FORMULATING EXTRUDED FOODS BASED ON DIOSCOREA (*Dioscorea rotundata* Poir) AND TARO (*Colocasia esculenta* (L.) Schott.)

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DECLARATION

I hereby declare that this thesis entitled "**Formulating extruded foods based on dioscorea (*Dioscorea rotundata* Poir) and taro (*Colocasia esculenta* (L.) Schott.)**" is a bonafide record of research work done by me during the course of research and that 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.

Vellayani,
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CERTIFICATE

Certified that this thesis entitled "**Formulating extruded foods based on dioscorea (*Dioscorea rotundata* Poir) and taro (*Colocasia esculenta* (L.) Schott.)**" is a record of research work done independently by Ms. Deepthi Karolin, K. (2002-16-08) under my guidance and supervision and that it has not previously formed the basis for the award of any degree, fellowship or associateship to her.

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LIST OF ABBREVIATIONS

C_1	–	Combination 1
C_2	–	Combination 2
C_3	–	Combination 3
C_4	–	Combination 4
CD	–	Critical difference
D	–	Dioscorea
D_1	–	Sree Priya
D_2	–	Sree Dhanya
g	–	Gram
ha	–	Hectare
K	–	Potassium
kg	–	Kilogram
M	–	Maida
mg	–	Milligram
Mt	–	Metric tonne
Na	–	Sodium
PET	–	Polyethylene terephthalate
R	–	Rice flour
S	–	Soya flour
SE	–	Standard error
T	–	Taro
T_1	–	Sree Rashmi
T_2	–	Thamarakkannan

Introduction

1. INTRODUCTION

Roots and tubers deserve particular attention because many of the developing world's poorest and most food insecure households look to roots and tubers as a contributing source of food, nutrition and cash income. Farm households see the value of roots and tubers in their ability to produce large quantities of dietary energy and in their stability of production under conditions where other crops may fail.

Tuber crops like cassava, sweet potato, aroids and yams have created a niche in the food security of the millions especially for poor, nationally and world wide, as they are the third most important food crops after cereals and grain legumes. This group of crops can supplement the cereals owing to their high biological efficiency in productivity and nutrition.

Some tuber crops are called minor tuber crops, due to their less popular cultivation. They are cultivated in the backyard or kitchen gardens and at times in small areas of one or two cents only. Nutritionally, minor tubers are rich sources of carbohydrates and provides the greater part of the calorie content of the diet. The nutritive value of minor tubers is considered to be far better than popular tubers like cassava and potato because they have some quantity of protein and minerals besides carbohydrates.

Minor tuber crops are bulky, vegetatively propagated and highly perishable. The major problem with minor tubers in post harvest period is lack of specific and novel processing techniques. Not much attention has been paid to the processing of minor tubers. Processing adds value at the farm level and reduces perishabiltiy and bulkiness, thereby facilitating sale of tuber crops based products in the off-season and in distant markets. Processing can also improve food security by generating employment, an income for non-growers thereby enhancing their purchasing power to gain more ready access to food (Scott *et al*., 2000). Considering the lesser cost, better nutritive value along with specific medicinal properties and ease of production, it is imperative that the development of value added products with minor tubers will go a long way in relieving hunger.

Development of processed products such as instant products and mixes adds convenience, saves time and labour and provides hygienic products of standard and uniform quality with enhanced shelf-life. Processed products could find a ready market among the urban middle income working couples, industrial labour force, restaurants, large catering establishments and non-civilian populations. More and more people are going for processed foods and it is estimated that over 10 per cent of total expenditure incurred in the household for foods is spent on processed foods (Ray and Athawali, 2000). So processing of novel food items utilising the locally available minor tubers will provide the consumer with a variety of wholesome foods. And inorder to synchronize production of tuber crops with marketing, it is necessary to open new avenues for its better utilization where traditional uses have already stabilized. Tuber crops provide vast scope for diversification and value addition. There lies a great opportunity for non-traditional uses of tuber crops in the form of convenience foods like extruded products.

Extrusion of food is an emerging technology for the food processing industries to process and market a large number of novel products of varying size, shape, texture and taste. Because of its versatile efficiency, flexibility, ease of obtaining products and economy of space and labour, extrusion technology has become more popular. Extrusion offers the feasibility of modifying functional properties of food ingredients and provides a wide range of noval shaped pre-cooked and texturised foods. Usually extruded products are processed with cereal flours. Processing of extruded products based on minor tubers will be novel and add value to the tubers. It will be of great help to the cultivators, farmwomen and small-scale entrepreneurs because of its income generation potential.

In the present study, an attempt is made to develop extruded products from dioscorea and taro and to assess their acceptability, nutritional and shelf life qualities.

Review of Literature

2. REVIEW OF LITERATURE

The study entitled “Formulating extruded foods based on dioscorea (*Dioscorea rotundata* Poir) and taro (*Colocasia esculenta* (L.) Schott) was reviewed under the following subtitles.

2.1 Cultivation, production and processing of Dioscorea and taro

2.2 Nutritional significance of dioscorea and taro

2.3 Extrusion technology

2.4 Acceptability studies on new foods

2.5 Storage studies on tuber flour and products

2.1 CULTIVATION, PRODUCTION AND PROCESSING OF DIOSCOREA AND TARO

2.1.1 Cultivation and Production

Tuber crops constitute an important food crop of man from time immemorial sustaining people during the days of famine or when there is shortage of food. They form the most important staple or subsidiary food for about 20 per cent of world’s population. They have biological efficiency and the highest dry matter production than all other crops. Most striking aspect is that they supply a cheap source of energy to the weaker sections of people (Edison, 1999).

Roots and tubers deserve particular attention because many of the developing world’s poorest and most food insecure household look to roots and tubers as a contributing source of food, nutrition and cash income (Alexandratos, 1995).

Tuber crops have been generally cultivated by poor and marginal sections of farming community mainly for their subsistence. Amongst the tuber crops, cassava, sweet potato, aroids and yams are the major ones considering their contribution to agricultural economy. The tuber crops put together occupy an area of 48 million hectares with an yield of 12 t ha^{-1} in the world as in India they are cultivated in an area of 1.4 million hectares with an yield potential of 16 t ha^{-1} (FAO, 2000).

Some tuber crops are called minor tuber crops, due to their less popular cultivation. They are cultivated in the backyard or kitchen gardens and at times in small areas of one or two cents only. In fact, the nutritive value of these minor tuber crops are considered to be far better than popular tubers like cassava or potato because they have some quantity of protein besides carbohydrates. Minor tubers are low cost calorie dense foods, which are suitable in the Indian situation to alleviate calorie malnutrition as reported by Shanmugavelu *et al*. (1987).

Chadha (1993) is also of the view that the productivity and dry matter production of minor tuber crops are higher than that of cereals and other food crops.

Edible aroids are the major staple food and vegetable of tropical regions. Aroids also have an established place in the production systems and food cultivars of countries with large and intensive agricultural economics such as China, India and Japan (Scott *et al*., 2000).

Edison (2000) had stated that area and production of tuber crops in Kerala has drastically come down due to prevalence of uncertainty in prices, competition from its substitutes and availability of few value added products.

Dioscorea production is essential to the survival and well being of many generations of people in the tropics and continuous to be highly important for ensuring sustainable food security and income generation (Scott *et al*., 2000).

According to Nweke *et al*. (1992) dioscorea would continue to have a high market potential because of the increased quantities consumed at low-income levels.

Dioscorea are second to cassava as the most important tropical root crop. These are the stable crop in many parts of Africa and South East Asia. In the South Pacific, dioscorea is a significant food crop, accounting for over 20 per cent, 8.1 per cent and 4.6 per cent of the total dietary calorie intake in the kingdom of Tonga, Solomon Islands and Papua New Guinea, respectively (Opara, 1999).

Dioscorea is cultivated in an area of 2.5 million ha with a production of 23.89 million tonnes in different yam growing areas of the world as reported by Padmaja, (1994).

Most of the world production of dioscorea is from Africa about (96 %) with Nigeria alone accounting for nearly 75 per cent of the total world production. World's annual production was estimated to be 25 million Mt in 1974 and 24million Mt in 1992. During the past five years, total world production has increased from 32.7 million Mt in 1995 to 37.5 million Mt in 2000. During the1975-90, total dioscorea cultivated area increased by about 38.8 per cent globally, while the total production increased by 45.8 per cent (Opara, 1999).

The major countries growing dioscorea are Nigeria, Ivory Coast, Gahana, Cameroon and Benin and aroids group of crops are found mostly in the South Pacific, West Africa, China and South and South East Asia. Yams are grown mostly under mixed cropping system in Eastern India, Kerala and in some tribal pockets (CTCRI, 1997).

The taro possesses indeterminate growth habit which accumulates food reserves in shortage stems mainly in the form of starch, and about 80-90 per cent of the total dry matter produced in this crop is consumable.

Usually the corm and cormels are consumed after boiling or frying in oil (Narazary and Rajendran, 1999).

Taro is one of the important tuber crops of the world from antiquity. It is one of the third important groups of dietary staple for low income consumers. Taro acts as a buffer in the shortage of other staple food. It is valuable as low cost food calorie for people in the tropical world. Its ability to produce a crop under both extremes of water regimes from dry land to shady moist places or flooded conditions make it a valuable crop for selective development programme (Chadha, 1993). It is the 14^{th} most consumed vegetable world wide and the annual production in developing countries is about 5.7 million hectares (FAO, 1998).

Total world production area of taro was estimated to be about 993 x 10^3 ha in 1983, with 80 per cent in Africa. During this period, global production of taro was 5.607 million Mt, with about 61.33 per cent in Africa and 38.67 per cent in Asia (FAO, 1991). Production declined by 5.3 per cent from 5.64 million Mt in the 1979-81 periods to 5.34 Mt in 1989. Current statistics indicates that the production increased slowly during the past five years from 5.6 million to 8.8 million Mt. Although exports increased by over 23 per cent in volume, the value of exports remained fairly uniform over this period (FAO, 2000). The crop is of great importance in the Carribean, Hawaii, Solomans, American Samoa, Western Samoa, Philippines, Fiji, Sri Lanka, India, Nigeria, Indonesia, Tonga, Nine, Papua New Guinea and Egypt (FAO, 1987).

Taro, being an unconventional foodstuff, can help in reducing feed protein costs and have some important cereals for industrial and human consumption (Anigbogu, 1996).

Maga (1992) had stated that taro, since ancient times has been the staple food in many areas of tropical and subtropical world. In addition to its corms many cultures consume its leaves and shoots and its importance in some cultures can be best appreciated by its traditional ceremonial uses.

In India, Thamarakannan, Kovur, Sahasramukhi, White Gauriya and Panchamukhi are the local varieties of taro grown in different regions (Ghosh *et al.*, 1988). Two elite clones namely Sree Rashmi and Sree Pallavi which are high yielders with good cooking quality have been released for cultivation (Unnikrishnan *et al.*, 1987).

2.1.2 Processing of Dioscorea and Taro

The concept of processed foods has caught the imagination of consumers in recent years because of their enhanced convenience, variety, nutrition and taste. The challenge therefore lies in continuously developing new variations of food items, as well as processes that will maximize its appeal and shelf-life and minimize the use of chemicals and preservatives. The swelling consumerism has seen the introduction of a range of new products like ready-to-eat snack foods, breakfast cereals, textures vegetables protein foods and so on. Different brands of the same item and attractive packaging vie for the consumer's attention (Anvita *et al.*, 1993).

Food processing is very important for prosperity of India. Food processing industry helps to avoid post harvest losses of agricultural produce. In India, the value addition of food production is only seven per cent compared to 23 per cent in China, 45 per cent in Philippines or 18 per cent in UK (Mallya, 2003).

According to Premakumari (1993) tuber processing industry has now assumed perennial importance as it assures a stable market to farmers and enables them to expand their production without fear of a fall in demand. Tuber crops contribute to income and food security in developing countries. There are many opportunities to improve traditional use of tuber crops and introduce them into a wide range of new foods and feed markets, particularly in the rapidly urbanizing societies of the developing world.

Dioscorea is one of the most important root crops grown for food in Nigeria. It is consumed in various forms such as boiled, roasted, fried, pounded, flour, mashed and chips. It possesses a fibrous root system (Ajav, 1998).

The largest proportion of dioscorea product annually is marketed as fresh tuber. Only a very small fraction goes to market in processed form such as boiled yam, mashed yam, fried yam, roasted yam and baked yam. Yam tubers make good feed for livestock (Onwueme and Charles, 1994).

A starchy staple food stuff, dioscorea is normally eaten as a vegetable, boiled, baked or fried. In West Africa they are consumed mainly as ‘fufu’ a stiff glutinous dough (Agav, 1998).

Traditionally in many Indian families, yam tubers are consumed after cooking and peeling. *D. alata* tubers are peeled and cooked or used as a vegetable. The utilization of taro and tannia is restricted to its use as a vegetable in India (Padmaja, 1994).

Thirumaran *et al*. (1988) had found that novel recipes like tuber mash, bitosy and sweet stuffed parathas could be prepared from fresh tubers of *Dioscorea* species.

Attempts had also been made to prepare some Indian fast food snacks like yam vegetable, yam vada, yam bonda and yam vegetable cutlet from fresh tubers of *Dioscorea* esculenta by Naik *et al*. (1993).

Value added food products such as nuggets from taro tubers and petioles and noodle snack from colocasia tubers have been prepared with wet ground legumes. The utilization of soybean with colocasia and legumes in the preparation of nuggets from colocasia tubers and petioles, and noodles snack from tubers was found to be acceptable in relation to the products quality (Singh, 2003).

Various products like murukku, wafers and papads were prepared from taro flour by Liya (2002) and the organoleptic evaluation revealed that products made from flour of Sree Rashmi and Thamarakannan had high acceptability.

Taro can be used as such for preparation of snack items like chips while the flour can be used as a substitute for cereal or pulse flour in many traditional snack items. Though in countries like Philippines and Hawaiian Islands, where taro is processed into a number of extruded products, such products are not available in India (Padmaja *et al*., 1999).

Gubage *et al*. (1996) reported that 'sapal' is a traditional fermented food made by mixing cooked grated taro corm with coconut cream and allowing it to ferment at ambient temperature.

Tu *et al.* (1992) reported about two new taro products – noodles and synthetic rice. Both products had upto 35 per cent of other plant products such as soy, pea nut or mung bean flour. The new products could be readily prepared for eating by immersion in boiling water for a few minutes.

Parkinson (1984) has reported that taro starch could be included in a number of manufactured foods such as noodles, biscuit and bread. Taro starch because of its good protein and vitamin content could be used as a good cereal substitute.

According to Aggarwal *et al*. (1999) taro flour has been evaluated as an additive to a wide range of bakery products including breads, cakes and biscuits where upto 15 per cent taro flour could be successfully incorporated in bread, 30 per cent in cakes and 20 per cent in biscuits.

High fructose syrup can be made from taro starch (Winarno, 1990). He also reported that root extract can be used as medicine for rheumatism.

The taro flour has been used to produce noodles, flakes, cookies, biscuit, infant foods etc. Fried taro chips prepared by deep frying in fat are common in Nigeria and India. Taro flour is used for developing baby weaning food and taro based bread (Predrana, 1989).

2.2 NUTRITIONAL SIGNIFICANCE OF DIOSCOREA AND TARO

A study of nutritive value is very essential while trying to improve the processing and utilization of under exploited crops. Nutritionally minor tubers are rich sources of carbohydrates and provide the greater part of the calorie content of the diet (Seralathan and Thirumaran, 1999).

According to Babu (2000) minor tubers are high carbohydrate low fat food having plenty of calories. The major constituent in all tuber crops is starch, the range of which varies from 13-30 per cent in different crops and within cultivars of the same crop. Tuber crops are excellent sources of dietary fibre.

Dioscorea is extremely high in starch (25 to 30 per cent) and also contains appreciable amounts of protein (1.5 to 3.0 per cent) making it a better food source than many of the other starchy roots and tuber (Eka, 1986).

According to Suja (2001) African white yam (*D. rotundata*) has a significantly high starch content of 23.70 per cent.

Dioscorea has high contents of moisture, dry matter starch, potassium but is low in vitamin A. It contains about 5-10 mg/100 g vitamin C, and the limiting essential amino acids are isoleucine and those containing sulphur. They also contain a steroid sapogenin compound called diosgenin (Opara, 1999).

Tuber crops are very poor sources of fat and yielding about 0.10 per cent (Colocasia and Xanthosoma) and 0.33 percent (Dioscorea) per 100 g (Seratlathan and Thirumaran, 1999).

Taro contains a lot of starch (30 per cent), a little bit of sugar (3 per cent) and some protein (1 per cent) (Heiser, 1990).

With regard to vitamin content, tuber crops are fairly good sources. Seralathan and Thirumaran (1999) reported that among minor tuber crops, taro was found to have highest thiamine content of 0.09 mg per 100 g.

According to Parkinson (1984) taro and xanthosoma have a higher thiamine value than other aroids, whilst the riboflavin and niacin values for all the species are fairly comparable. Taro leaves are an excellent source of folic acid, vitamin C, riboflavin and vitamin A. They are particularly useful for people with anaemia as the leaves provide blood building nutrients, iron and folic acid in addition to vitamin C, which assists iron absorption.

All plant parts of taro and xanthosoma are edible. Leaves of taro are exceptionally rich in minerals, vitamins and protein. Leaves contain between 3.9 to 7 g protein and 12.63 mg vitamin C per 100 g fresh matter (Babu, 2000).

Balagopalan (2000) opined that like other tuber crops, taro has high calcium and iron content. The leaves of taro are exceptionally rich in minerals, vitamins and protein. Leaves contain between 3.9 to 7 g protein, 225 to 460 mg calcium, 82 to 125 mg phosphorus, 10 to 12 mg carotene, 0.26 to 0.45 mg riboflavin and 12.6 mg vitamin C per 100 g. They are also rich in certain minerals especially potassium, calcium and phosphorus. Tubers are generally low in sodium, and the high K: Na ratio can be advantageous in low salt diets prescribed for patients with high blood pressure.

The most acrid tuber, taro was found to contain a high amount of calcium (36 mg per 100 g). Taro was found to yield the high amount of phosphorus (68 mg per 100 g) and magnesium (109 mg per 100 g) (Seralathan and Thirumaran, 1999).

2.3 EXTRUSION TECHNOLOGY

Extrusion may be defined as the process by which moistened expansible starchy or proteinacious materials are plasticized in a tube by a combination of pressure, heat and mechanical shear. A whole range of products with different textures, forms and densities can be developed through extrusion. The utilization of extrusion technique has grown at a rapid pace throughout the food industry. Extrusion appears to have great promise in less developed nations whereas ready supply of nutritious low cost preserved food is an urgent necessity to solve the existing food problem (Vaidehi and Rao, 1992).

Extrusion is a multivariable unit operation *i.e.,* mixing, shearing, cooking, puffing and drying in one energy efficient rapid continuous process. This process of HTST, extrusion brings about gelatinisation of starch, denaturation of proteins, modification of lipids and inactivation of enzymes, microbes and many antinutritional factors. The extrudates are texturally and histologically restructured. Considerable efforts have been made to develop protein-rich extrudate from various sources such as fish, livestock, microbial cells and oil seeds (Banerjee *et al*., 1998). It is often characterized by low production cost resulting from the small area required, reduced energy consumption and low numbers of personnel that are necessary (Smith and Singh, 1996).

Extrusion, a modern high temperature and short time heat processing technology, makes the protein available with optimal protein quality (Camire *et al*., 1990) and according to Rajawat *et al*. (2000), extrusion technology not only increases the protein content but also decreases the level of anti-metabolites associated with them.

Extrusion technology potentially offers a low cost means of producing convenience foods with variable functional and quality attributes. Modified flours, paste and noodle type of foods and expanded snack products can be produced through extrusion (Rickard and Paulter, 1990).

Extrusion is a popular means of preparing snack foods and ready-to-eat breakfast cereals using starch based raw materials. The raw materials such as flours of rice, wheat, corn, oat can be incorporated into a formulation with other ingredients to change the physical, chemical, sensory and nutritional properties of the product (Jha and Prasad, 2003).

Twin-screw food extrusion technology is an established process in Western countries for making ready-to-eat breakfast cereals providing high fibre food to combat colon cancer. This technology can be modified to make nutritionally balanced ready-to-eat foods based on locally available cereals, coarse grains, oil seeds, tubers, fish etc. for school feeding projects, diaster-relief programmes and nutritional intervention projects (Mukherjee, 2003).

Extrusion has been widely used in the food industry to produce texturized vegetable protein. Extruded proteins are usually coloured, flavoured and used in the hydrated form as 'meat-analogues' or they are ground to a powder and marketed as a functional ingredient (Smith and Singh, 1996).

Physical properties are important criteria of extruded foods. Most common physical properties are the expansion ratio, bulk density and porosity. Quality of the extruded products depends on extruder operating conditions (Ryu and Walker, 1995).

According to Jha and Prasad (2003) the expansion ratio during extrusion decreased with increase in salt and sugar content. Hseih *et al.* (1993) has also reported similar result for extrusion of rice four with salt and sugar. Bulk density and hardness of extruded products were found to increase with increase in salt and sugar content.

Kim and Maga (1994) reported that extrusion temperature and type of flavour influenced extrudate expansion. Difference in expansion were attributed to interactions of flavour compounds with the starch during extrusion.

According to Areas (1992) addition of protein to high starch flours could change the behaviour of transformation into a protein type extrudate when less expansion occurs and the products are harder and more resistant to water dispersion.

Extrusion studies done by Singh *et al*. (2003), using rice flour and replacing parts of it with either khesari dhal or chick pea flour, revealed that the expansion ratio of the extruded snacks increased with increase in the proportion of pulse. The extrudates with khesari dhal had more expansion or puffing when compared to chick pea flour. The bulk density decreased with increase in pulse content but the decrease is more khesari dhal snacks. The water holding capacity decreased with increased with increase in pulse content.

Lower moisture content during extrusion resulted in significantly lower nitrogen solubility index perhaps due to denaturation of protein. Oil absorption capacity also increased slightly but not significantly with increasing moisture content (Gujska and Khan, 1991).

According to Bjorck *et al*. (1994) extrusion of wheat flour caused an apparent increase in dietary fibre due to the formation of amylase resistant starch fractions and extrusion cooking of white wheat flour was found to cause a redistribution of insoluble dietary fibre.

The fragmentation of starch and aligning of low molecular weight fragments at the die during extrusion was well documented by Rodis *et al*. (1993).

Addition of gelatin results in the reduction in the conversion of starch during extrusion as reported by Kaur *et al*. (2003).

A decrease in the consistency index of the cooked mass slurry of extruded products could be attributed to the increased gelatinization and solubilization of starch upon extrusion (Singh *et al*., 1998).

Protease inhibitors are inactivated in the extrusion cooking, which increases the digestibility of protein, although this is offset by loss of essential amino acids and cross linking, which occur on heating. Lysine reduction is least at high extrusion moisture, but is comparable with that occurring in baking process (Smith and Singh, 1996).

According to Liu and Maga (1993) the presence of fats in foods can place constraints on processing and storage conditions relative to the development of rancidity. Extrusion processing can also have these limitations.

Extrusion substantially reduces the intensity of most flavour components. A dewatering technique, steam distillation decrease the high moisture content of raw materials that are passed through an extruder. Due to high pressure and resulting temperature, extrusion promotes more acceptable flavours by the rapid expansion of the extruded product as it exits the die (Southard and Maga, 1993).

The list of extruded products includes textured plant proteins, breakfast cereals, confectionary products, snacks, macaroni and pasta products, as well as animal feeds and pet foods (Battacharya, 1989).

Shirataki noodles are traditional noodles of Japan which are prepared by extrusion of a paste made from the tubers of the perennial herb Amorphophallus Konjae is also known as devil’s tongue. These noodles are stable in boiling water and are often used in the popular Japanese dish Sukiyaki (Passmore, 1991).

Ishigaki *et al*. (1990) reported about the processing of extruded noodles. The process involves kneading a starting powder mixture and passing kneaded material through an extrusion molding machine to obtain instant noodles.

Siwawag (1990) has reported about the processing of vermicelli from sorghum and Soya.

Thirumaran and Seralathan (1989) conducted a study to incorporate whole and defatted soy flour at ten, twenty and thirty per cent levels for the manufacture of vermicelli. It was found that incorporation of defatted soy flour for the extrusion of vermicelli was feasible at 30 per cent level with increased nutritive value. The successful incorporation of soy flour in extruded products was also reported by Lunine *et al*. (1992).

Confectionary items are another important type of products of extrusion cooking process (Best, 1994). Sucrose and glucose may be processed at low water contents to make boiled sweets and strands, making optimal use of the die shapes and co-extrusion.

Crisp breads may be produced by extrusion and these are formed into sheets, then creased so that they may be broken cleanly after drying and toasting. This compares with a traditional baking process (Smith and Singh, 1996).

Chocolate may also be manufactured using a twin screw extruder, making use of volatile removal and addition of cocoa nibs at the full length and of other ingredients nearer the die. The process removes off flavours and provides sterilization followed by development of desirable flavours (Smith and Singh, 1996).

Expanded rice cakes of fine structure can be produced by extrusion cooking compared to the harder texture and loner processing ties typical of conventional hot air drying. Extrusion cooked rice flour has also been reported to improve the quality of idli, a traditional South Indian food (Singh *et al*., 1995).

Extrusion of chewing gums offers advantages of sustained release of flavour over traditional processes. The flavour is added early in the extrusion process to ensure adequate dispersion mixing with the base gum (Smith and Singh, 1996).

Petfoods production is a major product type of the extrusion cooking processes. They encompass hard dry varieties based on cereals, protein meals and fat to semi-moist types with added humectants. Co-extruded multi laired pieces and biscuits are refinements of the basic product (Rokey, 1994).

An application of extrusion cooking in the brewing industry to treat hops to facilitate the transformation of bittering precursors to bittering components was also tried by Westwood (1994).

2.4 ACCEPTABILITY STUDIES ON NEW FOODS

The sensory sciences are central to fundamental studies of food choice and acceptability. The chemical senses (taste, smell and sensory irritation) are often considered to be the gatekeepers' of the body, whose function is to detect things that would be bad for the body and that should be rejected, and to identify things that the body need for survival and that should therefore be consumed. Appearance is the primary cue of expectation and texture has practical concerns for palatability, preferences and plays a role in flavour release. Perception of sensory properties can be studied by determining relationships between food stimuli, provided by composition and structure and consumer's response (Delahunty, 2001).

According to Kalia and Sood (1996) quality is the ultimate criterion of the desirability of any food product. Among various factors which influence quality of products, sensory attributes may be considered as major factor and these are liable to change during storage.

Organoleptic quality *viz*., eating quality consists of judging quality of foods by means of human sensory organs, eye, nose and mouth.

Sensory evaluation is designed to reflect common preference, to maintain the quality of food at a given standard, for the assessment of process variation, cost reduction, product improvement, new market development and market analysis (Manay and Shadaksharaswamy, 2001).

According to Mc Dermott (1992), sensory method in which palatability is evaluated by a panel of judges is essential to every standardisation procedure because they answer all important questions of the food tastes, smells, looks and feels.

Watts *et al*. (1989) revealed that sensory analysis is a multidisciplinary science that uses human panelists and their senses to measure the sensory characteristics and acceptability of food products. It is appreciable to product development and quality control. A sensory panel must be treated as a scientific investment to produce reliable valid results.

The panel is the analytical tool in sensory evaluation. The value of this tool depends on the objectivity, precision and reproductability of the judgment of the panelists (Pal *et al*., 1995).

Larmond (1987) has stated that panel size should approach, 10 individuals to avoid excessive dependence on responses obtained from any single participant.

The important sensory parameters are appearance, colour, flavour and texture. Usually appearance and colour are more or less synonymous terms one complementing the other (Donnelly, 1991).

Parameters like aroma, odour and taste are very important quality characteristics, which have to be evaluated by sensory perception (Kawale, 1997).

The sensory perception of a food involves many events occurring both before, during and after consumption that depend both on specific aspects of consumer physiology and food composition (macro and micro composition and structure). During consumption, the food structure is broken down and flavour is released continuously until time of swallow. This time dynamic dimensions is an important aspects of perception and its understanding is vital for successful formulation of new products with new ingredients that must deliver an 'in tune' sensory perception (Delahunty, 2001).

According to Christensen (1987) as the consumer's preference to appearance is one of the major factor leading to the increasing demand of the product, it is very essential to keep the appearance of the product very attractive. The aesthetic, safety, sensory characteristics and acceptability of food are all affected by colour (CFTRI, 1990). Food colour is known to influence flavour. Delahunty (2001) has stated that flavour is an important factor which enriches the consumer preferences of a particular product.

Flavour is the sum of several sensations originating from the stimulation of taste receptors, olfactory receptors and nerve fibres registering touch and chemical feelings (Jan, 1990).

The popularity of pasta, can be attributed to its sensory appeal, versatility, low cost, ease of preparation, nutritional content and excellent storage stability as well as increased consumer interest in ethnic foods in the western world (Cole, 1991).

The quality of cooked starch noodles is determined by appearance and texture (eating quality) (Galvez and Resurreccion, 1992). Ranganna (2001) states that texture is the property of food which is associated with the sense of feel or touch experienced by the finger or the mouth. The textural characteristics of cooked noodles in Korea include cohesiveness, elasticity and hardness (Seibel, 1996).

In India, the specifications prescribed for wheat noodles are generally followed for noodles from other cereals and millets. Consumer prefers to buy pasta having yellow, translucent appearance (for wheat), nearly free of broken pieces and small, loose fragments. Uniformity of piece size and shape also seems to be regarded as indicator of quality. Texture of the cooked pasta is a very important factor in shaping the consumer's final evaluation of the product. Any off flavours or odours such as musty, sour or stale are highly negative factors, whereas blandness of the noodles is a plus factor. This is the reason why flavoured pasta have never been very popular (Matz, 1991).

In Italy, for the evaluation of cooked pasta, characteristics like stickiness (surface disintegration of the cooked product estimated by visual inspection with or without the aid of a standard reference pasta), firmness (resistance of the cooked pasta when chewed or flattened between fingers or sheared between the teeth) and bulkiness (degree of adhesion of pasta strands after cooking, evaluated visually and manually) are widely applied and accepted (Fabriani and Lintas, 1988).

Dahl and Villota (1991) conducted acceptability trials with ready to eat extruded foods developed from soybean and were found to be highly acceptable.

The influence of the addition of maize, extruded maize and soy flour and soy / maize flour blends on the chemical and sensory properties of pasta were evaluated by Ugarcic-Hardi *et al*. (2003). The pasta samples were produced by substituting 5, 10, 15, 20 and 25 per cent of the soft wheat flour with soy, maize, extruded maize flour and soy / maize flour blends. The pasta was dried by high temperature drying edges. The results showed that the highest quality pasta was made from wheat flour with the addition of 25 per cent maize and the pasta produced with the addition of 20 per cent extruded maize flour.

Lower acceptability due to brown colour in soy incorporated vermicelli was observed by Mathew (1997).

The quality of vermicelli, an extruded product from blends of ragi and wheat flour and weaning food based on ragi and greengram have been studied by Malleshi *et al*. (1996).

Ahluwalia *et al*. (1995) reported that three ready to eat snack foods *viz*., savoury sev, sweet sev and murukku were made substituting defatted soy flour for chick pea flour consumer acceptable studies showed high acceptability of three snacks.

Dhavan and Singh (1991) reported studies on sev preparation and organoleptic evaluation of the product made from blends containing bengalgram flour, defatted soy flour and rice flour in the preparation 75:10:15 and 70:15:15 were similar to control preparation in their overall acceptability whereas other products different significantly.

Blends of hard wheat flour and taro and/or chaya were prepared for the processing of noodles. Mixing properties and pasting characteristics of the blends were determined. Noodles were evaluated for cooked weight, cooking losses, colour, compressibility and sensory properties. As the per cent of taro in the blend increased, cooked weight and weight of noodles increased (Vinas *et al*., 1999).

Vetrimani and Rahim (1994) have evaluated the quality of some of the commercial brands of wheat noodles in Indian market and found that the products manufactured by organized sector (medium / large industry) had better overall quality, with low (< 10 per cent) solid loss during test cooking and better appearance, texture and flavour of coked noodles in comparison to those produced by the cottage/small scale sector.

Reddy *et al*. (1990) found out that four weaning mixtures formulated with local foods and traditional processing techniques were highly acceptable to children and their mothers, even after a storage period of one month.

Potato flour used in the preparation of mash, gulab jamun with milk and potato flour in ratios of 3:1 and 5:1 and parathas made with 40 per cent potato flour were more acceptable than those made with wheat flour alone (Kulkarni *et al*., 1996).

2.5 STORAGE STUDIES ON TUBER FLOUR AND PRODUCTS

Food shelf life is that, finite time that a product remains of satisfactory quality after manufacture or retail purchase. The shelf life of a food product depends on its chemical nature and the way it has been processed, packaged, distributed and stored. The 'freshness' or quality of food ultimately depends on existing distribution and marketing systems (Hurst and Reynolds, 1993).

According to Bhattacharjee and Bhole (1984) food packaging and storage is the vital step to ensure product quality because it provides protection against deterioration and damage during storage, transportation and distribution.

Moisture is one of the important parameters, which determines the shelf life quality of any food product. Most stored products are considered to be safe in storage at particular moisture content, low moisture is highly important for longer storage period (Shankar, 1993).

Moisture in inappropriate amounts and places is very damaging to the useful life of food. Because of this, much effort is put into reducing the water content of dry foods in order to prolong their shelf lives. Once it is reduced to the desired level the product can then be packaged for storage. Unfortunately, merely reducing moisture content is not always sufficient. Environmental conditions can play a role as well (Sagar and Roy, 1997).

Diffusion of gases and vapour through microscopic holes or by activated diffusion of polythene pouches will contribute to increased moisture content during storage (Palling, 1990).

Jayaprakasha *et al*. (1997) felt that stability of food products during storage is greatly influenced by its water activity.

Changes in the moisture content of dried food and frozen food can affect the nutritional quality of food. Increase in moisture content of dried food will promote microbial deterioration (molding) and accelerate rancidity of fats and fat soluble vitamins such as vitamin A (Hurst and Reynolds, 1993).

Pests (insects / rodents) cause deterioration and spoilage of food products by damaging the integrity of the food itself or the package surrounding the food. Insects do not destroy food by consuming large quantities of it, but once they damage the product, further deterioration results from microbial invasion. Storage insects such as weevils and beetles infest food products, including grains, flour, cereals, beans, peas, dried fruits, dates, spices and nuts. They deteriorate food by eating holes in the food or packaging material, leaving their feces and body parts in the food and producing off-odours in the food (Hurst and Reynolds, 1993).

The microbiological load in the packaged food has a significant effect on the quality of the final product. A high microbial load, and temperatures higher than recommended for a particular food can reduce the shelf life of a product by 50-70 per cent (Manja and Sankaran, 1994).

Bacteria, molds, yeasts and enzymatic breakdown are the main causes of deterioration in fresh foods. Various chemical and physical reactions caused by enzyme take place in processed food during storage. Usually, bacterial deterioration occurs well before chemical or physical changes can be noticed. The most important factor in maintaining quality and extending the shelf life of food is a consistent low refrigeration (32 to 35°F) temperature (Hurst and Reynolds, 1993).

CTCRI has reported that *Dioscorea alata* and *D. rotundata* could be conserved for more than five months without losing regenerative capacity with the addition of three per cent mannitol CTCRI, 1991).

Fresh tubers of dioscorea was cured by exposure to sunlight for three days after harvest. The tubers were stored for 150 days as thin layers on the floor of a well ventilated room at room temperature. Sprouting started after 60-90 days' storage. Crude protein, starch and vitamin C contents decreased significantly during the first 60 days of storage, but the decrease was gradual thereafter. The results suggest that, yam tubers should be used within 60 days of harvest (Ravindran and Wanasundera, 1993).

Taro can best be stored in cool, dry, well ventilated surroundings. The best temperature for prolonged storage is about 7°C, did not deteriorate in storage for ever 3.5 months. Storage at higher temperatures (eg. 15-23°C) is not satisfactory for long period, while storage at lower, non-freezing temperatures (e.g., 2°C) results in death of the buds and decay of the corms within two months. A relative humidity of 85 per cent has been recommended for taro storage (Onwueme and Charles, 1994).

Potatoes can be conveniently stored upto 15 weeks in the evaporatively cooled store and they can be used to produce flour of good quality as reported by Marwaha and Sandhu (2003).

Potato accumulate sugars during cold storage; sugar accumulation being five times more at 4°C that at 10°C. Small amounts (0.10 – 0.33 per cent) of reducing sugars impart desirable colour and taste to chips but larger quantities cause browning and impart bitter taste (Parkin and Schwobe, 1990).

Flours prepared from different varieties of potato stored at high temperature were sealed in the polythene bags and stored at ambient temperature and at -18°C. The flour was found to be organoleptically acceptable upto six months of storage at ambient temperature, while the quality remained unchanged for more than one year at –18°C. Addition of five per cent groundnut oil to the potato flour resulted in no improvement in its storage stability at ambient temperature (Marawaha and Sandhu, 2003).

Storage studies of potato flour, revealed that potato flour can be stored safely in polyethylene bags for six months at room temperature and for nine months at low temperature. However, gain in moisture occurred in potato flour with increase in storage time (from 3-12 months storage) (Sagar and Roy, 1997).

Vaidehi and Sunanda (1982) reported that potato flour could be safely stored in polyethylene pouches for six months without any fungal or insect infestation and also there occurred no changes in colour, odour and flavour.

Dried chips of potato retained their light yellow colour and crisp texture during storage at RH ≤ 32.90 per cent. Storage under higher relative humidity caused softness and fading of colour / browning (Joshi and Nath, 2002).

Dried chips and fried chips had moisture content of 3.5 per cent and three per cent on dry weight basis, which corresponded to water activity of 0.10 and 0.09, respectively. Further, it was found that any increase in moisture content of two samples beyond 7.6 per cent and 6.0 per cent (d.b.) during storage caused rapid deterioration in their quality (Joshi and Nath, 2002).

High humidity will cause rancidity development in fried snack foods as a result of enzymatic action. Dried foods such as grains, breakfast cereals and dehydrated milk require a low humidity (50 to 60 %) to prevent rancidity development, molding and excessive caking or lumping (Hurst and Reynolds, 1993).

Studies on shelf life of snack products made from bajra were conducted by Seth and Rathore (1993). The products were stored in five different types of containers, *viz*., glass, tin, plastic and polyethylene bags of 200 and 400 guage. No significant change could be found in chemical attributes.

Vasin *et al*. (1990) studied keeping quality of pasta products with added protein starch improver. The products were considered suitable for use in soups or as a part of ready to serve meals, which may be stored for 10 months without quality changes.

Low density polyethylene bags are often used for packaging pasta products. These offer the same protection but do not have the clarity of cellophane. They also have the disadvantage of being difficult to stack on supermarket shelves. Many U.S. pasta manufactures prefer to package their products in cardboard boxes since they are easy to stack, provide food physical protection for the product and advertising is easier to print and read on boxes than plastic container (Donnelly, 1991).

Chellammal (1995) had reported that extruded products such as noodles and macaroni processed from cassava and sweet potato had good organoleptic and shelf-life qualities.

Sowbhagya *et al*. (2000) prepared maize vermicelli noodles with and without antioxidant and packaged in cost polypropylene and a laminate of metallised polyester with low density polyethylene. The packs were stored at 38°C, 92 per cent RH (accelerated storage) and 27°C, 65 per cent RH (normal storage) for 100 to 140 days. Solid loss of the product upon cooking decreased from 12.4 to 7.6 per cent at accelerated storage and to 9.6 per cent at normal storage condition. Firmness and elasticity of the cooked product, however, increased upon storage.

The organoleptic and shelf life quality of vermicelli prepared from sweet potato was found to be good (Chellammal, 2002).

Use of modified atmosphere and vacuum packaging has greatly increased the availability of fresh and semi-fresh pasta with better shelf life as reported by Miskelly (1993).

Kalra *et al*. (1990) studied the preparation, packaging and storage of dehydrated taro snacks. physico-chemical and organoleptic changes on the products were investigated during the storage period of six months at room temperature (13-38°C RH 30-90 per cent). The products were found to be quite acceptable without any acrid effect upto six months and could be consumed after deep fat frying.

Materials and Methods

3. MATERIALS AND METHODS

The present investigation on formulating extruded foods based on dioscorea (*Dioscorea rotundata* Poir) and taro (*Colocasia esculenta* (L.) Schott.) comprises of:

3.1 Selection of tubers

3.2 Standardisation of flour

3.3 Quality assessment of flours

3.4 Formulation of extruded products

3.5 Quality assessment of products and

3.6 Standardisation of recipes

3.1 SELECTION OF TUBERS

Minor tubers selected for the study were dioscorea (*Dioscorea rotundata* Poir) and taro (*Colocasia esculenta* (L.) Schott.).

Dioscorea is more or less cylindrical in shape. The skin of the tuber is smooth and brown, while the flesh is usually white and firm. Starch grains in the tuber are large and ovoid (Onwueme and Charles, 1994).

Taro is one of the important minor tuber crops of the world from antiquity. It was valuable as low cost food calorie for people in the tropical world (Chadha, 1993). As compared to dioscorea, taro is small in size but nutritional and other qualities are almost similar.

Two varieties each of dioscorea and taro were selected for the study. **Sree Priya** and **Sree Dhanya** of dioscorea and **Sree Rashmi** and

Thamarakkannan of taro were selected because of their popularity and high yielding potentiality. These are represented in the text as,

D_1 – Sree Priya

D_2 – Sree Dhanya

T_1 – Sree Rashmi

T_2 – Thamarakkannan

3.2 STANDARDISATION OF FLOUR

Tuber flour has a longer shelf life when compared to fresh tuber. One of the most pressing problems associated with tuber cultivation is that of storage and handling. The problem associated with the bulkiness of the tuber can best be solved if more of the harvested tuber is processed into flour. Processed forms are less bulky and less delicate to handle and store and are less prone to storage losses than the fresh tuber (Onwueme and Charles, 1994).

For the processing of extruded products, primarily flour was prepared as presented in Fig. 1.

Flours from the different varieties of tubers were prepared separately and were stored in air tight containers.

3.3 QUALITY ASSESSMENT OF FLOURS

The flours prepared from the tubers were analysed for nutritional, chemical, functional and shelf-life qualities.

3.3.1 Nutritional and Chemical Qualities

The nutritional and chemical characters like protein, starch, crude fibre, total ash, moisture and acidity were analysed by standard techniques to assess the quality of tuber flours.

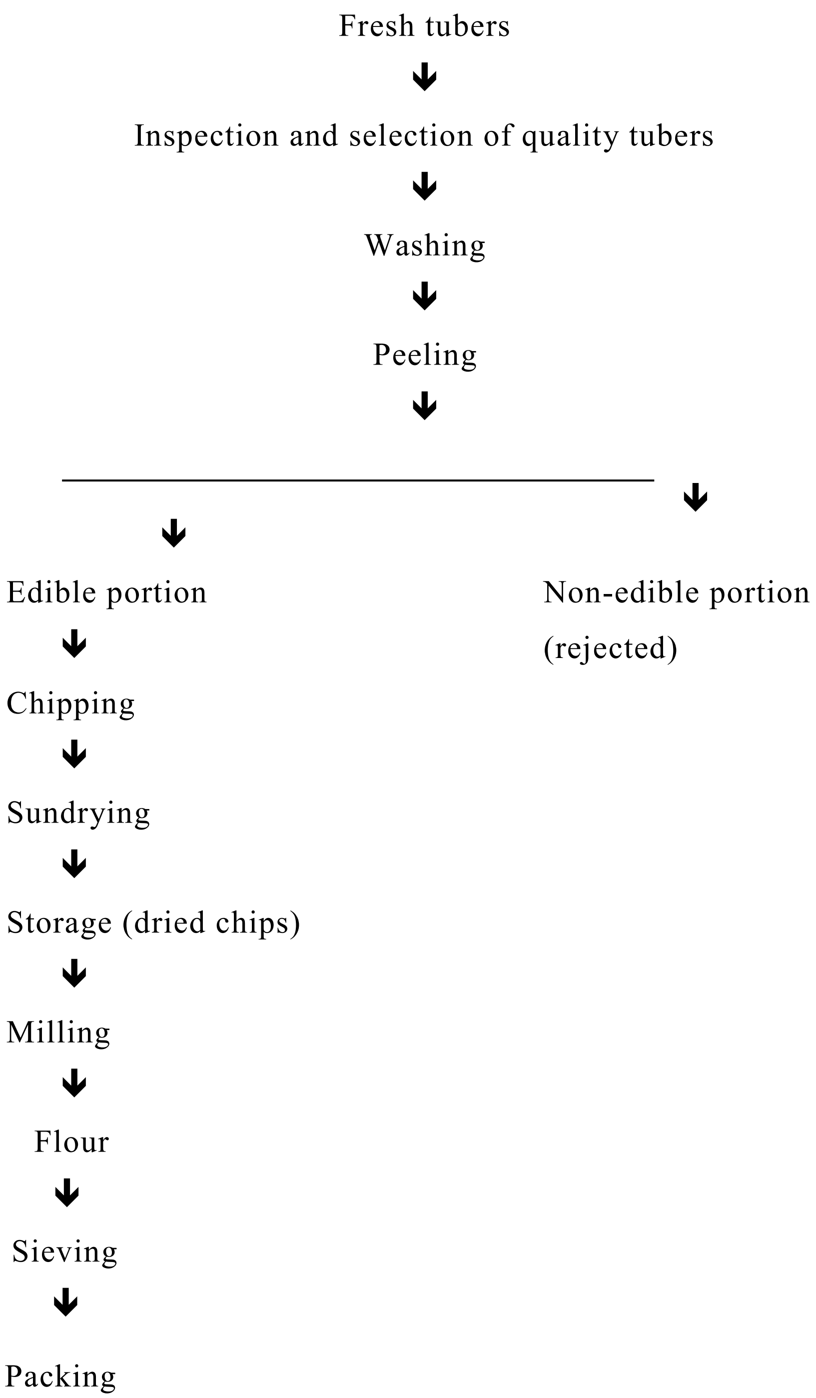
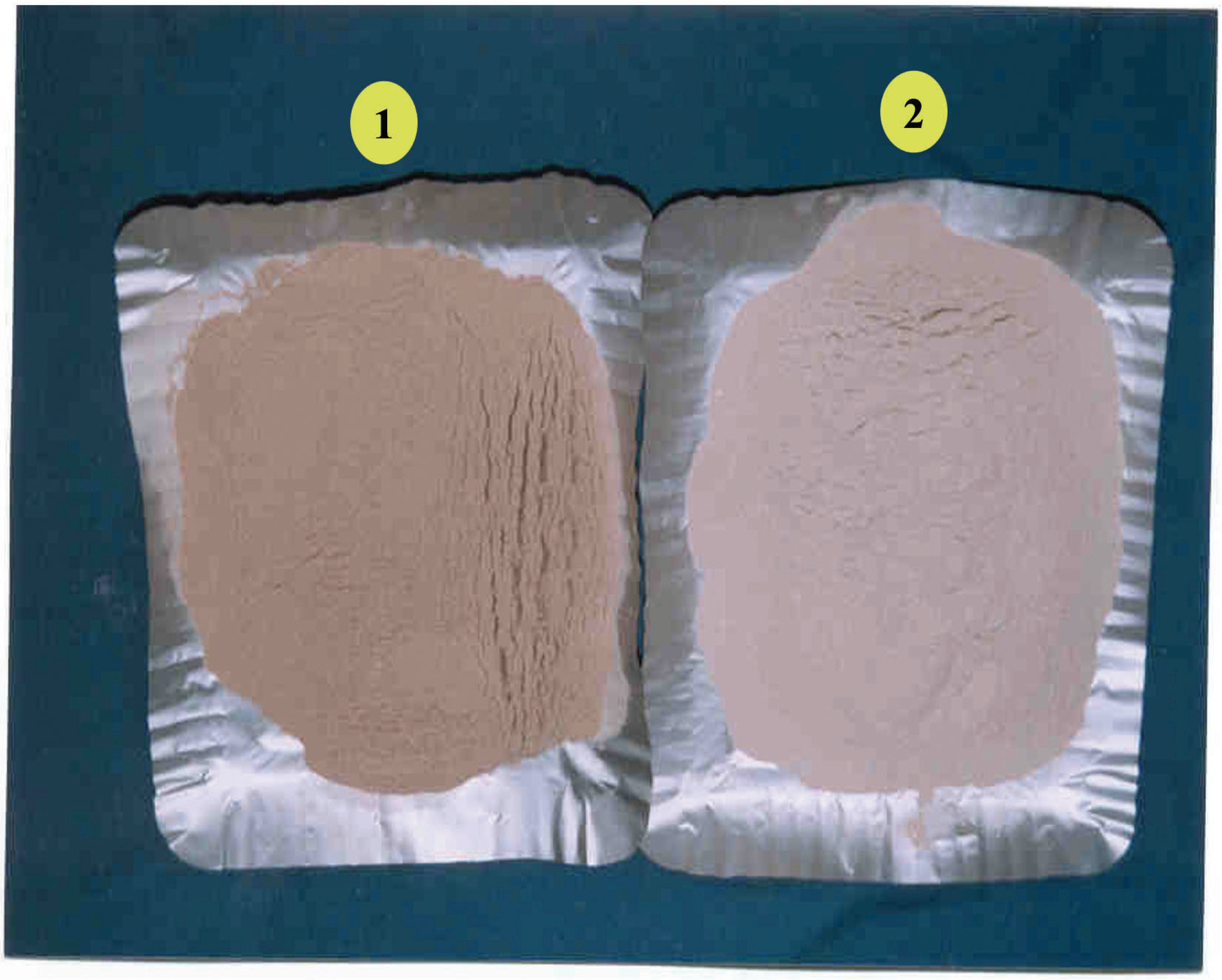


Fig. 1 Flow chart for the preparation of tuber flour



1. Dioscorea flour　　2. Taro flour

Plate 1. Dioscorea and taro flours

Table 1. Analysis of nutritional constituents of fresh tuber flour

Sl. No.	Nutritional constituents	References
1	Protein	Thimmaiah (1999)
2	Starch	AOAC (1984)
3	Crude fibre	Sadasivam and Manikam (1992)
4	Total ash	Ranganna (2001)
5	Moisture	Sadasivam and Manikam (1992)
6	Acidity	Thyagaraja *et al*. (1992)

3.3.2 Functional Qualities

Under functional qualities, yield ratio and processing loss were assessed.

Yield ratio of flour was analysed using the formula.

$$\text{Yield ratio} = \frac{\text{Weight of the tuber flour}}{\text{Weight of the raw tuber after peeling and before drying}}$$

Processing loss

Processing loss was computed using the formula

$$\text{Processing loss} = \frac{\text{AP weight} - \text{EP weight}}{\text{AP weight}}$$

where,

AP weight - Weight as purchased

EP weight - edible portion weight

3.3.3 Shelf Life Qualities of Flour

The flour prepared from each tuber was stored in polyethylene terephthalate (PET) containers and polypropylene covers for a period of three months. Since chemical and sensory qualities are influenced by storage period and container (Thakur *et al*., 1995) these containers were selected. The shelf-life qualities were assessed with respect to change in moisture, acidity, insect infestation and microbial count.

3.3.3.1 Assessment of Moisture in Stored Flour

Moisture content of the flour stored at different containers were analysed at monthly intervals (Sadasivam and Manikam, 1992).

3.3.3.2 Assessment of Acidity in Stored Flour

Acidity of the stored flours were analysed at monthly intervals (Thyagaraja *et al*., 1992).

3.3.3.3 Insect Infestation

Insects are responsible for the quality deterioration of flour and product by spoilage and contamination with their droppings and hair. During the storage period insect infestation was observed at monthly intervals.

3.3.3.4 Microbial Growth

Microbial evaluation was done by serial dilution method (Johnson and Curl, 1972). Microbial evaluation was done in fresh flour as well as in stored flour.

3.4 FORMULATION OF EXTRUDED PRODUCTS

3.4.1 Different Combinations Tried for the Development of the Extruded Products

A whole range of products with different textures, forms and densities can be developed through extrusion. The utilization of extrusion technique has grown at a rapid pace throughout the food industry. Extrusion appears to have great promise in less developed nations whereas ready supply of nutritious low cost preserved food is an urgent necessity to solve the existing food problem (Vaidehi and Rao, 1992).

The major food ingredients selected for the development of extruded products were taro and dioscorea flour. The method used for preparation of tuber flour was presented in Fig. 1. Maida, rice flour and soya flour were tried along with dioscorea and taro flour in different combinations for the development of extruded products, sev and vermicelli. Maida is a refined wheat flour contain gluten protein, which act as binders and provides strength. Such quality is essential for an ingredient selected for formulating extruded products. Maida gives greater volume and it is bland in taste and is easily digestible. Moreover maida has good binding capacity.

Fifteen kilogram maida was purchased in bulk from the supermarket. Maida was sundried for six hours to improve the shelf-life quality and then sieved twice in a sieve of 100 B.S. mesh to remove the impurities and their flour was stored in air-tight containers.

Rice is a good source of carbohydrate and also it is the most familiar food item of Kerala. Rice flour is an important ingredient for many ready-to-eat breakfast cereals and snacks (Janes and Guy, 1995).

Five kilogram of good quality raw rice was purchased and flour was prepared as shown in Fig 2.

Soybean is one of the cheapest source of protein available today. Addition of defatted soy flour will give a product with increased protein content. Soy fortified noodles not only increases the noodles strength but also increases the product yield with out any effect on colour and taste (Itapu, 2003).

Raw rice

↓

Winnowing

↓

Washing in water

↓

Draining

↓

Sun drying (for 2 days)

↓

Milling

↓

Sieving (twice)

↓

Packing

Fig. 2 Flow chart for the preparation of rice flour

Defatted soya flour has additional advantage of being comparatively less expensive than other pulses. 10 kg of defatted soya flour was purchased in bulk from Shakthi Soyas, Pollachi, Tamil Nadu.

Different proportions of maida, tuber flour, rice flour and soya flour were tried for the development of the product (Table 2).

Table 2. Combinations tried for the development of the products

Combination	Proportion
M : T : R	60: 30: 10
M : T : S	60: 30: 10
M : T : S	50: 40: 10
M : T : R	50: 40: 10

M – Maida, R – Rice flour, S – Soya flour, T – Tuber flour (D_1, D_2, T_1, T_2)

3.4.2 Selection of Best Combination for the Development of the Extruded Products

Sixteen combinations were tried for the development of the products. The principle governing the selection of suitable combinations were yield ratio, nutritional quality, extrusion behaviours, cost and acceptability.

3.4.2.1 Yield Ratio

Yield ratio of developed product were analysed using the formula.

$$\text{Yield ratio} = \frac{\text{Final weight of the product}}{\text{Weight of the raw ingredient}}$$

3.4.2.2 Nutritional Quality

Protein content of the different combinations was analysed (Thimmaiah, 1999). The energy value of the developed products was computed based on the amount of energy present in the ingredients and the protein energy ratio of the product was also computed (Swaminathan, 1984). The protein energy ratio was calculated using formula

$$\text{Protein energy ratio} = \frac{\text{Protein content in food } \times 4}{\text{Energy value of food}} \times 100$$

3.4.2.3 Chemical Score

Chemical score provides an useful estimate of the protein quality of blended foods and this is an acceptable substitute for the biological assay. Chemical score of different combinations were worked out from the ratio between the content of the most limiting amino acid in the test protein to the content of the same amino acid in the egg protein (Kalyanasundaram, 1998). The ratio is expressed as percentage.

$$\text{Chemical score} = \frac{\text{Limiting amino acid content of the test protein}}{\text{Content of the same amino acid in egg}} \times 100$$

Details of the chemical score of the different combinations are given in Appendix – I.

3.4.2.4 Extrusion Behaviour

The extrusion behaviour of the developed product was ascertained through observation by the technical experts for the uniformity in flow of strands and external appearance during extrusion.

3.4.2.5 Cost

Cost of different combinations were computed as per the market price of the ingredients selected and cost involved in processing.

3.4.2.6 Overall Acceptability

The overall acceptability of the combinations were assessed through organoleptic evaluation. Organoleptic quality *viz.*, eating quality consists of judging quality of foods by means of human sensory organs, eye, nose and mouth. Sensory evaluation is designed to reflect common preference, to maintain the quality of food at a given standard, for the assessment of process variation, cost reduction, product improvement, new market development and market analysis (Manay and Shadaksharaswamy, 2001). Organoleptic qualities such as colour, flavour, taste, texture and appearance were assessed with a panel of selected judges (Watts *et al.*, 1989). The combination which got the highest score was selected for the formulation of the products.

3.4.3 Development of the Extruded Products

Sev and vermicelli were prepared by mixing tuber flour, soya flour and maida with selected combination. All the ingredients after mixing were sieved three times in order to get uniform mixture.

The quantity of water was adjusted to such a level so that a pliable dough was obtained. The dough was fed into an extruder to get the finished products. The products thus obtained was dried and packed in polypropylene covers. Fig. 3 and 4 shows the processing of sev and vermicelli.

3.5 QUALITY ASSESSMENT OF PRODUCTS

Developed products, sev and vermicelli were analysed for the following characteristics to assess their quality.

3.5.1 Physical Characteristics

Fineness, shape, uniformity of strands, tensile strength and packaging quality were analysed to assess the physical characteristics of extruded products. Shape of each product was observed. The uniformity of each strands developed by extrusion was also noted. Each of these characteristics were analysed by technical experts using standardised score card (Appendix II).

Ingredients

↓

Grinding

↓

Sieving

↓

Weighing

↓

Batch continuous mixing

↓

Feeding

↓

Pre-conditioning

↓

Extrusion cooking

↓

Sizing

↓

Drying

↓

Packing

Fig. 3 Flow chart for the processing of sev

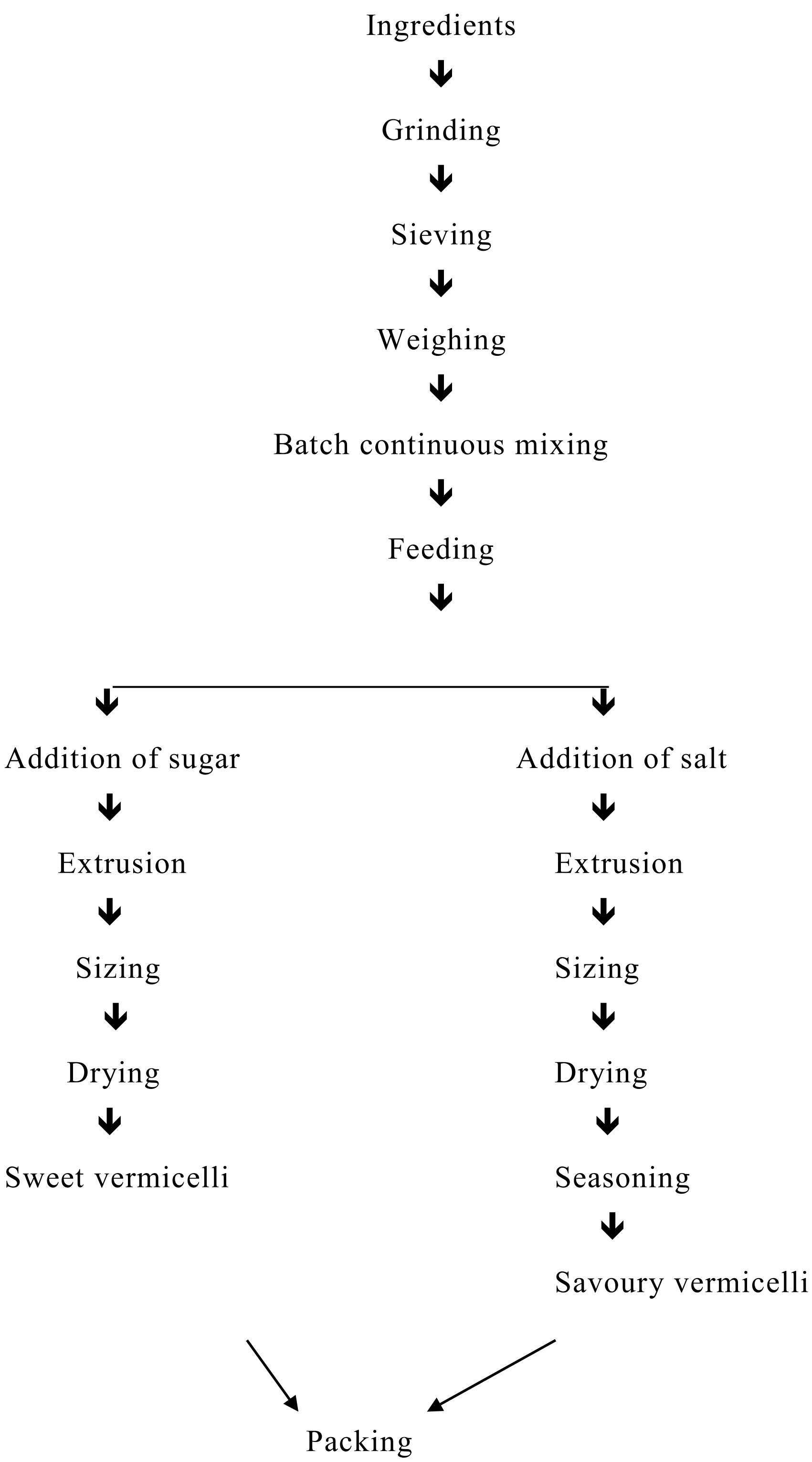


Fig. 4 Flow chart for the processing of vermicelli

1. M : D : R - 60 : 30 : 10
2. M : D : S - 60 : 30 : 10
3. M : D : S - 50 : 40 : 10
4. M : D : R - 50 : 40 : 10

Dioscorea based extruded products

1. M : T : S - 50 : 40 : 10
2. M : T : S - 60 : 30 : 10
3. M : T : R - 60 : 30 : 10
4. M : T : R - 50 : 40 : 10

Taro based extruded products

1. M : D : S - 50 : 40 : 10
2. M : T : S - 50 : 40 : 10

Dioscorea and taro based extruded products with selected combination

Plate 2. Dioscorea and taro based extruded products

3.5.2 Cooking Quality

The cooking quality of the product was ascertained through cooking time, water absorption index and bulk density.

3.5.2.1 Cooking Time

The cooking time of the products was assessed by cooking 25 g of sev/vermicelli with 100 ml of water. The product was cooked till done and the time taken was recorded. The end point was tested by pressing the cooked samples between two glass slides.

3.5.2.2 Water Absorption Index

Water absorption index is the quantity of water absorbed by a known quantity of food sample. This is mainly used to assess the rehydration capacity of the extruded product. 50 g raw sev/vermicelli was taken in a glass beaker. 100 ml of water was added to it. Water was drained after 10 minutes. The weight of hydrated sample was recorded. The water absorption index was calculated by weight of hydrated sample minus weight of raw sample (Bhattacharya and Hanna, 1984).

3.5.2.3 Bulk Density

Bulk density is the ratio of the weight of the sample to the weight of equal volume of water. Bulk density is used as an index for comparing the volume of different foods. The required quantity of sev/vermicelli sample was taken at a height of 20 cm in a 250 ml beaker until it is filled up. It was levelled without compressing. The weight of the sample with the beaker was recorded. The sample was then removed from the beaker and water was filled at the same level (20 cm). The weight of the water with beaker was recorded (Bhattacharya *et al.*, 1997).

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

3.5.3 Nutritional and Chemical Qualities

Under nutritional and chemical qualities protein, starch, crude fibre and total ash of the products were analysed as mentioned in 3.3.1. Mineral content of the product was also observed (Jackson, 1973).

3.5.4 Organoleptic Qualities

To determine the quality, sensory evaluation was done. According to Herrington (1991) sensory evaluation technology is a method using skilled management and trained panelists to provide confirmation on the acceptability of the product profile, consumer acceptability and consistency. The developed products were assessed for acceptability by technical experts using standardised score card (Appendix III).

3.5.5 Storage Stability and Shelf-life Qualities of the Products

The products formulated with selected combinations were stored in polypropylene covers for a period of three months and assessed for shelf life qualities. .

***3.5.5.1 Assessment of Moisture*:** Moisture content of the products was analysed at monthly intervals as mentioned in 3.3.1.

3.5.5.2 Assessment of Acidity: Acidity level of the product was assessed at monthly intervals as mentioned in 3.3.1.

***3.5.5.3 Insect Infestation* :** Insects are responsible for quality deterioration of the product. During the storage period insect infestation was observed at monthly intervals.

3.5.5.4 Microbial Growth : Microbial evaluation was done in the fresh sample as well as in stored products after three months of storage (Johnson and Curl, 1972).

3.5.6 I.S.I. Type Test

The Bureau of Indian Standard has developed certain type tests for various products to maintain quality during processing and marketing.

Estimation of moisture, total ash, protein and total solids in gruel are the major type tests administered to sev and vermicelli. These tests were carried out using standard techniques (IS 9487, 1980).

3.6 STANDARDISATION OF RECIPES

According to Tolule (1984) the procedure for recipe standardisation begin with the process of recipe modification or adjustment.

As a first step for the standardisation of the recipes, recipe sources such as cookery books, magazines were referred. Fifteen recipes based on sev or vermicelli were formulated and standardised in the laboratory. Details of the recipes are given in Appendix V.

3.6.1 Preference Studies on Developed Recipes

Preference study was done using scorecard. Scorecard for preference test is given in Appendix IV.

According to Swaminathan (1984) for preference test a large number of persons are required. Their evaluation should come spontaneously based on their judgment.

Preference test was conducted among technical experts, college students, working women and farmwomen. The hedonic rating test is used to measure the consumer acceptability of food products. A scale from nine to one was used, ranging from 'like extremely' to 'dislike extremely'.

Technical people are normally familiar with the qualities of different types of food. They are capable, with few preliminary test runs, of following instructions for tests given, discriminating differences and communicating their reactions (Srilekshmi, 2003). Such panel of 10 were used to find the acceptability or preference of the developed recipes. The developed recipes

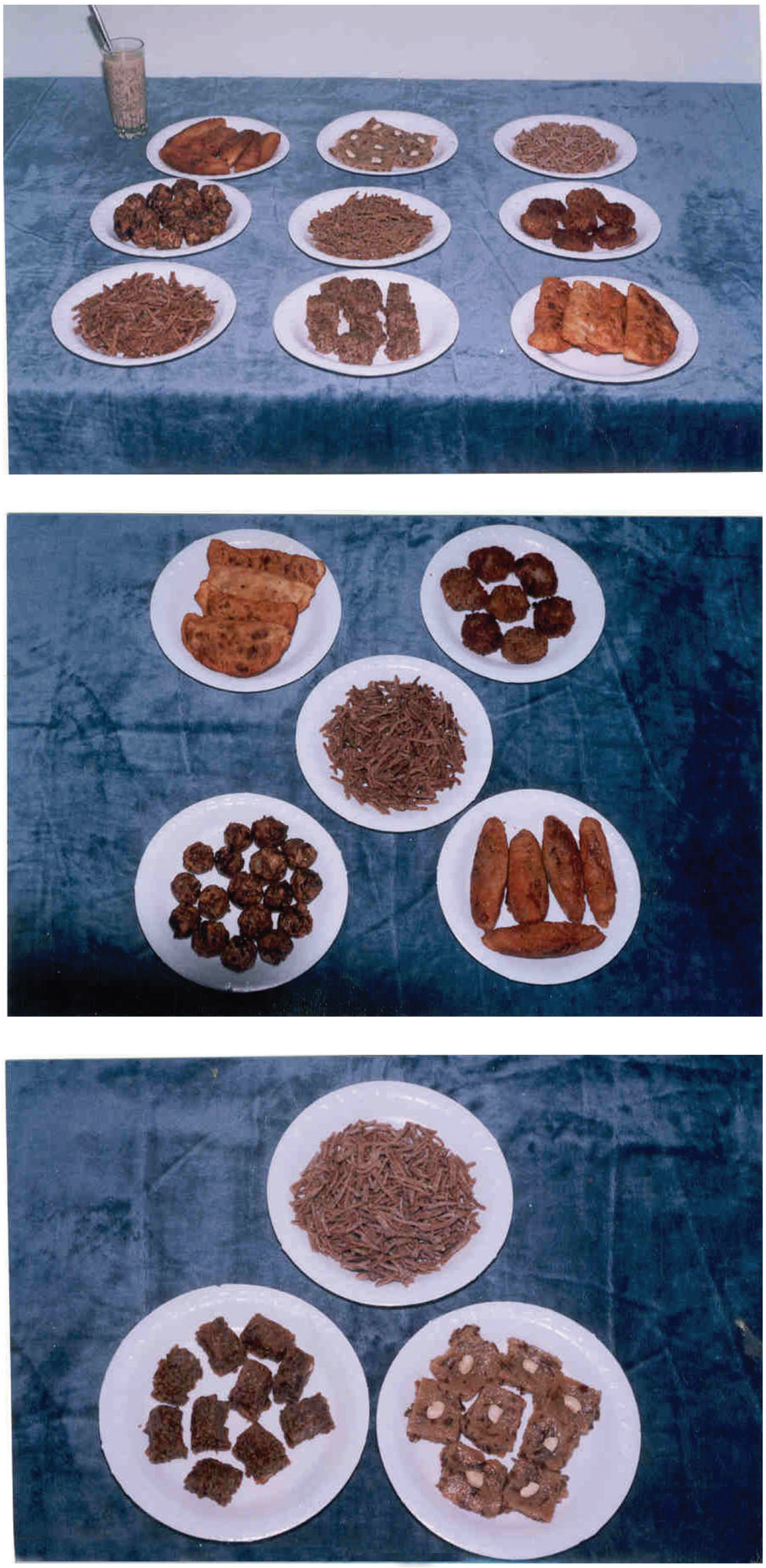


Plate 3. Recipes with dioscorea and taro based extruded products

were given to the technical experts and they marked their scores on the card and gave suggestions for the modification of the recipes.

The developed recipes were served to the college students, working women and farmwomen and they were requested to rank each recipe according to their preference. These panels are made up of untrained people chosen at random to represent a cross section of the population for which the product is intended. Their preferences were recorded by standardised scorecard.

Statistical Analysis

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

Results

4. RESULTS

The result of the study entitled 'Formulating extruded foods based on dioscorea (*Dioscorea rotundata* Poir) and taro (*Colocasia esculenta* (L.) Schott.) are presented under the following headings.

4.1 Selection of tubers

4.2 Standardisation of flour

4.3 Quality assessment of flour

4.4 Formulation of extruded products

4.5 Quality assessment of products and

4.6 Standardisation of recipes

4.1 SELECTION OF TUBERS

Minor tubers are low cost calorie dense foods which are suitable in the Indian situation to alleviate calorie malnutrition Minor tubers like Sree Priya and Sree Dhanya of dioscorea and Sree Rashmi and Thamarakkannan of taro were selected. The tubers were procured from Central Tuber Crops Research Institute, Sreekaryam and the Instructional Farm, College of Agriculture, Vellayani.

4.2 STANDARDISATION OF FLOUR

Usually in the preparation of vermicelli and sev, maida is used as a major ingredient. In the present study a major part of maida used for the development of extruded products was replaced with tuber flour. Hence tuber flour here processed from the four varieties of tubers (Fig. 1) and the quality of the flours were assessed.

4.3 QUALITY ASSESSMENT OF FLOUR

The flour prepared from the tubers were analysed for various characteristics like nutritional and chemical quality, functional quality and shelf-life qualities.

4.3.1 Nutritional and Chemical Qualities

The nutritional and chemical qualities such as protein, starch, crude fibre, total ash, moisture and acidity were analysed and results are presented in Table 3.

Table 3. Nutritional and chemical qualities of tuber flour

Sl. No.	Tuber flour	Protein (%)	Starch (%)	Crude fibre (%)	Total ash (%)	Moisture (%)	Acidity
1	D_1	2.56	20.96	1.83	1.07	11.40	0.38
2	D_2	2.47	20.28	1.67	1.00	11.46	0.38
3	T_1	2.35	15.10	1.08	1.13	9.46	0.25
4	T_2	2.49	15.73	1.67	1.27	9.40	0.25
	CD (0.05)	0.1612	0.860	0.756	0.266	0.1435	0.06

D_1 – Sree Priya, D_2 – Sree Dhanya, T_1 – Sree Rashmi, T_2 – Thamarakkannan

Protein content was found to be high in D_1 (2.56 per cent) and low in T_1 (2.35 per cent). In the case of dioscorea flour, D_1 (Sree Priya) was observed to have higher value for protein (2.56 per cent) than D_2 (Sree Dhanya) (2.47 per cent) whereas in taro, T_2 (Thamarakkannan) obtained higher value of 2.49 per cent than T_1 (Sree Rashmi) (2.35 per cent). Significant difference in protein content could be observed between tubers at five per cent level. Though there was slight difference in the protein content between varieties, it was not statistically significant.

Starch content of flours ranged from 15.10 per cent to 20.96 per cent. Data revealed that D_1 had a high starch content of 20.96 per cent and T_1 had the lowest value of 15.10 per cent. Between varieties D_1 had been highest starch content of 20.96 per cent whereas D_2 had only 20.28 percent. However, the difference was not statistically significant. In the case of taro, T_2 had a starch content (15.73 per cent) followed by T_1 (15.10 per cent). No significant difference could be observed between the taro varieties. Like protein starch content of dioscorea was significantly higher than that of taro.

Crude fibre content was higher in D_1 (1.83 per cent) and lower T_1 (1.08 per cent). When considering the varieties, D_1 had the higher fibre value of 1.83 per cent followed by D_2 (1.67 per cent). In taro, T_2 had fibre content of 1.67 per cent and that of T_1 was 1.08 per cent. There was no significant difference between tubers as well as varieties as far as crude fibre was concerned.

Total ash content was found to be higher in T_2 (1.27 per cent) and lower in D_2 (1.0 per cent). While comparing varieties, D_1 had higher value for ash (1.07 per cent) than D_2 (1.0 per cent). In taro, T_2 had the value of 1.27 per cent whereas ash content of T_1 was found to be 1.13 per cent. Like crude fibre content there was no significant difference in the ash content between tubers as well as between varieties.

Moisture analysis of flours revealed that it varied from 9.40 to 11.46 per cent. D_2 had the higher value for moisture (11.46 per cent) and T_2 had the lowest value of 9.40 per cent. In dioscorea, D_2 had higher moisture value (11.46 per cent) than D_1 (11.40 per cent). In taro T_1 obtained higher value of 9.46 per cent than T_2 (9.4 per cent). Moisture content of dioscorea flour was significantly higher than that of taro flour, but between varieties the moisture content was on par.

The acidity was higher (0.38) in dioscorea than taro (0.25). D_1 and D_2 had identical value for acidity (0.38) and T_1 and T_2 also had same value (0.25). Between tubers there was significant difference in acidity.

In dioscorea, Sree Priya (D_1) was found to be superior in protein, starch, crude fibre and total ash content than Sree Dhanya (D_2). In the case of taro, Tamarakkannan (T_2) was found to be superior in the above characters when compared to Sree Rashmi (T_1).

4.3.2 Functional Qualities

Yield ratio and processing loss were analysed for assessing the functional qualities of flour. The result of the study is presented in Table 4.

Table 4. Functional qualities of flour

Sl. No.	Tuber flour	Yield ratio (kg : g)	Processing loss (kg : g)
1	D_1	1: 0.670	1 : 0.330
2	D_2	1 : 0.630	1 : 0.370
3	T_1	1 : 0.710	1 : 0.290
4	T_2	1 : 0.730	1: 0.270
	CD (0.05)	0.0104	0.250

The yield ratio will give an estimate the amount of flour obtained from a known quality of fresh tuber after the removal of skin and other unedible portion. Analysis of yield ratio (Table 4) revealed that T_2 had the highest value of 0.730 per kilogram of tuber and D_2 had the lowest value of 0.630. Comparing two varieties of dioscorea, D_1 had the highest value of 0.670 whereas in case of D_2, it was found to be 0.630. But no significant difference between the two varieties of dioscorea. In the case of taro, T_1 had the lowest value of 0.710 and T_2 obtained highest value of 0.730. Here also there was no significant difference between the varieties.

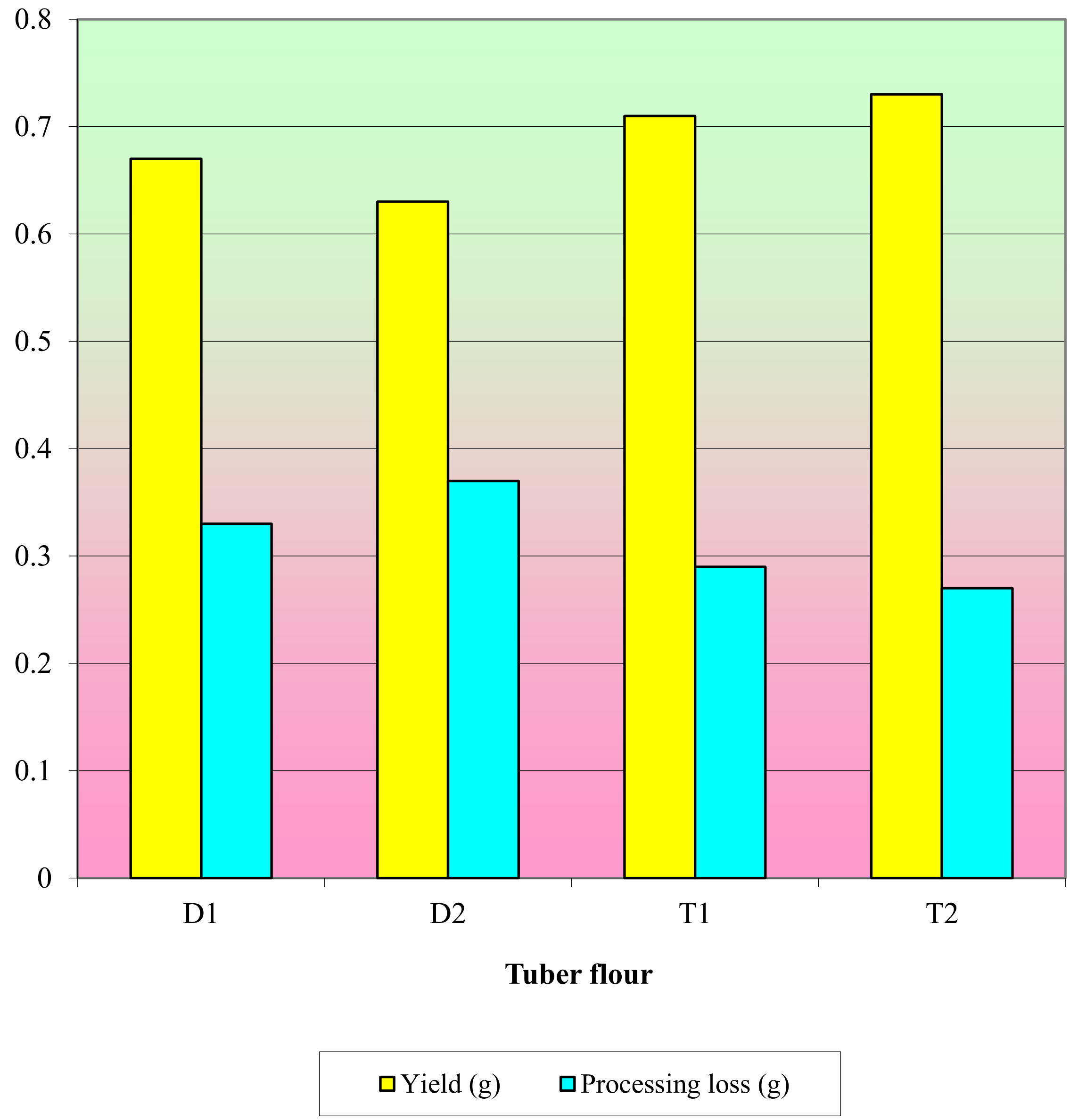


Fig. 5 Functional qualities of tuber flour

Yield ratio of taro was found to be significantly higher than that of dioscorea.

Processing loss was found to be higher in D_2 flour (0.370) and lower in T_2 flour (0.270). While comparing two varieties of dioscorea, D_2 had the high value of 0.370 whereas, in case of D_1 it was found to be 0.330. No significant difference was observed between the varieties. Processing loss of dioscorea was significantly higher than that of taro.

4.3.3 Shelf-life Qualities of Flour

Shelf-life of flour or product mainly depends upon the changes in moisture content, acidity, insect infestation and microbial quality.

4.3.3.1 Assessment of Moisture in Stored Flour

Moisture content of four flour stored in two different containers was analysed at monthly intervals upto three months (Table 5).

Table 5. Change in the moisture content of tuber flour

Tuber flour	Storage period								Increase (%)	
	Initial		1st month		2nd month		3rd month			
	PET	Poly-propylene cover	PET	Poly-propylene cover	PET	Poly-propylene cover	PET	Poly-propylene cover	PET	Poly-propylene cover
D_1	11.40	11.4	11.53	11.70	11.77	11.90	11.93	12.13	0.53	0.73
D_2	11.46	11.46	11.70	11.93	11.93	12.17	12.13	12.37	0.67	0.91
T_1	9.46	9.46	10.00	10.20	10.20	10.40	10.50	10.67	1.04	1.21
T_2	9.40	9.40	9.63	9.87	10.00	10.13	10.23	10.37	0.83	0.97
CD (0.05)	0.1435		0.22		0.82		0.75			

The initial moisture level of tuber flours were found to be 11.4, 11.46, 9.46 and 9.40 per cent for D_1, D_2, T_1 and T_2 respectively. After three months of storage, the highest moisture level of 12.37 per cent for D_2 and lowest value of 10.23 per cent for T_2 variety were observed.

Moisture analysis in stored flour showed that dioscorea varieties had higher moisture level than taro varieties. PET containers exhibited moisture increase of 0.53 per cent for D_1, 0.67 per cent for D_2, 1.04 per cent for T_1 and 0.83 per cent for T_2 flour respectively.

The samples kept in polypropylene covers exhibited moisture increase of 0.73 per cent, 0.91 per cent, 1.21 per cent and 0.97 per cent for D_1, D_2, T_1 and T_2 respectively.

Samples stored in PET containers exhibited comparatively low values than those in polypropylene covers. While comparing varieties, increase in moisture content was found to be higher in D_2 than D_1 whereas in taro, it was found to be higher in T_1 than T_2. The data revealed that D_1 (Sree Priya) and T_2 (Thamarakkannan) flour had better shelf stability than D_2 and T_1. The percentage increase of moisture was less in taro than in dioscorea.

Analysis of data further revealed that significant difference in the moisture level increase among tuber flours was observed in third month of storage. Here, significant difference was present between moisture value of same variety of tuber flour, when comparing each months of storage period of these flours. In first month, D_2 and T_2 flour stored in PET and polypropylene covers had significant difference but D_1 and T_1 had no difference in between PET and polypropylene cover. In second and third months of storage there was no significant difference between moisture level of flours stored in PET and polypropylene covers.

4.3.3.2 Assessment of Acidity in Stored Flour

The stored flours were analysed once in three months for any change in acidity. It was observed that there was no change in the acidity irrespective of the containers and storage period. Acidity level in dioscorea flour was found to be 0.38 while that of taro was 0.25.

Statistical analysis of flour revealed that there was no significant difference between Sree Priya and Sree Dhanya and also between Sree Rashmi and Thamarakkannan and containers. But significant difference between dioscorea and taro flour was present (CD = 0.06).

4.3.3.3 Assessment of Insect Infestation in Stored Flour

Insect infestation in stored flours was assessed through observation periodically. It was observed that there was no insect infestation in the stored flour irrespective of type and varieties during the storage period.

4.3.3.4 Assessment of Microbial Quality of Tuber Flour

Microbial analysis was carried out for the presence of bacteria, yeast and fungi colonies. Nutrient agar for bacteria, yeast extract for yeast and peptone dextrose agar for fungi were used as media for the estimation of microbial quality of flour. The details are presented in Table 6.

Table 6. Microbial profile of stored flour

Flour in containers	Fungal colonies		Yeast colonies		Bacterial colonies	
	PET	Polypropylene cover	PET	Polypropylene cover	PET	Polypropylene cover
D_1	0	0	0	4	0	1
D_2	0	1	0	6	0	2
T_1	1	2	4	7	0	1
T_2	0	2	1	3	0	1

The data revealed that there was no bacterial, yeast and fungal attack on fresh samples. All flours in PET container were free from bacteria while flours in covers had bacterial attack. In dioscorea, D_2 was found to be high in bacterial colonies than D_1, whereas no difference was observed between taro varieties irrespective of containers and varieties. Dioscorea was found to have more bacterial colonies than taro.

Dioscorea flour stored in PET containers were free from yeast, whereas these in polypropylene covers had yeast colonies was present. Number of yeast colonies were found to be more in D_2 than in D_1. In taro, flour kept in PET and polypropylene covers had yeast colonies. Flour kept in covers found to have more yeast colonies than in PET. Between varieties, T_1 contained more yeast colonies than T_2. Taro varieties recorded more yeast colonies than dioscorea varieties.

All flours kept in PET containers were free from fungal attack except T_1. while fungal colonies were observed in flour kept in polypropylene cover. In dioscorea, D_2 flour was attacked by fungus, whereas no fungi colonies were seen in D_1. In taro, there was no difference in fungal colonies irrespective of varieties.

Microbial evaluation showed that flours kept in PET containers were microbiologically safer than that in covers. Dioscorea samples were more shelf stable than taro. Between varieties, D_1 and T_2 were better than D_2 and T_1 flours.

Quality assessment of flours revealed that Sree Priya (D_1) and Thamarakkannan (T_2) were superior in all the quality parameters when compared to D_2 (Sree Dhanya) and T_1 (Sree Rashmi).

4.4 FORMULATION OF EXTRUDED PRODUCTS

4.4.1 Different Combinations Tried for the Development of the Product

The raw ingredients selected for any food product play an important role in determining the quality of the product. Mixing the ingredients selected in different combinations will decide the nutritional quality and extrusion behaviour. Maida and tuber flour were the basic materials used for the development of sev and vermicelli. Rice flour and defatted soy flour were tried with these ingredients in different proportions for the processing of sev and vermicelli. The different combinations attempted for the formulation of the products are presented in Table 7.

Table 7. Composition of food ingredients in different combinations

Sl. No.	Combination	Proportion
1	M : T : R	60: 30: 10
2	M : T : S	60: 30: 10
3	M : T : S	50: 40: 10
4	M : T : R	50: 40: 10

M – Maida, R – Rice flour, S – Soya flour, T – Tuber flour (D_1, D_2, T_1, T_2)

Sixty per cent of maida, 30 per cent of tuber flour (D_1/ D_2/ T_1/ T_2) and 10 per cent rice flour was used in the first combination. In the second combination rice flour was replaced with 10 per cent soya flour. Third combination had 50 per cent maida, 40 per cent tuber flour and 10 per cent soya flour and the fourth combination consisted of 50 per cent maida, 40 per cent tuber flour and 10 per cent rice flour.

4.4.2 Selection of Best Combination for the Development of the Extruded Product

The principles governing the selection of the suitable combination were yield ratio, nutritional quality, extrusion behaviour, cost and overall acceptability.

4.4.2.1 Yield Ratio

Yield ratio of the different combinations were analysed and the results are presented in Table 8.

Table 8. Yield ratio of different combinations

Combination tried		Yield ratio
60: 30 : 10 (C_1)	M : D_1 : R	0.81
	M : D_2 : R	0.73
	M : T_1 : R	0.40.
	M : T_2 : R	0.48
60: 30 : 10 (C_2)	M : D_1 : S	0.79
	M : D_2 : S	0.71
	M : T_1 : S	0.39
	M : T_2 : S	0.49
50: 40 : 10 (C_3)	M : D_1 : S	0.87
	M : D_2 : S	0.77
	M : T_1 : S	0.42
	M : T_2 : S	0.49
50: 40 : 10 (C_4)	M : D_1 : R	0.72
	M : D_2 : R	0.70
	M : T_1 : R	0.37
	M : T_2 : R	0.38
SE		0.017
CD (0.05)		0.049

The analysis of yield ratio of different combinations revealed that the third combination (C_3) having maida 50, tuber flour 40 and soya flour 10 per hundred gram of the mix had the highest value. Here, the product with D_1 had a yield ratio of 0.87 while for D_2 it was 0.77. In the third combination containing taro, T_2 obtained a high score of 0.49 while that of T_1 was 0.42. Among the combinations, fourth combination (C_4) with D_1, D_2, T_1 and T_2 had low value for yield ratio (0.72, 0.70, 0.37 and 0.38). Yield ratio of combinations with dioscorea flour obtained higher value than that with taro flour. In each combination, mixes with D_1 and T_2 recorded higher value than that with D_2 and T_1.

Statistical analysis of the data revealed that mixes made from D_1 and D_2 were significantly different in all combination. D_2 also showed the same trend. Whereas mixes with T_1 and T_2 had significant difference between third and fourth combinations. Between combinations with T_1 and T_2 a significant difference was found in the mixes of first, second and third combinations. Each combination of the D_1 and D_2 was found to be significantly different. Yield ratio of third combination was found to be superior to all other combinations

4.4.2.2 Nutritional Quality

Under this, protein content of the mixes were analysed and energy and protein energy ratio were computed.

Table 9. Protein content of different combinations

Combination tried		Protein (per cent)
60: 30 : 10 (C_1)	M : D_1 : R	15.28
	M : D_2 : R	14.82
	M : T_1 : R	15.17
	M : T_2 : R	15.40
60: 30 : 10 (C_2)	M : D_1 : S	16.92
	M : D_2 : S	16.45
	M : T_1 : S	16.01
	M : T_2 : S	16.48
50: 40 : 10 (C_3)	M : D_1 : S	23.80
	M : D_2 : S	23.22
	M : T_1 : S	21.93
	M : T_2 : S	22.40
50: 40 : 10 (C_4)	M : D_1 : R	17.62
	M : D_2 : R	17.15
	M : T_1 : R	17.03
	M : T_2 : R	17.50
SE		0.154
CD (0.05)		0.44

In general, the protein content was high in the third combination (C_3) which ranged from 21.93 to 23.80 percentage. In this, D_1 had higher value for protein (23.8 per cent) than D_2 (23.22 per cent). In the case of taro, T_2 had a value of 22.4 per cent while that of T_1 was found to be 21.93. When comparing all combinations, first combination had the lowest value for protein. The mixes with D_2 had very low value of 14.82 and that with T_2 had a higher value of 15.40 per cent than D_2. Combination with dioscorea flours obtained higher value than taro flour except in the second combination. In all combinations, mixes with D_1 and T_2 obtained higher value than that with D_2 and T_1.

Statistical analysis of data showed significant difference between combinations with same tuber flour. Between mixes with dioscorea, significant difference was observed in all combinations. T_1 in third combination was on par to T_2 in fourth combination whereas significant difference was present between T_1 and T_2 in other combinations. Protein content of third combination was significantly higher than that of other combinations.

Energy

Energy is essential for the normal growth and functioning of body. When the energy value of the combinations were computed it was found that energy value was found to be higher in second combination of dioscorea (287 kcal) and lower in fourth combination with taro (249 kcal) (Table 10). Combinations with dioscorea flours obtained higher value for energy than that with taro. Mixes with dioscorea obtained high value in C_2 (287 kcal) and low in C_4 (255 kcal). Combinations with taro also showed the same trend. Energy value was found to be higher for all mixes in second combination (C_2) when compared to other combinations.

Table 10. Computed energy and protein energy ratio of the extruded product

Combination tried		Energy (kcal)	Protein (%)	Protein : energy ratio
60: 30 : 10 (C_1)	M : D_1 : R	278	15.28	21.98
	M : D_2 : R	278	14.82	21.32
	M : T_1 : R	274	15.17	22.14
	M : T_2 : R	274	15.40	22.48
60: 30 : 10 (C_2)	M : D_1 : S	287	16.92	23.58
	M : D_2 : S	287	16.45	22.93
	M : T_1 : S	282	19.01	26.96
	M : T_2 : S	282	19.48	27.63
50: 40 : 10 (C_3)	M : D_1 : S	263	23.80	36.20
	M : D_2 : S	263	23.22	35.32
	M : T_1 : S	258	21.93	34.00
	M : T_2 : S	258	22.40	34.73
50: 40 : 10 (C_4)	M : D_1 : R	255	17.62	27.64
	M : D_2 : R	255	17.15	26.90
	M : T_1 : R	249	17.03	27.36
	M : T_2 : R	249	17.50	28.11

Protein Energy Ratio

When the ratio between protein and energy was computed (Table 10) higher values were obtained for the third combination with dioscorea and lower in first combination of dioscorea. Mixes with dioscorea also obtained high value in the third combination (36.20 for mixes with D_1 and 35.32 for that with D_2) and low in first combination (21.98 and 21.32 for product with D_1 and D_2). Combination with taro also obtained high value in third combination (34 and 34.73 for T_1 and T_2) and low in first combination (22.14 for mixes with T_1 and 22.48 for that with T_2). Protein energy ratio of the third combination was found to be higher than other combination.

4.4.2.3 Chemical Score

Chemical scores of different combinations were computed and are presented in Table 11. Since the amino acid content for the varieties of dioscorea and taro is not available, only chemicals for tried out for the combination of taro and dioscorea is computed.

Table 11. Chemical score of different combinations

Combination tried		Chemical score
60: 30 : 10 (C_1)	M : D : R	72.22
	M : T : R	85.56
60: 30 : 10 (C_2)	M : D : S	72.22
	M : T : S	85.56
50: 40 : 10 (C_3)	M : D : S	73.33
	M : T : S	91.10
50: 40 : 10 (C_4)	M : D : R	73.33
	M : T : R	91.10

Chemical scores of the combination with dioscorea were found to be higher in third and fourth combinations (73.33) and lower in first and second combinations (72.22). In the case of taro, also high value were obtained in C_3 and C_4 (91.10) and low in C_1 and C_2 (85.56). Combinations with taro had higher value for chemical score than those with dioscorea.

4.4.2.4 Extrusion Behaviour

The extrusion behaviour of the combinations was assessed by ten technical experts using a standardised pre-tested score card. Extrusion behaviour was observed by uniformity of strands and external appearance during extrusion.

The variation in extrusion behaviour of the combinations were statistically analysed and the results obtained are presented in Table 12.

Table 12. Extrusion behaviour of different combination

Combination tried		Extrusion behaviour (Score)
60: 30 : 10 (C_1)	M : D_1 : R	3.0
	M : D_2 : R	2.8
	M : T_1 : R	2.8
	M : T_2 : R	3.0
60: 30 : 10 (C_2)	M : D_1 : S	3.8
	M : D_2 : S	3.5
	M : T_1 : S	3.2
	M : T_2 : S	3.4
50: 40 : 10 (C_3)	M : D_1 : S	4.0
	M : D_2 : S	3.5
	M : T_1 : S	3.2
	M : T_2 : S	3.5
50: 40 : 10 (C_4)	M : D_1 : R	2.4
	M : D_2 : R	2.0
	M : T_1 : R	2.6
	M : T_2 : R	2.9
SE		0.232
CD (0.05)		0.643

Extrusion behaviour was found to be higher in third combination (C_3) and lower in fourth combination (C_4) (Table 12). Mixes with D_1 obtained high value in C_3 (4.0) and low in C_4 (2.40). Same trend was observed in combinations with D_2 also. In taro mixes with T_1 and T_2 also obtained high value in third combination (3.2 and 3.5 respectively) and low in fourth combination (2.6 and 2.90). Extrusion behaviour of second combination was found to be superior than that of C_1 and C_4. Combination with dioscorea obtained higher value than that with taro.

Mixes with D_1 were significantly different in all combinations. D_2 also showed the same trend, while mixes with T_1 and T_2 had no difference in between combinations. Between mixes with D_1 and D_2 and also between T_1 and T_2 were on par. Extrusion behaviour of third combination was found to be superior than other combinations.

4.4.2.5 Cost Analysis

The cost of each combination was computed according to the market price of the ingredients. The price of the ingredients were collected from the local markets and the actual price of the different ingredients used for 1 kg of the product were computed and are presented in Table 13.

Table 13. Cost analysis of combinations

Combination tried		Cost (Rs/kg)
60: 30 : 10 (C_1)	M : D_1 : R	18.70
	M : D_2 : R	18.00
	M : T_1 : R	18.80
	M : T_2 : R	19.50
60: 30 : 10 (C_2)	M : D_1 : S	17.10
	M : D_2 : S	17.40
	M : T_1 : S	18.30
	M : T_2 : S	18.90
50: 40 : 10 (C_3)	M : D_1 : S	16.65
	M : D_2 : S	17.05
	M : T_1 : S	18.25
	M : T_2 : S	19.10
50: 40 : 10 (C_4)	M : D_1 : R	17.25
	M : D_2 : R	17.65
	M : T_1 : R	18.85
	M : T_2 : R	19.65

Cost analysis of combinations revealed that combination in which taro flour was used had higher cost than dioscorea combinations. Fourth combination (C_4) with taro flour obtained highest cost (Rs. 18.85 and Rs. 19.65 for product with T_1 and T_2 respectively) and third combination (C_3) obtained the lowest cost (Rs. 18.25 for mixes with T_1 and Rs. 19.10 for that with T_2). Combination with dioscorea obtained lowest cost in third combination (Rs. 16.65 and Rs. 17.05 for D_1 and D_2) and highest cost in first combination (Rs. 18.70 for mixes with D_1 and Rs. 18.00 for that with D_2.

4.4.2.6 Overall Acceptability

Overall acceptability of extruded products were analysed on the basis of scores given for quality attributes like appearance, colour, flavour, texture and taste and the result are presented in Table 14. High score for overall acceptability was obtained in third combination (C_3). Dioscorea (3.98 and 3.88 for D_1 and D_2) and taro (3.68 for product with T_1 and 3.78 for T_2) had high score in third combination than other combinations. Overall acceptability was found to be low in C_4. Second combination (C_2) obtained higher scores than C_1 and C_4. All combinations with dioscorea flour obtained higher scores than that of taro except in C_4.

Table 14. Overall acceptability of different combinations of extruded product

Combination tried		Overall acceptability
60: 30 : 10 (C_1)	M : D_1 : R	3.46
	M : D_2 : R	3.36
	M : T_1 : R	3.28
	M : T_2 : R	3.34
60: 30 : 10 (C_2)	M : D_1 : S	3.58
	M : D_2 : S	3.46
	M : T_1 : S	3.44
	M : T_2 : S	3.58
50: 40 : 10 (C_3)	M : D_1 : S	3.98
	M : D_2 : S	3.88
	M : T_1 : S	3.68
	M : T_2 : S	3.78
50: 40 : 10 (C_4)	M : D_1 : R	3.16
	M : D_2 : R	3.00
	M : T_1 : R	3.20
	M : T_2 : R	3.32
SE		0.1454
CD (0.05)		0.4384

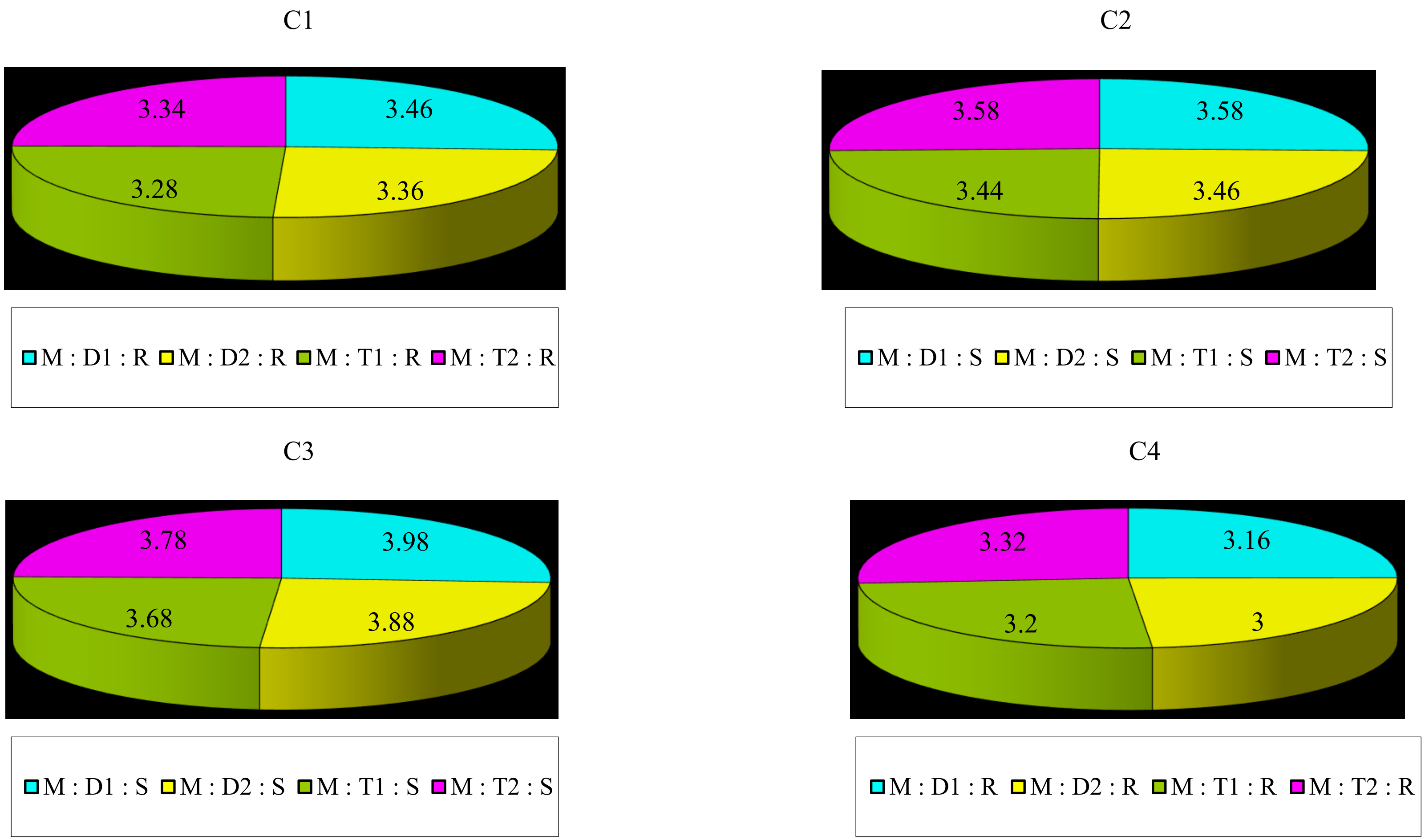


Fig. 6 Overall acceptability of different combinations of extruded food

Statistical analysis of data revealed that product with D_1 in C_3 had significant difference with C_1 and C_4. D_2 also showed the same trend. It could be observed that product with T_1 and T_2 had significant difference between C_3 and C_4.

4.4.3 Development of Extruded Products

When compared to all other combination, third combination was superior in all quality parameters like nutritional quality, extrusion behaviour, cost and overall acceptability. Hence, the third combination with maida 50 per cent, tuber flour 40 per cent and soya flour 10 per cent was selected for the formulation of extruded products, sev and vermicelli. 20 kg of sev and 20 kg of vermicelli were prepared with this combination.

4.5 QUALITY ASSESSMENT OF THE PRODUCTS

The quality of the developed products were ascertained with special reference to physical characteristics, organoleptic quality and storage stability. ISI type tests were also carried out.

4.5.1 Physical Characteristics of Extruded Products

The physical characteristics is an important criteria for product acceptance. The physical characteristics which may decide the acceptance of extruded products are fineness, shape, uniformity of strands, packaging quality and tensile strength.

The physical characteristics of the extruded products sev and vermicelli were assessed with a panel of ten technical experts, using a standardised score card. A scale from five to one was used, five representing the optimum for all the quality characteristics. The score obtained are presented in Table 15.

Table 15. Physical characteristics of extruded products

Products	Fineness	Shape	Uniformity of strands	Packaging quality	Tensile strength
Sev					
D_1	4.1	4.0	3.9	4.1	3.8
D_2	3.8	3.5	3.5	3.7	3.5
T_1	3.5	3.6	3.3	3.5	3.4
T_2	3.7	3.8	3.6	4.0	3.8
SE	0.217	0.201	0.223	0.207	0.224
CD (0.05)	0.625	0.576	0.640	0.595	0.643
Vermicelli					
D_1	4.0	4.1	3.8	3.6	3.5
D_2	3.7	3.7	3.6	3.4	3.3
T_1	3.4	3.7	3.4	3.2	3.2
T_2	3.7	3.8	3.5	3.4	3.6
SE	0.201	0.227	0.217	0.156	0.187
CD (0.05)	0.578	0.654	0.622	0.448	0.537

With respect to sev, T_1 secured lower scores for all quality parameters. The score for fineness of T_2 (3.70) was lower than for D_2 (3.80) and D_1 (4.10). D_1 obtained a higher score of 4.0 for shape followed by T_2 (3.80), T_1 (3.60) and D_2 (3.50). The score for uniformity of strands of D_1 (3.90) was also higher than that for D_2 (3.50). T_2 exhibited a higher score of 3.6 for uniformity of strands than T_1 (3.30). Packaging quality was found to be better for D_1 (4.10) followed by T_2 (4.0) and D_2 (3.70). Packaging quality of D_1 and T_2 were higher than that of D_2 and T_1. Regarding tensile strength, D_1 and T_2 obtained the highest score of 3.80. D_2 obtained a score of 3.50 for tensile strength and T_1 had a score of 3.40.

The data revealed that though there was difference in quality parameters, they were not statistically significant.

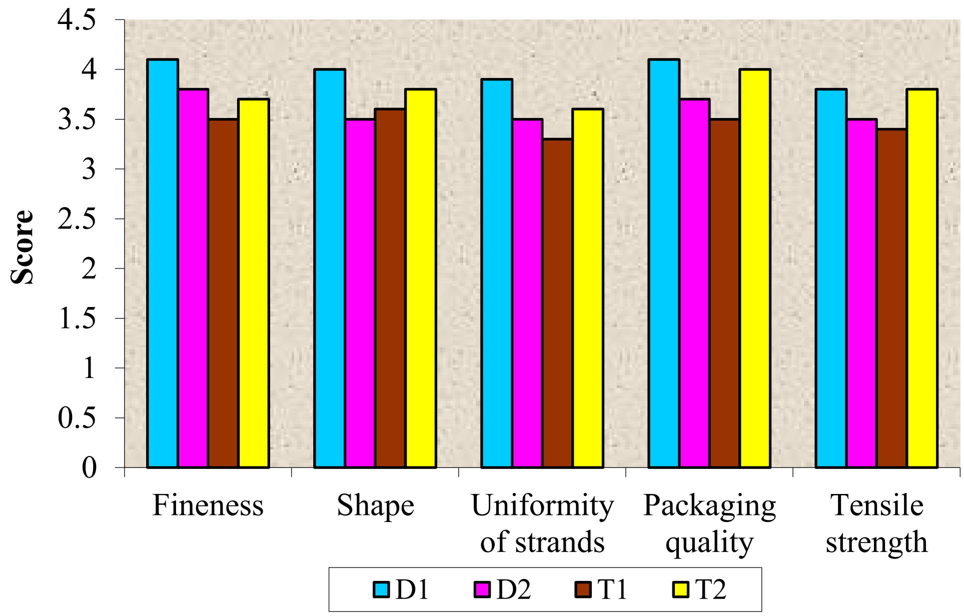


Fig. 7 Physical characteristics of extruded product - sev

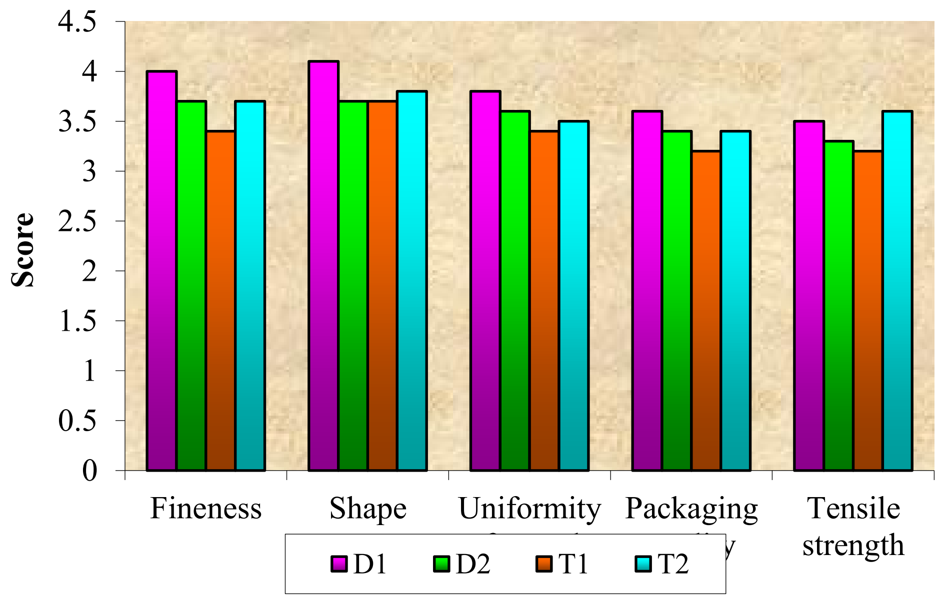


Fig. 8 Physical characteristics of extruded product - vermicelli

When the physical characteristics of vermicelli was analysed, the highest score for fineness was obtained by D_1 (4.0) followed by D_2 and T_2 (3.70) and T_1 (3.40). For shape, D_1 obtained the highest score of 4.10 whereas score of D_2 and T_1 was only 3.70. When the score for uniformity of strands was assessed, D_1 obtained a score of 3.80, which was higher than that of D_2, T_1 and T_2. Packaging quality was found to be better in D_1 (3.60) followed by D_2 and T_2 (3.20). For tensile strength, highest score was obtained by T_2 (3.60) followed by D_1 (3.50), D_2 (3.30) and then T_1 (3.20). Statistically the difference was not significant.

4.5.2 Cooking Quality of the Extruded Products

Time, labour and fuel saving factors of any food product play a decisive role in conditioning their popularity among consumers. Cooking quality of developed products was ascertained through cooking time, water absorption index and bulk density and data pertaining to these factors are presented in Table 16.

Table 16. Cooking characteristics of extruded products

Products	Cooking time (minute)	Water absorption index	Bulk density (g/100 ml)
Sev			
D_1	6.2	3.14	0.28
D_2	5.8	2.96	0.27
T_1	7.3	3.17	0.26
T_2	7.6	3.21	0.26
SE	0.132	0.1408	0.0152
CD (0.05)	0.408	0.406	0.0439
Vermicelli			
D_1	6.3	3.153	0.273
D_2	5.9	3.06	0.260
T_1	7.3	3.19	0.253
T_2	7.7	3.223	0.267
SE	0.046	0.123	0.005
CD (0.05)	0.1416	0.403	0.017

4.5.2.1 Cooking Time

Products which can be cooked using less energy will have a large potential (Nagarajan, 1993) and hence cooking time of the developed products were determined. Analysis of cooking time of sev showed that product with T_2 took more time for cooking (7.60 minutes) while D_2 took less time (5.80 minutes). The cooking time for D_1 was 6.20 minutes and that of D_2 was 5.80 minutes. In taro based products cooking was more (7.60) for T_2 than T_1 (7.3 minutes). No significant difference was found between cooking time of products with dioscorea varieties and products with taro also had no significant difference, while significant difference in cooking time between dioscorea and taro sev.

Cooking time of vermicelli was analysed and results showed that the product with D_2 took less time for cooking (5.90 minutes) whereas T_2 took more time (7.70 minutes). Products with taro flour took more time for cooking than that with dioscorea flour. The cooking time for D_1 was 6.3 minutes and that of D_2 was 5.9 minutes. In taro, cooking time was more (7.7 minutes) for T_2 than T_1 (7.3 minutes). Significant difference was present between cooking time of the products. Vermicelli took more time for cooking than sev.

4.5.2.2 Water Absorption Index

When the water absorption capacity of the sev was analaysed, it was found that (Table 16) the highest water absorption index (3.21) was observed for T_2 followed by T_1 (3.17), D_1 (3.14) and D_2 (2.96). D_1 had higher score for water absorption (3.14) than D_2 (2.96). But the difference was not statistically significant.

The water absorption capacity of vermicelli was analysed and it was found that highest score was obtained by T_2 (3.22) and lowest score was for D_2 (3.06). D_1 obtained higher score (3.153) for water absorption than D_2 (3.06) whereas in taro, T_2 had higher score (3.22) than T_1 (3.19). But the difference was not statistically significant.

4.5.2.3 Bulk Density

Bulk density is one of the most common simple measurements in food analysis, which can be used for the analysis of solid foods. The volume of different food products can be compared through bulk density. The products exhibited variation in bulk density and the data is presented in Table 16. D_1 sev and vermicelli had higher bulk density than products made with other flours. Bulk density of products with taro flour had lower value than dioscorea flour. D_1 sev (0.28) obtained higher score for bulk density than D_2 sev (0.27) whereas T_1 and T_2 sev had same score of 0.26. Bulk density of vermicelli was found to be higher in D_1 (0.273) followed by T_2 (0.267), D_2 (0.26) and T_1 vermicelli (0.253). Statistically the difference in bulk density was not significant.

4.5.3 Nutritional and Chemical Qualities of the Products

Acceptability, nutritive value and cost are the prime elements of good food. Traditional food satisfied these parameters adequately. So any new food products should be developed based on these principles (Potty, 1993). The nutritive value of the extruded foods developed was assessed in the laboratory. The data is presented in Table 17.

Table 17. Nutritional and chemical qualities of the developed product

Products	Protein (%)	Starch (%)	Crude fibre (%)	Total ash (g)	Minerals		
					Calcium (g)	Phosphorus (g)	Iron (mg)
1. Sev							
D_1	23.8	36.74	0.91	0.57	0.057	0.125	2.187
D_2	23.22	34.51	0.843	0.43	0.038	0.122	2.17
T_1	21.93	19.92	1.10	0.60	0.045	0.163	2.43
T_2	22.40	22.23	1.23	0.73	0.047	0.165	2.433
SE	0.154	0.580	0.0336	0.05	0.004	0.003	0.022
CD (0.05)	0.44	1.756	0.1014	0.1506	0.013	0.009	0.072
2.Vermicelli							
D_1	23.45	35.57	0.90	0.50	0.053	0.125	2.183
D_2	23.10	34.00	0.83	0.36	0.036	0.119	2.17
T_1	21.80	19.76	1.10	0.53	0.044	0.160	2.43
T_2	22.28	22.23	1.10	0.66	0.046	0.163	2.43
SE	0.184	0.417	0.0304	0.0288	0.004	0.003	0.028
CD (0.05)	0.602	1.258	0.0917	0.0869	0.013	0.106	0.094

Protein

Protein is one of the most important nutrient required by the body to carry out a wide range of functions essential for the maintenance of life. When the protein content of the developed foods was analysed, it was found that sev and vermicelli with dioscorea flour obtained higher level of protein. Protein value of sev was slightly higher than that of vermicelli.

Protein content of D_1 (23.8 %) was found to be higher than that of D_2 (23.22 %). In taro, T_2 sev obtained high score (22.4 %) for protein than T_1 (21.93 %). Same result was obtained in the case of vermicelli, D_1

and T_2 had high score for protein than D_2 and T_1 vermicelli. Statistically significant difference was present between D_1 and D_2 sev and also between T_1 and T_2 sev whereas in vermicelli, all products are on par.

Starch

Starch analysis of sev showed that product with dioscorea flour obtained higher value than taro flour. D_1 sev had high starch value of 36.74 per cent than that of D_2 (34.51 %). T_2 obtained high value of 22.23 per cent while that of T_1 was 19.92 per cent. Statistically significant difference was found between tubers and between varieties.

Starch content of vermicelli was found to be higher in D_1 (35.57 %) and lower in T_1 (19.76 %). Here also product with dioscorea flour obtained higher starch value than that with taro. T_2 had higher value for starch (22.23 %), while that of T_1 was only 19.76 per cent. Statistically significant difference was observed between tubers and between varieties.

Crude Fibre

Crude fibre content was found to be higher in T_2 sev and lower in D_2 sev. Products with taro flour obtained higher value for fibre than that with dioscorea flour. D_1 had higher fibre value of 0.91 per cent followed by D_2 (0.84 %), while T_2 had higher value of 1.23 per cent and T_1 had a value of 1.10 per cent. Significant difference was present between tubers.

Crude fibre analysis of vermicelli showed that product with taro flour had higher value for fibre than that with dioscorea flour. T_1 and T_2 vermicelli obtained same value (1.10 %), D_1 recorded slightly higher value (0.90 %) than D_2 (0.83 %). Significant difference was present only between tubers.

Total Ash

Ash content of sev was found to be higher in T_2 (0.73 %) and lower in D_2 (0.43 %). Sev with dioscorea flour had lower value for ash than that with taro flour. Significant difference was observed between D_1 and T_2 sev.

Analysis of ash content in vermicelli revealed that the product with dioscorea flour obtained lower value for ash than that with taro. D_1 vermicelli had high value of 0.50 per cent and that of D_2 was 0.36 per cent. T_1 obtained value of 0.53 per cent and the value was 0.66 per cent for T_2. Significant difference was observed between tubers and varieties.

Calcium

The analysis of calcium content of the product revealed that sev and vermicelli had almost similar values. Product with D_1 obtained higher value for calcium (0.057 g for D_1 sev and 0.053 g for D_1 vermicelli) than product with D_2 flour (0.038 g for D_2 sev and 0.036 g for D_2 vermicelli). Product with T_1 flour had lower value (0.045 g for sev and 0.044 g for vermicelli) than T_2 sev and vermicelli (0.047 and 0.046 g respectively). Statistically all values were on par.

Phosphorus

Phosphorus content was found to be higher in D_1 sev (0.125 g) than D_2 (0.122 g). D_1 vermicelli had same value of that of D_1 sev (0.125 g) whereas D_2 vermicelli had lower value (0.119 g) than D_2 sev (0.122 g). T_2 products recorded higher value for phosphorus than T_1 products. Eventhough there was difference in the phosphorus content it was not statistically significant.

Iron

Iron is the chief among the trace elements required for the body. Analysis of iron content in the developed products showed that taro varieties obtained higher value for iron than dioscorea. There was difference between products in D_1. Iron content of D_1 sev (2.187 mg) was found to be higher than that of D_1 vermicelli (2.183 mg) whereas products with D_2 had same value (2.17 mg). Sev and vermicelli with taro flour obtained similar value for iron (2.43 mg). The difference in the values were not statistically significant.

4.5.4 Organoleptic Quality

Quality is the ultimate criterion of the desirability of any food product. Food quality can be evaluated by sensory and objective methods. Organoleptic qualities of the developed products were analysed by a panel of judges with standardised scorecard. Any new food product should be formulated, keeping in mind the requirements and acceptance of consumers and their regional bias. It should aim at the targeted groups of consumers, opines Datta (1993). Appearance, colour, flavour, texture and taste are the important parameters which were used for analysing the quality of products. The results obtained in this aspects are presented in Table 18.

Appearance

Surface characteristics of food products contribute to the appearance. Appearance of T_2 sev was found to be higher (4.10) than that of other sev, while D_1 and T_2 vermicelli obtained same value for appearance (3.90), which was found to be higher than that of D_2 and T_1 vermicelli (3.60). No significant difference could be found between products, tubers and varieties.

Colour

In addition to giving pleasure, the colour of food is associated with other attributes. Analysis of colour revealed that D_1 sev had higher score of 4.30 and lower score was obtained by T_1 sev (3.50). Significantly higher value was observed for D_1 sev than T_1 sev. D_1 vermicelli exhibited higher score of 3.90 for colour than others. Lower score was observed in T_1 vermicelli (3.40). Significant difference was observed between tubers.

Table 18. Organoleptic qualities of the extruded product

Products	Quality parameters				
	Appearance	Colour	Flavour	Texture	Taste
1. Sev					
D_1	4.00	4.30	3.60	3.20	3.10
D_2	3.60	3.90	3.20	2.80	2.60
T_1	3.70	3.50	2.90	2.90	2.60
T_2	4.10	3.80	3.30	3.40	3.00
SE	0.220	0.230	0.217	0.238	0.245
CD (0.05)	0.610	0.661	0.623	0.685	0.704
2.Vermicelli					
D_1	3.90	3.90	3.40	3.50	3.30
D_2	3.60	3.70	3.10	3.30	3.0
T_1	3.60	3.40	2.80	3.30	2.90
T_2	3.90	3.60	3.20	3.60	3.30
SE	0.171	0.164	0.214	0.175	0.140
CD (0.05)	0.492	0.473	0.614	0.504	0.403

Flavour

D_1 sev obtained higher score of 3.60 for flavour followed by T_2 (3.30), D_2 (3.20) and T_1 sev (2.90). Significant difference was present only between D_1 and T_1 sev. Higher score for flavour was obtained in D_1 vermicelli (3.40) and lower score in T_1 vermicelli (2.80). The difference was not statistically significant.

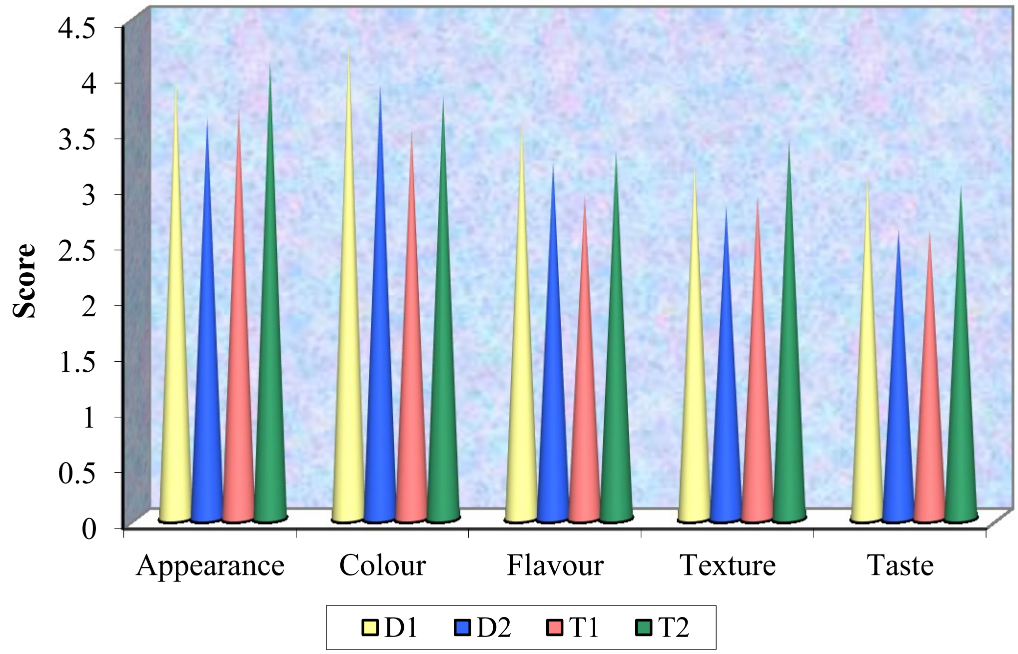


Fig. 9 Organoleptic qualities of the extruded product - sev

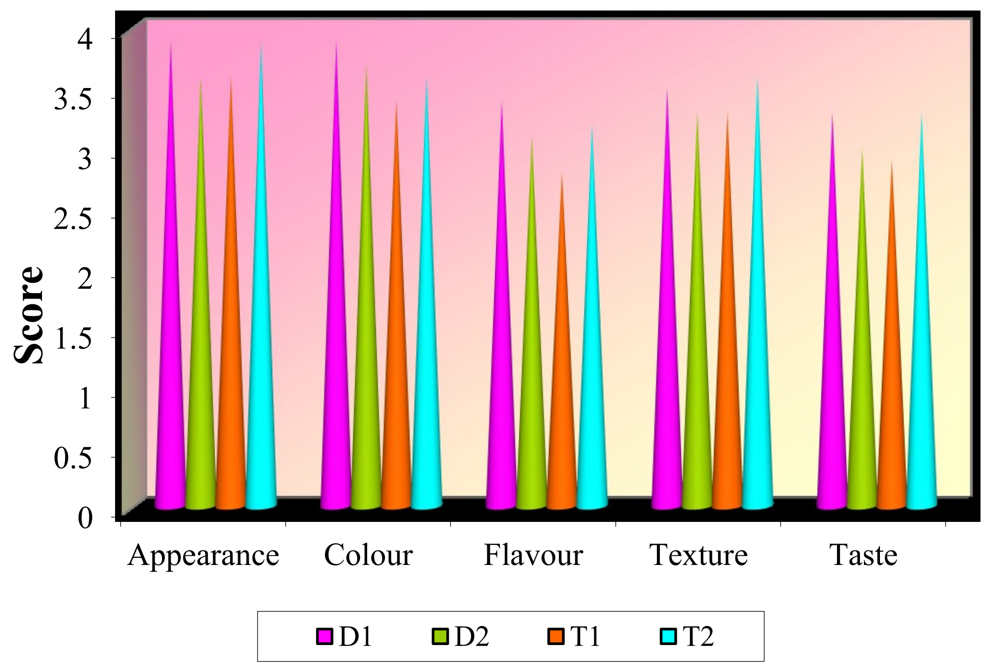


Fig. 10 Organoleptic qualities of the extruded product - vermicelli

Texture

Analysis of texture of the developed products showed that T_2 sev obtained higher score for texture (3.40) and D_2 sev obtained low score of 2.80. Texture of D_1 sev was found to be better (3.20) than that of D_2 sev (2.80). There was no significant difference between texture of sev prepared with different tuber flours. T_2 vermicelli obtained higher score of 3.60 for texture followed by D_1 vermicelli (3.50) and then D_2 and T_1 vermicelli (3.30). Here also there was no significant difference.

4.5.5 Storage Stability and Shelf-life Qualities of the Product

Shelf-life qualities of the products mainly depend upon its moisture content, acidity, insect infestation and microbial evaluation.

4.5.5.1 Assessment of Moisture Content in Stored Product

Sev and vermicelli prepared with tuber flours were kept in polypropylene covers and the moisture content of stored products were analysed at monthly intervals upto three months. The result of the study is presented in Table 19.

The initial moisture level of sev was 10.67, 10.73, 10.67 and 10.60 per cent for D_1, D_2, T_1 and T_2 sev respectively. After three months of storage, the highest moisture value of 11.47 pre cent for D_2 sev and lowest value of 11.13 per cent for T_2 sev were observed. Moisture analysis of the products showed that products with dioscorea flour had higher moisture value than products with taro flour. After three months of storage D_1 sev had lower value of 11.37 per cent than that of D_2 sev (11.47 per cent) whereas T_1 sev obtained higher value (11.3 per cent) than T_2 sev (11.13 per cent). Statistically there was no significant difference in the moisture content of the products.

Table 19. Moisture level of the products

Products	Storage period			
	Initial (%)	1^{st} month (%)	2^{nd} month (%)	3^{rd} month (%)
1. Sev				
D_1	10.67	10.87	11.13	11.37
D_2	10.73	10.93	11.23	11.47
T_1	10.67	10.87	11.07	11.30
T_2	10.60	10.73	10.93	11.13
SE	0.05	0.066	0.06	0.064
CD (0.05)	0.163	0.217	0.195	0.210
2.Vermicelli				
D_1	10.63	10.83	11.13	11.33
D_2	10.73	10.90	11.23	11.43
T_1	10.70	10.93	11.17	11.37
T_2	10.63	10.87	11.07	11.27
SE	0.057	0.057	0.083	0.083
CD (0.05)	0.188	0.188	0.271	0.271

The initial moisture level of vermicelli was found to be 10.63, 10.73, 10.70 and 10.63 per cent for D_1, D_2, T_1 and T_2 vermicelli. After three months of storage, high score was obtained for D_2 vermicelli (11.43 per cent) and lower score was recorded in T_2 vermicelli (11.27 %). D_1 vermicelli had lower value for moisture (11.33 per cent) than D_2 vermicelli (11.43 per cent). T_1 vermicelli obtained higher value of 11.37 per cent than that of T_2 vermicelli (11.27 per cent). Statistically there was no significant difference in the moisture level of vermicelli prepared with different tuber flours.

4.5.5.2 Assessment of Acidity in Stored Products

The stored products sev and vermicelli, were analysed once in three months for any change in acidity. It was observed that there was no change in acidity irrespective of the products, tubers and storage period.

4.5.5.3 Assessment of Insect Infestation in Stored Products

The assessment of the incidence of insects and pests in stored products were observed once in a month throughout the storage period of three months. It was observed that there was no insect infestation in sev as well as vermicelli upto three months.

4.5.5.4 Assessment of Microbiological Quality of Products

Microbial quality of stored products was analysed on the basis of presence of fungus, bacteria and yeast in it. Initially there was no microbes in any of the products. But fungus and yeast were observed after three months of storage. The results are presented in Table 20.

Table 20. Microbial profile of stored products after three months

Sl. No.	Products	Fungal colonies	Bacterial colonies	Yeast colonies
1	D_1 sev	0	0	1
2	D_2 sev	1	1	2
3	T_1 sev	2	1	2
4	T_2 sev	1	0	1
5	D_1 Vermicelli	2	1	2
6	D_2 Vermicelli	1	2	3
7	T_1 Vermicelli	2	1	2
8	T_2 Vermicelli	1	0	1

Fungal attack was found to be higher in vermicelli than sev. D_1 sev was free from fungal attack. In D_2 and T_2 sev and also in D_2 and T_2 vermicelli one colony of fungus was observed. These product were attacked by mould like *Aspergillus niger* and *Rhizopus nigaricans*.

Bacterial count was found to be higher in D_2 vermicelli. D_1 sev, T_2 sev and T_2 vermicelli were free from bacterial attack while one colony was observed in D_2 and T_1 sev and also in D_1 and T_1 vermicelli.

Yeast colonies were found to be higher in all products. D_2 vermicelli contained more yeast colonies than other products. In D_2 and T_1 sev and also in D_1 and T_1 vermicelli there were two yeast colonies. In other products one colony was observed.

The microbial analysis of the products showed that sev and vermicelli with D_1 and T_2 flour were microbiologically safer than that with D_2 and T_1 flour.

4.5.6 Type Test Administered to the Extruded Product

Implementation of quality system standards for the food products would result in several benefits. The Bureau of Indian standards has specified certain type tests for various products to maintain quality during marketing. Estimation of moisture, total ash, acid insoluble ash, protein and total solids in gruel, are the major type tests administered to sev and vermicelli (Table 21).

Table 21 ISI type tests

Sl. No.	Tests	Sev				Vermicelli				ISI speci-fication
		D_1	D_2	T_1	T_2	D_1	D_2	T_1	T_2	
1	Moisture (%)	10.67	10.73	10.67	10.6	10.63	10.73	10.70	10.63	11.00*
2	Total ash (%)	0.57	0.43	0.60	0.70	0.60	0.48	0.62	0.73	0.70*
3	Acid insoluble ash (%)	0.04	0.04	0.05	0.045	0.04	0.04	0.05	0.045	0.05*
4	Total protein (%)	23.80	23.22	21.93	22.40	23.45	23.10	21.80	22.28	10.00**
5	Total solids in gruel (%)	7.50	7.80	8.00	7.80	7.60	7.80	8.20	8.00	8.00*

*Maximum **Minimum

Moisture content of sev was found to be 10.67, 10.73, 10.67 and 10.60 per cent for D_1, D_2, T_1 and T_2 sev while the ISI has specified a maximum limit of 11.00 per cent. Moisture content of vermicelli was also found to be lesser than ISI specification.

A total ash content of 0.57, 0.43, 0.60 and 0.70 per cent was recorded for D_1, D_2, T_1 and T_2 sev while the ISI has specified a maximum limit of 0.70 per cent. Total ash content was comparatively less in sev than vermicelli. The ash content of dioscorea sev was 0.57 and 0.43 per cent for D_1 and D_2 respectively, while for sev based on taro, it was 0.60 and 0.70 for T_1 and T_2 sev respectively. Vermicelli based on dioscorea obtained ash content of 0.6 and 0.48 while vermicelli based on taro had 0.62 and 0.73 per cent for T_1 and T_2 vermicelli.

The acid insoluble ash, which gives information regarding the inorganic salts present in the product. It was found to be 0.04 per cent for D_1 and D_2 sev and vermicelli, 0.05 per cent for T_1 sev and vermicelli and 0.045 per cent for T_2 sev and vermicelli. However, these values were within the limit specified by ISI (0.05 %).

ISI has prescribed 10 per cent protein for extruded products. But the product processed in the present investigation was found to be higher in protein content, which will help in improving the nutritional quality of the product. D_1 and D_2 sev had higher protein content of 23.80 and 23.22 per cent for D_1 and D_2 than that of T_1 and T_2 (21.93 and 22.4 per cent) respectively. Vermicelli recorded slightly lower value than that of sev.

The total solids in gruel will give information regarding the water soluble ingredients and percentage of cooking loss. For T_1 sev and T_2 vermicelli total solids in gruel was estimated as 8.0 per cent, which was the same as specified by the ISI. Same value of 7.8 was recorded for D_2 and T_2 sev and also for D_2 vermicelli. T_1 vermicelli recorded higher value of 8.20 per cent for total solids in gruel than that of ISI specification (8.0 %). D_1 sev and vermicelli obtained 7.50 and 7.60 per cent which was lower than the value specified by the ISI. All the values were below the values specified by ISI except T_1 vermicelli (8.20 %) revealing that the cooking loss is comparatively less.

4.6 STANDARDISATION OF RECIPES

Any recipe that is new or has to be changed should be tested in small quantity before being used in regular production. The procedure of standardisation consisted of;

(i) Listing ingredients required for each recipe with their amounts

(ii) Converting the ingredients of each recipe to metric system

(iii) Determination of the edible portion weight from the 'as purchased weight'

(iv) Cooking the recipes according to the procedure by maintaining the time, quality and quantity.

In the present study fifteen recipes based on the extruded products sev and vermicelli, were standardised in the laboratory.

4.6.1 Preference Test for the Developed Recipes

Development of new food products or the reformulations of existing products can be attained either by introducing different processing methods, or by the use of new ingredients, and the acceptability of these products could be assessed by conducting preference test on a large number of consumers (Watts *et al.*, 1989). Preference studies are designed to determine consumer's subjective reactions to external phenomena and their reasons for having them. While conducting preference test the consumer expects to be favourably impressed with the food he tastes and expressed displeasure if the product does not measure upto his anticipation.

In the present study, preference test was conducted among technical experts, college students, workingwomen and farmwomen. Data was collected using a nine point rating scale varied from 'like extremely' (9) to 'dislike extremely' (1). Since none of the developed recipes were rated as 'dislike very much' and 'dislike extremely', these two rating were deleted, while discussing the data. The data is presented in Table 22.

Table 22 Preference of technical experts for the developed recipes

(n = 10)

Sl. No.	Foods	Rating						
		Like extremely	Like very much	Like moderately	Like slightly	Neither like or dislike	Dislike slightly	Dislike moderately
1	Stuffed bread roll	-	5 (50)	5 (50)	-	-	-	-
2	Burfi	-	3 (30)	2 (20)	3 (30)	2 (20)	-	-
3	Sugar stick	-	2 (20)	2 (20)	2 (20)	3 (30)	1 (10)	-
4	Sev halwa	-	2 (20)	5 (50)	3 (30)	-	-	-
5	Coco stick	-	3 (30)	3 (30)	1 (10)	2 (20)	1 (10)	-
6	Pakoda	-	1 (10)	3 (30)	2 (20)	-	3 (30)	1 (10)
7	Patties	1 (10)	5 (50)	4 (40)	-	-	-	-
8	Sweet stick	2 (20)	2 (20)	4 (40)	2 (20)	-	-	-
9	Samosa	-	3 (30)	5 (50)	2 (20)	-	-	-
10	Payasam	-	-	3 (30)	2 (20)	3 (30)	2 (20)	-
11	Sev pak	-	4 (40)	2 (20)	3 (30)	1 (10)	-	-
12	Coconut sev	-	5 (50)	2 (20)	3 (30)	-	-	-
13	Burger	-	3 (30)	3 (30)	2 (20)	2 (20)	-	-
14	Sev madhuri	-	3 (30)	4 (40)	3 (30)	-	-	-
15	Toffee	-	2 (20)	3 (30)	2 (20)	3 (30)	-	-

Numbers in parenthesis denotes percentage

Stuffed bread roll, patties and coconut sev were 'liked very much' by 50 per cent of technical experts. 30 per cent of technical experts scored burfi, coco stick, samosa, burger and sev madhuri as 'like very much' and 40 per cent of the experts scored sev pak as 'like very much'. Forty per cent of experts scored negatively for pakoda and 20 per cent scored negatively for payasam. About 10 per cent of technical experts gave negative scores such as 'dislike slightly' in the case of sugar stick

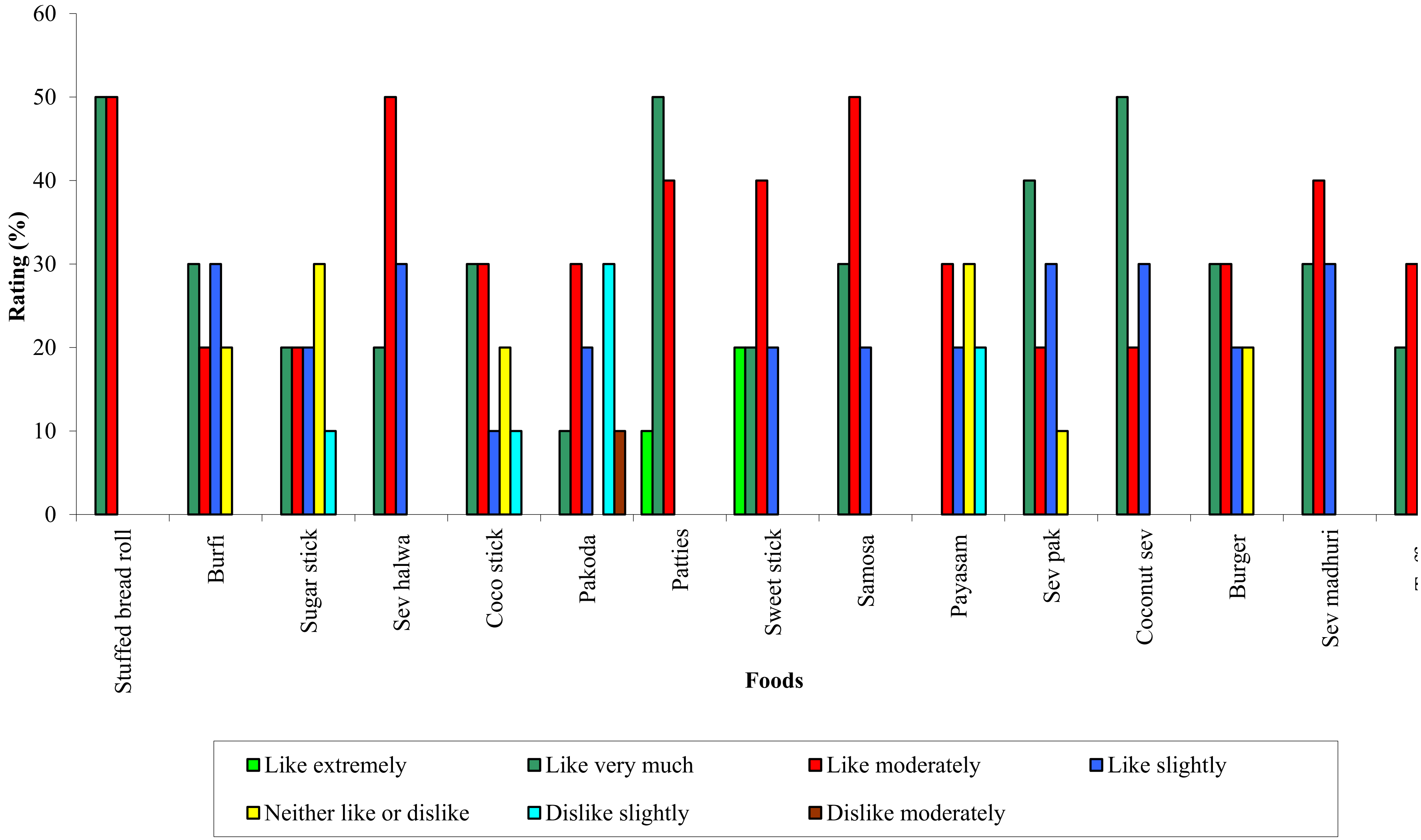


Fig. 11 Preference of technical expert for the developed recipes

and coco stick. None of the experts rated the products as ‘disliked very much’ or ‘disliked extremely’.

Maximum per cent of college students liked stuffed bread roll and patties (50 per cent) (Table 23). All recipes were rated positively. No negative scores were assigned to any of these recipes except pakoda. About 10 per cent of student scored pakoda as neither like or dislike.

Thirty per cent of students scored coco stick, pak and coconut sev as ‘like extremely’. Sev halwa, pakoda and samosa were scored ‘like extremely’ by only 10 per cent of students while 40 per cent recorded sev halwa as ‘like very much’.

Table 23. Preference of college students for the developed recipes

(n = 10)

Sl. No.	Foods	Rating						
		Like extremely	Like very much	Like moderately	Like slightly	Neither like or dislike	Dislike slightly	Dislike moderately
1	Stuffed bread roll	5 (50)	2 (20)	3 (30)	-	-	-	-
2	Burfi	2 (20)	6 (60)	2 (20)	-	-	-	-
3	Sugar stick	2 (20)	4 (40)	2 (20)	2 (20)	-	-	-
4	Sev halwa	1 (10)	4 (40)	3 (30)	2 (20)	-	-	-
5	Coco stick	3 (30)	4 (40)	3 (30)	-	-	-	-
6	Pakoda	1 (10)	1 (10)	6 (60)	1 (10)	1 (10)	-	-
7	Patties	5 (50)	1 (10)	2 (20)	2 (20)	-	-	-
8	Sweet stick	2 (20)	2 (20)	4 (40)	2 (20)	-	-	-
9	Samosa	1 (10)	2 (20)	4 (40)	3 (30)	-	-	-
10	Payasam	2 (20)	6 (60)	-	2 (20)	-	-	-
11	Sev pak	3 (30)	5 (50)	2 (20)	-	-	-	-
12	Coconut sev	3 (30)	3 (30)	2 (20)	2 (20)	-	-	-
13	Burger	2 (20)	3 (30)	3 (30)	2 (20)	-	-	-
14	Sev madhuri	2 (20)	2 (20)	3 (30)	3 (30)	-	-	-
15	Toffee	2 (20)	2 (20)	2 (20)	4 (40)	-	-	-

Numbers in parenthesis denotes percentage

The details regarding the preference of workingwomen is presented in Table 24. Sixty per cent of women preferred patties as the extremely liked product. Among the 15 recipes sev patties was recorded as high followed by stuffed bread roll and samosa. Forty per cent of women recorded samosa as the 'liked extremely' product. Stuffed bread roll, burfi, coconut sev and burger were 'liked moderately' by 30 per cent of women. Negative scoring such as neither like or dislike was rated by 20 per cent of women for pakoda, sweet stick and toffee and 10 per cent for sev halwa.

Table 24. Preference of working women for the developed recipes

(n = 10)

Sl. No.	Foods	Rating						
		Like extremely	Like very much	Like moderately	Like slightly	Neither like or dislike	Dislike slightly	Dislike moderately
1	Stuffed bread roll	3 (30)	6 (60)	1 (10)	-	-	-	-
2	Burfi	3 (30)	2 (20)	4 (40)	1 (10)	-	-	-
3	Sugar stick	2 (20)	4 (40)	3 (30)	1 (10)	-	-	-
4	Sev halwa	-	5 (50)	2 (20)	2 (20)	1 (10)	-	-
5	Coco stick	-	5 (50)	3 (30)	2 (20)	-	-	-
6	Pakoda	-	4 (40)	2 (20)	1 (10)	2 (20)	1 (10)-	-
7	Patties	6 (60)	4 (40)	-	-	-	-	-
8	Sweet stick	-	4 (40)	1 (10)	3 (30)	2 (20)	-	-
9	Samosa	4 (40)	5 (50)	-	1 (10)	-	-	-
10	Payasam	2 (20)	2 (20)	3 (30)	3 (30)	-	-	-
11	Sev pak	2 (20)	3 (30)	3 (30)	2 (20)	-	-	-
12	Coconut sev	3 (30)	3 (30)	3 (30)	1 (10)	-	-	-
13	Burger	3 (30)	3 (30)	2 (20)	2 (20)	-	-	-
14	Sev madhuri	-	3 (30)	3 (30)	4 (40)	-	-	-
15	Toffee	-	2 (20)	3 (30)	3 (30)	2 (20)	-	-

Numbers in parenthesis denotes percentage

Sixty per cent of women recorded stuffed bread roll as ‘like very much’ while 50 per cent scored sev halwa, coco stick and samosa as ‘liked very much’.

Table 25 Preference of farmwomen for the developed recipes

(n = 10)

Sl. No.	Foods	Rating						
		Like extremely	Like very much	Like moderately	Like slightly	Neither like or dislike	Dislike slightly	Dislike moderately
1	Stuffed bread roll	4 (40)	5 (50)	1 (10)	-	-	-	-
2	Burfi	3 (30)	3 (30)	2 (20)	2 (20)	-	-	-
3	Sugar stick	2 (20)	4 (40)	2 (20)	2 (20)	-	-	-
4	Sev halwa	4 (40)	2 (20)	3 (30)	1 (10)	-	-	-
5	Coco stick	1 (10)	5 (50)	3 (30)	1 (10)	-	-	-
6	Pakoda	-	3 (30)	3 (30)	2 (20)	2 (20)	-	-
7	Patties	3 (30)	6 (60)	1 (10)	-	-	-	-
8	Sweet stick	4 (40)	4 (40)	2 (20)	-	-	-	-
9	Samosa	3 (30)	4 (40)	2 (20)	1 (10)	-	-	-
10	Payasam	2 (20)	3 (30)	3 (30)	2 (20)	-	-	-
11	Sev pak	3 (30)	3 (30)	3 (30)	1 (10)	-	-	-
12	Coconut sev	4 (40)	3 (30)	3 (30)	-	-	-	-
13	Burger	3 (30)	3 (30)	2 (20)	2 (20)	-	-	-
14	Sev madhuri	3 (30)	4 (40)	3 (30)	-	-	-	-
15	Toffee	2 (20)	5 (50)	2 (20)	1 (10)	-	-	-

Numbers in parenthesis denotes percentage

Table 25 presents preference of farmwomen for the developed recipes. It was found that, stuffed bread roll, sev halwa, sweet stick and coconut sev were liked extremely by 40 per cent of women. Thirty per cent of women liked burfi, patties, samosa, sev pak, burger and sev madhuri. Ten per cent liked coco stick. Negative scoring such as nether like or dislike was rated by 20 per cent of women for pakoda.

Sixty per cent of women scored patties as 'liked very much' while 50 per cent recorded stuffed bread roll, coco stick and toffee as 'liked very much'. Sugar stick, sweet stick, samosa and sev madhuri were preferred as 'like very much' by 40 per cent of women. Majority of recipes were scored positively except pakoda by the different categories of consumers.

In the above study flours were prepared from two varieties each of dioscorea and taro. Nutritional, chemical, functional and shelf life qualities were found to be better in Sree Priya (D_1) variety in dioscorea and Thamarakkannan (T_2) variety in taro. Two extruded products sev and vermicelli were processed with the tuber flour along with maida, rice flour and soya flour. The organoleptic and shelf life qualities of the products were found to be better. Cost-benefit ratio was also analysed and found to be less than the standard products available in the market (Appendix VI). Fifteen recipes were developed with these products and majority of recipes were scored positively by the consumers.

Discussion

5. DISCUSSION

The results obtained in the present study entitled "Formulating extruded food based on dioscorea and taro' are discussed under the following headings.

5.1 Selection of tubers

5.2 Standardisation of flour

5.3 Quality assessment of flour

5.4 Formulation of extruded products

5.5 Quality assessment of product and

5.6 Standardisation of recipes

5.1 SELECTION OF TUBERS

The nutritive value of minor tuber crops are considered to be for better than popular tubers like cassava or potato because they have some quantity of protein besides carbohydrates (Shanmugavelu *et al*., 1987). Hence dioscorea and taro were selected for the present study. Generally raw materials rich in carbohydrates and starch and having binding capacity will be selected for preparing extruded foods. Hence dioscorea and taro were selected based on the carbohydrate and starch content. Thirumaran *et al*., (1988) as also of the opinion that extruded products, wafers and biscuits could be prepared from minor tubers. Liya (2002) reported that various products like murukku, wafers and papads could be prepared from taro flour. Tu *et al*. (1992) felt that products like noodles and synthetic rice could be prepared from taro flour and the products are rigid, non hydroscopic and non-sticky.

5.2 STANDARDISATION OF FLOUR

Flour was prepared from each of the tubers and stored in containers. Processing of tubers into flour, improves the shelf-life of tubers and reduces its bulkiness and perishability. Therefore flour was prepared from these tubers.

5.3 QUALITY ASSESSMENT OF FLOUR

Quality is the ultimate criterion of the desirability of any food product. Food quality can be evaluated by objective and sensory methods.

In the present study, quality assessment of dioscorea and taro flours was carried out by analysing nutritional, chemical, functional and shelf-life qualities.

5.3.1 Nutritional and Chemical Qualities

Protein content was reported to be higher in D_1 flour (2.56 %) and lower in T_1 flour (2.35 %). Dioscorea variety obtained slightly higher value than that of taro flour. Seralathan and Thirumaran (1999) reported high protein value for taro (3.2 %) and low value for dioscorea (2.1 %) This may be due to the varietal difference. Heiser (1990) has reported a low value for protein in taro (1 %). The value obtained for dioscorea was in line with the findings of Eka (1986) who reported that the protein content of dioscorea was 1.5 to 3.0 per cent.

Starch is an important constituent of tuber crops. Among the four tuber flours evaluated, Sree Priya (D_1) recorded the highest starch content of about 20.96 per cent. This is in uniformity with the findings reported by Moorthy and Nair (1989) who stated that starch recovery of dioscorea ranges between 20 to 24 per cent. According to Suja (2001) African white yam (*D. rotundata*) has a significantly high starch content of 23.7 per cent. Eka (1986) also reported the same result. He found out that dioscorea was extremely high in starch (25-30 per cent). The starch content of dioscorea and taro flour in the present study is not in line with the value reported by

Seralathan and Thirumaran (1999) who stated that taro was found to yield the highest starch content of 21.2 per cent while dioscorea had the lowest amount of 19.3 per cent. The starch content in Sree Rashmi was found to be similar to the value reported by CTCRI (1999) stating the starch content in Sree Rashmi to be 14.50 per cent. The variation in the starch content may be due to varietal variation.

The crude fibre contents in the flour of all the four tuber varieties were on par, in the range of 1.08 to 1.83 per cent. Taro had lesser crude fibre than dioscorea. These findings are in agreement with the findings of Gopalan *et al*. (1977) who found that crude fibre content of taro corms was one per cent. Liya (2002) also reported lower crude fiber content in the taro corms ranging from 0.75 to 0.85 per cent. This may be due to varietal variation or due to variation in maturity of tubers.

Among the four tuber flours, ash content was found to be higher in Thamarakkannan (T_2) (1.27 %) and lower in Sree Dhanya (1.0 %). Onwueme and Charles (1994) reported that vitamins and minerals are minor components of yam tuber. This may be the reason for less ash content in dioscorea flour than in taro flour. Opara (1999) reported higher ash content for dioscorea tuber (0.60 – 1.70 g/100 g) and Bradbury (1988) reported ash content in taro as 0.87 per cent.

Moisture is one of the important constituent of tuber crops. Among the four tuber flour, Sree Dhanya (D_2) showed the highest moisture value (11.46 %) and Thamarakkannan (T_2) got the lowest value (9.4 %). Increased moisture value cause reduction in the shelf-life of the flour. Here flour made from dioscorea varieties obtained higher value for moisture than taro flour, while, Seralathan and Thirumaran (1999) reported higher moisture value for taro tuber than dioscorea. They found out that moisture content of dioscorea was 67.6 per cent and taro was 70.3 per cent. Moisture content in dioscorea flour was almost same the value reported by Ajav (1998) who stated that the average moisture content of the tail region of dioscorea was 62 per cent whereas that of middle and head regions were 60 and 58 per cent respectively.

Acidity level was found to be higher in dioscorea than taro. This may be due to difference in the composition of these tubers.

5.3.2 Functional Qualities

The analysis of yield ratio of tuber flour revealed that Thamarakkannan (T_2) flour got higher value of 0.730 whereas lower value was obtained for D_2 (Sree Dhanya) flour (0.630). This may be due to varietal or structural differences of the tubers.

Grewal and Uppal (1989) reported that the yield of the chips increased with the progressive increase in the specific gravity of tubers. Marwaha (1997) also reported that yield of chips were higher and oil content was lower from high specific gravity tubers.

Processing loss was found to be higher in D_2 flour (0.370) and lower in T_2 (Thamarakkannan) (0.270). Yield ratio was found to be higher in T_2 flour expressing the lower processing loss in T_2 variety.

5.3.3 Shelf-life Qualities of Flour

Most stored products are considered to be safe in storage at a particular moisture content, low moisture is highly important for longer storage period (Shankar, 1993). There was an increase in the moisture content of the stored flour irrespective of the storage containers. Variation in moisture content was found to be lowest in PET containers than polypropylene covers. The same trend could be observed throughout the storage period.

5.3.3.1 Assessment of Moisture in Stored Flour

Moisture content was increased in flour stored in polypropylene covers. This may be due to the water absorption capacity of these covers. Because of this reason, in polypropylene covers, the increase in moisture content was 12.13, 12.37, 10.57 and 10.23 per cent for D_1, D_2, T_1 and T_2

flour respectively. Moisture content of the flour stored in PET containers was found to be less. This observation is in line with the findings of Purushottam *et al*. (1992) who had observed that the quality of the flours stored in glass containers was comparable with that of fresh flours with special reference to moisture.

In the present study, the highest moisture content was recorded to the flour stored in polypropylene covers. This observation is in line with the findings of Beerah *et al*. (1990) who had observed a steady increase in the moisture content throughout the storage period of six months from the initial levels of 11.0 per cent to 13.0 per cent of cold stored potato stored in polythene bags. Highest moisture content was recorded to the flour stored in polythene bags by Augustine (1999).

Moisture content was found to increase as the duration of storage advanced. Gain in moisture occurred in potato flour with increase in storage time (Sagar and Roy, 1997). However the moisture content of tuber flour, which was stored in the polypropylene covers was higher than that in the PET containers during he storage period. 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, 1990).

5.3.3.2 Assessment of Acidity in Stored Flour

Among the four tuber flours, dioscorea flour obtained higher value for acidity (0.38) than taro flour (0.25). It was observed that there was no change in acidity throughout the storage period of three months.

5.3.3.3 Assessment of Insect Infestation in Stored Flour

The assessment of the incidence of insect pest in the stored flours revealed that there was no insect infestation in the PET and polypropylene covers. Insects have preference for moist flour materials and increased moisture level aggravates infestation. A similar result was reported by

Chellammal (1995) and Augustine (1999) who observed that during the storage period there was no insect infestation in the flour stored in glass and plastic containers. Vaidehi and Sunanda (1982) also reported that potato flour could be stored in polyethylene pouches for six months without any fungal or insect infestation.

5.3.3.4 Assessment of Microbial Growth in Stored Flour

The assessment of microbial quality revealed that all the four tuber flours were free from bacterial attack. Yeast and fungus colonies were found to be present. Flours stored in PET containers had no microbial attack except in T_1 flour in PET even after the storage period of three months. This may probably be because of the lower moisture content of the flours stored in PET containers. Similar result was observed in stored tuber products by Chellammal (1995) who observed that the products stored in glass and plastic containers had neither fungal or bacterial attack even after the storage period of six months.

5.4 FORMULATION OF EXTRUDED PRODUCT

5.4.1 Different Combinations tried for the Development of the Product

Sixteen combinations were tried for the development of the products. Major ingredients used for making these combinations were maida, tuber flour, rice flour and soya flour. Different proportion of these ingredients were tried for product development.

5.4.2 Selection of Best Combination for the Development of the Extruded Product

The best combination was selected based on the yield ratio, nutritional quality, extrusion behaviour, cost and overall acceptability of the products.

5.4.2.1 Yield Ratio

Yield ratio of the extruded products varied from 0.40 to 0.81, 0.39 to 0.79, 0.42 to 0.87 and 0.37 to 0.72. Products with dioscorea flour obtained high yield than that with taro flour. Yield ratio of combination with maida 50, tuber flour 40 and soya flour 10 per cent was found to be higher than that of other combinations. This may be due to the raw ingredients present in each combinations.

5.4.2.2 Nutritional Quality

Protein

Analysis of protein content of the products revealed that protein content of each products varied from 14.82 to 15.4, 16.01 to 16.92, 21.93 to 23.8 and 17.03 to 17.62 per cent. Combination with maida 50, tuber flour 40 and soy flour 10 per cent obtained higher value for protein than other combinations. The raw materials or ingredients present in the products may be the reason for the variation in protein content.

Energy

Energy is essential for rest, activity, growth and maintenance of good health. Energy value of the developed products were computed. The computed value for energy ranged from 249-287 kcal. While, Jacob (1997) who stated that the estimated value for energy of the extruded food was found to be 360 kcal. The variation in the energy content may be due to the ingredients present and the type of the developed products.

Protein Energy Ratio

The ratio between protein and energy was also computed. It was found that the protein energy ratio was found to be higher in combination with maida 50, tuber flour 40 and soya flour 10 per cent. Energy content of this combination was found to be lesser and protein content found to be more than that of other combinations. Increased protein content is always acceptable in processed products. Increased protein content of this combination may be the reason for increased value of protein energy ratio.

5.4.2.3 Chemical Score

Chemical score of each combination, varied from 72.22 to 91.10. Combination with taro flour obtained highest value for chemical score than that with dioscorea flour. It was observed that highest chemical score was obtained in combination third and fourth with taro flour. Combination with dioscorea flour was also obtained high score in third and fourth combination.

5.4.2.4 Extrusion Behaviour

Extrusion behaviour of the combinations was assessed by technical experts using standardised pre-tested score card. The result of the study showed that highest score for extrusion behaviour was obtained for combination with maida 50, tuber flour 40 and soya flour 10 per cent and lowest score was obtained for the combination containing maida 50, tuber flour 40 and rice flour 10 per cent. Maida has the binding capacity and pliability which may added to the extrusion behaviour. Products with dioscorea flour obtained higher value for extrusion than that with taro flour. Dioscorea gives viscous pastes with higher gel strength than that of taro. This may be the reason for better extrusion behaviour in product with dioscorea flour.

5.4.2.5 Cost

Extrusion technology potentially offers a low cost means of producing convenience foods with variable functional and quality attributes (Rickard and Poulter, 1990). The strategies for the development of food products have to be based on affordable price and cost effectiveness. The continuous thrust shall be to reduce cost, improve quality, improve convenience so as to attract consumers. This clearly shows that if prices are kept in tune with market prices of fresh produce, food products can attract consumers (Mallya, 2003). Hence the challenge in developing new food products is to keep the cost to a minimum. The results revealed that cost of dioscorea products varied from Rs. 16.65 to 18.00 whereas products with taro flour varied from Rs. 18.30 to 19.65. It was clear that by the reduction of maida in each product the cost of the products could be reduced. A slight increase in cost was recorded in taro based products than in dioscorea based products. This was due to the higher price of the taro tubers.

5.4.2.6 Overall Acceptability

Overall acceptability depends on the concentration or amount of particular components, the nutritional and other hidden attributes of a food and its palatability or sensory quality. Sandhu and Joshi (1995) reported that the quality is the main criteria on which the acceptability of any product depends.

The overall acceptability of the products with different combination revealed that combination with maida 50 per cent, tuber flour 40 per cent and soya flour 10 per cent scored the highest value and combination with maida 50, tuber flour 40 and rice flour 10 per cent scored the lowest value. The low score for overall acceptability of this combination was due to the lower scores of parameters like appearance, colour, flavour, texture and taste. All combinations with dioscorea flour obtained higher score than that with taro flour.

5.4.3 Development of the Extruded Product

When compared to all other combinations, combination with maida 50 per cent, tuber flour 40 per cent and soy flour 10 per cent was superior in all quality parameters like nutritional quality, extrusion behaviour, cost and overall acceptability. Hence, this combination was selected for the development of extruded products, ‘sev and vermicelli’.

5.5 QUALITY ASSESSMENT OF THE PRODUCTS

Sev and vermicelli were prepared with the selected combinations and the products were analysed for physical characteristics, nutritional and chemical qualities, organoleptic quality and shelf-life quality. ISI type test was administrated to assess the quality of these developed products.

5.5.1 Physical Characteristics

In India more emphasis is given to the chemical standards of the food product rather than to the physical and culinary standards. The physical characteristics is an important criteria for product acceptance. The physical characteristics which may decide the acceptance of extruded products are fineness, shape, uniformity of strands, packaging quality and tensile strength. Consumer prefers to buy pasta having yellow, translucent appearance (for wheat), nearly free of broken pieces and small, loose fragments. Uniformity of piece size and shape also seems to be regarded as indicator of quality (Matz, 1991).

Extrudate breaking strength is important to both the processor and consumer. If the product has a low breaking strength, it will break easily and disintegrate during packaging and distribution. On the other hand, if the product has a large breaking strength, the consumer will find the product difficult to bite and to chew (Liu and Maga, 1993). Prince *et al.* (1994) also reported that tensile strength is the ability to withstand force.

Fineness was found to be high in D_1 sev (4.10). This is line with the findings of Jacob (1997) who stated that the fineness of sev was found to be 4.60. Score obtained for shape of sev varied form 4.00 to 3.50 while Jacob (1997) reported higher score for shape of sev (4.90). This may be due to the variation of ingredients present in the product. D_1 sev obtained higher score for uniformity of strands.

Packaging of food is a method of preservation, which eliminates physical contact between the food and contaminants. Packaging quality is the ability of the product to withstand insect infestation, microbial contamination, absorption of moisture, gases, heat and dynamic stress (Sivasankar, 2002). Packaging quality was found to be high in D_1 sev (4.10). The packaging quality of the developed sev was slightly lower than the standard sev was reported by Jacob (1997). D_1 and T_2 sev obtained higher score for tensile strength. Tensile strength of the product varied from 3.40 to 3.80. Incorporation of soya flour in the developed sev has increased the protein content and that may be the reason for higher score obtained for tensile strength. This is in line with the findings of Chellammal (1995) who stated that an increasing trend in tensile strength with the increased level of soya in dough mix. Prince *et al*. (1994) also reported the same result. Karleskind *et al*. (1991) also reported that soy based food products can be manufactured with good physical and functional properties.

In the case of vermicelli, physical characteristics were found to be high in vermicelli with D_1 and T_2 flour. This may be due to the improved extrusion behaviour and nutritional qualities of these tuber flours. Vermicelli obtained less score for physical characteristics than that of sev. This may be due to processing difference of sev and vermicelli.

5.5.2 Cooking Quality

The cooking characteristics of pasta products are the ultimate tests in determining its quality. In general, cooked pasta should be neither 'mushy' nor 'rubbery'. It should retain its shape during cooking and be firm to bite (al dente) (Donnelly, 1991).

Cooking quality of the developed products were analysed through cooking time, water absorption index and bulk density.

5.5.2.1 Cooking Time

Food products are considered as convenient food because of their three proven advantage in time, labour and fuel saving and these factors play a decisive role in conditioning their popularity among consumers. Nagarajan (1993) in his study found out that products which can be cooked using less energy will have a large potential. Cooking time is important in terms of relative speed of cooking and tolerance to overcooking (Donnelly, 1991). 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 of the product is minimal. The product with dioscorea flour take less cooking time than the product with taro flour. Dioscorea give much higher gel strength than that of taro. This may be the reason for low cooking time of the products with dioscorea flour.

5.5.2.2 Water Absorption Index

Water absorption generally depends on starch, protein contents and particle size. The water absorption index of extrudates were relatively low (4.16 to 6.35 g gel/g sample) but increased as the initial moisture of the raw material as well as the extrusion temperature was elevated (Gutkoski and El-Dash, 1999). Water absorption was found to be high in T_2 sev and vermicelli. Vermicelli obtained higher water absorption than sev. This may be due to the variation in particle size of the products. This is in line with the findings of Kulkarni *et al*. (1996) who stated that fine particle size of the product was associated with higher water absorption than coarse particle size. Molecular degradation or breakdown of product was less because of good water holding capacity. Pan *et al.* (1998) indicated that samples with low water absorption display a high degree of molecular degradation.

5.5.2.3 Bulk Density

Bulk density is one of the most common simple measurements which can be used for analysis of solid foods (Potter, 1988). Both linear as well as quadratic term effects of die temperature, screw speed and moisture content were found to have significant effect on bulk density of the extruded product as reported by Jha and Prasad (2003). Bulk density was found to be high in D_1 sev and vermicelli (0.28 and 0.27 respectively). But there was slight variation between bulk density of these two products. This may be due to variation in particle size of the products because bulk density is generally affected by the particle size and the true density of the matter in the products (Kulkarni *et al.*, 1996). Higher bulk density was reported in sev (0.46) by Jacob (1997) and in vermicelli (0.42) by Mathew (1997).

5.5.3 Nutritional and Chemical Qualities

Acceptability, nutrition and cost are the prime elements of good food. Traditional food satisfied these parameters adequately. So, any new food product should be developed based on these principles (Potty, 1993). According to Rao (1992) the consumer expects to meet his nutritional needs as much from processed foods as from the nutritional food when the partially substitutes the later for the former. Amla (1993) feel that while developing new food products, the nutritive value may get lost because of the inappropriate processing methods.

In the present study, protein, starch, crude fibre, total ash and mineral content of the products were analysed.

Protein

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. Result of the study showed that the highest protein value of 23.8 per cent for D_1 sev and lowest value of 21.8 per cent for D_2 vermicelli. Extrusion cooking, makes their protein available with optimal protein quality (Camire *et al.*, 1990) and according to Rajawat *et al.* (2000) extrusion technology not only increases the protein content but also decreases the level of anti-metabolites associated with them. Incorporation of soy flour also increases the protein value of the product. The protein content of sev varied from 21.93 to 23.8 per cent and that of vermicelli varied from 21.80 to 23.45 per cent. While 13.50 g of protein was reported in rice-soya sev by Jacob (1997). The protein content of ready-to-eat products based on cassava was 12.26 g, reported by Mathew (1997). This variation may be due to quantity and quality of ingredients present in the products.

Sev and vermicelli with dioscorea flour obtained higher value of protein than that with taro flour. Protein value of sev was slightly higher than that of vermicelli. This may be due to the loss of protein during the processing of the products. Percentage loss of 7.60 and 8.40 g protein for sweet and savory vermicelli was reported by Mathew (1997). Chellammal (2002) also reported that there is loss of protein during processing of both noodles and macaroni.

Starch

Starch is the most important carbohydrates in human diet. Starch content was found to be higher in D_1 sev (36.74 per cent) and lower in T_1 vermicelli (19.67 per cent). Starch content was found to be higher in products with dioscorea flour than products with taro flour. This may be due to the higher starch content of dioscorea tubers. Starch content of sev varied from 19.92 to 36.74 per cent while that of vermicelli varied from 19.76 to 35.57 per cent. Starch content of sev was slightly higher than that of vermicelli.

Crude fibre

Crude fibre is a mixture of substance which make up the frame work of plant and is composed of cellulose, hemicellulose and lignin of the cell walls. Crude fibre of the product was found to be higher in T_2 sev and lower in D_2 vermicelli. Crude fibre content was found higher in taro based products than dioscorea based products. This may be due to the higher crude fibre content in taro flour than dioscorea flour. Crude fibre content of the sev varied from 0.843 to 1.23 per cent and in vermicelli, it varied from 0.83 to 1.1 per cent. Sev had slightly higher value for fibre than that of vermicelli.

Total Ash

The ash content of a food stuff is the inorganic residue remaining after the organic matter has been burnt away. T_2 sev obtained high value for ash (0.73 %) whereas D_2 sev had less value (0.45 %). Sev and vermicelli with dioscorea flour obtained less value for ash than that with taro flour. The higher mineral content of taro being the main reason for this variation. Sev obtained slightly higher value for ash than vermicelli. High ash content of 0.70 to 0.86 mg was reported in sweet potato and cassava based products by Chellammal (1995).

Minerals

Minerals play a vital role in nutrition and slight changes in the concentration of the important minerals may rapidly endanger life.

Calcium content was found to be high in developed extruded products. High calcium content of 85.90 to 86.90 mg was reported to cassava and sweet potato based extruded products by Chellammal (1995). Both sev and vermicelli obtained almost similar values for calcium, whereas sev obtained slightly higher value for calcium than vermicelli. This may be due to the processing difference of sev and vermicelli. Products with D_1 flour obtained higher value for calcium than others. Dioscorea based products obtained high value than taro based products. This may be due to the increased calcium content of dioscorea than taro. Opara (1999) reported high value of calcium in dioscorea (12-69 mg/100 g) while in taro was found to be 32 mg/100 g (Bradbury, 1988). Calcium content of sev (38-57 mg) was found to be similar to the value reported by Jacob (1997) who Stated that calcium content of the rice soya extruded food was found to be 53.00 mg. The raw materials present in the product may be the reason for the variation in the calcium content of the product.

Phosphorus content of the developed products were analysed and it was found to be higher in the product with T_2 flour than others. Products with dioscorea flour obtained lower value (0.119 – 0.122 g) for phosphorus than the products with taro flour (0.160 – 165 g). This may be due to the lower phosphorus content of the dioscorea flour. This is in line with the findings of Seralathan and Thirumaran (1999) who stated that taro was found to yield the highest amount of phosphorus (68 mg/100 g) than dioscorea (33 mg/100g). Phosphorus content of taro was found to be higher (70 mg/100 g) by Bradburry (1988).

Iron content of the developed extruded products were found to be high in all products. Analysis of iron content of the products revealed that product with taro flour obtained a slightly higher value for iron than that with dioscorea flour. This may be due to the processing loss of the iron. This may be due to the iron content of the dioscorea flour. Seralathan and Thirumaran (1999) reported that iron content of dioscorea (0.69 mg) was slightly higher than that of taro (0.63 mg). Opara (1999) also reported high iron content in dioscorea (0.7 – 5.20 mg/100 g) and iron content of taro was reported as 0.43 mg/100 g (Bradhury, 1988). Both sev and vermicelli with same tuber flour obtained same value for iron. No varietal difference could be found. Iron content of the sev (2.14 – 2.43 mg) was found to be similar to the value reported by Jacob (1997) who found that iron content of the developed product was 2.23 mg. The value obtained for iron content of vermicelli was 2.17 to 2.43 mg. The raw materials or constituents present in the product may be the reason for the variation in iron content.

5.5.4 Organoleptic Qualities

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. For an average consumer, the concept of food quality consists of those related to the sensory characteristics which may be classified in accordance with the human senses of perception as appearance, texture, odour and taste.

Sensory evaluation is designed to reflect common preference, to maintain the quality of food at a given standard, for the assessment of process variation, cost reduction, product improvement, new market development and market analysis (Manay and Shadksharaswamy, 2001).

Quality is the composition of parameters which have significance in determining the acceptability of any product. A number of factors which include yeast strains, fermentation conditions, mineral contents, composition of must and sensory attributes are known to influence the quality (Sandhu and Joshi, 1995). Quality parameters such as appearance, colour, flavour, texture and taste of the developed products were assessed by ten technical experts.

Appearance

The first impression of food is usually visual and a major part of our willingness to accept a food depends on its appearance. It is one of the important factor which influences the consumer's inclination. It is basically the recognition and assessment of properties such as colour, surface structure etc. associated with the product (Sandhu and Joshi, 1995). The appearance of the developed extruded products were assessed by technical experts and the result revealed that the highest score was obtained for the product based on T_2 flour and the lowest score for the product with D_2 and T_1 flour. The score obtained for appearance of sev varied from 3.60 to 4.10 while that of vermicelli was between 3.60 to 3.90. The score obtained for the appearance of the developed sev was lower the value reported by Jacob (1997) who stated that score for appearance of rice-soya sev was found to be 4.50. The presence of tuber flour in the product causes brown colour in the appearance of a product and that might have contributed to the low score.

Colour

Colour, one of the important visual attributes, has been used the judge the overall quality of foods for a very long times. The score obtained for the colour of sev was found to be 3.50 to 4.30, while that of vermicelli was 3.40 to 3.90. The brown colour of the product was not appealing and that may be the reason for its low score. The presence of tuber flour and soy flour in the product was the reason for the brown colour. Colour of noodles was reported to darken with increase in protein content in noodles (Miskelly, 1984). Tania and Rajalakshmi (2004) reported that colour of noodles was affected by taro addition, it produce a brown gray tint colour. Lower acceptability due to brown colour in soy incorporated vermicelli was observed by Mathew (1997).

Flavour

Colour preference is generated by stimulation of the sensory cells by specific compounds present in the food. Food colour is known to influence flavour. In short, "there is more to eating than taste" (Jan, 1990). Flavour analysis of the product revealed that the sev and vermicelli obtained almost similar scores for flavour. The score obtained for flavour of sev varied form 2.90 to 3.60 and a score of 2.80 to 3.40 for vermicelli. Tuber flour had a bland flavour and that might have been the reason for the low score. D_1 sev and vermicelli recorded higher score for flavour and products with T_1 flour recorded lower score.

Texture

Texture constitute a physical property of food stuffs apprehended by the eye, the skin and muscle sense located in the mouth. Texture is a per cent resulting from interaction between food and its consumer (Jack *et al*., 1995). Texture of cooked pasta is a very important factor in shaping the consumer's final evaluation of the product as report by Matz (1991). The extruded products usually have a sticky texture (Kohlwey *et al*., 1995). The score for texture of sev varied from 2.90 to 3.40 whereas Jacob (1997) reported that the score obtained for texture of rice-soya sev was 4.30. This may be due to the difference in ingredients present in the product. Siwawaj (1990) had reported that incorporation of 10, 20 and 30 per cent soy flour gave products of acceptable flavour.

The score obtained for vermicelli varied from 3.30 to 3.60. The highest score of 3.60 was secured for T_2 vermicelli and lowest score of 3.30 was recorded for D_1 and T_1 vermicelli.

Taste

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. The scores for taste for sev ranged from 2.60 to 3.10 while that for vermicelli ranged from 2.90 to 3.30. The score obtained for taste of vermicelli was slightly higher than that of sev. Highest score for taste was obtained for the product with D_1 flour and lowest score for products with T_1 flour. Dioscorea based products obtained higher score for taste than taro based products. Astringent taste was found to be less in dioscorea. This may be the reason for higher score for dioscorea based products.

5.5.5 Storage Stability and Shelf-life Qualities of the Product

Food shelf-life varies with the age and type of ingredients, the process, the package, environmental conditions during distribution and consumer holding. The quality of food ultimately depends on existing distribution and marketing systems and consumer food storage habits (Hurst and Reynolds, 1993). Storage of foods has become so complex that an entire industry has been developed to satisfy the need. The mechanism and the kinetics of food deterioration can be controlled by the storage technique applied (Varsanyi, 1993).

In the present study, shelf-life of both sev and vermicelli was ascertained by packing in polythene cover, sealed and studied for a period of a three months. Polythene bags have better keeping quality in view of economy and transparency.

5.5.5.1 Assessment of Moisture in Stored Products

Moisture is one of the important parameters which determine the shelf-life quality of any food product. Most stored products are considered to be safe in storage at a particular moisture content, low moisture is highly important for longer storage period (Shankar, 1993).

When considering the two products, 'sev and vermicelli', it could be observed that there was an increase in moisture content throughout the storage period of three months. Sev had slightly higher moisture content as compared to vermicelli. The increase in moisture content may be due to the water absorption capacity of polythene bags. This observation is in line with the findings of Beerah *et al*. (1990) who had observed a steady increase in the moisture content throughout the storage period of six months from the initial level of 11.00 per cent to 13.00 per cent of cold stored potato stored in polythene bags. Mathew (1997) also reported that there was an increase in moisture content of the vermicelli stored in the polythene bags throughout the storage period of six months form the initial level of 10.50 to 11.65 per cent.

5.5.5.2 Assessment of Acidity in Stored Products

The stored products were analysed once in three months for any change in acidity. It was observed that there was no change in acidity throughout the storage of three months. A similar result was also reported by Chellammal (1995) in stored noodles and macaroni.

5.5.5.3 Insect Infestation

The assessment of the incidence of insect pests in the stored products revealed that there was no insect infestation in the extruded products during the storage period of three months. A similar result was also reported by Mathew (1997) who observed that there was no insect infestation in stored vermicelli during the storage period of a six months.

5.5.5.4 Assessment of Microbial Growth of Stored Products

Processed foods which are stored and consumed after a period of storage require certain microbial criteria to be employed to ensure their quality and safety. Many organisms causing food borne illness may grow in processed foods. The microbiological load in the packaged food has a significant effect on the quality of the final product. A high microbial load, and temperatures higher than recommended for a particular food can reduce the shelf-life of a product. According to Sankaran (1993) several factors such as raw material quality, storage temperature, storage containers, process employed, the environment in which it is processed etc. will have an effect on the microbiological quality of processed foods. Since processed foods and ready-to-eat foods provide ample scope for contamination with spoilage and pathogenic microorganisms, the microbiological quality was assessed.

The results revealed that the products were free from bacterial attack. Some fungi and yeast colonies were observed in the products after three months of storage. Fungus observed in the products were *Rhizopus nigaricans* and *Aspergillus niger*. Chellammal and Prema (1997) reported that sweet potato noodles stored in glass and plastic had no bacterial growth, but fungal growth could be observed in these samples, but it was within the limit specified by ISI.

5.5.6 Type Tests Administered to the Developed Products

The Bureau of Indian Standards has specified certain type tests for various products to maintain quality during marketing.

Estimated values of different type of tests were compared with the ISI specification. The results showed that the moisture content of the extruded products were slightly lower in all the products than the ISI specification. The lower moisture content of the products is beneficial since it may improve the keeping quality of the products. Moisture content of 10.00 per cent was reported for extruded products, vermicelli by Thirumaran (1993). Chellammal (2002) reported a moisture content of nine per cent for noodles and macaroni. Jacob (1997) reported that rice – soya based extruded products showed a moisture content of 8.20 per cent, the ISI specification was 11 per cent.

Estimation of total ash content of the product showed that the ash content of all the products were slightly lower than ISI specification except T_2 vermicelli. T_2 vermicelli had higher value for total ash than ISI specification. Taro based products had higher ash content than dioscorea based product. Mineral content was found to be higher in taro than dioscorea as reported by Seralathan and Thirumaran (1999). This may be the reason for the higher ash content in taro based products.

The acid insoluble ash, gives information regarding the inorganic salt present in the product. The acid insoluble ash present in the product were lower than the ISI specification. According to Chellammal (2002) the acid insoluble ash in sweet potato based extruded products was higher than the ISI specification.

Total protein of the product was found to be higher than the ISI specification (10.00 %). The incorporation of soy flour in the products may be the reason for this higher value. 11.20 per cent of protein was observed for soy-incorporated vermicelli by Thirumaran (1993). Generally processed foods were not considered as protein rich foods. By the addition of various ingredients the protein content of the product may change.

The total solids in gruel will give information regarding the water soluble ingredients and percentage of cooking loss on any product. Results revealed that the total solids in gruel was found to be lower in all product except T_1 vermicelli. For T_1 sev and T_2 vermicelli, the total solids in gruel was found to be same to the value specified by the ISI. Among the products, vermicelli exhibited higher processing techniques may be the reason for this variation.

5.6 STANDARDISATION OF RECIPES

5.6.1 Preference Studies on Developed Recipes

During the development of new food product or the reformation of existing products, the identification of changes caused by processing methods, by storage or by the use of new ingredients, their acceptability could be assessed by conducting preference test on a large number of consumers (Watts *et al.*, 1989).

The preference scores of technical experts evidently showed that most of the experts considered sweet stick, stuffed bread roll, patties were the most ‘like very much’ product and pakoda was rated much negatively (40 %). Appearance and texture of the pakoda was the reason for this low score. All the quality parameters were found to be good in stuffed bread roll, patties and sweet stick. So these products obtained highest score for preference.

The preference score of the college students for the developed recipes showed that most of the student scored stuffed bread roll and patties as ‘like extremely’ products and pakoda rated negatively by a small group (10 %). Most of the recipes were scored positively by the students. Now a days college students prefer novel foods and that may be the reason for the positive scores.

The preference score among working women showed that most of the women scored patties as ‘like extremely’ product and pakoda was scored negatively (30 %). All quality parameters of patties was good. It was the reason for obtaining high score for patties. Taste of the pakoda was good but it appearance and texture was not acceptable. It was the reason for low score in pakoda. Stuffed bread roll, burfi, samosa, coconut sev and burger were also rated as like extremely by the women.

The preference rating of farm women for the recipes showed that most of them considered stuffed bread roll, sev halwa, sweet stick, coconut sev were the ‘like extremely’ product and a very small group of women scored pakoda as negatively (20 %). All the other products were scored positively by the women. All the quality parameters of these products were found to be good, this was the reason for the maximum score obtained for the products. Majority of the recipes were scored positively by these groups. Stuffed bread roll and patties were preferred mostly by these groups.

Summary

6. SUMMARY

The present study on "Formulating extruded food based on dioscorea and taro" was undertaken with the objective to ascertain their acceptability, nutritional and shelf-life qualities. The study comprised of selection of tubers, standardisation of flour and assessing the nutritional, chemical, functional and shelf-life qualities, formulation of extruded products and assessing the quality of products through physical characteristics, cooking quality, nutritional and chemical qualities, organoleptic and shelf-life qualities and standardisation of recipes with the developed product.

Generally carbohydrate and starch rich raw materials will be selected for processing of extruded foods. Dioscorea and taro are rich in carbohydrate and starch. Hence the tubers were selected for the development of the products based on its carbohydrate and starch content. Two varieties in each Sree Priya and Sree Dhanya of dioscorea and Sree Rashmi and Thamarakkannan of taro were selected for the study.

Flour prepared from dioscorea and taro were analysed for nutritional, chemical, functional and shelf-life qualities.

Sree Priya (D_1) had the highest protein, starch and crude fibre content. Total ash content was greater in Thamarakkannan (T_2) while moisture was higher in Sree Dhanya (D_2). Acidity was higher in dioscorea varieties as compared to taro varieties. In dioscorea, Sree Priya was found to be superior in protein, starch, crude fibre and total ash than Sree Dhanya (D_2). In taro, Thamarakkannan (T_2) was found to be superior in these characters when compared to Sree Rashmi (T_1).

In functional qualities yield ratio was higher in Thamarakkannan and lower in Sree Dhanya while processing loss was much less in

Thamarakkannan. Yield ratio of taro was significantly higher than that of dioscorea while processing loss was significantly higher in dioscorea.

The shelf-life qualities of the flour revealed that Sree Priya (D_1) and Thamarakkannan (T_2) had the highest shelf-life and Sree Dhanya (D_2) and Sree Rashmi (T_1) had the lowest shelf-life. There was a steady increase in moisture content throughout the storage period irrespective of containers. Moisture content was higher in flour stored in polypropylene covers. The percentage increase of moisture was less in taro than in dioscorea. Acidity was higher in dioscorea varieties. There was no change in acidity throughout the storage period of three months. There was no significant difference between varieties and containers. Observation on insect infestation revealed that there was no insect infestation in stored flours irrespective of type and varieties of tubers during the storage period. Microbial quality of the stored tuber flour was analysed and the data revealed that microbial count was high in flour stored in polypropylene covers. Dioscorea flour had less microbial attack than taro flour.

Dioscorea and taro flour were the main ingredients for the formulation of the sev and vermicelli. To increase the protein content and in binding capacity maida, rice and soya flour were tried along with tuber flour. Sixteen combinations with the above food ingredients were tried for the development of the product. The principle governing the selection of the suitable combination were yield ratio, nutritional quality, extrusion behaviour, cost and overall acceptability.

Yield ratio of the combinations were assessed by comparing weight of sample with the weight of the raw ingredients. Nutritional quality was assessed through analysing protein content of the combinations and also through computing the energy and protein energy ratio of each combinations. Extrusion behaviour was assessed through observation by ten technical experts. Cost of the different combinations were computed according to the market price of the ingredients. The overall acceptability of the combinations were assessed through organoleptic evaluation with a panel of selected judges. The combination which got the highest scores for all these parameters has selected for product development and the best combination was maida, tuber flour and soya flour in the proportion of 50 : 40 : 10. 20 kg of sev and 20 kg of vermicelli were developed with this combination.

The physical characteristics such as fineness, shape, uniformity of strands, packaging quality and tensile strength were found to be good in products with D_1 (Sree Priya) and T_2 (Thamarakkannan). Taro based sev and vermicelli secured lower scores for all the parameters than dioscorea based products. Though there was difference in the quality parameters, it was not statistically significant.

The cooking quality of the developed product was ascertained through cooking time, water absorption index and bulk density and it was found to be good in products with D_1 and T_2. Water absorption index was higher in products with T_2 while bulk density was higher in D_1 products. Bulk density of products with taro flour had lower value than dioscorea products. But the difference in water absorption and bulk density was not statistically significant.

Nutritional and chemical qualities of the product revealed that products with D_1 (Sree Priya) had the highest protein and starch content while crude fibre and total ash content was higher in products with T_2 (Thamarakkannan). Significant difference was present between tubers and between varieties. Nutritive value of sev was slightly higher than that of vermicelli.

In mineral analysis, calcium content was found to be higher in products with D_1 while phosphorus and iron content was higher in T_2 products. Eventhough there was difference in mineral contents it was not statistically significant.

The organoleptic qualities of the developed products were analysed by a panel of 10 judges. For appearance and texture, high score was obtained for product with T_2 while for colour, flavour and taste high score was obtained in D_1 products. Dioscorea based products secured higher scores than taro based products. Organoleptic qualities of sev was slightly higher than that of vermicelli. Though there was difference in the quality parameters it was not statistically significant.

Shelf-life qualities of the products mainly depends upon its moisture content, acidity, insect infestation and microbial evaluation. Moisture analysis of the products showed that there was a steady increase in the moisture level of the products during storage period. Products with dioscorea flour had higher moisture content than products with taro flour. D_1 and T_2 products had lower moisture level than D_2 and T_1 products. Statistically there was no significant difference in the moisture level of the products prepared with different tuber four. Assessment of acidity in stored products revealed that there was no change irrespective of the products, tubers and storage period. Analysis of insect infestation on the stored products showed that there was no insect infestation in sev and vermicelli upto three months. Microbial analysis of the product noticed that almost all products were free from bacterial attack. It was observed that sev and vermicelli with D_1 and T_2 flour were more microbiologically safer than D_2 and T_1 products. Sev and vermicelli prepared with D_1 and T_2 had more shelf-life than D_2 and T_1 products with less microbial contamination and less moisture content.

Type tests administered to the development products showed that all quality parameters of the products were within the limits specified by ISI.

Fifteen recipes with the developed sev and vermicelli such as stuffed bread roll, burfi, sugar stick, sev halwa, coco stick, pakoda, patties, sweet stick, samosa, payasam, sev pak, coconut sev, burger, sev madhuri and sev toffee were standardised in the laboratory. The acceptability of the recipes were assessed among technical experts, college students, working women and farmwomen. All the groups rated majority of the recipes positively. Stuffed bread roll and patties were preferred mostly by these groups.

From the above study, it can be concluded that it is possible to develop extruded foods based on minor tubers, dioscorea and taro, with good nutritional, organoleptic and shelf-life qualities and thereby value addition could be done to these tubers. Novel recipes could also be standardised through these products.

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Appendices

APPENDIX – I

Chemical score of different combinations of the extruded food

Ingredients	Quantity (g)	Arginine	Histidine	Lysine	Tryphtophan	Phenylanine	Tyrosine	Methionine	Cystine	Theronine	Leucine	Isoleucine	Valine
Maida	60	114	72	66	36	174	78	54	84	90	240	132	144
Dioscorea	30	144	36	84	21	90	60	30	-	66	120	69	87
Rice flour	10	48	13	23	8	28	29	15	9	23	50	30	38
Total	100	306	121	173	65	292	167	99	93	179	410	231	269
Chemical score = 72.22													
Maida	60	114	72	66	36	174	78	54	84	90	240	132	144
Dioscorea	30	144	36	84	21	90	60	30	-	66	120	69	87
Soya flour	10	45	15	40	8	30	21	8	10	24	48	32	32
Total	100	303	123	190	65	294	159	92	94	180	408	233	263
Chemical score = 72.22													
Maida	50	95	60	55	30	145	65	45	70	75	200	110	120
Dioscorea	40	192	48	112	28	120	80	40	-	88	160	92	116
Soya flour	10	45	15	40	8	30	21	8	10	24	48	32	32
Total	100	332	123	207	66	295	166	93	80	187	408	234	268
Chemical score = 73.33													
Maida	50	95	60	55	30	145	65	45	70	75	200	110	120
Dioscorea	40	192	48	112	28	120	80	40	-	88	160	92	116
Rice flour	10	48	13	23	8	28	29	15	9	23	50	30	38
Total	100	335	121	190	66	293	174	100	79	186	410	232	274
Chemical score = 73.33													
Maida	60	114	72	66	36	174	78	54	84	90	240	132	144
Taro	30	141	33	90	33	96	69	24	48	84	153	81	114
Rice flour	10	48	13	23	8	28	29	15	9	23	50	30	38
Total	100	303	118	179	77	298	176	93	141	197	443	243	296
Chemical score = 85.56													
Maida	60	114	72	66	36	174	78	54	84	90	240	132	144
Taro	30	141	33	90	33	96	69	24	48	84	153	81	114
Soya flour	10	45	15	40	8	30	21	8	10	24	48	32	32
Total	100	300	120	196	77	300	168	86	142	198	441	245	290
Chemical score = 85.56													
Maida	50	95	60	55	30	145	65	45	70	75	200	110	120
Taro	40	188	44	120	44	128	92	32	64	112	204	108	152
Soya flour	10	45	15	40	8	30	21	8	10	24	48	32	32
Total	100	328	119	215	82	303	178	85	144	211	452	250	304
Chemical score = 91.10													
Maida	50	95	60	55	30	145	65	45	70	75	200	110	10
Taro	40	188	44	120	44	128	92	32	64	112	204	108	152
Rice flour	10	48	13	23	8	28	29	15	9	23	50	30	38
Total	100	331	117	198	82	301	186	92	143	210	454	248	310
Chemical score = 91.10													

APPENDIX – II

Scorecard for physical characteristics of the extruded product

Product :   Tested by:
Date   :   Age   :

1. Fineness

5	4	3	2	1
Very fine				Not at all fine

2. Shape

5	4	3	2	1
Uniform stick				Ununiform stick

3. Strands

5	4	3	2	1
Round strands				Uneven strands

4. Packaging quality

5	4	3	2	1
Highly suitable				Not at all suitable

5. Tensile strength

5	4	3	2	1
Withstand weight				May not withstand weight

APPENDIX – III

Scorecard for organoleptic qualities of the extruded food

Product :
Date :

Tested by:
Age :

1. Appearance
   - Excellent ☐
   - Good ☐
   - Satisfactory ☐
   - Mediocre ☐
   - Poor ☐
2. Colour
   - Light brown ☐
   - Brown ☐
   - Dark brown ☐
   - Blackish brown ☐
   - Black ☐
3. Flavour
   - Excellent ☐
   - Good ☐
   - Satisfactory ☐
   - Mediocre ☐
   - Poor ☐
4. Texture
   - Soft ☐
   - Spongy ☐
   - Hard ☐
   - Very hard ☐
   - Shiny ☐
5. Taste
   - Excellent ☐
   - Good ☐
   - Satisfactory ☐
   - Mediocre ☐
   - Poor ☐

APPENDIX – IV

Scorecard for preference test

Sl. No.	Name of recipes	Like extremely	Like very much	Like moderately	Like slightly	Neither like or dislike	Dislike slightly	Dislike moderately	Dislike very much	Dislike extremely
1	Stuffed bread roll									
2	Burfi									
3	Sugar stick									
4	Sev halwa									
5	Coco stick									
6	Pakoda									
7	Sev patties									
8	Sweet stick									
9	Samosa									
10	Payasam									
11	Sev pack									
12	Coconut sev									
13	Burger									
14	Sev madhuri									
15	Toffee									

APPENDIX – V

RECIPES

1. Taro sev stuffed bread roll

1. For stuffing		
Cooked sev	–	60 g
Cooked vegetables	–	60 g
2. Bread slices	–	4
3. Oil	–	for frying

Dampen bread slices on both sides with water carefully squeeze out liquid by flattening each slice between palms of our hands. Divide stuffing into four portions and place in the centre of each bread slice. Roll up the slice and seal edges together. Deep fry in hot oil till golden brown and crisp. Serve with chutney or tomato sauce.

2. Taro sev burfi

Sev	-	200 g
Milk	-	240 ml
Raisins	-	20 g
Cardamom	-	2 nos.
Dalda/ghee	-	60 g
Sugar	-	200 g
Grated coconut	-	75 g

Cook the sev in water. Add grated coconut in boiled milk and stir well. Add cooked sev to it. Take half of the ghee in another vessel, heated and then added the sev-coconut mixture into the ghee and stirred continuously. Add little corn flour into it. Add remaining ghee along the side of the vessel. When the burfi starts coming away from the edges of the pan, add the roasted raisins, heat five minutes and then pour on to greased plate. After it cools cut into small pieces.

APPENDIX – V Continued

3. Taro sev sugar stick

Sev	-	200 g
Sugar	-	100 g
Cardamom	-	1 no
Ghu	-	10 ml

Roast the sev in a pan and keep it aside. Make thick sugar syrup. Add crushed cardamom and roasted sev and stir well. When it reach the crystal stage immediately take out the sugar stick from the vessel.

4. Dioscorea sev halwa

Sev	-	250 g
Sugar	-	160 g
Ghee	-	120 g
Cashew nuts	-	25 g
Raisins	-	20 g
Powdered cardamom	-	5 g
Saffron	-	a few strands
Milk	-	250 ml
Warm milk	-	5 ml

Soak the saffron in warm milk and keep aside. Heat 5 ml ghee in a shallow pan and roast the broken sev. Add milk into it and cook well. In a separate pan, make a thin sugar syrup. Pour this into the cooked sev and stir continuously to mix well. Add 15-20 g of corn flour to this and mix well. Add ghee little by little along with cashew nuts, raisins and powdered cardamom. Cook till the ghee starts separating from the halwa. Add saffron just before removing from fire. Serve warm.

5. Dioscorea sev coco stick

Sev	-	200 g
Sugar	-	120 g
Coco powder	-	30 g
Ghee / oil	-	10 ml

Heat ghee in a shallow pan and roast the broken sev. In a separate pan, make this sugar syrup. Add coco powder into it and mix well till thick syrup obtained. Then add roasted sev and stir continuously. When the crystallization of sugar starts, take out from the pan and keep for cooling.

6. Taro vermicelli pakoda

Vermicelli	-	100 g
Maida	-	100 g
Finely chopped vegetables (carrot, beans, cabbage)	-	100 g
Finely chopped onion, ginger, green chilli, coriander leaves	-	50 g
Hot oil	-	30 g
Salt	-	to taste
Oil -	-	for frying

In a basin put the maida, vegetables and salt, pour hot oil into it and make soft dough. Add brokened sev and mix carefully. Make small balls of dough and fry in hot oil till crisp. Remove from fire and drain away excess oil before serving.

APPENDIX – V Continued

7. Dioscorea sev patties

Boiled and mashed potato	-	100 g
Sev	-	50 g
Onion	-	20 g
Green chillies	-	8 g
Egg	-	1 no.
Bread crumbs	-	40 g
Salt and spices	-	to taste
Ghee	-	for frying

Add spices, cooked sev, green chillies and onion into mashed potato. Mix carefully and divide mixture into small balls, flatten into round shape. Dip in egg and coat with bread crumbs. Shallow fry to golden brown colour and serve hot with chutney.

8. Dioscorea sev jaggery stick

Sev	-	200 g
Jaggery	-	100 g
Ghee/oil	-	10 ml

Roast broken sev in heated ghee/oil. Make jagery syrup, add roasted sev to it and stirred continuously. When thejaggery forms crystals on top of the sev, take out from the pan immediately and allow to cool.

9. Dioscorea sev samosa

Maida	-	200 g
Sev	-	250 g
Carrot	-	25 g
Beans	-	25 g
Cabbage	-	10 g
Dalda	-	45 g

Salt	-	to taste
Green chilli	-	10 nos.
Mustard	-	5 g
Onion (small)	-	6 nos.
Lemon juice	-	30 g
Turmeric powder	-	2 g
Oil	-	for frying.

Add little dalda / oil, salt and water to maida and make dough. Covered it with wet cloth and kept for half an hour. Cook broken sev along with salt, turmeric powder and water. Heat oil and season mustard. Saute onion and green chilli, then add the vegetables and cook well. Add cooked sev and lemon juice. Make small ball and roll it. Put sev-vegetable mixture in its centre, fold into triangle shape. Deep fry in oil. Serve hot.

10. Taro vermicelli payasam

Vermicelli	-	480 g
Ghee	-	45 g
Water	-	500 ml
Sugar	-	480 g
Cashew nuts	-	20 nos
Cardamom	-	5 no
Milk	-	1000 ml

Break vermicelli into small pieces and roast in 30 ml of ghee. Add water and cook. When vermicelli is cooked add milk and allow to boil for sometime stirring occasionally. Add sugar and simmer for sometime. Roast cashew nuts in the rest of the ghee and add to payasam. Sprinkle powdered cardamom and remove from fire. Serve either hot or cold.

10. Taro sev pak

Sev	-	200 g
Maida	-	150 g
Ghee	-	60 g
Cashew nuts	-	30 g
Rose water	-	5 drops
Sugar	-	500 g
Corn flour	-	5 g

Cook the broken sev with water. Roast maida with ghee. Mix cooked sev and roasted maida. Boil sugar with water. When it become thread stage add sev-maida mix into it along with ghee. Add corn flour and mix carefully. When the pak starts coming away from the edges of the pan, add rose water and then pour them on to a greased plate. Flatten the top of the mixture with a laddle. After it cools, cut into pieces and decorate with the cashew nuts on the top of the each pieces.

12. Taro coconut sev

Sev	-	250 g
Scraped coconut	-	90 g
Black gram dhal	-	5 g
Dry red chillies	-	15 g
Green chillies	-	3 nos.
Cashew nuts	-	25 g
Oil	-	30 g
Ghee	-	10 g
Curry leaves	-	15 g
Asafoetida	-	1 g
Salt	-	to taste

APPENDIX – V Continued

Soak and wash and drain black gram dhal. Chop cashew nuts in halves and red chillies into two or three bits. Chop green chillies into five or six bits each. Pour ghee and oil together in a ‘kadhai’, heat it and splutter mustard, red chillies and asafoetida, add cashew nuts. When it turns golden brown add black gram dhal and fry till it is dry. Add coconut scrapings and fry till it is light brown in colour. Add curry leaves finally. Add this to cooked cooled sev and add table salt and mix well.

13. Dioscorea vermicelli burger

Vermicelli	-	100 g
Salt	-	to taste
Pepper	-	to taste
Corn flour	-	20 g
Egg	-	2 nos.
Sauce	-	15 – 20 g
Bread crumbs	-	100 g
White flour	-	25 g
Oil	-	100 ml

Season the sev with salt, pepper and sauce. Mix in the corn flour and egg yolk and bind together to form hamburger patties. Cover the patties with seasoned flour, then dip in beaten egg white and finally coat with bread crumbs. Shallow fry till medium brown in colour. Serve hot.

14. Dioscorea sev madhuri

1. Sev	-	120 g
Sugar	-	14 g
Water	-	100 ml
2. Sugar	-	480 g
Water	-	120 ml
Cloves	-	4 nos.

Cinnamon (1" length)	-	1 piece (2 g)
3. Grated coconut	-	480 g
4. Milk powder	-	120 g
5. Corn flour	-	20 g

Sev cooked along with sugar and water. Add grinded cloves and cinnamon in the sugar syrup. When it becomes thread – like consistency add coconut and stir continuously. Then add cooked sev and corn flour. When it become a thick stage take out from the fire and add milk powder carefully. Pour on to a greased plate and allow to cool. Then cut into small pieces.

15. Dioscorea vermicelli toffee

Vermicelli	-	240 g
Sugar	-	240 g
Coconut	-	90 g
Ghee	-	120 g
Raisins	-	25 g
Cashew nuts	-	25 g
Corn flour	-	20 g

Grate the coconut and extract three cups of milk from it in three different consistency. The first cup should be thick milk, without any water added to it. The second and third cups should have water added to the grated coconut. Heat two table spoon full of ghee in a pan over slow fire and roast the cashew nuts and raisins till the nuts are golden brown. In the same ghee put vermicelli and fry. Add the second and third extract of coconut milk to it, add sugar and keep stirring with a long, flat ladle until it begins to thicken. Add remaining ghee and first coconut milk. When the toffee starts coming away from the edges of pan, add the roasted cashew nuts and raisins and pour on to greased plate. After it cools cut into diamond shaped wedges.

APPENDIX – VI

Cost – benefit ratio

Fixed cost

Sev - Rs. 24 / kg

Vermicelli - Rs. 28/kg

Variable cost

Particulars	Quantity (g)	Value
Maida	500	9.25
Sree Priaya (D_1)	400	5.60
Soya	100	1.80
Overhead charges	-	3.33
Total		19.98

Particulars	Quantity (g)	Value
Maida	500	9.25
Sree Dhanya (D_2)	400	6.00
Soya	100	1.80
Overhead charges	-	3.41
Total		20.46

Particulars	Quantity (g)	Value
Maida	500	9.25
Sree Rashmi (T_1)	400	7.20
Soya	100	1.80
Overhead charges	-	3.65
Total		21.90

Particulars	Quantity (g)	Value
Maida	500	9.25
Thamarakannan (T_2)	400	8.00
Soya	100	1.80
Overhead charges	-	3.81
Total		22.86

FORMULATING EXTRUDED FOODS BASED ON DIOSCOREA (*Dioscorea rotundata* Poir) AND TARO (*Colocasia esculenta* (L.) Schott.)

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Abstract of the
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for the degree of

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ABSTRACT

The study on "Formulating extruded foods based on dioscorea and taro" was undertaken to utilize dioscorea and taro for the development of the extruded products to ascertain their acceptability, nutritional and shelf-life qualities.

The nutritional and chemical qualities of four tuber flour *i.e.,* Sree Priya, Sree Dhanya, Sree Rashmi and Thamarakkannan were evaluated. Sree Priya had the highest protein, starch and crude fibre content. Thamarakkannan (T_2) exhibited the highest total ash content while moisture content was higher in D_2 (Sree Dhanya). Acidity was found to be higher in dioscorea variety. In dioscorea, Sree Priya (D_1) was found to be the superior in protein, starch, crude fibre and total ash than Sree Dhanya. In taro, Thamarakkanan (T_2) was found to be superior in the above characters when compared to Sree Rashmi (T_1).

Yield ratio was higher in Thamarakkannan and lower in Sree Dhanya while processing loss was much less in Thamarakkannan. Yield ratio of taro was significantly higher than that of dioscorea. Processing loss was significantly higher in dioscorea.

The storage study of the flour revealed that there was a steady increase in moisture content of the flour. Sree Priya (D_1) and Thamarakkannan (T_2) had highest shelf life than Sree Dhanya (T_2) and Sree Rashmi (T_1). There was no change in acidity throughout the storage period of three months. There was no significant difference between varieties and containers. There was no insect infestation upto three months of storage period irrespective of containers and flours. Microbial quality of the stored flour was analysed and the data revealed that microbial count was less in flour stored in PET containers than

polypropylene covers. Dioscorea flour had less microbial attack than taro flour.

Dioscorea and taro flours were the main ingredients for the formulation of the sev and vermicelli. To increase the protein content and the binding capacity maida, rice flour and soya flour were tried along with tuber flour. Sixteen combinations with above ingredients were tried for product development and the principle governing the selection of the suitable combinations were yield ratio, nutritional quality, extrusion behaviour, cost and overall acceptability.

The combination with maida, tuber flour and soya flour in proportion 50 : 40 : 10 got the maximum score and this combination was selected for the development of the products, ‘sev and vermicelli’.

The physical characteristics such as fineness, shape, uniformity of strands, packaging quality and tensile strength of the D_1 and T_2 products were found to be good. Dioscorea based products secured higher scores for all the parameters than taro based products. Though there was difference in the quality parameters, it was not statistically significant.

The cooking characteristics such as cooking time, water absorption index and bulk density was found to be good in D_1 and T_2 products. But the difference in these characters was not statistically significant .

Nutritional and chemical qualities of the product showed that protein and starch content was found to be higher in Sree Priya (D_1) products while crude fibre and total ash content was higher in product with T_2 (Thamarakkannan). Significant difference was present between tubers and between varieties. Minerals like phosphorus and iron content was higher in D_1 products. Eventhough there was difference in mineral contents it was not statistically significant.

Organoleptic qualities such as appearance and texture was found to be higher in T_2 products while other quality parameters were found to be higher in D_1 products. Dioscorea based products secured higher scores than taro based products. Though there was difference in the organoleptic qualities, it was not statistically significant.

Shelf-life studies of the products revealed that there was steady increase in the moisture level of the products during the storage period. Products with dioscorea flour had higher moisture content than products with taro flour. While there was no change in acidity irrespective of the products, tubers and storage period. There was no insect infestation in stored products throughout the storage period. Microbial analysis of the products showed that products with D_1 and T_2 were more microbiologically safer than D_2 and T_1 products. Sev and vermicelli prepared with D_1 and T_2 had more shelf-life than D_2 and T_1 products with less moisture content and less microbial contamination.

Type tests administered to the developed products showed that all the values were below the values specified by the ISI.

Fifteen recipes with sev and vermicelli were formulated and standardised in the laboratory such as stuffed bread roll, burfi, sugar stick, sev halwa, coco stick, pakoda, patties, sweet stick, samosa, payasam, sev pak, coconut sev, burger, sev madhuri and sev toffee.

The acceptability of the fifteen recipes were assessed among technical experts, college students, working women and farm women. Majority of the recipes were scored positively by these groups. Stuffed bread roll and patties were preferred mostly by these groups.

From the above observations, it can be concluded that, it is possible to develop extruded food based on minor tubers dioscorea and taro with good nutritional, organoleptic and shelf-life qualities and thereby value addition could be done to these tubers. Novel recipes could also be standardised through these product.