of polyunsaturated fatty acids and essential amino acids. Due to its high nutritional benefits and the unexploited abundant availability, value addition of banana peel was selected as the area of study.

Banana peel of *cv* nendran was utilized for the study. Nendran is a popular variety in Kerala. It is not only relished as a fruit but also has got wide applications in the processing industry, thus it ranks first in commercial value

Plate 1. Nendran peels selected for the study

among all varieties. Banana chips is a flourishing cottage industry in Kerala. The characteristic flavour of banana chips fried in coconut oil is an exotic identity among the commercial food products of Kerala. Surplus amount of the peel of nendran is generated as waste from the banana chips industry which is found to have application only as cattle feed. Fresh peels of nendran were collected from chips making unit at East fort, Trivandrum.

3.2 STANDARDIZATION AND PRODUCT DEVELOPMENT

Recipe standardization is the process of tailoring recipes to suit a specific purpose. Standardization requires repeated testing to ensure that the product meets the standards of quality and quantity that have been set (Spearson and Gregoire, 2012)

Three banana peel based dishes were identified for standardization namely, Instant soup mix (ISM), Ready to cook (RTC) curry mix and sauce.

In the recipe verification the selected recipes were reviewed for ingredients and quantity. The selected recipes were standardized to ensure consistency in the quality and quantity of product. Each recipe was prepared three times. Each time the yield and acceptability of the products were noted for bringing about any changes.

3.2.1 Standardization of Instant soup mix (ISM)

3.2.1.1 Preliminary Processing

Fresh peels were washed under running water and cut into medium sized slices and the peels were subjected to blanching to prevent darkening and control microbial infestation.

3.2.1.2. Standardization of Blanching Time

Blanching is a cooking process wherein the food, usually a vegetable or fruit, is plunged into boiling water, removed after a brief time interval, and finally

plunged into iced water or placed under cold running water to halt the cooking process (Michael *et al.*, 2011)

The sliced and pre treated banana peel were subjected to blanching. The optimum blanching time was identified by analyzing the scores of Overall visual quality (OVQ) of dehydrated slices, using a 1 -9 point scale where, 9 refers to excellent appearance, 7 to good, 5 to fair (limit of marketability), 3 to fair useable but not saleable and 1 to unusable, This evaluation was conducted by a panel comprising of 10 members (Yuan *et al.*, 2010) . The different periods of time studied are depicted in Table 1.

Table 1. Variation in blanching time of raw material

Sl.No.	Treatments	Time (min)
1.	T_1	3
2.	T_2	5
3.	T_3	7
4.	T_4	10
5.	T_5	15

3.2.1.3.Standardization of pre-treatment media

Pre treating fruits and vegetables for storage is an important step for preserving the produce. It helps the food product to maintain its natural colour and destroy enzymes that can cause food spoilage (Joseph *et al.*, 2001).

Hundred grams of blanched slices were immersed in one litre water with the various additives for 15mts. The best of these variations were again identified by analyzing the scores of Overall visual quality (OVQ) of the drained and dried product as rated by the sensory panel.

Table 2. Composition of various pre-treatment media

Sl. No.	Treatments	Particulars
1.	T_1	Citric acid(0.1%) +salt(1%)
2.	T_2	Citric acid (0.2%) +salt(1.5%)
3.	T_3	Citric acid(0.3%) +salt(2%)
4.	T_4	Citric acid(0.4%) +salt(2.5%)
5.	T_5	Citric acid(0.5%) +salt(3%)

3.2.1.4. Standardization of immersion time

Banana peels were immersed in the selected media for various duration of time. The optimum immersion time in the selected media for retaining maximum sensory qualities was identified, on the basis of scores obtained on a hedonic scale for overall visual quality (OVQ), the best treatment was identified.

Table 3. Variations in immersion time

Sl.No.	Treatments	Time (min)
1.	T_1	5
2.	T_2	10
3.	T_3	15
4.	T_4	20
5.	T_5	25

3.2.1.5 Formulations of banana peel based soup mix

The peels were dried in an electric oven at 60-65°C for 4-8 hrs till breaking stage. The product was then cooled and powdered in a food processor and sieved.

The adjuncts in soup namely onion powder, citric acid, corn flour, capsicum powder, coriander leaves powder, white pepper powder, ginger powder, garlic powder and salt were mixed in different combinations and proportions (g) as given in Table 4. The ingredients were all dried and powdered for blending.

Table 4.Formulations of banana peel based soup mix

Sl. No.	Soup mix	Ingredients	Proportion of ingredients (gm)
1.	S_1	Banana peel flour +onion powder +corn flour+ citric acid + capsicum powder + coriander leaves powder + white pepper powder +ginger powder +garlic powder +salt	5: 4: 1.5: 0.5: 0.25: 0.25: 0.5: 0.25: 0.25: 2
2.	S_2	Banana peel flour +onion powder +corn flour +citric acid+ capsicum powder + coriander leaves powder + white pepper powder +ginger powder +garlic powder + salt	5: 3: 1.5: 0.4: 0.25: 0.25: 0.5: 0.25: 0.25: 2
3.	S_3	Banana peel flour +onion powder +corn flour +citric acid + capsicum powder + coriander leaves powder +white pepper powder +ginger powder +garlic powder + salt	4: 4: 1.5: 0.3: 0.25: 0.25: 0.5: 0.25: 0.25: 2
4.	S_4	Banana peel flour +onion powder +corn flour +citric acid + capsicum powder + coriander leaves powder +white pepper powder +ginger powder + garlic powder + salt	4: 5: 1.5: 0.2: 0.25: 0.25: 0.5: 0.25: 0.25: 2
5.	S_5	Banana peel flour +onion powder +corn flour +citric acid + capsicum powder + coriander leaves powder + white pepper powder +ginger powder + garlic powder + salt	5: 4: 1.5: 0.1: 0.25: 0.25: 0.5: 0.25: 0.25: 2

All the adjuncts were dehydrated at 65°C and powdered. They were then mixed thoroughly to form the instant soup mix.

Soup was prepared by boiling 200ml of water and adding the soup mix as a paste and simmering for 1 mt. The 5 treatments were prepared and subjected to sensory evaluation. The cooked weight of product was noted.

Fig. 1

Processing of banana peel based soup mix (flow chart)

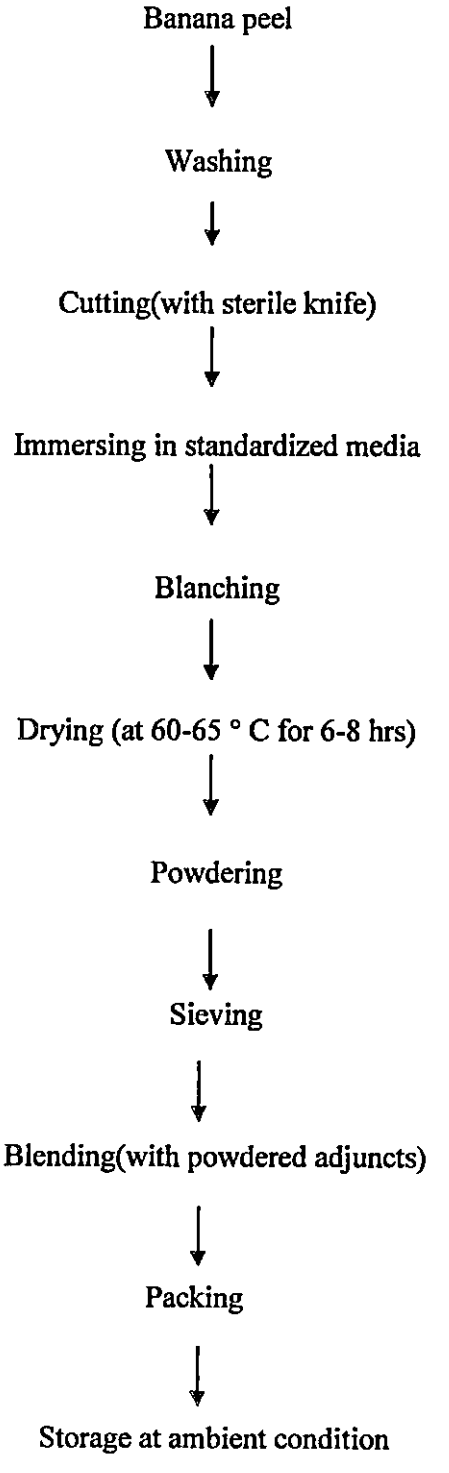


Plate 2. Banana peel based instant soup mix (ISM)

Plate 3. Banana peel based soup

Plate 4. ISM stored in laminated pouch

Here in, the drying and blending technique was adopted where in the dried and powdered ingredients along with the base materials were blended in different proportions.

3.2.2 Standardization of Ready to cook curry mix

3.2.2.1. Standardization of dimensions of Slices

Selection of appropriate dimensions of slices of vegetables to be dried is essential in processing, thicker slices will dry at a slower rate or may not dry fully and it may subsequently deteriorate after packing than thinner pieces. But in the case of very thin pieces there is a tendency for the pieces to stick on to the drying trays which will be difficult to remove. So the length and breadth of the banana peel were standardized. The banana peels were sliced into groups of various dimensions. The best of these variations were identified by evaluating the Overall visual quality (OVQ) of the dehydrated material. The variations in dimensions that were evaluated are given in Table 5.

Table 5.Variations in dimensions of raw material

Sl.No.	Treatments	Dimensions(cm)
1.	T_1	0.5 x 0.5
2.	T_2	1 x 1
3.	T_3	1.5 x 1
4.	T_4	1.5 x 1.5
5	T_5	1.5 x 2
6	T_6	2 x 2

The pre treatment media and time of immersion identified for Instant soup mix was followed here too.

3.4.2.2 Formulation of Ready To Cook (RTC) curry mixes from banana peel

The ingredients in the RTC product are sliced green chilli, crushed red chilli, red chilli powder, pepper, garlic, turmeric, cumin and curry leaves, They were mixed in different combinations and proportions (gm) as given in Table 6.

Table 6. Proportion of adjuncts in RTC curry mix

Sl.No.	Treatments	Ingredients	Proportion of ingredients (gm)
1.	S_1	Banana peel +Crushed Red chilli + Garlic + cumin+ Turmeric powder + Curry leaves	1000: 30:50: 10: 20:50
2.	S_2	Banana peel + Red chilli powder + Garlic +cumin + Turmeric powder + Curry leaves	1000: 30:50: 10: 20:50
3.	S_3	Banana peel +Green chilli + Garlic + cumin + Turmeric powder + Curry leaves	1000: 30: 50:10: 20: 50
4.	S_4	Banana peel + Pepper + Garlic + cumin + Turmeric powder + Curry leaves	1000: 30: 50: 10: 20: 50
5.	S_5	Banana peel +Pepper + Green chilli + Garlic+ cumin + Turmeric powder + Curry leaves	1000: 15: 15: 50: 10: 20: 50

All the formulations were dehydrated at 65°C till crisp. These dehydrated formulations were rehydrated for various durations of time, cooked and subjected to organoleptic evaluation.

3.2.2.3 *Optimization of Reconstitution Time of RTC Products*

The dehydrated RTC mix were reconstituted in different time durations. For this the formulated Ready to cook mixes were soaked in cold water and evaluated for overall visual quality (OVQ) of the product.

Table 7. Variations in reconstitution time of formulations

Sl.No.	Treatments	Time (min)
1.	T_1	10
2.	T_2	15
3.	T_3	20
4.	T_4	25
5.	T_5	30

3.2.2.4. *Optimization of Cooking Time*

The reconstituted mix was subjected to cooking. Cooking time was evaluated for the mix by members of the sensory panel.

Table 8. Variations in cooking time

Sl. No.	Treatments	Time (min)
1.	T_1	5
2.	T_2	7
3.	T_3	9
4.	T_4	11

Grated coconut and coconut oil are essential ingredients in Kerala cuisine. Since they are perishable ingredients they were not included in the RTC mixes. So the amount of coconut and oil to be added at the consumer level was evaluated. Hundred gm of Grated coconut and 15 gm coconut oil were added into RTC mix and subjected to organoleptic evaluation. The cooked weight of the product was noted.

Fig 2

Preparation of banana peel based RTC product (Flow chart).

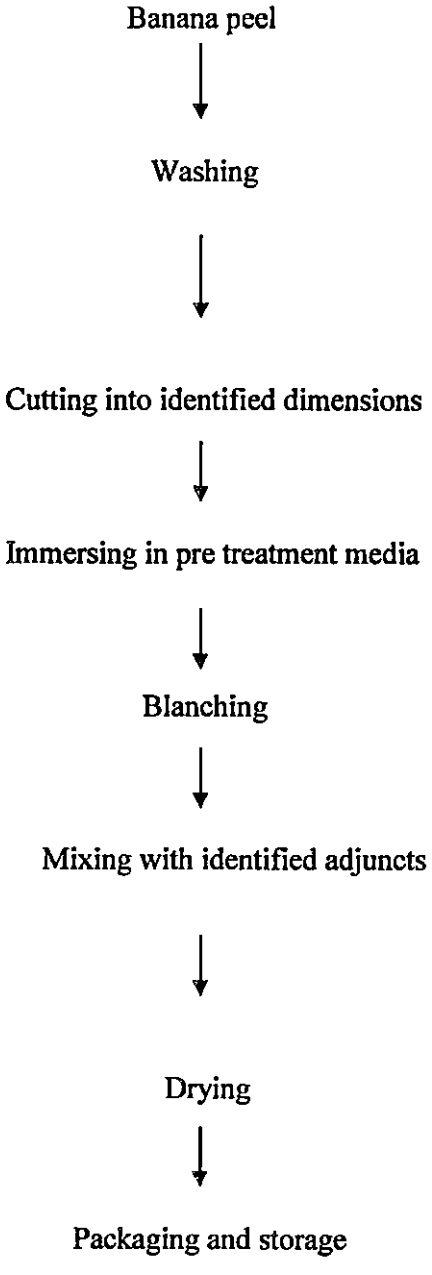


Plate 5. Banana peel based RTC curry mix

Plate 6. RTC curry mix stored in laminated pouch

3.2.3 Standardization of sauce

The banana peel slices were blanched for a time duration standardized earlier and immersed in standardized pre treatment media.

3.2.3.1 Formulation of banana peel based sauce

The adjuncts in *sauce* namely coriander leaves, vinegar, garlic, chilli and sugar were mixed in different combinations and proportions. A spice bag was used to extract the flavour of spices. It comprised of 10 grams of crushed clove, cardamom, pepper, fennel seeds and cinnamon. All the ingredients were blended and processed to sauce consistency and subjected to organoleptic evaluation. The cooked volume of sauce obtained was noted.

Table 9. Formulation of banana peel based sauce

Sl.No.	Treatments	Ingredients	Proportion of ingredients (gm)
1.	S_1	Banana peel +coriander leaves + garlic + green chilli +sugar + spices	100:50:5:5:5:5
2.	S_2	Banana peel + coriander leaves + garlic + green chilli + vinegar + spices	100:50:5:5:5:5
3.	S_3	Banana peel+ coriander leaves +garlic + red chilli +sugar + spices	100:50:5:5:5:5
4.	S_4	Banana peel+ coriander leaves +garlic + vinegar + red chilli + spices	100:50:5:5:5:5
5.	S_5	Banana peel+ coriander leaves + garlic + vinegar + red chilli + sugar + spices	100:50:5:2.5:2.5: 5:5

3.4.3.2. Optimization of Cooking Time

The ideal time duration needed for Cooking of sauce was evaluated for sauce by the members of the sensory panel.

Table 10. Variations in cooking time

Sl. No	Treatments	Time (min)
1.	T_1	3
2.	T_2	6
3.	T_3	9
4.	T_4	12
5.	T_5	15

Fig 3

Preparation of banana peel based sauce (Flow chart).

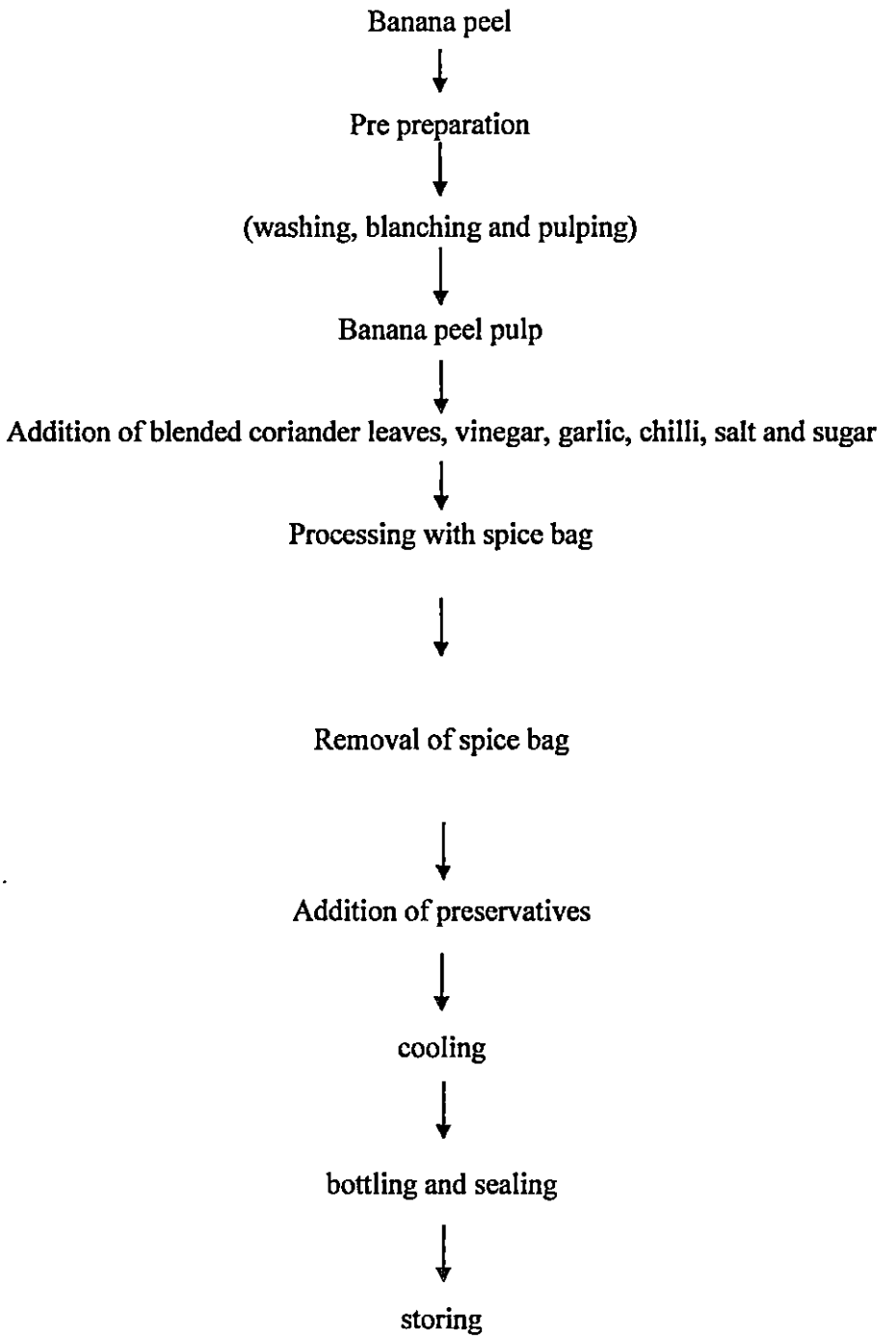


Plate 7. Banana peel based sauce

Plate 8. Banana peel based sauce stored in glass bottle

3.2.4 Acceptability of the developed recipes

Selection of judges

A panel of 10 judges including the staff and students of the department of Food science and Nutrition were selected as sensory panel. Panel members were selected based on the result of the duo-trio test conducted to analyse their taste accuracy and consistency in evaluating the developed recipes.

The selected panel members were those who were aware about nutrition and health; who were not suffering from cold and had not ingested any other food for at least an hour before tesing, They were non smokers, non colour blind and those who had no strong likes or dislikes for the food to be tested (Brown, 2000)

Organoleptic evaluation

The numerical scoring test is generally used to evaluate a particular characteristic of one or more samples indicating the rating as either excellent or good or fair or poor. Acceptability of the developed products with respect to appearance, colour, flavour, texture and taste was estimated using a score card. A scale from 1-5 was used to rate the product, 5 corresponding to the excellent quality and 1 for poor (Manay and Swamy, 2012). .

3.3. PACKAGING AND STORAGE

The standardized banana peel based Instant soup mix and Ready to cook curry mix were stored in laminated pouches and the sauce was stored in glass bottles kept in ambient conditions. The shelf life was assessed at periodic intervals for 3 months.

3.4. QUALITY EVALUATION OF THE DEVELOPED BANANA PEEL BASED PRODUCTS

Quality parameters with respect to physical, chemical and nutritional characteristics were analyzed. Besides parameters like cost, shelf life and sensory attributes were also evaluated to ascertain consumer acceptance.

3.4.1. Physical Characteristics of Dehydrated Mixes

Appearance, yield, dehydration ratio, bulk density and water absorption index of the developed banana peel products were studied.

3.4.1.1. Appearance

Appearance is the criteria of desirability of any food product. Appearance of the dehydrated mixes and sauce was evaluated by a sensory panel.

3.4.1.2. Moisture

Five grams of sample was weighed into a previously weighed crucible and dried in an oven at 130°C till a constant weight was attained.

$$\text{Moisture \%} = \frac{\text{Initial weight (g)} - \text{Final weight (g)}}{\text{Sample weight (g)}} \times 100$$

3.4.1.3. Yield ratio

The weight of the product in relation to raw material used was calculated using the formula.

$$\text{Yield ratio} = \frac{\text{Weight of product}}{\text{Weight of fresh banana peel}}$$

3.4.1.4. Rehydration Ratio

Rehydration ratio of RTC mix was recorded. About ten gram of the sample was mixed with 100ml of distilled water, stirred and kept for 5 minutes. The contents were filtered using a filter paper. The rehydrated sample was weighed and rehydration ratio was calculated using the formula.

$$\text{Rehydration ratio} = \frac{\text{Initial weight of the sample}}{\text{Drained weight of the sample}}$$

3.4.1.5. Bulk Density

Bulk density is the ratio of the weight of the sample to the weight of an equal volume of water. The sample of Instant soup mix and RTC mix was taken at a height of 20 cm in 50 ml beaker. It was leveled without compressing. The weight of the sample with the beaker was recorded. The sample was then removed from the beaker and water was filled to the same level. The weight of the water with beaker was recorded and calculated using the formula.

$$\text{Bulk density} = \frac{\text{Weight of the sample}}{\text{Weight of equal volume of water}}$$

3.4.1.6 Water absorption index

Water absorption is the difference in weight of cooked product (RTC mix), expressed as the percentage to the weight of uncooked mix. (Ocloo *et al.*, 2010).

3.4.2. Nutrient Composition.

Nutrient and chemical composition of the developed products were analysed using the standard procedures. The details of procedures are depicted in Table 11.

Table 11. Nutrient Composition

Constituents	**Method adopted**
Carbohydrate (g)	Sadasivam and Manikkam (1992)
Protein(g)	Bradford (1976)
Calories(Kcal)	Gopalan*et al* (2009)
Fibre (g)	Sadasivam and Manikkam (1992)
Total minerals(mg)	Raghuramalu (1983)
Calcium (mg)	Jackson (1973)
Iron(mg)	Jackson (1973)
Chemical composition	
Moisture (%)	Sadasivam and Manikkam (1992)
Total acidity(%)	AOAC (1965)
Reducing sugar(g%)	AOAC (1965)
pH	pH meter
TSS(°brix)	Refracto meter

3.4.3. Shelf Life Study

The shelf life of the three developed products were evaluated at monthly intervals up to three months in terms of, moisture, microbial profile and sensory attributes.

3.4.3.1. Moisture

Moisture content of the dehydrated food material is an important factor which affect the stability of the food. So it is necessary to maintain the moisture to a level where microorganisms may not be able to grow and spoil the product (Liji, 2013). The moisture level was noted periodically, for a period of 3 months.

3.4.3.2. Microbial Profile

The stored product samples were analysed for the presence of various microorganisms *viz.*, bacteria, fungi and yeast at monthly intervals up to three months. The serial dilution of the samples followed by pour plating was employed to estimate the population of viable microorganisms in the developed products.

3.4.3.3. Sensory Attributes

Sensory quality evaluation plays an important role in acceptability of a new product. Sensory characteristics like appearance, colour, flavour, texture, taste and overall acceptability of the banana peel based soup, curry mix and sauce were assessed by a panel of judges using a five point scale periodically for 3 months.

3.4.4 Cost of the Developed Products

Cost of the developed products of the mixes were analyzed based on input cost *ie* cost of different ingredients used for the preparation of the product, with cost of packaging materials and over head charges (10 per cent of the cost of products were added as overhead charges for fuel and labour, to the total input cost).

3.4.5. Statistical Analysis

In order to obtain suitable inter pretation, the generated data was subjected to statistical analysis – Measures of central tendency, Anova test and Kruskal wallis test were the main tools adopted. Graphical interpretation of analyzed data is also presented.

RESULTS

4. RESULTS

The results of the present study entitled " Development of value added products from banana peel" is presented under the following heads:-

4.1. Standardization and product development

4.2. Packaging and storage

4.3. Quality assessment of developed banana peel products

4.4. Shelf life studies

4.1. STANDARDIZATION AND PRODUCT DEVELOPMENT

Food processing is the transformation of raw ingredients, by physical or chemical means into other acceptable forms. Food processing aims to convert raw food ingredients to marketable food products that can easily be prepared and served to the consumer. Food processing typically involves activities such as mincing, macerating, liquefaction, emulsification, cooking (such as boiling, broiling, frying, or grilling),pickling, pasteurization, preservation and canning, followed by suitable packaging. Benefits of food processing includes removal of toxins, preservation and also facilitation of marketing and distribution tasks. In addition, it increases the annual availability of many foods, enables transportation of delicate perishable foods across long distances and makes many kinds of foods safe to eat by de-activating spoilage and pathogenic micro-organisms (Levenstein *et al.*, 2003).

Standardisation plays a key role in food product development, which in turn facilitates the growth of food industries. According to Carson *et al.* (2001), the standardization process can be summarized in three phases: product verification, product evaluation, and quantity adjustment. Product verification consists of reviewing the product in detail, preparing it, verifying its yield, and recording changes. Product evaluation focuses on determining the acceptability of the product produced from the recipe. Changing the product yield and ingredient amounts occurs in the quantity adjustment phase.

4.1.1 Standardization of Instant soup Mix

4.1.1.1. Preliminary Processing

Pre –treating fruits and vegetables for storage is an important step in preserving the produce. It helps the food product to maintain its natural colour and destroy enzymes that may cause food spoilage (Devahastin and Niamnuy, 2010).

Preliminary processing was done to control the enzymatic browning of banana peel. The various treatments were evaluated by a panel of 10 members to screen out the best treatment. Since the attribute to be assessed was only appearance ' Overall visual quality' (OVQ) scores were ascertained by the panel.

4.1.1.2. Standardization of Blanching Time

Blanching is a unit operation prior to freezing, canning, or drying in which fruits or vegetables are heated for the purpose of inactivating enzymes, modifying texture, preserving color, flavor, and nutritional value and removing trapped air (Ramesh *et al.*, 2002).

Banana peel was blanched in various durations of time *viz.*, 3min, 5min, 7min, 10min and 15 minutes and subjected to dehydration. The scores of OVQ of the dehydrated banana peel were analysed . Table 12 indicates OVQ scores of blanched banana peel in different time duration.

Among all the treatments, highest rank score of visual quality was obtained for T_2 (42.9), being 5 minutes. This was followed by $T_1$and T_3 (28.4 and 24.5 respectively). T_5 scored the lowest mean rank value among all the five treatments (16.2). So T_2(42.9) was selected as the optimum time for blanching. There was no significant difference the scores of T_1 and T_5.

Table 12. Overall Visual Quality (OVQ)of blanched raw material

Sl.No.	Treatments	OVQ scores
1.	T_1 (3min)	28.4
2.	T_2 (5min)	42.9
3.	T_3(7min)	24.5
4.	T_4(10min)	18.1
5.	T_5(15 min)	16.2
	CD(0.05)	18.07

(OVQ scores indicate mean rank values)

4.1.1.3 Standardization of Pre-Treatment Media

In order to prevent browning and to preserve colour of the banana peel, different pre-treatment media comprising of citric acid and salt and their combinations were used before dehydration.

On analysing the OVQ scores, the treatment T_5 with citric acid and salt was observed to have the highest mean rank score (42.2) from amongst the 5 treatments. This was followed by T_4 with citric acid and salt (31.0). The treatmentT_1 (12.2) and T_2 (15.1) recorded the lowest scores, which were also found to be on par (CD = 18.07 at 5% level of significance). Hence T_5 was selected from among the 5 treatments as best pre-treatment media for raw material. In other words T_5 retained the colour and appearance of the raw material to the maximum.

Table 13. Overall Visual Quality(OVQ)of pre treated raw material

Sl.No.	Treatments	OVQ scores
1.	T_1(Citric acid(0.1%) +salt(1%))	12.2
2.	T_2(Citric acid(0.2%) +salt(1.5%)	15.1
3.	T_3(Citric acid(0.3%) +salt(2%)	26.0
4.	T_4(Citric acid(0.4%) +salt(2.5%)	31.0
5.	T_5(Citric acid(0.5%) +salt(3%)	42.2
	CD(0.05)	18.07

(OVQ scores indicate mean rank values)

4.1.1.4. Standardisation of Immersion Time

According Firueroa *et al.* (2000), dipping or briefly soaking produce in salt water solution will help to create appropriate conditions for the growth of micro-organisms that form acids, which will in turn preserve the produce and also improve the colour, odour and taste.

The immersion time of raw material in pre-treated media was set in different time durations such as 5min, 10min, 15min, 20min and 25min .The products were then dehydrated in uniform

conditions. On evaluation of OVQ scores,T_2 (10 min) got the highest mean rank score (42.7) and T_5 (25 min) got the lowest mean rank score. Values of T_4 and T_5 were found to be on par (CD = 18.07 at 5% level of significance). Hence T2 was selected as the optimum time duration for the immersion of raw material.

Table 14. Overall Visual Quality (OVQ)of immersed raw material

Sl.No.	Treatments	OVQ scores
1.	T_1(5min)	33.6
2.	T_2(10min)	42.7
3.	T_3(15min)	23.8
4.	T_4(20min)	15.1
5.	T_5(25min)	12.2
	CD(0.05)	18.07

(OVQ scores indicate mean rank values)

4.1.1.5. Formulation of instant soup mix(ISM)

Soup is a food product which is dense with low energy and high-volume . It is valued as a food helping to regain health, along with being an appetiser. Dried soup mixes play an important role in the nutrition of people because they fulfill present and future nutrient requirements of consumers. The advantages of the dehydrated foods, particularly, dry soup mix is that they are protected from enzymatic and oxidative spoilage and are ensured of flavour stability at room temperature over long periods of time (6 - 12 months). Moreover they possess a high nutritional profile and do not need refrigeration (Krejčová *et al.*, 2007).

In the present study, five combinations of instant soup mixes were formulated keeping the banana peel flour as the major ingredient and varying the amount and proportion of adjuncts used. A Sensory panel comprising of 10 judges evaluated the various formulations with respect to the five parameters namely, appearance, colour, texture, flavour, taste and overall acceptability.

For the processing of ISM, drying and blending technique was used. In this processing method the ingredients such as banana peel, onion, capsicum, coriander leaves, white pepper ,ginger and garlic were dried and powdered at 60-65 °C for 6-8 hours. They were blended with other adjuncts such as corn flour, citric acid and salt in different proportions.

4.1.1.6 Sensory quality of ISM

The blended mixes were boiled with 200 ml of water in paste form and simmered for 1 mt. The product was served hot to the sensory panel members, the rating of quality with respect to appearance, colour, texture, flavour, taste and overall acceptability are presented below (Table.15).

Appearance

The first impression of food depends on its appearance. The mean rank values for appearance of the five formulations of *instant soup mix* ranged from 19.1-39.2. The highest mean rank score (39.2) for appearance was obtained in S_1 which was the combination of banana peel flour, onion powder, corn flour, citric acid, capsicum powder, coriander leaves powder, white pepper powder, ginger powder, garlic powder and salt. The score of S_1 was observed to be significantly higher than all other treatments.

Analyses of scores revealed that the formulation S_1 was significantly higher in scores for appearance than the other formulations.

Colour

Colour is one of the important visual attributes that has been used to judge the overall quality of foods for a very long time. Among the formulations S_1 was noted to get the highest mean rank score (37.5) because of its slight yellow colour while S_5 recorded the lowest mean rank score (19.3) for this parameter. There was significant difference in these scores of the formulations.

Consistency

Texture constitutes the physical property of a food stuff as apprehended by the eye, skin and muscle senses located in the mouth. The highest mean rank score (42.0) in consistency was

again obtained for the formulation S_1. The combination S_5 got the lowest mean rank score (18.5) among the treatments. The score of S1 was significantly higher than that of other treatments.

Flavour

Odour preference is generated by stimulation of sensory cells by specific volatile compounds present in foods. The flavour of different formulated soup mixes differed in mean rank values, which ranged from 18.6 – 39.9. The highest mean rank value was recorded by S_1 (39.9) and least mean rank value was scored by S_5 (18.6). These differences in values were statistically significant too. The combination of different spices such as coriander leaves, capsicum powder, ginger and garlic powder was responsible for the flavour of S_1 formulation.

Taste

Taste is the major attribute which determines the acceptability of a food. Taste is the sensation produced when a substance in the mouth reacts chemically with receptors of taste buds. Superior taste was found for S_1 with the highest mean rank score of 42.2 and least was noted in S_5 (16.3). The difference in these scores were also found to be significant.

Overall Acceptability

Overall acceptability also clearly depicted that among the 5 formulations S_1 obtained maximum mean rank value (38.5) and therefore the highest preference. Least mean rank value (17.3) and less preference was recorded for S_5. Results indicate that there was significant difference in the rank scores obtained for the parameters of the five formulations for S_1 and S_5. On the basis of analysis of scores S1 was selected as best combination.

Table 15. Sensory quality of various formulations of instant soup mix

Treatments	Appearance	Colour	Flavour	Consistency	Taste	Overall acceptability
S_1	39.2	37.5	39.9	42.0	42.2	38.5
S_2	26.5	25.7	25.2	26.2	26.8	25.4
S_3	21.3	22.5	23.0	23.9	22.0	25.4
S_4	19.1	22.5	20.8	16.8	20.1	20.7
S_5	21.3	19.3	18.6	18.5	16.3	17.3
K value	15.37	11.92	16.07	25.22	27.53	15.3
CD (0.05)	18.07					

(Scores indicated are mean rank values)

4.1.2 Standardisation of Ready to cook curry mix

4.1.2.1 Standardization of dimension of Slices

Cutting the vegetables into uniform slices will improve its appearance and consumptionIt is important that all of the pieces are about the same size, so that they will dry at the same rate.

The mean rank values of scores allotted by the panel members for Overall visual quality was evaluated. The six dimensions were dehydrated and rated by panel members. Overall visual quality (OVQ) scores for dimension of slices of raw material revealed that T_2 scored the highest mean rank value (51.8) and T_6 scored the lowest mean rank value (13.7). Thus T_2 was selected as the best dimensions of raw material. The values were found to be significantly different as revealed by the CD value (Table 15).

Table 16. Overall Visual Quality (OVQ) of dimensions of raw material

Sl No	Treatments	OVQ Scores
1	T_1(0.5X0.5 cm)	17.1
2	T_2(1x1 cm)	51.8
3	T_3(1.5x1 cm)	45.3
4	T_4(1.5x1.5 cm)	32.2
5	T_5(1.5x2 cm)	22.8
6	T_6(2x2 cm)	13.7
	CD (0.05)	22.02

(OVQ scores indicate mean rank values)

4.1.2.2 Formulations of Ready to cook (RTC) dehydrated product from banana peel

Ready To Cook products are primarily targeted for persons having busy life styles, and those who are convenience seekers and also mobile women. The newly emerging era of fast foods, convenient foods and instant foods are becoming increasingly popular among Indian households (Rajpur, 2007). According to Solanki (2000), there is an urgent need to develop low cost ready to cook mixes to improve the nutritional status of our population along with saving time.

In the present study, different combinations of dehydrated RTC products were formulated keeping the banana peel as the major ingredient and varying the amounts and proportion of adjuncts used. A Sensory panel evaluated the various formulations with respect to the five parameters namely, appearance, colour, texture, flavour, taste and overall acceptability. The analysed data is presented in the Table 17.

Appearance

The appearance parameter increases the appeal of a product. Among the RTC curry mixes the formulation S_1 obtained significantly higher mean rank value (40.1) for appearance . This

formulation comprised of banana peel, crushed red chilly, garlic, cumin, turmeric powder and curry leaves. While formulation S_5 got the lowest mean rank value (19.7). Hence the combination S_1 was selected as the best. The mean rank values obtained were found to be significantly different.

Colour

Colour is another important parameter for the consumer acceptance of any food product. If the colour is un attractive, a potential consumer may not be impressed by any other attributes. Among the formulations S_1 recorded the highest mean rank score of 40.5 while S_5 recorded the least mean rank score 18.There existed significant difference between S_1 and S_5. But the difference between S_2, S_3 and S_4 were on par.

Texture

Texture is an overall assessment of the sensations of the mouth and hand or it is the sense of touch by hand and mouth, S_1 got the highest mean rank value (38.0) for this attribute and S_5 got lowest mean rank value (20.5). The difference in these scores were found to be significant. The scores obtained by S_2 and S_3 were on par with regard to this parameter.

Flavour

Flavour distinguishes one food from another, therefore it is considered an important parameter in the acceptance of any food product. The maximum mean rank value for flavour was noted for S_1 (39.7) while least mean rank value (16.7) was obtained for S_5. Data on the mean rank score obtained for flavour of different treatment revealed a significant difference.

Taste

Consumers generally value food for its taste. In this case mean values revealed that there was a significant difference in the taste of the formulated RTC curry mix. The obtained mean rank values ranged from 20.3– 37.8. S_1 gained the highest mean rank value (37.8) and S_5 got the lowest mean rank value (20.3) for this attribute. The scores obtained for S_3 and S_4 were on par with each other.

Overall Acceptability

Statistical analysis revealed that there was significant difference in this parameter between the formulations developed (between $S_1$and S_5). It is noted that S_1 obtained the highest mean rank value (38.4) in overall acceptability than other formulations, second position was obtained by S_2 (25.5) and least mean rank value was noted for S_5 (21.2). On the basis of analysis of values, $S_1$was selected for the further study.

Table 17. Sensory quality of various formulations of RTC curry mix

Treatments	Appearance	Colour	Flavour	Texture	Taste	Overall acceptability
S_1	40.1	40.5	39.7	38.0	37.8	38.4
S_2	24.0	23.0	27.7	25.5	26.7	25.5
S_3	21.8	23.0	20.5	23.0	22.4	23.3
S_4	21.8	25.5	22.9	20.5	22.3	19.0
S_5	19.7	18.7	16.7	20.5	20.3	21.2
K value	24.83	22.61	24.22	20.82	16.39	17.50
CD (0.05)	18.07					

(Scores indicated are mean rank values)

4.1.2.3. Optimization of Reconstitution Time of RTC curry mix

The formulated RTC mix were reconstituted by various treatments. A measured quantity of mix (116g) was soaked in cold water for 10min, 15min, 20min, 25min and 30min. The reconstitution time was evaluated with respect to OVQ scores of the product for appearance. When the scores of OVQ were analysed, treatment T_3 was found to be get the highest mean rank value (43.0) and T_1 got lowest mean rank score (12.9). The difference among the scores were found to be significant. It ranged from 12.9-43.0. Therefore T_3 was selected as the optimum time duration for the reconstitution of RTC curry mix.

Table 18. Overall Visual Quality(OVQ) of reconstituted RTC curry mix

Sl No	Treatments	OVQ Scores
1	T_1(10 min)	12.9
2	T_2(15 min)	25.8
3	T_3(20 min)	43.0
4	T_4(25 min)	27.9
5	T_5(30 min)	17.8
	CD (0.05)	18.07

(OVQ scores indicate mean rank values)

4.1.2.4. Optimization of Cooking Time of Dehydrated RTC Mix.

Optimization of cooking time of dehydrated mix is also an important information to be conveyed at the consumer level. Formulation 1 comprising of banana peel, crushed red chilly, garlic, cumin, turmeric powder and curry leaves were cooked at various duration of time (5 min – 11 min). The product was evaluated on the basis of OVQ scores of the 10 panel members. The results of OVQ scores are presented in the Table 19.

The mean rank values ranged from 10.2 – 32.2. T_2 was found to be give the highest mean rank value (32.2) and T_1 got lowest mean rank value (10.2). These scores were found to be significantly different (CD=13.79 at 5% level of significance). Thus for different treatments,T_2 was found to be the optimum cooking time for RTC curry mix.

Table 19. Overall Visual Quality(OVQ) of RTC mixes cooked in different timings

Sl No	Treatments	OVQ Scores
1	T_1 (5 min)	10.2
2	T_2 (7 min)	32.2
3	T_3 (9 min)	27.2
4	T_4 (11 min)	12.4
	CD (0.05)	13.79

(OVQ scores indicate mean rank values)

4.1.3 Standardization of sauce

Sauce is a semi-solid food served on foods or used in preparing other foods. Sauces give flavor, moisture, and visual appeal to many dishes. Sauces are an essential element of cuisines all over the world.

4.1.3.1 Formulations of banana peel based sauce

Five combinations were formulated for *sauce*. The organoleptic evaluation of formulated sauce cooked for a constant time (10 min) was done by panel of 10 judges and the data in the form of mean values are presented in the Table 20.

Appearance

Surface characteristics of the food products contribute to appearance. The mean rank scores obtained for the appearance of the formulated *sauce* developed from banana peel ranged from 19.1 – 41.0. The statistical analysis of data showed that, there was significant difference in the mean rank values for appearance of the formulated *sauces* (between S_1 and S_5). Combination S_5 comprising of banana peel, coriander leaves, garlic, red chilly, vinegar, sugar and spices got the highest mean rank value (41.0). Formulation S_1 developed using the ingredients such as banana peel, coriander leaves, garlic, green chilly, sugar and spices obtained the lowest mean value. But it was seen to be on par with the mean values for appearance of S_2, S_3 and S_4.

Colour

The mean rank values of colour ranged between 18.6-35.4. Among the five formulations S_5 secured the highest mean rank value (35.4) *ie* dull green colour which was the most preferred colour for sauce and reddish tint made it more attractive. Data on the mean score obtained for colour of different treatments revealed a significant difference.

Consistency

With regard to the consistency of the sauce samples, S_5 attained the highest mean rank score (38.1) compared to other formulations S_1 obtained the lowest mean rank value (19.0). Statistically the five formulations were found to be significantly different. Formulation S_5 with the highest mean rank value was selected as the best, which has semi liquid consistency.

Flavour

The mean rank flavour scores of sauce ranged between 18.3-39.3.The blending of flavours was rated best for the combination S_5. This suggests that sauce with appreciable aroma could be prepared from a blend with major share of banana peel in combination with coriander leaves and red chilly. The higher aroma score confirmed the presence of desirable aromatic compounds in the mix. S_1 scored the lowest with respect to flavour. There existed a significant difference in the flavour of the different combinations.

Taste

Taste is the major attribute which determines the acceptability of food. It is not only a sensory response to soluble materials but also an aesthetic appreciation in the mouth. When taste of different samples of sauce were tested by sensory evaluation, the combination S_5 recorded a distinctly superior grade (38.1) while S_1 recorded the least rank score (20.2). The mean rank values obtained were significantly different. So on the basis of taste, formulation S_5 was selected as the best.

Overall Acceptability

While considering the overall mean rank scores the best sauce was that of formulation S_5 (36.3) followed by S_2 (26.3) and S_3 (23.19). Lowest mean rank score was obtained by the treatment S_1 (19.5). A significant difference was noted among the samples in overall acceptability (CD=18.07at 5% level of significance).

On the basis of mean rank values S_5 was selected as the best formulation of sauce developed from the banana peel.

Table 20. Sensory quality of various formulations of sauce

Treatments	Appearance	Colour	Flavour	Texture	Taste	Overall acceptability
S_1	19.1	18.6	18.3	19.0	20.2	19.5
S_2	22.0	20.5	22.5	23.4	22.3	26.3
S_3	21.0	25.3	22.5	25.9	24.5	23.9
S_4	23.5	27.7	24.9	21.0	22.3	21.5
S_5	41.0	35.4	39.3	38.1	38.1	36.3
K value	25.61	13.47	25.34	20.62	17.53	4.61
CD (0.05)	18.07					

(Scores indicated as mean rank values)

4.1.3.2 Optimization of cooking time of banana peel based sauce

The best cooking time was selected from the five timings namely 3 min, 6 min, 9 min 12 min and 15 min. The OVQ of formulated sauce samples were evaluated by the panel of 10 judges and the scores are presented in the Table 21.

The mean rank values obtained ranged from 12.3 – 41.3. It was observed that T2 scored the maximum mean rank value (41.3) with 6 min cooking time, followed by T_3 with the mean rank value (28.9) with cooking time of 9 min. T_1 obtained the minimum mean rank value (12.3). The statistical analysis of data depicted that the difference in scores were significant. So T_2 was selected as the optimum cooking time for banana peel based sauce.

Table 21. Overall Visual Quality(OVQ) of sauce processed in different time duration

Sl No	Treatments	OVQ Scores
1	T1 (3 min)	12.3
2	T2 (6 min)	41.3
3	T3 (9 min)	28.9
4	T4 (12 min)	18.1
5	T5 (15 min)	26.9
	CD (0.05)	18.07

(OVQ scores indicate mean rank values)

4.1.4 COOKING CHARCTERISTICS

Cooking time – When instant soup mix required 1 minute for cooking, RTC curry mix took 7 minute after reconstitution for thorough cooking. As for sauce 170 gm of raw material required six minutes for processing.

Cooked weight – 10 g of instant soup mix formed 135 gms of soup on cooking with 200 ml of water. As for RTC curry mix 10 g of dry sample when cooked with 200 ml of water yielded 40g of product. On processing 170 ml of raw materials for sauce, the final product weighed 85ml.

4.2. PACKAGING AND STORAGE

Food packaging plays a vital role in preserving food throughout the distribution chain. Without packaging, the quality of food gets compromised as it can get contaminated by direct contact with physical, chemical, and biological contaminants. In recent years, the development of novel food packaging (modified atmosphere and active packaging) has not only increased the shelf life of foods, but also their safety and quality - thus bringing more convenience to consumers.

The standardized Instant soup mix (ISM) and Ready To Cook curry mix were packed in laminated pouches and banana peel based sauce was sealed in glass bottles and they were stored in ambient conditions for studying their shelf life at monthly intervals up to three months.

4.3. QUALITY EVALUATION OF INSTANT SOUP MIX,RTC CURRY MIX AND SAUCE

Food quality is the quality characteristic of food that is acceptable to consumers. This includes external factors such as appearance (size, shape and gloss), colour, texture, and flavour and quality is also considered as an important food manufacturing requirement (Potter *et al.*, 2009).

Quality is a very important parameter for judging the edible nature of any food product. These include physical characteristics, sensory attributes, proximate composition and shelf life studies.

4.3.1. Physical Characteristics of the developed products.

Physical characteristics are associated with the overall quality of the developed food product. It helps in the quality assessment and acceptability of any food product . The physical characteristics namely yield, rehydration ratio, bulk density and water absorption index were studied.

4.3.1.1. Yield ratio

Drying removes moisture and as a result the food shrinks and decreases in size and weight, thus requiring less space for storage. Yield of dried products are directly related to the amount of water is in the original product. The yield ratio of the developed banana peel products are given in Table 22.

It was noted that when 1000g of sliced pre-treated banana peel was dried and processed the yield ratio of Instant soup mix and RTC mix were 0.06 and 0.13 respectively. The yield of pulped and processed sauce was found to be 1.4.

4.3.1.2. Rehydration ratio

Drying brings about a substantial reduction in weight and volume there by making it suitable for packaging, storage and transportation and also enables storability of the product under ambient temperature (Senadeera *et al.*, 2005). Rehydration of dried foods is a complex procedure influenced by several factors such as chemical composition, drying techniques used,

composition of the immersion medium and also temperature, which play a major role on the quality attributes of the product (Kaymak, 2002).

Rehydration ratio is the weight of dehydrated sample to drained weight of rehydrated sample. The rehydration ratio of the developed RTC mix is presented in the Table 22. The rehydration ratio of RTC mix was found to be (0.38) .

4.3.1.3. Bulk density

Bulk density is a property of dehydrated products. It is defined as the mass of many particles of the material divided by the total volume they occupy. The total volume includes particle volume, inter-particle void volume and internal pore volume. Bulk density of *soup* mix was 0.81and curry mix was 0.73. The bulk density of developed RTC mixes is given in the Table 22.

4.3.1.4 Water absorption index

Water absorption index of soup mix was 13.5 per g and curry mix was 4.0 per g.

Table 22. Physical characteristics of the developed products

Products	Yield ratio	Bulk density (g/ml)	Water absorption index(per g)	Rehydration ratio
Instant soup mix	0.06	0.81	13.5	-
RTC curry mix	0.13	0.73	4.0	0.38
Sauce	1.40	-	-	-
CD (0.05)	0.01			

(OVQ scores indicate mean rank values)

4.3.2 Chemical composition of developed products

Chemical composition of the banana peel based products were ascertained with respect to moisture (%), acidity(%), reducing sugar, fibre (g), pH and TSS.

4.3.2.1 Moisture

Moisture content is one of the vital parameters which interferes with the quality of the banana peel products during the storage. This affects the physical and nutritional composition of the developed products. The total moisture content of the developed RTC mixes are shown in Table 22.

The moisture level of the dehydrated products ranged from 4.4-5.4 per cent. The moisture content noted for sauce was72.2 per cent. and the moisture content observed in curry mix was 5.4 per cent.The moisture content of soup mix was found to be 4.4 per cent. However these values were in the safe range with respect to shelf life and FSSAI specification, because moisture content of dehydrated products should be 5-7 per cent, and sauce should be not more than 75 per cent.

{Moisture content for soup powder-not more than 5 per cent -FSSAI regulation 2011.2.3.15.}

4.3.2.2 Acidity of developed products

Acidity is one of the prime chemical constituents which indicates the deteriorative changes in the product. Acidity of the developed products are presented in the Table 23. The acidity of the formulated banana peel products was found to be in the range of 0.76-1.75 per cent. The highest value was 1.75 per cent was noted in sauce. Then next high value of 0.85 per cent was observed in banana peel based RTC curry mix which was on par with sauce.The lower value was observed in Instant soup mix 0.76.

{Acidity of sauce not less than 1.2% - FSSAI regulation 2011.2.3.28}

4.3.2.3 Reducing sugar of developed products

Reducing sugar is expressed in terms of glucose since glucose is the most predominant reducing sugar present in fruits. Among the three products high value for reducing sugar was obtained in soup mix (1.07 g%) which was on par with sauce (1.01 g%).Lowest value for reducing sugar was obtained in RTC curry mix (0.97g%). These values indicate that reducing sugar content of the banana peel based products was relatively low.

4.3.2.4 Fibre content of the developed products

Fibre is the indigestible portion of food derived from plants, which is low in calorie density and help in regulating bowel movements, reduces blood cholesterol promotes chewing and decreases the rate of ingestion.

The total fibre content of the developed mixes is shown in the Table 23. Fibre content of the mixes ranged from 2.06-14.10gm. Higher fibre content was noted for RTC curry mix (14.10gm/100gm) and less fibre was recorded for sauce (2.06gm/100gm). Fibre content of soup mix was (9.4gm/100gm).

The ANOVA results reveal that there was significant difference between the fibre content of the developed banana peel products.

4.3.2.5 TSS of developed products

Sugar content of fruit is measured as Total Soluble Solids or Soluble sugar content. It is partially influenced by fruit maturity. TSS content of sauce was found to be 20.
{TSS content of sauce not less than 15%-FSSAI regulation 2011.2.3.15.}

4.3.2.5 pH of developed products

pH of soup mix, RTC curry mix and sauce were found to be in the range of 4.06-5.20. The result indicated that the developed products were acidic in nature.

Table 23 Chemical composition of developed banana peel products

PRODUCTS	Moisture (%)	Acidity(%)	Reducing sugar (g%)	TSS(°brix)	pH	Fibre(g)
Instant soup mix	4.4	0.76	1.07	-	5.20	9.4
RTC curry mix	5.4	0.85	0.97		5.10	14.10
Sauce	72.2	1.75	1.01	20	4.06	2.06
CD(0.05)		0.02	0.02		0.01	0.19

(Values indicated are mean of 3 replications)

4.3.3.Nutrient composition of developed banana peel products

Proximate composition of the mixes were ascertained with respect to carbohydrate (g), protein (g), calories (Kcal) and total minerals (mg). The results are depicted in the table 24.

4.3.3.1. Carbohydrate

Carbohydrate is one of the major biologically essential organic molecules found in all living organisms. They are used as the main form of energy storage and are responsible for the production and regulation of blood glucose. It spares the use of proteins for energy and also helpin the breakdown of fatty acids to prevent ketosis.

Table 24 gives the carbohydrate content of developed banana peel products. The statistical analysis of data reveals that there was significant difference between carbohydrate content of the developed banana peel products.

The higher carbohydrate content was noted for RTC curry mix (62.0gm/100gm) and lower levels was recorded for sauce (46.2gm/100gm) whereas for instant soup mix, carbohydrate content was 48.6gm/100gm.

4.3.3.2. Protein.

Proteins are large, complex molecules that play many critical roles in the body. Proteins serve a variety of functions within cells. Some are involved in the structural support and movement, others in enzymatic activity. The functions of individual proteins are as varied as their unique amino acid sequences and complex three-dimensional physical structures.

The protein content of the developed banana peel products are depicted in Table 24. From the table it is observed that there was significant difference in the protein content of the products. Protein content ranged from 6.0- 9.8gm. The protein content was found to be higher for RTC curry mix (9.8gm/100gm) and lower protein content was noted for sauce (6.0gm/100gm).Protein content of soup mix was 7.5gm/100gm.

4.3.3.3. Calories

A calorie is a measure of how much energy the protein, carbohydrates, and fat contained in the product can supply to the body. Food plays a vital role in providing energy for body functions such as breathing and physical activity.

The energy content of the products developed from banana peel Viz. instant soup mix, RTC curry mix and sauce is presented in Table 24.

The statistical analysis reveals that there was significant difference in the calorie content of developed banana peel products . The energy content was found to be highest for instant soup mix (268 kcal/100gm) and minimum for sauce (220 kcal/100gm). The calorific value of RTC curry mix was 262 kcal/100gm.

Table 24 Nutrient composition of developed banana peel products.

PRODUCTS	CHO(g)	PROTEIN(g)	ENERGY(kcal)
Instant soup mix	48.6	7.5	268
RTC curry mix	62.0	9.8	262
Sauce	46.2	6.0	220
CD(0.05)	0.26	0.3	4.19

(Values indicated are mean of 3 replications)

Table 25. Mineral content of developed banana peel products.

PRODUCTS	SODIUM (mg/100g)	POTASSIUM (mg/100g)	CALCIUM (mg/100g)	IRON (mg/100g)
Instant soup mix	18.5	62.8	40.7	2.62
RTC curry mix	25.6	82.5	69.4	1.94
Sauce	31.49	116.4	67.0	0.94
CD(0.05)	0.24	0.28	0.36	0.02

(Values indicated are mean of 3 replications)

4.3.3.4 Mineral content of developed banana peel products

4.3.3.4.1. Sodium

Sodium occurs naturally in most foods. The body uses sodium to control blood pressure and blood volume. It regulates the total amount of water in the body and also plays a role in critical body functions.

As far as sodium content (presented in table 25) is concerned, the highest value was obtained for sauce (31.49 mg/100g) which was followed by RTC curry mix (25.6 mg/100gm). The lowest sodium content of product was observed in instant soup mix (18.5 mg/100g). There was significant difference in the sodium content of the developed banana peel products.

4.3.3.4.2. Potassium.

Potassium is a very significant body mineral, important to both cellular and electrical function. It is one of the main blood minerals called "electrolytes". Potassium is essential for functioning of heart and plays a key role in skeletal and smooth muscle contraction, and also help in the normal functions of digestive and muscular system.

The potassium content of the developed products are depicted in Table 25. The data reveals that the potassium content was highest for sauce (116.4mg/100gm). RTC curry mix contained 82.5 mg/100gm.The lowest sodium content was observed in soup mix (62.8/100g). There existed a significant difference in the potassium content of different products.

4.3.3.4.3 Calcium

Calcium is the most abundant mineral in the body. Body uses 99 percent of calcium to keep the bones and teeth strong, thereby supporting skeletal structure and function. The rest of the calcium in the body plays key roles in cell signaling, blood clotting, muscle contraction and nerve function.

The calcium content of the developed RTC mixes are depicted in Table 25. From the table it may be noted that the calcium content ranged from 40.7-69.4 mg. The maximum calcium content was noted for RTC Curry mix (69.4mg/100gm) which was on par with sauce (67mg/100gm) .The least calcium content was recorded for soup mix (40.7mg/100gm). There was significant difference between the calcium content of the developed products. (CD= 0.36 at 5% level of significance)

4.3.3.4.4. Iron

Iron is an essential trace element found in nearly all living organisms Iron is also an essential element for blood production. The immune system depends on iron for its efficient functioning and physical and mental growth. Iron deficiency can lead to conditions like iron deficiency anaemia

The iron content of the developed banana peel products are presented in the Table 25. The statistical data revealed that there was significant difference in the iron content of the developed products. Iron content was higher in soup mix (2.62mg/100gm) and lowest in sauce (0.94mg/100gm). Iron content of RTC curry mix was 1.94mg/100gm. Data on the value

obtained for iron content of different products revealed a significant difference between the treatments.(CD= 0.02 at 5% level of significance).

4.4. SHELF LIFE STUDIES

Product development becomes reliable only when it produces homogeneous products consistently from batch to batch. Physical and chemical factors that influence the capacity of bacteria to grow, like pH, water activity and evenness of mix distribution, moisture, salt and preservative must be well controlled. For this the physical, chemical and microbiological profile of finished product should be evaluated (NACMCF,2009).

The shelf life quality of the developed banana peel products were analysed by assessing the moisture content, microbial profile and sensory parameters for three months at monthly intervals.

4.4.1. Moisture Content of Stored Products

Moisture content is one of the most commonly measured properties of food materials. Knowledge of the moisture content is often necessary to predict the behaviour of foods during processing. The moisture content of the stored products -soup mix and RTC curry mix in laminate pouches and sauce in glass bottle were analysed. The evaluation of products in their respective packagings were conducted periodically for three months and the data is shown in Table 26.

Initial moisture content of soup mix was 4.4 per cent. At the end of first month soup mix did not shown any increase in moisture content, it remained constant. At the end of second month of storage moisture content of soup mix was 4.7 per cent and at the end of third month it was 4.8 percent. The data reveals that there was slight increase in the moisture content of soup mix during storage.

As for RTC curry mix, initial moisture content was 5.4 per cent and at the end of first month it was 5.6 per cent, at the end of second month moisture content of curry mix did not

show any difference but showed little increase in the moisture content at the end of third month ie 5.8 per cent. In the case of sauce intial moisture content was 72.2 per cent. At the end of first month it increased in to 72.4 percent and at the end of second month it again increased in to 72.7 percent. By the end of third month the moisture content remained constant.

Table 26. Moisture content (%) of developed banana peel products

Storage period	Instant soup mix(ISM)	RTC curry mix	Sauce
Initial	4.4	5.4	72.2
I st month	4.4	5.6	72.4
II nd month	4.7	5.6	72.7
III rd month	4.8	5.8	72.7
CD(0.05)	0.17	0.16	0.16

(Values indicated are mean of 3 replications)

4.4.2. Microbial Profile of developed products

Processed foods which are stored and consumed after a period of storage require to satisfy specifications with regard to microbial growth for quality and safety. Many organisms causing food borne illness may grow and cause significant effect on the quality of final product. A high microbial load and storage temperature higher than recommended for a particular food can reduce the shelf life of a product.

Food products that have been subjected to an adequate heat-treatment during processing are generally free of vegetative pathogens. Thus, initially it is regarded as very much safe. Microbial analyses of stored products were conducted to ascertain the shelf life of the products. The products were stored in ambient conditions for three months. The microbial evaluation was done initially and at 30 days intervals up to 3 months. The growth of bacteria, fungi, and E-coli were determined using Nutrient Agar (NA), Potato Dextrose Agar with Rose Bengal (PDARB),

and Eosin Methylene Blue (EMB) respectively. The evaluation was done by serial dilution of the samples followed by pour plating techniques suggested by Johnson and Curl (1972).

During the storage period no bacterial colonies were found to appear in the developed soup mix and curry mix packed in laminated pouches. But in the case of sauce two bacterial colonies were seen in 10^{-5} dilution during third month, however this was within permissible limits. No other pathogenic organisms could be detected in the developed products.

4.4.3 Sensory attributes

Among numerous factors which influence the quality of products. sensory attributes are considered as the major factors which are susceptible to change during storage. Organoleptic studies were undertaken to study the influence of storage on the acceptability of the products. Changes in these attributes for the three products namely Instant soup mix, RTC curry mix and sauce were carried out periodically by the sensory panel members. The details are presented below.

Table 27 Sensory quality of Instant soup mix during storage

Treatments	Appearance	Colour	Flavour	Texture	Taste	Overall acceptability
Initial period	27.4	25.1	27.1	27.0	23.0	29.0
First month	26.5	23.5	26.1	26.0	21.0	26.5
Second month	24.2	22.6	24.3	24.0	20.6	24.6
Third month	23.4	20.8	23.5	23.0	20.0	22.8
K value	11.70	8.56	10.46	10.11	3.72	10.48
CD (0.05)	13.79					

(Values indicated are mean of 3 replications)

Appearance

Appearance is the criteria for the desirability of any food product. The highest mean rank score in appearance was obtained in initial period (27.4), which gradually decreased in later

months. The lowest mean rank value was noted in third month (23.4). The mean rank scores were not found to be significantly different between initial stage and final stage.

Colour

The results show that the mean rank values for colour was higher in soup mix initially (25.1). The scores decreased by third month (20.8). However the result indicates that after three months of storage only a slight decrease in score was observed in the colour.

Flavour

While comparing the mean values of flavour highest mean rank score was found in the fresh sample (27.1) and after first and second month of storage slight variation in rank scores (26.1and 24.3) was observed. Scores further reduced by third month(23.5). This difference was not found to be significantly different too.

Texture

In the case of texture highest mean rank value was obtained in fresh soup mix (27.0) which was followed by the mean rank scores for second and third month (26.0 and 24.0). Scores further reduced in the third month (23.0). There was a overall decrease in the mean rank scores for texture after three months of storage.

Taste

Change in scores for taste through out the storage period was noticed at monthly intervals. The highest taste rank score was found in fresh product (23.0) and the lowest mean rank score was noted in third month of storage (20.0). The results revealed that there was only a negligible decrease in the score after three months of storage.

Overall acceptability

Result indicates that highest rank score of overall acceptability was found in fresh sample (29.6) followed by first and second month (26.5 and 24.6). Score further decreased by third month (22.8).

From the above observation it may be concluded that the changes in sensory attributes namely appearance, colour, texture and taste of soup mix were negligible over three months of storage.

Table 28 Sensory quality of Ready to cook curry mix during storage.

Treatments	Appearance	Colour	Flavour	Texture	Taste	Overall acceptability
Scores indicated are mean rank values						
Initial period	25.8	30.1	30.6	28.0	28.9	29.6
First month	23.6	28.3	28.8	26.5	25.2	27.7
Second month	22.2	26.4	26.9	26.0	24.5	25.4
Third month	21.4	25.1	24.6	24.4	23.4	24.2
K value	7.48	17.54	17.84	11.88	13.29	14.25
CD (0.05)	13.79					

Sensory evaluation of Ready To Cook curry mix (RTC curry mix)

Appearance

In the initial and the first month of storage the mean rank values for appearance were found to be onpar. The highest score in appearance was obtained in fresh product (25.8), and it gradually decreased with storage. The value decreased to 21.4in third month. The mean rank scores were not found to be significantly different.

Colour

The results revealed that the colour obtained was highest in curry mix when freshly prepared (30.1). The lowest mean rank score was obtained in third month (25.1). The results

further indicated that after three months of storage only a slight decrease in score was observed for the colour parameter.

Flavour

While comparing the mean rank values of flavour highest score was found in initial period (30.6) for the freshly prepared sample and after first and second month of storage there was slight variation in scores (28.8 and 26.9). Lowest mean rank score was obtained in third month(24.6). This difference was not found to be significantly different too.

Texture

With regard to the parameter texture, highest mean rank value was obtained in initial sample for RTC curry mix (28.0) which was followed by second and third month (26.5 and 26.0). The lowest mean rank score was noted in third month (24.4). There was a decrease in the texture score after three months of storage.

Taste

Change in values for taste was observed through out the storage period interval. The highest taste mean rank score was found in fresh product (28.9) and the lowest mean rank score was noted in third month of storage (23.4). The results revealed that there was no significant difference in the scores after three months of storage.

Overall acceptability

Results indicate that highest mean rank score of overall acceptability of RTC curry mix was found for the fresh product(29.6), followed by first and second month (27.7 and 25.4). Lowest mean rank score was obtained in third month (24.2). There was significant difference in the organoleptic qualities such as appearance, colour, flavour, texture, taste and overall acceptability of the RTC curry mix during storage life.

Table 29. Sensory quality of banana peel based sauce during storage.

Treatments	Appearance	Colour	Flavour	Texture	Taste	Overall acceptability
Initial period	29.7	28.4	29.8	29.6	29.0	27.9
First month	27.8	26.5	26.2	27.7	27.6	25.3
Second month	25.9	25.0	25.5	25.4	26.4	24.5
Third month	24.7	24.4	24.5	24.2	24.9	23.3
K value	15.60	13.17	17.60	14.25	13.12	9.6
CD (0.05)	13.79					

(Scores indicated are mean rank values)

Sensory evaluation of banana peel based sauce during storage.

Appearance

The highest mean rank score in appearance was obtained for the freshly prepared sample (29.7), which gradually decreased in later months. The lowest value was noted in third month (24.7). The mean rank scores was found to be significantly different.

Colour

Results revealed that the mean rank values for colour was higher in sauce when freshly prepared (28.4). The lowest mean rank score was obtained in third month (24.4). The results indicated that after three month of storage only a slight decrease in mean rank score was observed in colour perspective.

Flavour

While comparing the mean value of flavour highest mean rank score was found in initial sample (29.8). After first and second month of storage there was slight variation in mean rank scores (26.2 and 25.5). Lowest mean rank score was obtained in third month (24.5). This difference was not found to be significantly different too.

Texture

With regards to texture also highest mean rank values were obtained in initial stage (29.6) which was followed by second and third month (27.7 and 25.4). The lowest score was noted in third month (24.2). There was a decrease in the mean rank score for texture after three months of storage.

Taste

Change in taste through out the storage period was observed at monthly intervals. The highest taste mean rank score was found in fresh product (29.0) and the lowest mean rank score was noted in third month of storage (24.9).The results revealed that there was significant difference in the mean rank scores after three months of storage (CD=13.79 at 5% level of significance).

Overall acceptability

Results indicated that highest mean rank scores of overall acceptability of sauce was found in the sample prepared in the initial period (27.9) followed by first and second month (25.3 and 24.5). Lowest mean rank score was got after the third month (23.3). There was significant variations in the organoleptic qualities such as appearance, colour, flavour, texture, taste and overall acceptability of the sauce during storage.

4.5 Cost of the developed products

In order to realize the economic feasibility of the developed banana peel products the cost of the product were worked out by taking individual cost of the ingredients used and adding 10 per cent over head charge. The cost of 1Kg packets of products were thus calculated.

Table 30. Cost of the banana peel based products

Name of the product	Cost of the finished product/ kg (Rs)	Cost of the finished Product/pack
Instant soup mix	33.00	5.5/14.5 g
RTC curry mix	28.00	4.6/100 g
Sauce	80.00	16/200 ml

The results obtained are reviewed and discussed hence forth in the ensuing chapter.

DISCUSSION

5. DISCUSSION

The results of the investigation entitled "Development of value added products from banana peel" is discussed below as.

5.1 Standardization and product development

5.2 Packaging and storage

5.3 Quality assessment of developed banana peel products

5.4 Shelf life studies

5.1 STANDARDIZATION AND PRODUCT DEVELOPMENT

Waste utilization from food processing industries is highly indispensable and at the same time challenging task to mankind all round the globe. Generation of this waste is inevitable, because to produce a finished product consistently no consideration is given to the amount of waste produced. The amount of food waste from the fruit and vegetable peel is increasing with the development of processing industries. By-product recovery from food wastes can improve the overall economics of processing units. (Anbuselvi *et al.*, 2014).

According to Emaga *et al.* (2007), banana peel is rich in dietary fiber, protein, essential amino acids, polyunsaturated fatty acids and potassium . It also contains antioxidant compounds including polyphenols, catecholamines and carotenoids. Antioxidant compounds present in banana peel, particularly their polyphenols, could contribute positively to human health. Dietary polyphenols, by means of their well-known antioxidant properties help in the modulation of oxidative stress and also play an important role in the prevention of degenerative diseases, particularly cardiovascular diseases and cancers. He has also pointed out that the addition of 15–30 percent banana peels in the diet helps to reduce the weight significantly without causing health problems or affecting palatability.

Bananas are one of the fruits produced in large quantities and consumed worldwide. Therefore the potential use of the peel would be of great relevance. Banana peel is an under used by-product that can be processed to obtain various products which can be stored for further use (Hernan and Chandak, 2000).

In the present investigation, three products were standardized using banana peel as a main ingredient namely Instant soup mix (ISM), Ready to cook curry mix (RTC curry mix) and Sauce.

According to Poduval (2002), one of the fore most purpose of standardization 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 product. Liaqat *et al.* (2009) found that recipe standardization is important to achieve optimal accuracy in determining the nutrient estimation and also helps to ensures that that the menu items will be consistent in quality, each time they are prepared and served which results in increased customer satisfaction.

5.1.1 Preliminary processing

Pretreatment of food materials includes blanching, chemical pretreatment, osmotic dehydration and many more such processes . Pretreatment reduces oxidation, giving a better color, to the product reducing vitamin loss, and lengthening shelf life. Research studies have shown that pre treating fruits and vegetable with an acidic solution enhances the destruction of potentially harmful bacteria during drying. Dandamrongrak *et al.* (2003) reported that, pretreatment methods that can improve the quality of dried products and the drying rate is necessary in order to optimise the drying process. Pretreatment reduced the effect of skin thickness, which is usually a normal resistance to water loss at the surface of the product. This resulted in faster drying when compared to the untreated or control samples.

The various treatments in this study were, evaluated by a panel of 10 members using Overall visual quality scores to screen out the best treatment.

5.1.1.1 Standardization of blanching time

Blanching is an old and well-established practice in the food industry. Blanching as a pretreatment is a short-time heat-treatment generally applied to fruits and vegetables primarily to inactivate natural enzymes. The blanching process involves immersing the fruits or vegetables in boiling water for a specified period of time. When it used for pre-treating of vegetables, it destroys enzymes and loosens tissues, which sometimes fixes the natural colour and affords more rapid drying. Blanching can be done in a number of ways which usually includes water, steam and oil blanching (Akpinar, 2005).

According to Piga *et al.* (2004) scalding vegetables in boiling water or steam for a short time stops enzymatic actions which can cause loss of flavor, color and texture. Blanching cleanses the surface of raw materials from dirt and organisms, brightens the color and helps retard loss of vitamins. It also wilts or softens vegetables and makes them easier to pack. Blanching removes trapped air and metabolic gases within vegetable cells and facilitates peeling and dicing, and is also accompanied by microbial load reduction.

Hassini *et al.* (2002) reported that potato slices were blanched for 5 mts in 95^0 C water and sliced carrots were subjected to hot water blanching by holding them in a muslin cloth in boiling water at 100^0 C for 6 minutes to inactivate peroxidase.

Banana peel slices in this study were subjected to water blanching. For standardization of blanching time there were five treatments with different time durations. Among all the treatments T_2 *ie* blanching for five minutes was selected as the optimum time for pretreatment.

5.1.1.2 Standardization of pretreatment media

Research studies have shown that pretreating with an acidic solution enhances the destruction of potentially harmful bacteria during drying. Blanching in a solution that contains ½ teaspoon of citric acid per quart of water is recommended for most vegetables. This enhances the destruction of potentially harmful microorganisms and slows the enzyme reactions that will continue during drying and storage (Stanley *et al.*, 2000).

According to Devece (1999), immersion of fruits and vegetable in a solution containing 3¾ teaspoons of powdered ascorbic acid or ½ teaspoon of powdered citric acid in 2 cups water for 10 minutes helped to prevent enzymatic browning.

Velasco *et al.* (2001) suggested that acidification of canned whole tomatoes with 0.1 to 0.2 per cent citric acid can be recommended to increase acidity to a safer and more desirable level.

According to Kanchana *et al.* (2010), banana blossom treated in 0.2 per cent citric acid solution for 30 min followed by 6 hours dehydration gave acceptable products with respect to appearance, flavour and overall quality.

Midhila (2013) reported that for the development of RTC curry mix from banana blossom, which is treated with 2 per cent citric acid found to have less browning compared to other treatments. Citric acid (0.5%) and salt (3%) were selected as the optimum pretreatment media for the standardization of banana peel products.

5.1.1.3 Standardisation of immersion time

Immersion is a pretreatment used in fruits and vegetables to prevent enzymatic spoilage. Fruit juices high in vitamin C (lemon, orange, pineapple, grape, etc.), or commercial products containing ascorbic or citric acid may be used for immersion. Dipping sliced fruit and vegetable pieces in a mixture of citric acid crystals and water (1 teaspoon citric acid crystals per 1 cup of water), or dipping directly in fruit juice for 3 to 5 minutes was found to prevent browning. (Andress *et al.*, 2006).

For standardization of immersion time there were four treatments with different time durations. Among all the treatments T_2 *ie*, 10 minutes was selected as the optimum time for immersion.

5.1.2 Formulation of Instant soup mix (ISM)

There is an increasing trend in the consumption of ready to eat food products due to more number of working women in the population; along with the increase in per capita income, urbanization, scarcity of household labour, lack of time and hectic schedules. This has compelled consumers to look for foods with convenience, that are easily available, at the same time culturally acceptable with, adequate nutrients and which are minimally processed with longer shelf-life (Ronald, 2000).

Fruits and vegetables are important in human diet and have great potential in the development of low cost beverages of high nutritional value. Even though many processed products are available, consumer prefers dehydrated products. Among all dehydrated products, instant soup mixes has gained popularity in the recent years Hence, there is great scope to develop Instant soup mixes with prolonged shelf life (Gopalan *et al.*, 2009).

As reported by Abate and Peterson (2008), soup is a favorite comfort food and is relished by people of all age groups. Soup supplies nutrients needed for the overall good health and are consumed by both healthy and sick people.

According to Rekha *et al.*(2010), soups are consumed for nutritive benefits and also by patients whose intake of solids is considerably reduced due to several pathological reasons.

The present research work aimed to prepare and supplement dried vegetarian soup mix with banana peel as the major ingredient. Sen and Morga (2011) have pointed out that soup mixes are coming generally as a mixture of vegetables. In the present study also onion powder, corn flour, capsicum powder, coriander leaves powder and ginger-garlic powder were used along with banana peel flour as the base material in different proportions for the development of instant soup mix.

In this study instant soup mix was developed using the drying blending process. Singh *et al.* (2003) reported that dry soup mixes are prepared by blending dried ingredients and it can be produced by a variety of processes. The processes differ primarily by the type of drying methods used, type of ingredients and type of characteristics of the final product.

5.1.2.1 Sensory quality of ISM

The quality of food is a combination of the attributes that determine the degree of acceptability of the product. These include nutrient value, microbiological safety, cost, convenience and organoleptic qualities. The concept of food quality encompasses characteristic related to the sensory parameters, which may be classified in accordance with the human senses of perception as appearance, colour, texture, flavour and taste (Potter, 2009).

Manay and Swami (2012) reported that sensory evaluation is designed to reflect the consumers preference, so as to maintain the quality of food at a given standard. This helps in the assessment of process variation, cost reduction, product improvement, new market development and market analysis.

According to Osman *et al.* (2000), a good food should appeal to all the senses and It is all a matter of proportion – the right texture, colour, aroma and taste Parameters such as appearance, colour, flavour, texture, taste and overall acceptability of the developed products were assessed by ten technical experts. According to Thakkur *et al.* (2009), sensory evaluation consists of judging the quality of food by a panel of judges using score cards.

Result of sensory evaluation revealed that among the five formulation, S_1 combination had higher acceptability, which comprised of banana peel flour, onion powder, corn flour, citric acid, capsicum powder, coriander leaves powder, white pepper powder, ginger powder, garlic powder, garlic powder and salt.

Rosette *et al.* (2001) reported that any dehydrated soup mix should be rehydrated and cooked within a minimum time of period and should be as nutritious and palatable as canned or frozen products. In comparison to freshly prepared soup, instant dry soup should also possess desired qualities, representing the dominant flavour and aroma of the ingredients used. It is desirable that the product be free from off flavor, off taste, unacceptable aroma and faulty texture.

Capsicum is always milder in taste, which adds texture to the soup mix. Ginger is a pungent tasting root which aids digestion and also help to the rejuvenation of the body. Onion was choosen as it is considered as a flavouring agent, a condiment and a vegetable (Abeysinghe and Illeperuma, 2006) .

Colour is one of the important visual attributes that has been used to judge the overall quality of food for a very long time. If the colour is unattractive, a potential consumer may not be impressed by any other attributes (Osman *et al.*, 2000). Among the five formulation S_1 was noted to get the highest mean rank score for colour (37.5) *ie* slight yellow in colour.

Texture constitutes a physical property of food stuffs which is apprehended by the eye, the skin and the muscle sense located in the mouth. Texture is a perception resulting from interaction between food and its consumer (Jack *et al.*, 2000). The highest mean rank score in consistency was obtained for the formulation S_1 (42.0). Consistency of S_1 was smooth and liquid, such as tomato soup and fluid runs off the spoon and which cannot be eaten with a fork.

Oledinma *et al.* (2004) reported that in soup making, viscosity is an index of thickness. Corn flour was used as thickening agent to provide the desirable body and viscosity to the soup mix. Flavour is the blend of taste and smell perceptions noted when the food is in the mouth. The overall flavour impression is the result of the tastes perceived by the taste buds in the mouth and the aromatic compounds detected by the epithelium in the olfactory organ in the nose (Hayat *et al.*, 2005). The mean rank value recorded by S_1 was (39.9).

Garlic has a pungent flavour. There are several advantages of consuming garlic. It lowers the blood cholesterol by 10-12 per cent, is able to reduce the occurrence of stomach cancer and also acts as an antibacterial and antifungal agent (Zang and Tao, 2009).

Halpern *et al.* (2002) reported that coriander leaves gives the delicate flavour to the soup. Black pepper was used as a ground spice in seasoning because the piperine present in it stimulates the flow of saliva and gastric juices to aid in digestion.

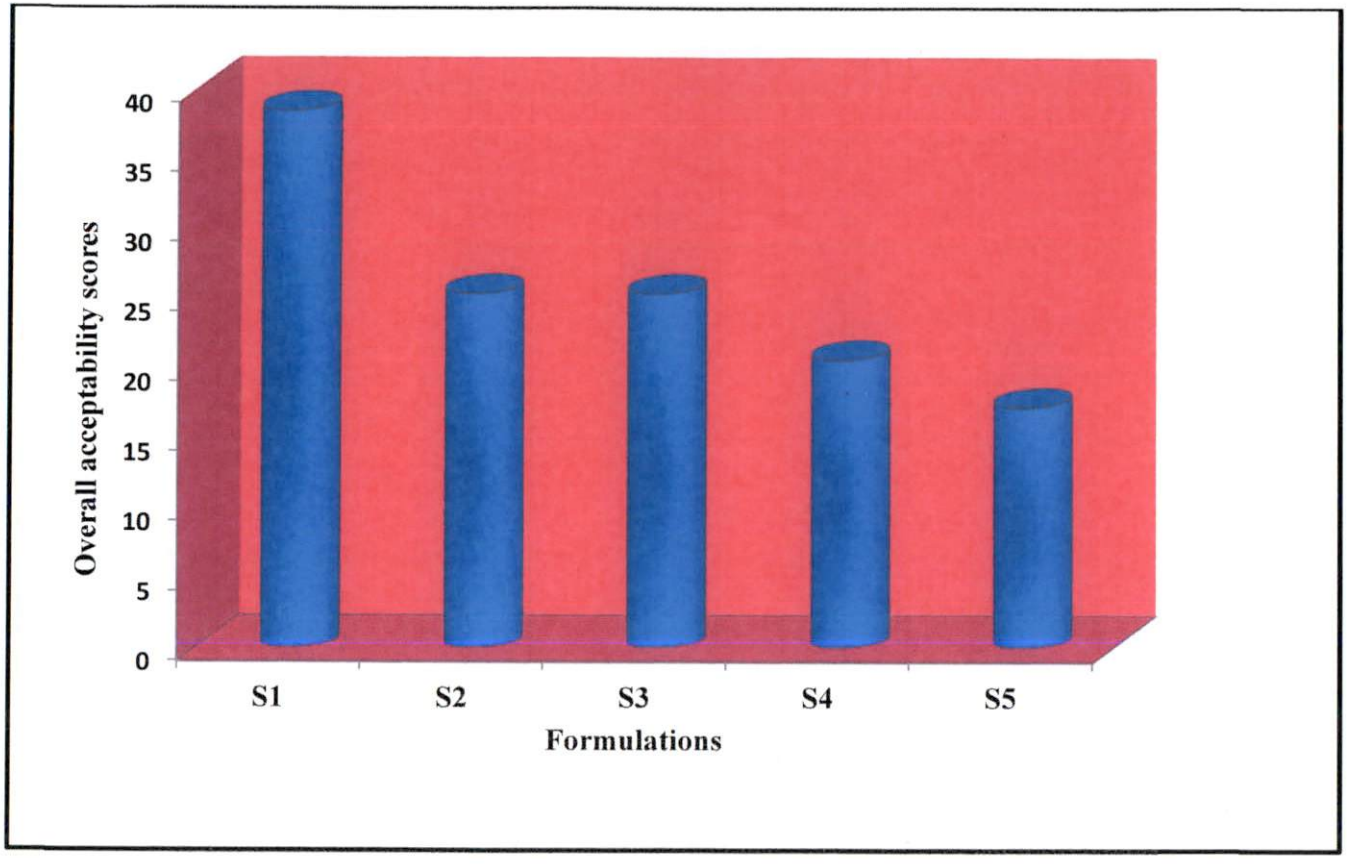


Fig.4 Sensory quality of various formulations of ISM

Taste is the major attribute which determines the acceptability of a food material.it is not only a sensory response to soluble materials but also aesthetic appreciation of the mouth (Kin and Larmord, 2001).

Kays (2003) reported that taste is mainly due to sugar acid ratio. It is percieved by the specialized taste buds on the tongue. Although there are many different tastes, most of these appear to primarily represent combinations of four dominant chemical sensations hot, sweet, sour and bitter. Superior taste was found for S_1 with the highest mean rank score.

According to Savithri and Rajeswari (2000), The overall acceptability depends on the concentration or amount of particular components, the nutritional and other attributes of the food and its palatability or sensory quality. Overall acceptability scores clearly depicted that among the 5 formulations S_1 obtained the maximum mean rank value (38.5) and therefore the highest preference.

5.1.3 Standardization of RTC curry mix

5.1.3.1 Standardization of dimension of slices

According to Senadeera *et al.* (2005), drying is a complex process accompanied by physical and structural changes. There is a continuous change in the dimensions of fruits and vegetables during drying due to the removal of water and internal collapse of the particulates. Shrinkage is one of the major changes taking place during the drying process. Dimensional changes are needed in evaluating heat transfer and determining packaging volume.

Abano and Samamoah (2011) reported that the rate of drying time depends on temperature of drying air and thickness of the slices because thickness of the slices increases the drying time to achieve a desirable moisture ratio also increases.

Islam *et al*, (2012) reported that cassava tubers were cut in to chips of 2.0 cm thickness for faster dehydration. Tomatoes were cut into slices with thickness of 5mm for optimum drying (Mozumder *et al*., 2012).

For standardization of dimensions of slices there were six treatments with different dimensions. Among all the treatments T_2 *ie* 1x1 cm was selected as the optimum dimension for RTC curry mix based on the rank means.

5.1.3.2 Formulation of RTC curry mix from banana peel

Anand (2008) reported that these days there is a greater demand for ready-to-eat foods. Major attractions for these products are their convenience, availability and lesser cooking time. Due to life style changes and long working hours, people are choosing these products and are ready to go with it.

Saha and Dunkwal (2009) opined that Instant food means simple, fast, and convienient foods, which are easy and fast to prepare. Mathur and Sabikhi (2002) opined that today's consumers are more health conscious, which is the driving force for designing newer foods.

The demand for Ready –To-Cook and Ready-To-Eat foods have captured a large amount of the food retail markets in India. There is a rise in demand for foods based on traditional Indian recipes across different states and abroad because of its nostalgia, good quality, taste and convenience (Rahman and Shamsuddin, 2003).

5.1.3.3 Sensory quality of RTC curry mix from banana peel

Quality is the combination of parameters which have significance in determining the acceptability of any product. A number of factors which include yeast strains, fermentation condition, mineral contents and sensory attributes are known to influence quality. Sensory quality is a scientific method of sensory analysis

of food and is becoming increasingly important in evaluating the acceptability of the food products (Sandhu and Joshi, 2000).

A sensory panel evaluated the various formulations with respect to the five parameters namely, appearance, colour, texture, flavour, taste and overall acceptability.

Appearance is the criterion for the desirability of any food product. The appearance of the food product is contributed by surface characteristics *viz* size, shape, colour, transparency, opaqueness, turbidity and dullness (Srilakshmi, 2003). Among the five RTC curry mixes the formulation S_1 obtained significantly higher a mean rank values for appearance (40.1). This formulation comprised of banana peel, crushed red chilly, garlic, cumin, turmeric powder and curry leaves.

Colour is used as an index of the quality of a number of foods, so it is taken as the parameter for assessing the quality. Colour is one of the most important cues used by consumers to assess the quality of the food product. Colour is not just a physical attribute, it is one of the input signals to the brain that reacts to the perception of appearance. It may be defined as the individual's response to visual signals generated by the light on a product (Dougall, 2002). Among the formulations S_1 recorded the highest mean rank score for colour .

Brain (2003) reported that texture is very important for the enjoyment of food, So it is is a key factor for determining quality of foods. Texture refers to those qualities of a food that can be felt with the finger, tongue, palate or teeth. Among the 5 formulations S_1 got the highest mean rank value (38.5).

Flavour is an important sensory attribute, which is a result of combination of taste and odour. According to Sharma and Joshi (2004), flavor is the sensory

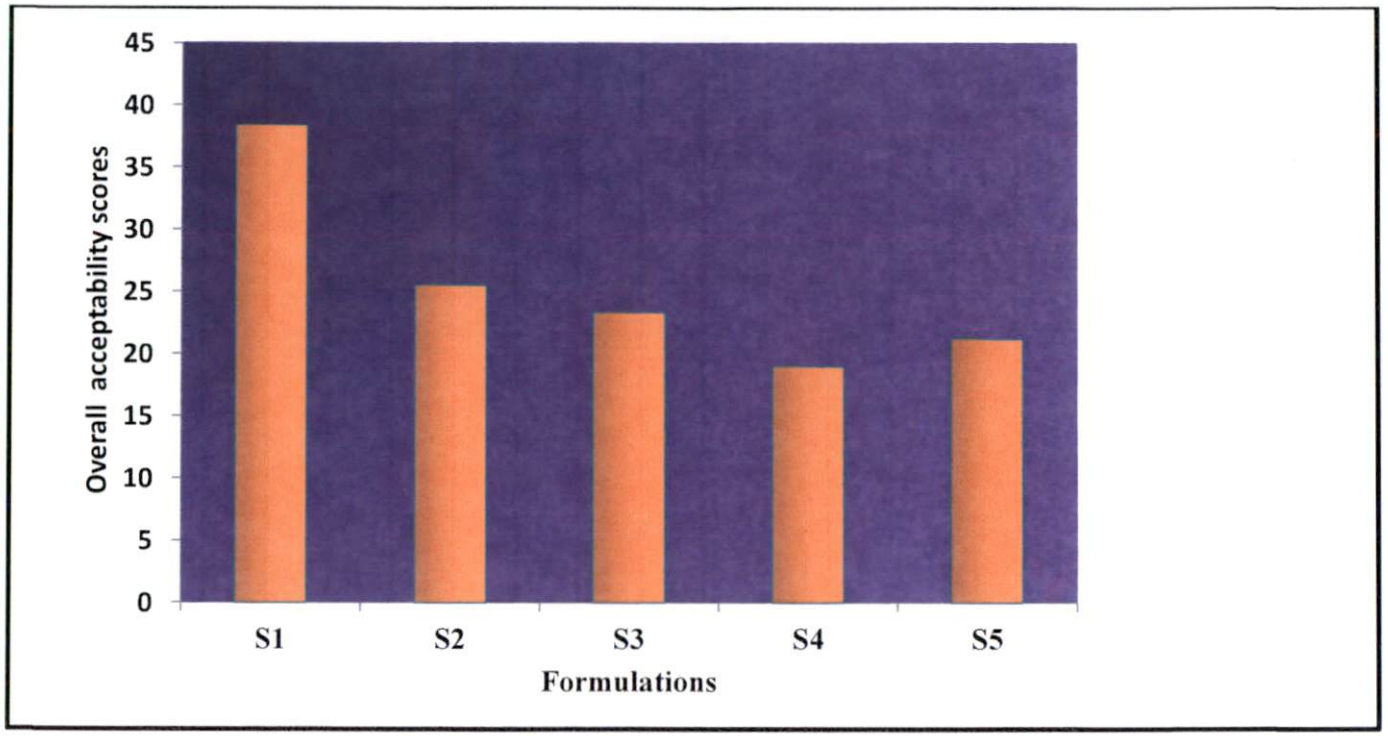


Fig.5 Sensory quality of various formulations of RTC curry mix

impression of a food or other substance, and is determined mainly by the senses of taste and smell. The maximum mean rank value for flavour was noted for S_1 (39.7). S_1 also got highest mean rank score in taste and overall acceptability.

5.1.3.4 Standardization of reconstitution time

According to Kendall *et al.* (2003) dried fruits and vegetables are reconstituted by soaking the food in water. reconstitution time depends on the size and shape of the food. Most dried fruits can be reconstituted within 8 hours, whereas most dried vegetables take only 2 hours. One cup of dried fruit would yield approximately 1½ cups of reconstituted fruit. One cup of dried vegetable would yield approximately 2 cups of reconstituted vegetable. Reconstituted fruits and vegetables should be cooked in the water in which they are soaked.

The optimum amount of water required for reconstitution depends largely on the product.Too little water will be expected to slow down the rate of water absorption and at the same time large quantity of surplus water should be avoided because flavouring factors and valuable nutrients such as water soluble vitamins and minerals may be lost to a large extent (Pervin *et al.*, 2008).

The dehydrated mixes were reconstituted for 10 min, 15 min, 20 min, 25min and 30 min. The treatment with 30 min of reconstitution time was found to give the most acceptable product.

Midhila (2013) reported that at least 10 minutes soaking time to be given to attain maximum rehydration of banana blossom for the development of RTC product from banana blossom.

According to Pervin *et al.* (2008) presoaking of 50 min was found to be more favorable for dried beans. Dehydrated oyster mushroom could be rehydrated at room

temperature for 30 min for giving better product (Apati *et al.*, 2010). Thus it can be inferred that rehydration time varies with the raw material.

5.1.3.5 Optimization of cooking time of RTC curry mix

Cooking time can have a big impact on the nutrient content of vegetables because many vitamins are sensitive to heat and air exposure (vitamin C, the B vitamins especially folates). Loss of nutrients increases as cooking time increases. Cooking time depends on whether the vegetable is fresh, frozen, or canned. Vegetables are softened during the cooking process. Undercooking makes them too crisp while overcooking makes vegetables mushy (Robert and Cox, 2000).

The developed RTC mixes were cooked at different timings such as 5 min ,7 min,9 min and 11min. It was found that 10 min was necessary for cooking RTC curry mix. Khetarpaul *et al.* (2004) reported that pre-soaking reduced the cooking time of products.

5.1.4 Formulation of banana peel based sauce

According to Robert and Cox (2007), sauce is a hot or cold seasoned liquid either served or used in the cooking of a dish. The word comes from the Latin word salsus (salted) and sauce is an aromatic, nutritive flavourful liquid or semi liquid which, increases the taste, moisture, appearance and colour of a dish.

The function of sauce is to add flavour to the dish which is compatible with the ingredients. Sometimes the colour is in contrast to the main items thus giving a contrasting colour effect, thus elevating the presentation style of the dish. It is an excellent accompaniment of dishes which complements the taste and flavour thus elevating the overall nature of the dish (Kin and Miga, 2001).

5.1.4.1 Sensory quality of banana peel based sauce

Sensory evaluation of food is assigned to be of increasing significance, as this provides information useful for product development. The organoleptic qualities are usually assessed by sensory evaluation. According to Herington (2002), sensory evaluation technology is a method, which needs skilled management and trained panelists to provide information on the consumer acceptability of the product profile.

Appearance tends to be the first milestone in food quality evaluation. According to Monika (2013), the appearance of all objects including foods is based primarily on their structure and pigmentation. Appaerance cues are significant in the identification of a foods and in the assessment of the condition of that food. Among the five formulations S_5 got the high mean rank score for appearance which comprised of banana peel, coriander leaves, garlic, green chilly, suagar and spices.

It is often said that consumers eat with their eyes as the major quality characteristic that create attraction towards the food is its colour, which is one main quality parameter. Fergus (2001) observed that colour influences food acceptability ,choice and preference. The mean rank score obtained for colour in S_5 was 35.4.

Flavour is an important factor which enriches the consumers preference to particular product. Stillman (2000) had stated that flavour is seen as a general sensation originating from the elements of the taste receptors and nerve fibres, touch and chemical feelings.

Birch *et al.* (2001) opines that flavour is the mingled but unique experience of sensation produced by a material taken in the mouth perceived principally by the senses of basic smell and also other cutaneous smell in the mouth. For this parameter also S_1 got the highest mean rank value. This suggest that sauce with appreciable aroma could be prepared from a blend comprised of a major share of banana peel in

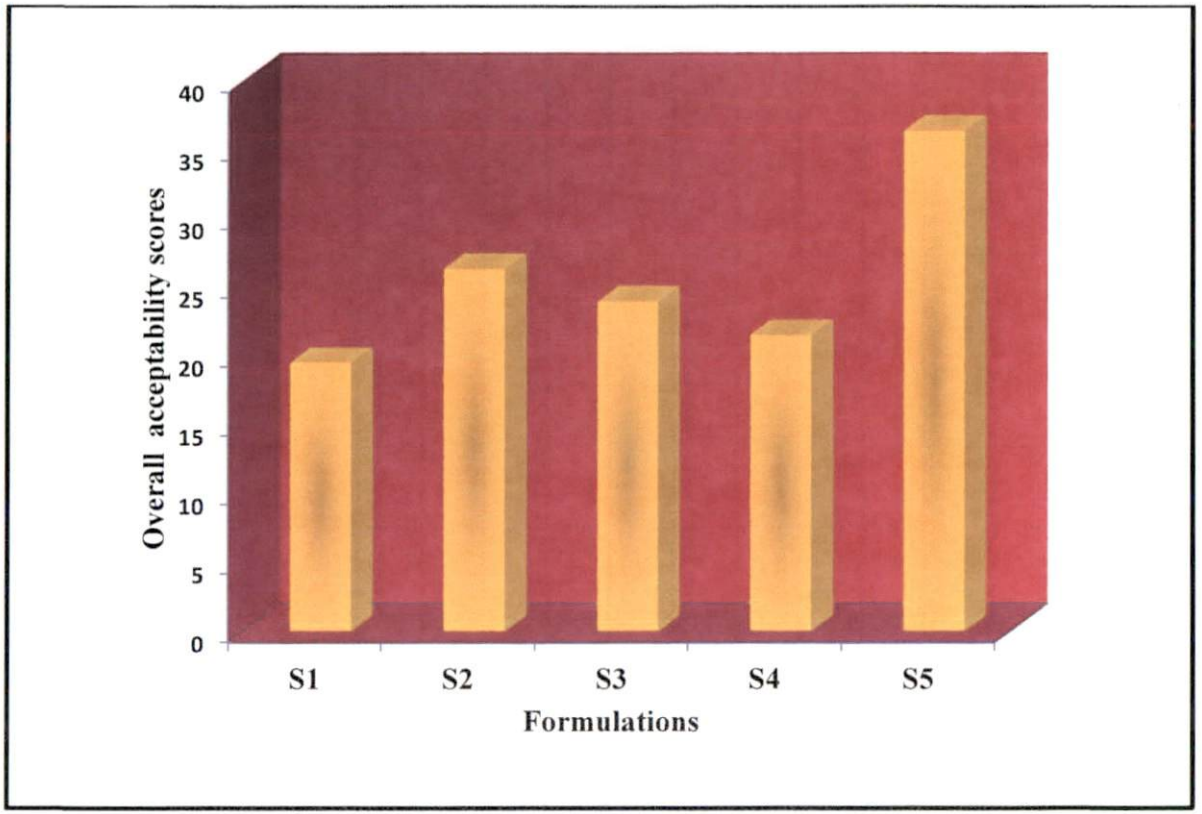


Fig.6 Sensory quality of various formulations of banana peel based sauce

combination with coriander leaves and red chilly. Higher aroma scores confirmed the presence of desirable aromatic compounds in the mix.

Texture is one of the important quality parameters in sensory evaluation which plays an important role at the time of selection of food by a consumer (Kudachikar *et al.*, 2001). Among the 5 formulations S_5 got the highest mean rank value for texture (38.0).

The sense of taste is an important determinant of what we eat. So it should be considerd as the major quality factor for the acceptance of food. According to Savarian (2004) the taste of a food is a combination of five major tastes salt, bitter, sour and sweet which is detected by the taste buds at the tip, sides and back of the tongue. It refers to the ability to detect the flavor of substances such as food and certain minerals. Combination S_5 recorded a distinctly superior grade (38.1) for taste due to its sweet and salt mixed taste. In the case of overall acceptability and it got the highest mean rank score (36.3).

5.1.4.2 Optimization of cooking time of sauce

Food products are considered as convenient foods because of its three proven advantages with respect to saving time, labour and fuel and these factors play a decisive role in conditioning their popularity among consumers. Nagarajan (2000) in his study found out that products which could be cooked using less energy would have a large demand. Cooking time is important in terms of relative speed of cooking and tolerance to overcooking.

Donelly and Busta (2001) observed that cooking time was determined from the time of adding the product to boiled water till it got completely cooked. Analysis of cooking time of the product revealed that the time taken for cooking time of the sauce was minimal.

John *et al*, (2006) observed that sauces are thickened by the process of simmering down a liquid. Sauces can be cooked down to one- half or one fourth of its original amount which concentrates the flavour due to the reduction in water concentration.

The developed sauce was processed at different timings such as 3 min ,6 min, 9 min, 12min and 15 min. It was found that 6 min was optimum for the processing of sauce .

5.2 PACKAGING AND STORAGE

The standardized dehydrated ISM and RTC curry mixes were packed in laminated pouches and banana peel based sauce was sealed in glass bottles. They were stored in in ambient conditions for studying their shelf life at monthly intervals up to three months.

The principal roles of food packaging are to protect the food products from outside influences and damage to contain the food and to provide consumers with ingredients and nutritional information (Coles and Robertson, 2003).

According to Arvanitoyannis *et al*, (2004) the goal of food packaging is to contain food in a cost-effective way that satisfies both industry requirements and consumer desires . It also maintains food safety and minimizes environmental impact. Food packaging can retard product deterioration and retain the beneficial effects of processing, it can extend shelf-life, and maintain or increase the quality and safety of food. Packaging provides protection from three major classes of external influences: chemical, biological, and physical (Kirwan *et al*., 2003).

According to Peter and Otler (2000), glass bottles are impervious to moisture, gases, odours and microorganisms, they are inert and do not react with or migrate into food products. They are suitable for heat processing when thermically sealed. At

the same time they are re-useable and recyclable and also transparent to display contents.

Molla *et al.* (2008) indicated that the jackfruit chips packed in metalex foil pouches performed the best and those packed in polypropylene pouches could not be kept for longer periods.Similiar observations were found by Rahman and Shamsuddin (2003) studies on papaya chips laminated polyethylene packages were found to be suitable in packing supplementary foods and could be kept for 90 days (Salve *et al.*, 2011).

5.3 QUALITY ASSESSMENT OF DEVELOPED BANANA PEEL PRODUCTS

Food quality is a complex concept that is frequently measured using objective indices related to the nutritional, microbiological and physicochemical characteristics of the food, in terms of the opines of designated experts (Cardello, 1995).

Nambiar and Parnami (2005) reported that development of nutritious and organoleptically acceptable recipes with locally available foods is a challenge for food scientists to prevent micronutrient malnutrition.

In the present investigation products developed from banana peel were assessed for their physical properties, nutrient content, chemical composition, shelf life stability and cost of products were also assessed.

Physical characteristics of the developed products

The physical characteristics determine the overall behavior of food during production, processing, storage and consumption (Agunbiade *et al.*, 2006). Physical characteristics help in the qualitative assessment and acceptability of any new product. To assess the physical characteristics, yield ratio, rehydration ratio, bulk density and water absorption index were calculated.

Yield ratio

The yield of the developed banana peel products ranged from 0.06-1.40. Yield ratio of soup mix was 0.06, RTC curry mix was 0.13 and sauce was1.40. Udoro *et al.* (2008) reported that the yield of dried chips from cassava roots was about 20-40 per cent. Yield is greatly affected by moisture content and processing methods.

Rehydration ratio

Rehydration characteristics are used as the quality index of the dried product (Vrac and Gurner, 2004). Rehydration is used to express the ability of dried materials to absorb water. In the present investigation, the rehydration ratio of developed RTC curry mix was 0.38. Abano and Sammoah (2011) reported that the rehydration ratio of dried banana slices treated with ascorbic acid was 1.21.

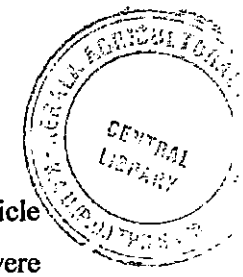
Bulk density

Bulk density is one of the most common measurements which can be used for analysis of solid foods (Potter, 2009). Bulk density is generally affected by the particle size and the true density of the matter in the products.

Induruwa *et al.* (2009) opined that, bulk density or litre weight is one of the important physical parameters which indicate the quality of food products, higher bulk density lower the package volume.

Bulk density indicates the weight of substance held in a unit volume and it is known to influence the packaging and transportation costs (Ranganna, 2001).

Bulk density of ISM was 0.81g and RTC curry mix was 0.73gm.The bulk density of the vegetable soup mix was found to be 0.67 g per ml (Sen and Morga, 2011). Midhila (2013) reported that the bulk density of flour of Rasakadali variety was found to be 0.97 g per ml.



Water absorption index

Water absorption generally depends on starch, protein contents and particle size. Kulkarni *et al.* (2000) stated that the fine particle size of the products were associated with higher water absorption than coarse particle size. Molecular degradation or breakdown of products was less because of good water holding capacity.

Water absorption index of ISM was 13.5gm and RTC curry mix was 4.0.

Chemical composition of developed products

Suitable laboratory techniques were followed to test the chemical constituents like moisture, acidity, reducing sugar, fiber, pH, and TSS. As suggested by Saxsena (2003), laboratory analysis is one of the best methods to assess the quantity of different constituents present in the product.

Stability of original quality of any processed food product is of paramount importance during storage and it should be checked to detect the acceptability of the product. Sharma and John (2006) has viewed that chemical estimation of food products is an useful criterion to judge quality and lessser or higher amount of certain chemicals in food make them acceptable or non acceptable.

Moisture

Moisture can adversely affect the quality of food . It is an important parameter in dehydrated foods, which directly influences the microbial activity, non enzymatic browning solubility and hygroscopicity.

Rathore *et al*, (2007) reported that lower moisture content would give longer shelf stability. Most of the stored product are considered to be safe when stored at particular moisture content (Pandey, 2004).

The moisture level of the dehydrated products ranged from 4.4-5.4 per cent. The moisture content noted for sauce was 72.2 per cent and the moisture content observed in curry mix was 5.4 per cent. The moisture content of soup mix was found to be 4.4 per cent.

According to Rekha *et al.* (2010), soup mixes exhibited caking tendency if the moisture content was above 8.9 per cent corresponding to a critical relative humidity of 56 per cent. Sen and Morga (2011) reported vegetable soup mixes with 2.39 gm of moisture per 100 gm on a dry weight basis. Saha and Dunkwall (2009) developed a dehydrated spread which contained 8.4 per cent moisture.

Saranya (2012) reported that the moisture content of soup mix developed from moringa ranged between 3.9-4.7 per cent. Nasheeda (2006) reported that robusta and rasakadali banana flour contain 3.52 and 3.26 per cent moisture content.

Fahima *et al.* (2007) studied the proximate composition of prepared soup powders and observed 7, 6.7, 7.2 and 11.3 per cent of moisture in corn based, rice based, wheat based and commercial soup mixes respectively.

Premakumari *et al.* (2012) reported that moisture content in RTC Indian recipes such as dosa mixes, vermicelli and kozhukattai incorporated with rice bran was 7.1-8.9 per cent.

According to Tarasova and Taghiyev (2009), moisture content of the fermented sauce developed from vegetable purees and corn starch was 85.1 per cent.

Moisture content was found to increase as the duration of storage advanced. Sagar (2001) observed that gain in moisture occurred in onion flour with increase in storage time. Diffusion of gases and vapour through microscopic holes or by activated diffusion of polythene pouches might have contributed to increase in moisture content during storage (Palling, 2001).

Solanki (2000) reported an increase of moisture content from 5.16-5.39 percent in the developed RTC mixes after a storage period of 28 days.

Acidity of the developed products

Acidity indicates flavour as well as wholesomeness of the products. It also gives antimicrobial protection to the beverages. (Mehta *et al.*, 2002). According to Prasad and Mali (2000) increase in the acidity might be due to the formation of organic acids.

The acidity is measured by the number of free hydrogen ions available in the foods and this causes a sour taste (Shi and Maguer, 2000).

The acidity of the banana peel products was found to be in the range of 0.76-1.75 per cent.

Forsyth (2001) reported that the presence of malic acid, citric acid and oxalic acid are responsible for the acidity in banana.

Reducing sugar of developed products

Reducing sugar is expressed in terms of glucose since glucose is the most pre dominant reducing sugar present in fruits. Reducing sugar content of the developed banana peel products ranged from 0.7-1.07.

Fiber content of developed products

The interest in foods rich in dietary fiber increased in the recent decades and this has led to the development of a large market with fiber rich products and ingredients (Sudha *et al.*, 2007). The specific properties of dietary fiber has been reported to play an important role in the prevention and treatment of various gastrointestinal disorders (hernia, duodenal ulcer, gall stones, constipation. colon

carcinoma) obesity, atherosclerosis, coronary heart diseases, colorectal cancer and diabetes (Escaladapla *et al.*, 2007).

The fruit fiber has a better quality than other fibre sources due to its high total and soluble fiber content, along with water and oil holding capacities, and colonic fermentability, as well as a lower phytic acid and caloric value content (Figuerola *et al.*, 2005). A high dietary fiber content of banana peel (about 50 gm/ 100 gm) is indicative of a good source of dietary fibre (Emaga *et al.*, 2007).

In this study, fiber content of ISM was found to be that of 9.4gm, RTC curry mix was 14.10 gm and sauce was 2.06 gm.

Sen and Morga (2011) reported that vegetable soup mix contained 2.08gm of fiber per 100 gm of sample. Saha and Dunkwal (2009) developed an instant mix spread which contained 4.13gm of crude fiber on a dry weight basis. Abeysinghe and Illeperuma (2006) developed instant dehydrated vegetable soup mixes which contained 2.7 per cent of fiber.

According to Liji (2014) fiber content of jackfruit based RTC mixes ranged from 6.54-8.31 gm/100gm.

Chiraporn (2013) observed that the addition of 1.5 per cent banana peel cellulose (BPC) was found to be the optimum level for improving the fiber content and quality of the butter cake.

TSS of the developed products

Mehta *et al.* (2002) reported that TSS is an important criteria influencing the acceptability of the product. TSS content of sauce was observed to be 20°brix .

pH of the developed products

pH is an indirect measure of sweetness or sourness of a product. 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).

pH of soup mix, RTC curry mix and sauce were found to be in the range of 4.06-5.20. This result indicates that the developed products were acidic in nature.

Nutrient composition of developed banana peel products

Potty and Mully (2000) observed that nutrients are invisible chemicals in the foods which are necessary for keeping the body healthy. Nutritive value of a food is an important parameter considered for the development of any new food. The proximate composition of banana peel flour and developed convenient mixes on a moisture free basis varied depending upon major food ingredients used in their preparation.

According to Kalia and Sood (2001), nutritional quality is the combination of nutrients of a product that have significance in determining the degree of acceptability of the product to a user.

In the present study banana peel based products was formulated and the nutrients such as carbohydrate, protein, energy and minerals like sodium, potassium, calcium and iron were analyzed.

Carbohydrate performs a number of functions ranging from being stores of potential energy in animals to being source of energy for the supporting tissues in plants.The carbohydrate content of banana peel based products ranged between 46.2-62.0gm/100gm. The maximum carbohydrate content was noted for RTC curry mix (62.0gm/100gm) and minimum was recorded for sauce (46.2mg/100gm whereas for

instant soup mix, the carbohydrate content was 48.6gm/100gm. Carbohydrate produces bulk to the diet and hence given satiety value. Carbohydrate content of banana peel is reported to be 59 per cent (Anhwange, 2008).

Abeysinghe and Illeperuma (2006) developed instant dehydrated vegetable soup mixes which contained 55 per cent carbohydrate.

Saha and Dunkwal (2009) standardized instant spread mix which contained 59.89 gm of carbohydrate per 100 g of dry weight basis. Sen and Morga (2011) reported that the vegetable soup mix standardized contained 65.99 gm of carbohydrate per 100 g of soup mix. Rekha *et al.* (2010) developed dry soup mix using *Anethwm sowa* leaves contain 69 gm of carbohydrate per 100gm of soup mix.

Fahima *et al.* (2007) showed that the corn based, rice based and wheat based soup mixes contained 66.37, 65.08 and 66.87 per cent of carbohydrate respectively.

Lakshmana *et al.* (2013) reported that RTE tender jackfruit curry contained 12.03gm/100gm carbohydrate.

Protein is one of the most important nutrients required by the body to carry out a wide range of functions essential for the maintenance of life (Ensiminger, 2002). Protein content of developed products ranged from 6.0- 9.8gm. The protein content was found to be higher for RTC curry mix (9.8gm/100gm) and lower protein content was noted for sauce (6.0gm/100gm).Protein content of soup mix was 7.5gm/100gm. Protein content of banana peel is reported to be 0.9 per cent (Anhwange, 2008).

Tilakaratne (2012) found that nutritionally superior and low cost cereal based soup mix contained 19.44gm per 100gm of crude protein. Rekha *et al.* (2010) developed a dry soup mix with *Anethwm sowa* leaves contained 9.2 per 100gm of protein. Saha and Dunkwal (2009) developed instant spread mix which contained 22.64 per 100gm of protein.

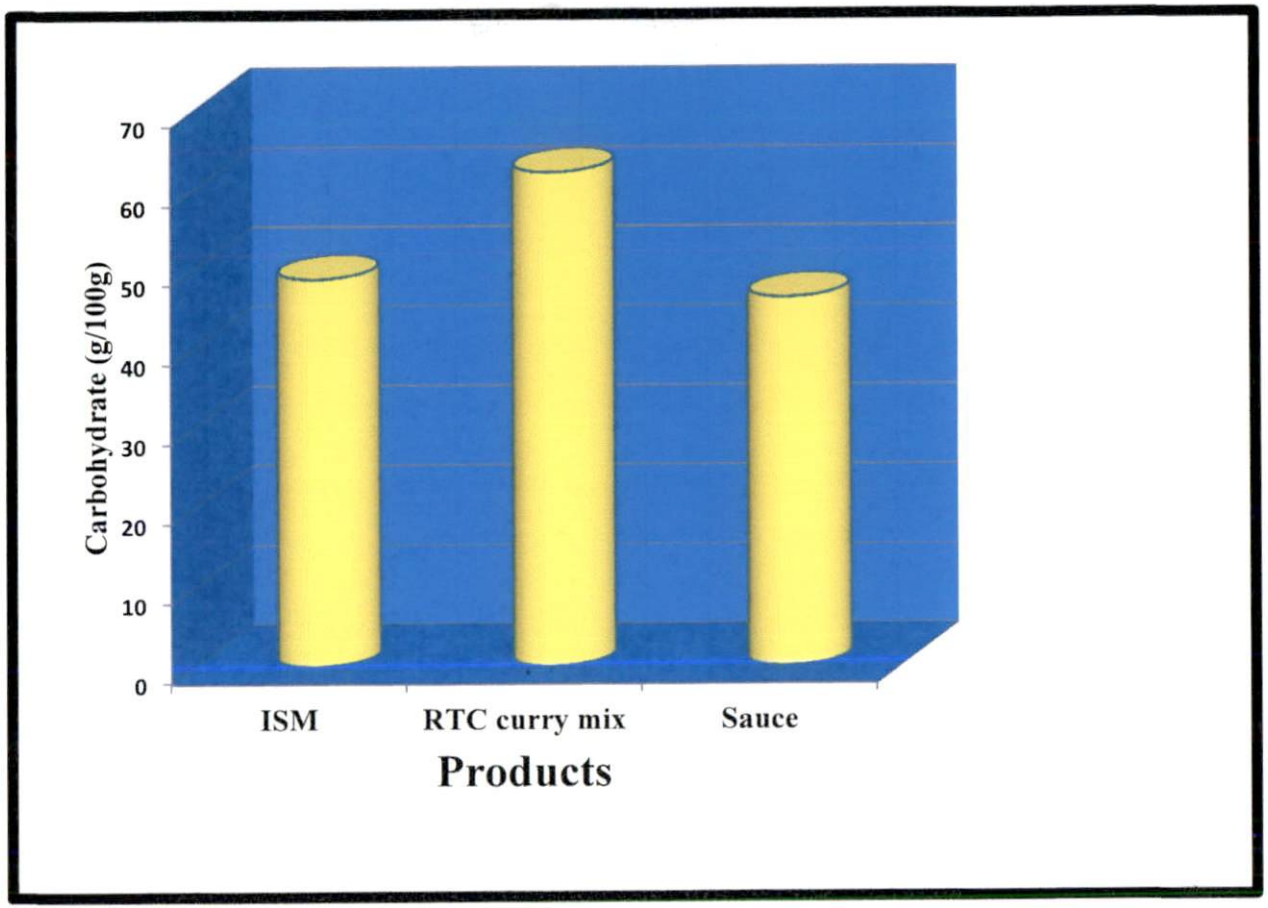


Fig.7 CHO content of developed banana peel based products

Sgarbieri *et al.* (2000) formulated a soup mix with soyabean which contained 21.3 per cent protein. Patki and Arya (2001) developed mung bean soup mixes which had a protein content of 20-24 per cent.

Fahima *et al.* (2007) showed the proximate composition of protein content of corn based (19%), rice based(18.78%) and wheat based (19.4%) soup mixes.

Sen and Morga (2011) suggested that the actual nutrient composition of soup mixes differed depending on the ingredients. The statistical analysis reveals that there was significant difference in the calorie content of developed banana peel products. The energy content was found to be highest for instant soup mix (268 kcal/100gm) and minimum for sauce (220 kcal/100gm). The calorific value of RTC curry mix was 262 kcal/100gm.

Saranya (2012) reported that the soup mix developed from moringa pulp using drying and blending process found to have highest energy value (429 Kcal).

Sen and Morga (2011) reported that dried vegetable soup mixes contained 353 kcal per 100gm of energy. Santos *et al.* (2011) reported that dehydrated jackfruit bulb contained 271.18 Kcal/100gm of energy.

Sodium occurs naturally in most foods. As far as sodium content is concerned, the highest value was obtained for sauce (31.49 mg/100gm) which was followed by RTC curry mix (25.6 mg/100gm). The lowest sodium content of product was observed in instant soup mix (18.5 mg/100gm). Sodium content of banana peel is 24.30mg/gm (Anhwange, 2008).

Potassium is a very significant body mineral, important to both cellular and electrical function. The data reveals that the potassium content was highest for sauce (116.4mg/100gm). RTC curry mix contained 82.5 mg/100gm. The lowest sodium content was observed in soup mix (62.8/100gm). Potassium help in the regulation of

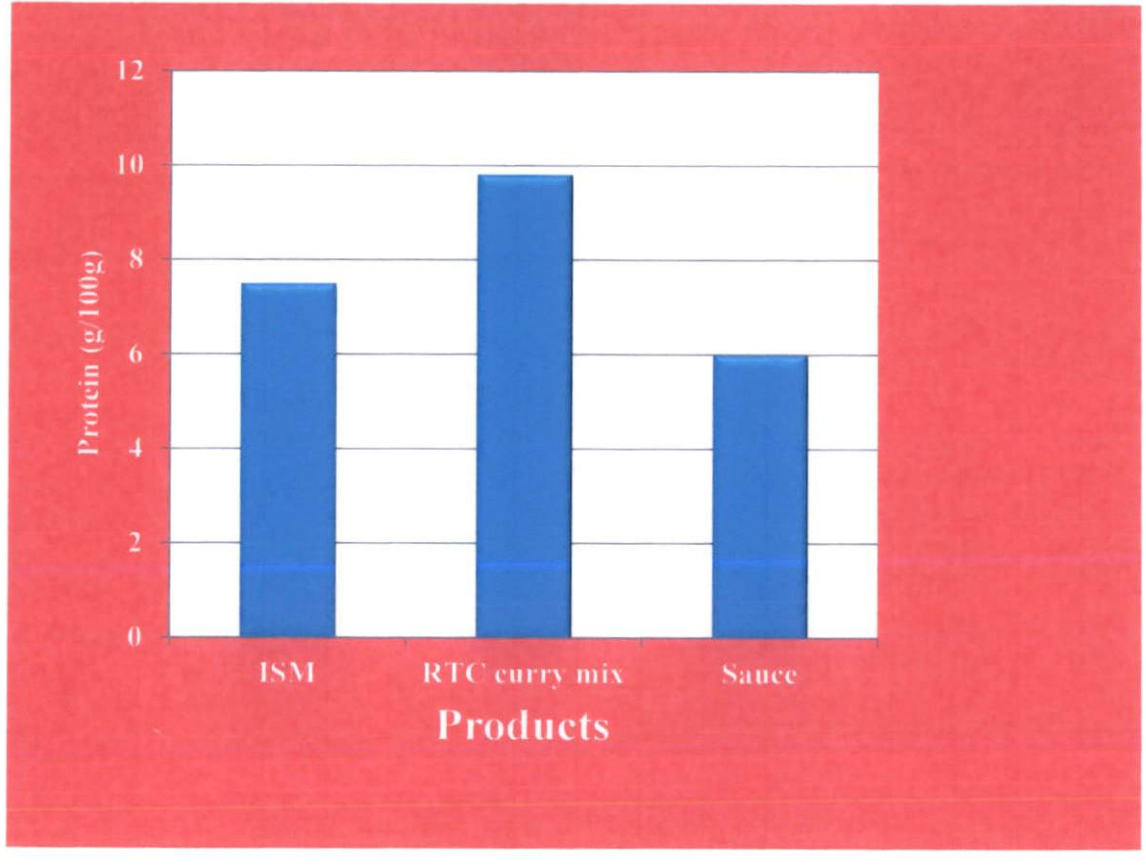


Fig.8 Protein content of developed banana peel based products

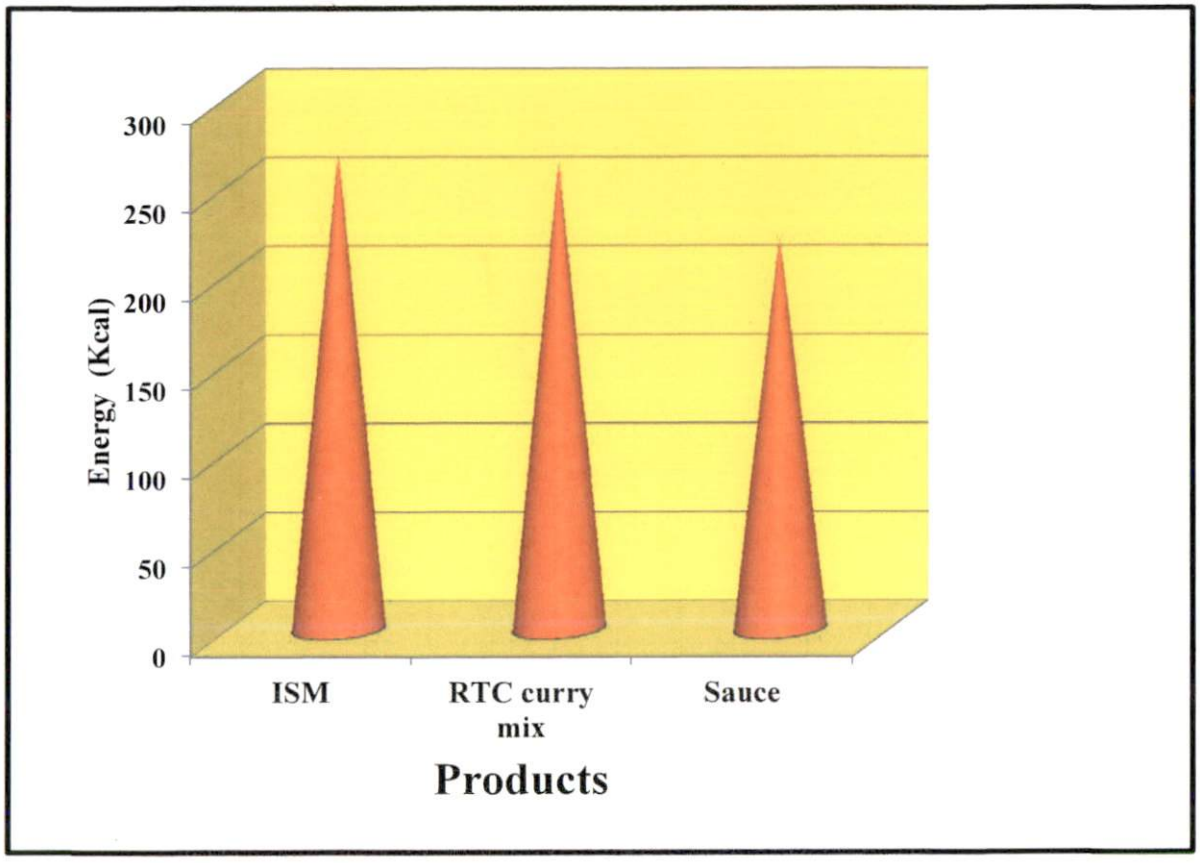


Fig.9 Energy content of developed banana peel based products

body fluids and maintained normal blood pressure. It will also help in controlling kidney failure, heart oddities and respiratory flaw. The concentration of potassium content is found to be highest (78.10mg/gm) in banana peel (Anhwange, 2008). Potassium content of tomato sauce was found to be 287.5mg/100gm (Jarmila, 2009).

Calcium is the most abundant mineral in the body. calcium content of developed products ranged from 40.7-69.4 mg. Higher calcium content was noted for RTC Currry mix (69.4mg/100gm) and lower levels were found to be in ISM (40.7mg/100gm). The least calcium content was recorded for soup mix (40.7mg/100gm). Calcium content of banana peel is 19.20mg/gm (Anhwange, 2008). Calcium content of tomato sauce was found to be 24.3mg/100gm (Jarmila, 2009).

Iron is an essential trace element found in nearly all living organisms. Iron content was higher in soup mix (2.62 mg/100gm) and lowest in sauce (0.94mg/100gm). Iron content of RTC curry mix was 1.94mg/100gm. Data on the value obtained for iron content of different products revealed a significant difference.

Iron carries oxygen to the cells and is necessary for the production of energy, synthesis of collagen and the proper functioning of the immune system. Iron content of banana peel is 0.61mg/gm (Sharrock, 2002).

Amla amd Mulky (2003) found that while developing new products, nutrients. may get lost because of the inappropriate processing methods. But in this study nutrients in the developed products were retained due to appropriate processing techniques.

5.4 SHELF LIFE STUDIES

Assessment of shelf life quality is important since it determines the suitability of a particular ingredient for product development(Livingstone *et al.*, 2000).

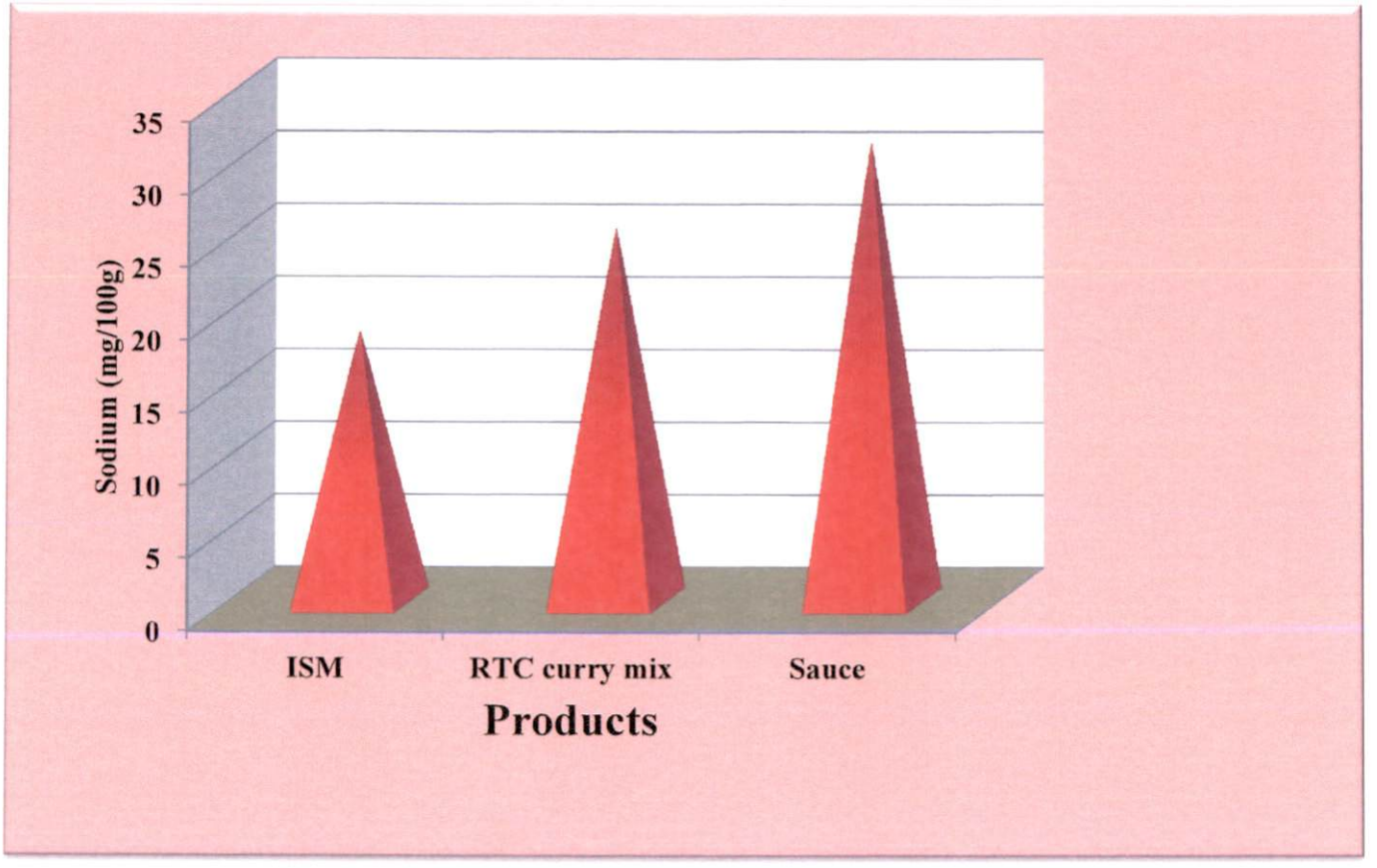


Fig.10 Sodium content of developed banana peel based products

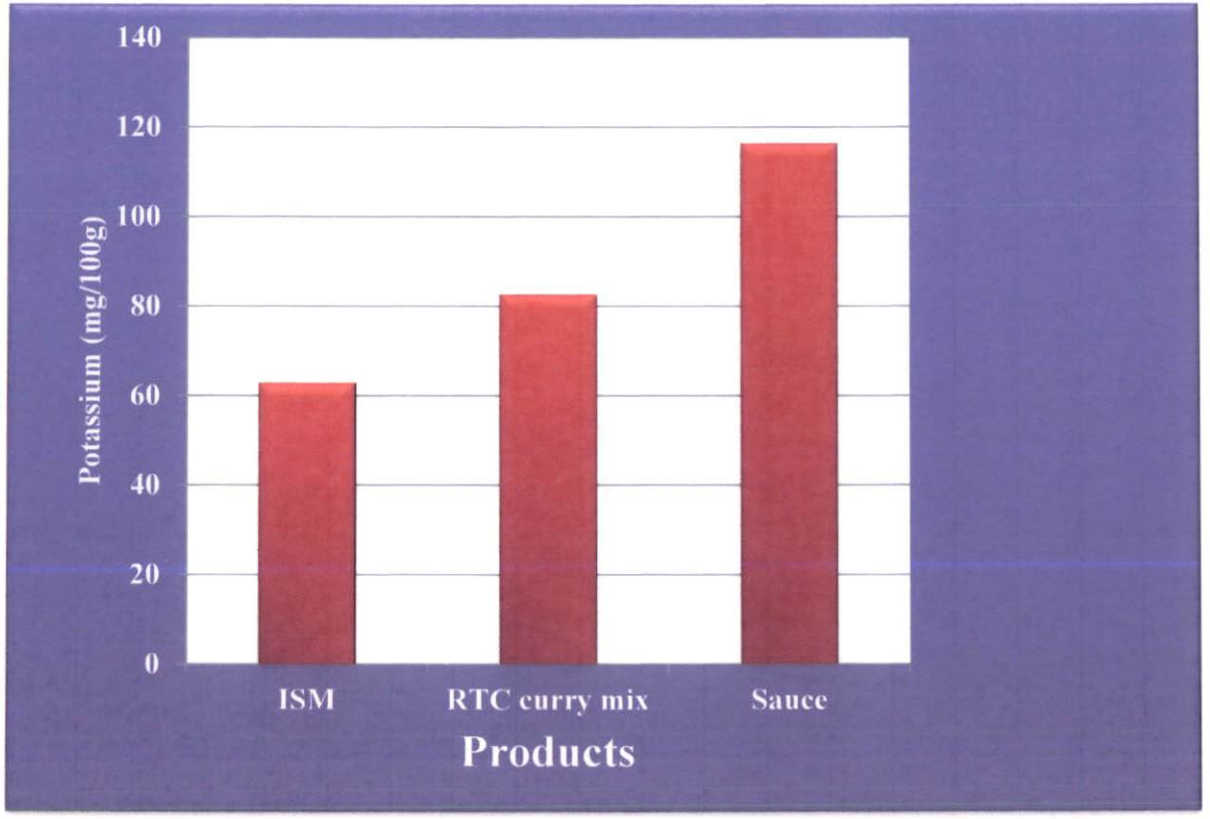


Fig.11 Potassium content of developed banana peel based products

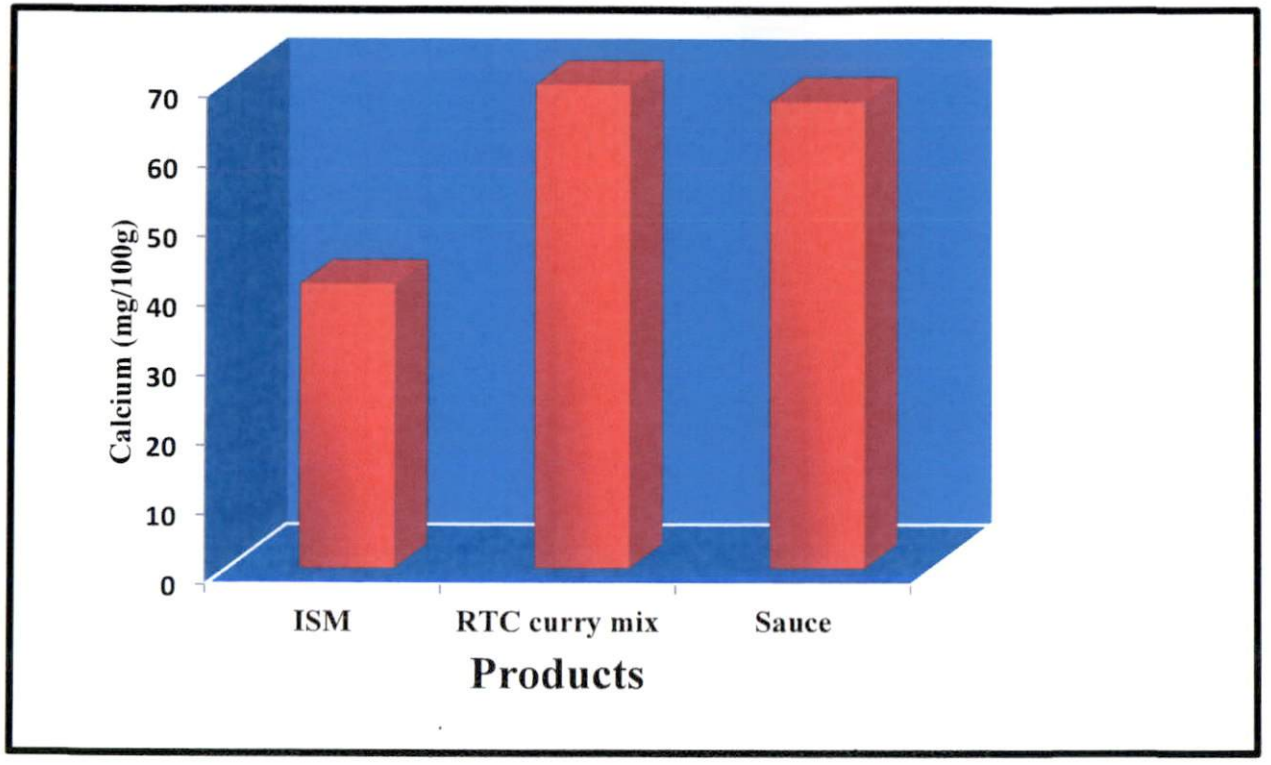


Fig.12 Calcium content of developed banana peel based products

Varsanay (2003) reported that the mechanism and kinetics of the food deterioration can be controlled by the storage techniques applied. Factors like raw material quality, storage temperature, storage containers, process employed and the environment in which it is processed affects the shelf life quality (Shankar *et al.*, 2002).

According to Daniel *et al.* (2001) Shelf life is the time during for which a combination of food processing and packaging can maintain satisfactory eating qualities under the particular system and by which the food is distributed in containers and the conditions at the point of sale. Shelf life can be used as a marketing tool for promoting the concept of freshness. Extended products or products with long shelf life also provide the consumer with the time, convenience of use and reduced risk of food wastage.

In the present investigation, sensory evaluation, moisture and microbial profile were conducted periodically up to a period of three months. The results revealed maintenance of quality through the storage period.

Moisture

Moisture is one of the important parameters which determine the shelf life quality of food products. Low moisture is highly important for longer storage period (Shankar *et al.*, 2002).

Initial moisture content of soup mix was 4.4 per cent and at the end of third month moisture content of soup mix rose to 4.8 percent. As for RTC curry mix it was 5.4 per cent initially and at the end of third month moisture content became 5.8 per cent. In the case of sauce initially it was 72.2 per cent and it increased up to 72.4 per cent. The data reveals that there was slight increase in the moisture content of soup mix, RTC curry mix and sauce during storage.

Saranya (2012) observed that the moisture content of stored ESM was found to enhanced gradually during the storage period. But the increase in moisture content does not influenced the quality of the RTC product.

Midhila (2013) reported that moisture content of the RTC produced from banana blossom was found to increase gradually during the storage period. But the increase in moisture content did not influence the quality of the developed banana peel products because the increase in moisture content was negligible.

Syama (2000) reported that the moisture content of stored vermicelli was 10.28 per cent and was found to increase by 11.27 per cent during storage period.

Tilakaratne (2012) reported that during the storage period of 12 weeks moisture content, water activity and colour of the dried soup mixture did not change significantly.

Microbial profile of developed products

The development and type of spoilage of food products depend on several factors such as physical state of the foods, its colloidal nature, type of preparation, treatments, chemical composition and nature of containers and such other factors (Khan *et al.*, 2002). Spoilage causing microorganisms are responsible for the development of an off flavour and off taste that leads to economic loss (Rao, 2001). Spoilage by micro organisms is the primary cause that curtails the shelf life and hence reduces initial microbial population (Zargory, 2003).

Chellammal (1997) observed that the products stored in glass and plastic containers had neither fungal or bacterial attack, even after the storage period of six months.

During the storage period, in this study no bacterial colonies were found to appear in the developed soup mix and curry mix packed in laminated pouches. But in the case of sauce two bacterial colonies were seen in 10^{-5} dilution during third month, however this was within permissible limits. No pathogenic organisms could be detected in the developed products.

Nasheeda (2006) reported that bacterial population of banana powder packed in polypropylene pouches ranged between 5.6-6.8x10 ^{3}cfu/gm.

According to Abeysinghe and Illeperuma (2006) an areobic plate count of the developed soup mix was within a safe range (2.3x10 ^{3} cfu/gm).

According to FSSAI regulation dehydrated fruits and vegetable products such as soup and RTC products should have less than 40.000 cfu/gm of microbial count. In the case of sauces it is not more than 50.000 cfu/gm.

Sensory evaluation of stored banana peel based products

Monitoring the storage behavior in terms of sensory analysis is an easy and important method of testing the acceptability of the product. John (2006) stated that for consumers the perceivable sensory attributes-appearance, colour, flavour, texture and taste are the deciding factors for the acceptance of any food products.

The acceptability of the products was examined at monthly intervals up to three months. The sensory attributes such as appearance, colour, flavour, texture, taste and overall acceptability were found to decrease in three developed products namely ISM, RTC curry mix and sauce. Evaluation of snack foods packed in laminated pouches and stored for 90 days was established to have acceptable colour, taste, texture, flavour and crispiness to the panel members (Shukla *et al.*, 2013).

Singh (2011) reported that sensory qualities of RTE pizza was acceptable for 45 days when packed in MAP compared to conventional packaging.

On the basis of shelf life studies, the developed banana products were found to have a shelf stable up to three months.

Cost of the developed products

Costing can be defined as the process of determining how much a product costs to prepare and sell a product. Costing is very important as the cost of the product can decide its profit or loss. The cost of processed products depends on the purchase of the raw material, cost involved in processing, packaging and marketing and the profit margin set by the industry (Kumbhar and Singh, 2001).

Amla and Mulky (2003) reported that while developing new products, the cost is to be kept to the minimum and the strategy for the development of the food product is to be based on affordable prices and cost effectiveness. In order to realize the economic feasibility of the developed products, cost per kg was computed separately. All the products developed under the present study were found to be reasonable in price. The cost of 1 Kg packets of products were thus calculated. The cost of 1 kg soup mix calculated was Rs 33, RTC curry mix was Rs 28 and sauce was Rs 80 . The cost of products were found to less than the market products.

In the present investigation the result revealed that the three products namely ISM, RTC curry mix and sauce developed from banana peel are rich in nutrients and have a reasonable shelf life. They were also adjudged with good sensory quality. The recommendation of the present study is to transfer the technology to large scale processors after scaling up and to harness the potentials in the food processing industry.

SUMMARY

6. SUMMARY

The present investigation entitled' Development of value added products from banana peel' was carried out with the aim of developing convenient to use products from banana peel (*cv* nendran). The objective of the study was to develop value added products from banana peel and ascertain their quality and shelf life. The experiment was carried out in the Department of Home Science, College of Agriculture, Vellayani, Thiruvananthapuram during the period of 2014-2015. The major findings of the study are summarized below.

Banana peel of *cv* nendran was utilized for the study. Fresh peels of nendran were collected from chips making unit at East fort, Trivandrum. Three banana peel based dishes were identified for standardization namely, Instant soup mix (ISM), Ready to cook curry mix (RTC curry mix) and sauce. For standardization, fresh peels were washed under running water and cut into medium sized slices and pretreated with citric acid (0.5%) and salt (3%) for 10 min to control enzymatic browning. Then the peels were subjected to blanching for 5 minutes to prevent darkening and control microbial infestation .

Various formulations of the instant soup mix, RTC curry mix and sauce were prepared and the best combination was selected based on the sensory evaluation by a 10 member panel using a five point scale. The identified soup mix comprised of banana peel flour onion powder, corn flour, citric acid, capsicum powder, coriander leaves powder, white pepper powder, ginger powder, garlic powder and salt the ratio being 5: 4: 1.5: 0.5: 0.25: 0.25: 0.5: 0.25: 0.25: 2.Drying blending method was adopted for the soup preparation. Soup was prepared by boiling 200ml of water and adding the soup mix as a paste and simmering for 1 min.

In the case of RTC curry mix dimensions of banana peels (1x1cm) was selected based on OVQ scores. The identified curry mix contained banana peel, crushed red

chillies, garlic, cumin, turmeric powder and curry leaves the ratio being 1000: 30:50: 10: 20: 50. In order to give the hints for using the product to the consumer reconstitution time and cooking time were also standardized. After the standardization reconstitution time 20 minutes was found to be best for RTC curry mix and it needed 7 minutes for complete cooking.

In the case of sauce the best treatment comprised of banana peel, coriander leaves, garlic, vinegar, red chilly, sugar and spices, the ratio being 100: 50: 5: 2.5: 2.5: 5 and six minutes was selected as the optimum processing time.

After standardization quality parameters with respect to physical, chemical and nutritional characteristics of the products were analyzed. In physical characteristics yield, rehydration ratio, bulk density and water absorption index of the products were studied. After analyzing the physical properties of ISM, RTC curry mix and sauce, yield ratio for the products in the same order was found to be 0.06, 0.13 and1.4 respectively, Bulk density of ISM and RTC curry mix was found to be 0.81 and 0.73 gm/ml, water absorption index of ISM and RTC curry mix was found to be 13.5 and 4.0 per gm and rehydration ratio of curry mix was observed to be 0.38.

Chemical composition of the banana peel based products were ascertained with respect to acidity (%), moisture, reducing sugar, fibre (gm), pH and TSS. Chemical analysis of the products revealed that acidity of soup mix, RTC curry mix and sauce were 0.76, 0.85 and 1.75 per cent respectively. Moisture content the products were found to be 4.4,5.4 and 72.2 per cent respectively. Reducing sugar levels were found to be in the range of 0.97 to 1.07. Fiber content was found to be in the range of 2.06 to 14.10 gm, pH of the products were found to be 5.20, 5.10 and 4.06 ; TSS of sauce was observed to be 20°brix.

Nutrient composition of the developed products were analysed using the standard procedures. Proximate composition of the mixes were ascertained with

respect to carbohydrate (gm), protein (gm), calories (Kcal) and total minerals (mg). The higher carbohydrate content was noted for RTC curry mix (62.0gm/100gm) and lower levels was recorded for sauce (46.2gm/100gm) whereas for instant soup mix, carbohydrate content was 48.6gm/100gm. Protein content of the product ranged from 6.0- 9.8gm. The protein content was found to be higher for RTC curry mix (9.8gm/100gm). Lower protein content was noted for sauce (6.0gm/100gm), Protein content of soup mix was 7.5gm/100gm. The energy content was found to be highest for instant soup mix (268 kcal/100gm) and lower for sauce (220 kcal/100gm). The calorific value of RTC curry mix was observed to be 262 kcal/100gm.

As far as sodium content is concerned, the highest value was obtained for sauce (31.49 mg/100gm) which was followed by RTC curry mix (25.6 mg/100gm). The lowest sodium content was observed in instant soup mix (18.5 mg/100gm). Data reveals that the potassium content was higher for sauce (116.4mg/100gm); while RTC curry mix contained 82.5 mg/100gm. Sodium content was lowest in soup mix (62.8/100gm). Calcium content of the products ranged from 40.7-69.4 mg. Higher calcium content was noted for RTC Curry mix (69.4mg/100gm) which was on par with sauce (67 mg/100gm). The least calcium content was recorded for soup mix (40.7mg/100gm). In the case of iron content it was higher in soup mix (2.62 mg/100gm) and lowest in sauce (0.94 mg/100gm). Iron content of RTC curry mix was 1.94mg/100gm.

Shelf life parameters were assessed by storing the products for three months at ambient conditions; ISM and RTC curry mix were stored in laminated pouches and sauce was stored in glass bottles. Herein, moisture content, microbial profile and sensory parameters were analyzed. Moisture and sensory parameters of the products during storage period showed only slight changes compared to fresh samples. In the case of microbial profile, during the storage period no bacterial colonies were found to appear in the developed soup mix and curry mix packed in laminated pouches. But

in the case of sauce two bacterial colonies were seen in 10^{-5} dilution during third month, however this was within permissible limits. No other pathogenic organisms could be detected in the developed products.

In order to realize the economic feasibility of the developed products, cost per kg was computed separately. All the products developed under the present study were found to be of reasonable price. The cost of products per kg was calculated. When the cost of soup mix calculated was Rs 33, that of curry mix was Rs 28 and for sauce it was Rs 80. The cost of products were found to less than the market products.

This study highlights the scope for value addition of banana peel of nendran variety. Although, banana peel has been used traditionally by many communities of Kerala and Karnataka as a vegetable, it has not been processed to commercial products. This study has confirmed the acceptability of three convenient, nutritive and appealing products with shelf life to the urban consumer.

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ABSTRACT

DEVELOPMENT OF VALUE ADDED PRODUCTS FROM BANANA PEEL

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Abstract of the thesis

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ABSTRACT

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(2013-16-104) **Time:10.00-10.30 am**

The present investigation entitled "Development of value added products from banana peel" was conducted at the Department of Home science, College of Agriculture,Vellayani. The objective of the study was to develop banana peel based food products and to ascertain their quality and shelf life. The study intended to utilize this nutritionally significant raw material through value addition, thereby reducing its large scale wastage from the processing industry and also avoiding the related environmental pollution.

Banana peel of *cv* nendran was utilized for the study and the peels were collected from chips making units in East fort, Trivandrum. The collected peels were pretreated with different proportions of citric acid (0.1-0.3%) and salt (1-3%), to control enzymatic browning. Three products were standardized namely, a banana peel based Instant soup mix (ISM), a Ready to cook (RTC) curry mix and a sauce.

For standardization of the products the best formulations were selected by a panel comprising of 10 members. Parameters like colour, appearance, taste, texture and overall acceptability were evaluated. In the case of instant soup mix, the best formulation identified was S_1 which comprised of banana peel flour, onion powder, corn flour, citric acid, capsicum powder, coriander leaves powder, white pepper powder, ginger powder, garlic powder and salt (Their ratio being , 5: 4: 1.5: 0.5: 0.25: 0.25: 0.5: 0.25: 0.25: 2). In the case of the RTC curry mix, S_1 was selected as the best formulation, which contained banana peel, crushed red chilly, garlic, jeera, turmeric powder and curry leaves (Their ratio being , 100: 3:5: 1: 2:5). As for sauce, formulation S_5 got the highest scores in sensory evaluation, which comprised of Banana peel,

coriander leaves, garlic, vinegar, red chilly, sugar and spices (Their ratio being, 100: 50: 5: 2.5: 2.5: 5)

Physical properties of ISM, RTC curry mix and sauce were analyzed. Moisture content the products were found to be 4.4, 5.4 and 72.2 per cent respectively, yield ratio for the products in the same order was found to be 0.06, 0.13 and 1.4 respectively, Bulk density of ISM and RTC curry mix was found to be 0.81 and 0.73 gm/ml, water absorption index of ISM and RTC curry mix was found to be (13.5 and 4.0 per gm) and rehydration ratio of curry mix was observed to be 0.38.

Chemical analysis of the products revealed that acidity of soup mix, RTC curry mix and sauce were 0.76, 0.85 and 1.75 per cent respectively. Reducing sugar levels were found to be in the range of 0.97 to 1.07g%. Fiber content was found to be in the range of 2.06 to 14.10, pH of the products were found to be 5.20, 5.10 and 4.06 ; TSS of sauce was observed to be 20° brix.

Nutrient analysis reports revealed that CHO levels of the ISM, RTC curry mix and sauce were 48.6, 62.0 and 46.2 gm respectively. Similiarly the protein levels were found to be 7.5, 9.8 and 6.0 gm for the 3 products. Calorie content in these products were analyzed to be in the range of 220 -268 kcal. Mineral content of the products were analyzed as; sodium (18.5, 25.6 and 31.49 mg), potassium (62.8, 82.5 and 116.4 mg), calcium (40.7, 69.4 and 67.0 mg) and iron (2.62, 1.94 and 0.94 mg). Shelf life parameters were assessed by storing the products for three months at ambient conditions. Moisture and sensory parameters of the products during storage period showed only slight changes compared to fresh samples. Microbial infestation was found to be within safe limits.

This study has confirmed the acceptability of three convenient, nutritive and appealing banana peel based products namely ISM, RTC curry mix and sauce with appreciable shelf life suiting to the urban consumer.

APPENDICES

APPENDIX-1

Score card for organoleptic qualities of ISM

Tested by

Age

Date: / /2014

Particulars	Criteria	Score	1	2	3	4	5
Appearance	Very good	5					
	Good	4					
	Average	3					
	Poor	2					
	Very Poor	1					
Colour	Very good	5					
	Good	4					
	Average	3					
	Poor	2					
	Very Poor	1					
Flavour	Very Good	5					
	Good	4					
	Average	3					
	Poor	2					
	Very Poor	1					
Taste		5					
	Very Good	4					
	Good	3					
	Average	2					
	Poor	1					
	Very poor						
Consistency	Thin	5					
	Mod.Thin	4					
	Sl.Thin	3					
	Thick	2					
	Very Thick	1					
Overall Acceptability	Very Good	5					
	Good	4					
	Average	3					
	Poor	2					
	Very Poor	1					

APPENDIX-11

Score card for organoleptic qualities of RTC curry mix

Tested by

Age

Date: / /2014

Particulars	Criteria	Score	1	2	3	4	5
Appearance	Very good	5					
	Good	4					
	Average	3					
	Poor	2					
	Very Poor	1					
Colour	Very good	5					
	Good	4					
	Average	3					
	Poor	2					
	Very Poor	1					
Flavour	Very Good	5					
	Good	4					
	Average	3					
	Poor	2					
	Very Poor	1					
Taste		5					
	Very Good	4					
	Good	3					
	Average	2					
	Poor	1					
	Very poor						
Texture (Doneness)	Optimum doneness	5					
	Mod.Doneness	4					
	Low Doneness	3					
	Slightly undercooked	2					
	Highly undercooked	1					
Overall Acceptability	Very Good	5					
	Good	4					
	Average	3					
	Poor	2					
	Very Poor	1					

APPENDIX-111

Score card for organoleptic qualities of banana peel based sauce

Tested by

Age

Date: / /2014

Particulars	Criteria	Score	1	2	3	4	5
Appearance	Very good	5					
	Good	4					
	Average	3					
	Poor	2					
	Very Poor	1					
Colour	Very good	5					
	Good	4					
	Average	3					
	Poor	2					
	Very Poor	1					
Flavour	Very Good	5					
	Good	4					
	Average	3					
	Poor	2					
	Very Poor	1					
Taste		5					
	Very Good	4					
	Good	3					
	Average	2					
	Poor	1					
	Very poor						
Consistency	Free flowing	5					
	Slightly watery	4					
	Very much watery	3					
	Very thick	2					
	Thick	1					
Overall Acceptability	Very Good	5					
	Good	4					
	Average	3					
	Poor	2					
	Very Poor	1					

APPENDIX-1V

Overall Visual Quality (OVQ) Score card

(1-9 Point scale)

Criteria	Score
Excellent and fresh appearance	9
Good	7
Fair (limit of marketability)	5
Fair useble but not saleable	3
Unusable	1