VALUE ADDITION AND EVALUATION OF NUTRITIONAL QUALITY IN ELEPHANT FOOT YAM
(*Amorphophallus paeoniifolius* (Dennst.))

BY

SINI. S

THESIS

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DECLARATION

I hereby declare that this thesis entitled **"Value addition and evaluation of nutritional quality in elephant foot yam (*Amorphophallus paeoniifolius* (Dennst.))"** 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.

Sini

Vellayani,
13.06.2002

SINI. S
(99-12-22)

CERTIFICATE

Certified that this thesis entitled **"Value addition and evaluation of nutritional quality in elephant foot yam (*Amorphophallus paeoniifolius* (Dennst.))"** is a record of research work done independently by Ms. Sini. S (99-12-22) 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.

Vellayani,
13-06-2002

Dr. Philipose Joshua
(Chairman, Major Advisor),
Associate Professor and Head
Department of Processing Technology,
College of Agriculture,
Vellayani,
Thiruvananthapuram.

APPROVED BY

CHAIRMAN

Dr. PHILIPOSE JOSHUA
Associate Professor and Head,
Department of Processing Technology,
College of Agriculture, Vellayani
Thiruvananthapuram- 695 522

MEMBERS

1. **Dr. VIJAYARAGHAVAKUMAR,**
   Associate Professor,
   Department of Agricultural Statistics,
   College of Agriculture, Vellayani,
   Thiruvananthapuram-695 522

2. **Dr. THOMAS GEORGE,**
   Assistant Professor,
   Department of Soil Science and
   Agriculture Chemistry,
   College of Agriculture, Vellayani,
   Thiruvananthapuram-695 522

3. **Dr. B. T. KRISHNAPRASAD,**
   Assistant Professor,
   Department of Plant Physiology,
   College of Agriculture, Vellayani,
   Thiruvananthapuram-695 522

EXTERNAL EXAMINER

DR. V CHIKKA SUBBANNA
PROFESSOR
DEPT. OF HORTICULTURE
UAS, GKVK, BANGALORE

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SINI.S.

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INTRODUCTION

1. INTRODUCTION

Elephant Foot Yam (*Amorphophallus paeoniifolius* (Dennst.)) is a tuberous, stout, indigenous herb cultivated almost throughout India, belonging to the family Araceae. The crop comes up well under shadey conditions in the coconut gardens of Kerala.

The nutritive value of this minor tuber crop is considered to be far better than popular tubers like cassava or potato because they contain protein besides carbohydrates. The economic part, corm can be consumed after boiling and also ideal for making chips. Besides being a nutritious food, it has medicinal properties too. In Ayurveda it is described as 'The King of Tubers'. This tuber is widely described as a drug in the context of dietetics and medicine. It cures piles, dyspepsia, used in spleenic disorders and gastric problems.

Elephant foot yam is conventionally grown in the homesteads of Kerala. The corms can be easily stored without rotting for five to six months under ambient conditions, and thus become a good stand-by in households. Considering the least cost, better nutritive value, good medicinal properties and ease of production, it is imperative that the popularisation of this crop will go a long way in aleviating hunger. This economically cheaper food source should be tapped to decrease the pressure on cereals like rice and wheat to feed the population.

There are many opportunities to improve traditional uses of root crops with a wide range of new food products and feed markets, particularly in the rapid urbanising societies of the developing world. There exists vast potential for *Amorphophallus* in the production of value added products that will become popular and widely used. Large scale production of these value added products would benefit farmers, food processors and consumers. Farmers can receive better markets for their produce, food processors can take advantage of the relative cheapness and nutrient rich raw material and consumers will be offered low priced nutritious food products.

A study of nutritive value is very essential while trying to improve the processing and utilisation of under exploited crops. The present investigation "Value addition and evaluation of nutritional quality in Elephant Foot Yam" (*Amorphophallus paeoniifolius* (Dennst.)) was carried out with the following objectives.

1. To evaluate the nutritional qualities of *Amorphophallus* cultivars
2. To examine the potentiality to develop value added products.
3. To assess the storage and shelf life of the *Amorphophallus* products

REVIEW OF LITERATURE

2. REVIEW OF LITERATURE

Research work on *Amorphophallus* is meagre as compared to other tropical root crops. Efforts have been made to collect the available literature on root and tuber crops in general and *Amorphophallus* in particular and whatever information is lacking, relevant work on other tuber crops has been reviewed.

2.1 Importance and nutritional significance

2.1.1 Importance of elephant foot yam

Elephant foot yam has played an important role in the food habits and economy of many countries.

According to Massal and Barrau (1955) edible aroids make up a major portion of the diet of the people in the Pacific and Oceania Islands and are widely consumed as food in Africa and in many parts of Asia. Gaillard (1984) reported that there has been a marked decline in the cultivation and utilization of edible aroids. Part of this decline has been due to storable cereals and cereal based convenience foods. Another reason is the displacement of one culture by another, which often result in the attitude that introduced foods are superior to local foods

Shanmughavelu *et al.* (1987) has opined that minor tuber crops have some quantity of protein besides carbohydrates. Minor tuber crops are low cost, calorie dense foods, which are suitable in the Indian situation to alleviate calorific malnutrition.

Being concentrated sources of energy, tuber crops are utilized as a component of human food in almost all countries where these are cultivated Balagopalan *et al.*, (1988). Maga (1992) stated that taro is a root crop since ancient times and 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.

According to Edison (1999) 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. Among these crops the most important are cassava, sweet potato, yams and aroids. They form the most important staple or subsidiary food for about 20 per cent of world's population. They have high biological efficiency and highest dry matter production than all other crops. Most striking aspect is that they supply a cheap source of food and energy to the weaker sections of the people. They are also rich in different nutrients, vitamins and minerals.

2.1.2 Nutritional significance

The nutritional quality of *Amorphophallus* has been studied by several scientists and was found to have high quantities of starch and fair amounts of proteins, vitamins and minerals.

Steamed corms of colocasia that contain 30 percent starch and three per cent sugar constitute a high- energy food. The starch grains are among the smallest in food plants, and the tuber is more easily digested than other starchy foods. It is also a good source of calcium and phosphorus (CSIR, 1950).

The protein content of cassava, though low, contains all the essential amino acids. The starch content ranges from 78.1 - 90.1 per cent on dry weight basis. The protein content of cassava was reported to be as low as 1.6 - 2.6 per cent (Anon 1975).

Babu (1977) opined that dietary fibre in sweet potato is superior, content as well as in component wise, to that of cereals and other staples.

Sakai (1979) reported that, edible aroids of the family Araceae often contain acrid factors which cause sharp irritation and burning of the mouth after consumption of cooked material. Different degrees of acridity are observed from low levels in some cultivars of taro and tannia to appreciably high levels in giant taro and *Amorphophallus* spp.

According to Parkinson (1984), colocasia and xanthosoma have a higher thiamine value than other aroids, whilst the riboflavin and niacin values for all the species are fairly comparable. A high thiamine content is an advantage in modern diets where a lot of refined carbohydrates are eaten. Taro provides 67 percent more thiamine than is needed to metabolize its carbohydrate content. He also opined that 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.

According to Ghosh *et al.*(1988), amorphophallus tuber has a carbohydrate content of about 18.0 per cent, protein between one and five per cent and fat upto two per cent. The tubers contain higher quantities of fat than other aroids and the vitamin A content is also quite high. Starch content of tuber varies between four and 12 per cent. Leaves of amorphophallus contain two to three per cent protein, three per cent carbohydrate and four to seven per cent crude fibre. Also, the tubers and leaves contain large amounts of oxalate and they are quite acrid and require a long time of cooking before consumption.

Kays (1992) stated that the fibre content in sweet potato is having the capacity to decrease blood cholesterol level by daily use.

Padmaja (1994) reported that the nutritive value of cassava has been higher than that of corn or sorghum. The principal component of cassava tuber is starch which is responsible for the high calorific value of the tuber.

Raghu *et al.* (1999) has reported that *Amorphophallus konjac* cultivated in Japan possesses hypoglycemic and hypocholesteroleamic properties due to presence of glycomannans. *Amorphophallus* cures piles, increases the digestive fibre, cures dyspepsia and is used in spleenic disorders. It is used externally as a paste in reducing the inflammation. It stimulates the liver secretion. It is an excellent laxative, possesses rejuvenator and aphrodisiac properties. The external application is also good for filarial swelling, joint swelling and some types of tumours. It destroys the excess body fat. It can be used for gastro-intestinal tract disorders.

Seralathan and Thirumaran (1999) reported that among minor tuber crops, *Colocasia* was found to have highest thiamine content. *Amorphophallus* was found to be an excellent source of beta - carotene (260 mg per 100g). In *Colocasia* and *Amorphophallus* calcium is bound to oxalates as needle like crystals or raphides, which is suspected to be the cause of acridity.

Balagopalan (2000) opined that, like other tuber crops, calcium content is high in *Colocasia* and *Alocasia* while *Amorphophallus* and *Xanthosoma* are poor in calcium. Iron content is good in *Colocasia* and *Amorphophallus* and all aroids have high amounts of phosphorous (49-60 mg per 100g fresh weight). Also the leaves of *Colocasia* are exceptionally rich in minerals, vitamins and protein. Leaves contain 3.9 - 7g protein 225 - 460 mg calcium, 82 - 125 mg phosphorous, 10-12 mg carotene 0.26 - 0.45 mg riboflavin and 12.6 mg. Vitamin C per 100 g fresh tissue. 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. Starch is the major component of the drymatter in edible aroids and ranges from 18-28 per cent of fresh weight in *Colocasia* and allied species and 15-20 per cent in *Amorphophallus*. Some species of *Amorphophallus* contain appreciable amounts of glucomannans. The presence of glucomannans could be the prime reason for employing amorphophallus tubers for certain ayurvedic preparations for piles and dysentery. Dietary fibre per 100 g tuber is reported to be 1.5 g in *Amorphophallus*, 4.3 g in *Colocasia*, 1.9 g in *Alocasia* and 3.6 g in *Xanthosoma*. Aroids especially amorphophallus have good protein content ranging from 1.5 -4 per cent of fresh weight

According to Lila (2000) tuber crops rank foremost among cultivated plants in terms of energy produced per unit area per unit time. 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.

She also opined that all plant parts of *Xanthasoma* and *Colocasia* are edible while only corms and petioles are used as food in *Amorphophallus*. Leaves of *Colocasia* are exceptionally rich in minerals, vitamins and protein. Leaves contain 3.9-7 g protein and 12.63 mg Vitamin C per 100 g fresh matter. Most of the tubers contain appreciable amounts of vitamin C while certain cultivars of sweetpotato, cassava, dioscorea and amorphophallus are high in beta carotene which has recently been attributed anticarcinogenic properties. Tuber crops are generally regarded low in protein with the possible exception of aroids. In contrast to tubers, leaves of tuber crops contain very high amounts of protein and low amounts of starch. They are rich in iron, calcium, potassium and most of the vitamins and are nutritionally better than other leafy vegetables.

2.2 Traditional food uses

Amorphophallus has been an important component of the local cuisine in many countries. Its uses as food in different places are briefly reviewed.

2.2.1 Corms as food

Sliced sweet potato tubers are mixed with other tubers and green leaves, moistened with coconut milk, wrapped in a banana leaf and braised in an oven (Massal and Barrau, 1955).

Chibber and Choudhari (1959) has reported that amorphophallus corms are ideal for frying into crisp chips and considered as good food for invalids, and they can also be made into pickles.

Fufu is a product prepared by boiling or steaming peeled cassava roots and then pounding them using a wooden pestle and mortar until a homogenous paste is obtained which is eaten with soups or stews or meat or fish (Affran, 1968).

In Egypt, cubes of colocasia corms are commonly given an initial washing and soaking in warm water for 15 minutes or are washed and lightly fried in order to remove the mucilagenous material and then prepared for consumption by cooking with meat to which either onion and tomato or garlic and chard are added (Warid, 1970).

According to Yen (1974) in the Philippines, dried flakes of sweet potato are prepared for storage and pounded into flour as required in the preparation of gruel. A popular dish is prepared by mixing the flour with water and sometimes with sugar, and making small balls of dough, which are wrapped in sugarcane leaves and boiled.

For immediate consumption aroid corms are normally boiled, baked, roasted or fried, a thorough cooking for several hours often being needed to remove the irritating effect of calcium oxalate raphides and other acrid principles present in many species (Sakai, 1979).

Lyonga (1980) has described various taro products. Nda sese - a porridge prepared by boiling small pieces of boiled tuber mixed with palm oil, fish or meat, vegetable leaves, onion, salt, pepper etc. Ekwancoco - prepared by grating peeled tuber mixing with pieces of cray fish, meat, palm oil, tying into packets with vegetable on plantain leaves. Esubaka - also called fufu and is boiled tuber pounded to a soft pulp. Achu - Similar to esubaka but mixed with boiled banana. It is eaten with a special sauce, made with palm oil and meat to which a small amount of sodium carbonate is added. Taro flour - is mixed with hot water to a smooth thick paste and eaten with rich vegetable soup.

Padmaja (1994) reported that parboiling is a practice followed in the traditional preparation of cassava foods. This is done by steeping cassava pieces, after peeling off the skin and rind, in boiling water for 5-10 minutes and then draining the water. The pieces are then taken out and sundried. Parboiled chips have better keeping quality and are less susceptible to damage by storage insects. She has opined that cassava flour is used in a number of Indian traditional preparations like puttu, dosai, uppuma and chappathis.

Gubag *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.

Raghu *et al.* (1999) has reported that elephant foot yam in Kerala is eaten as big pieces after boiling it well. In typical Kerala diet, curries like sambar, avial etc. elephant foot yam is one of the major ingredients. Kalan is a curry of Northern Kerala , made with elephant foot yam and butter milk.

2.2.2 Petioles as food

Tender petioles of taro have a very pleasing taste when the leaves are still young and unexpanded. They are cooked thoroughly as they contain numerous stinging crystals. They are considered a great delicacy in the Philippines (CSIR, 1950). The fried pieces of the tuber are also used in special occasions.

According to Pena (1970) young taro leaves are used as main vegetable throughout Malaysia and Polynesia. They are either boiled or covered with coconut cream, wrapped in banana or bread fruit leaves and cooked on hot stones.

Ghosh *et al.* (1988) states that leaves and petioles of taro are also used as food. Young leaves and starch can be cooked and used like spinach, but a pinch of baking soda is added to remove acridity. Leaves which have just opened or unopened considered better. In Hawaii the petioles and leaves are used with meat and coconut water.

According to Balagopalan (2000) young petioles and leaf blades of amorphophallus are boiled and eaten while the corms and cormels are boiled and eaten as vegetable. Chips are also made by slicing tubers and deep fat frying frying in oil.

2.3 Value addition and product development

In Japan *Amorphophallus rivieri* is stored in the form of a flour konnyaku or konjac. The tubers (which consist of mannans) are first peeled, washed and cut into pieces which are then skewered on lengths of bamboo to dry in the sun for about a week. The dried pieces are broken into fragments known as arako and further pulverized into flour. The flour is prepared for eating by mixing with water to form a paste which is mixed with slaked lime and water and boiled until it forms a gelatinous mass (Motte, 1932).

Greenwell (1947) reported that taro flour can be prepared from raw or precooked tubers, and flour that obtained from precooked tuber is considered better. The flour can be mixed in soups and in making pancakes, biscuits and bread. It is excellent for gravies and puddings as it is not glutinous like wheat flour. Tarolactin and taro malt prepared form the flour are said to form good infant and invalid foods.

Cassava flour is used to make one of the traditional Indian foods such as chappathis (Hiranandani and Advani, 1955). According to Tallantire and Goode, 1975), the simplest method used and probably the most widespread in Africa and Asia, for preparing flour from cassava is by sun drying slices or chips of peeled roots, which can then be stored as dried chips and ground into flour when needed. Cassava flour is sometimes mixed with flours from other crops such as millet and made into a porridge.

Kasasian and Dendy (1977) have reported that cassava flour has been used to produce bread. Incorporation of 15 per cent cassava flour into wheat flour for bread production has been found to give an acceptable product in Columbia.

Murray (1977) reported that in United States, taro is peeled, sliced and deep fat fried in the same manner as in the manufacture of potato chips.

According to Nip (1978) taro alone and in combination with fruits such as guava and papaya has been successfully drum dried. These flakes can be used alone to produce a beverage or incorporated as an ingredient in a wide variety of other foods.

Griffin (1979) has documented the possibility of using taro starch in the production of biodegradable plastics.

Taro starch could be included in a number of manufactured foods such as noodles, biscuits and bread. In many parts of the world, wheat flour is replaced by 10-15 per cent of starch from root crops. Taro starch, because of its good protein and vitamin content, could provide a good cereal substitute (Moy *et al.*, 1979).

Moy *et al.* (1980) reported that taro flour mixed with 15 per cent winged bean flour or 15 per cent soya protein have been extruded into rice, noodle and macaroni in Hawaii. The taro macaroni and rice are quite acceptable.

Moy and Nip (1983) reported that 'poi' is easily digestible and practically non-allergic and is considered as an excellent food especially for patients with food allergies. In addition, they also stated that a taro flour based baby food called tarolactin which consists of taro flour, cocoa milk, unrefined cane juice and sodium chloride, is produced in Hawaii.

According to Wang (1983) dehydrated taro was used in combination with skim milk and other ingredients to prepare infant gruels and drinks. Similar chocolate flavoured beverage powders have also been formulated.

According to Siviero *et al* (1984) 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.

The effect of incorporation of sweet potato flour in South Indian and baked recipes was studied by Seralathan and Thirumaran (1988). Incorporation at a level of 100 per cent gave a highly acceptable product for idiappam, pakoda, omapodi, murukku and halwa. Toffee was found to be acceptable at 76 per cent incorporation while only 50 per cent incorporation was possible in chappathies. Baked products like cakes and biscuits could be made with 50 per cent replacement of maize with sweet potato flour.

Balagopalan *et al.* (1988) reported that steam treatment of less than five minutes at 5 psi or immersion in boiling water for only upto 5 min are necessary for obtaining good quality cassava rava.

Ghosh *et al.* (1988) has described a process developed by CFTRI Mysore, India, in the production of taro flour, where taro corms are washed, peeled, cut in to six mm thick slices, washed thoroughly to remove mucilage and kept immersed over night in water, washed again, immersed in 0.75 per cent potassium bisulphite solution for three hours. The slices are then blanched in hot water for five minutes, sun dried and tunnel dried at 57 - 60^{0}C, ground, sieved and packed. This flour produced can be used in baby weaning foods and taro-based bread.

Thirumaran and Seralathan(1988) found that novel recipes like tuber mash, bitsoy and sweet stuffed parathas could be prepared from flesh tubers of both the *Dioscorea* sp. Wafers, cripples and biscuits made out of *D. alata* tubers were found to have good acceptability.

According to El-Dash and Chang (1990) extruded products are very popular with children and they can serve as an effective means for the introduction of important nutrients.

Sevian was produced with colocasia mass by Manan *et al.* (1991). The organoleptic studies conducted revealed that the products were highly acceptable to the panel members.

Zoizima (1992) opined that since the price of sweet potato is several times cheaper than wheat flour, it could be used as a substitute to wheat flour in bread making.

The acceptability as well as nutritional significance of cassava chappathis was studied by Chellamal and Prema (1994) in their study on nutritional enrichment of cassava flour.

Konjac flour has been used in Japan as part of a healthy diet. Konjac flour is ground dried root of the perennial herb Amorphophallus konjac. It is used as a thickening agent in soups, sauces and dressings. A dense, gelatinous substance with a bland flavour called konnyaku is also made from

Amorphophallus konjac powdered and encapsulated konnyaku is sold as a diet aid in the United States of America under the name 'glycomannan' (Anon 1999).

Edison (1999) stated that area and production of tuber crops in traditional areas like Kerala have drastically come down due to prevalence of uncertainty in prices and competition from its substitutes. Many value added products from tuber crops are not able to compete in the international market due to high prices of domestic products.

Padmaja *et al.* (1999) reported that gulab jamun mixes were prepared from cooked and mashed sweet potato, maida and milk powder. It was found that the formulation incorporating 30 per cent and 40 per cent cooked sweet potato gave gulab jamuns with the over all acceptability score of 3.5.

To increase market, home front technologies will enable the producer to develop low cost, value added intermediary products like yam sauce, pickles, pregelatinised starches, instant drinks etc (CTCRI, 2000).

2.4 Shelf life studies

A method for extending the storage life of chips to twelve months and also speeding up the drying process is by parboiling them before drying, a technique often used in India and West Africa (Hiranandani and Advani, 1955).

Moy *et al.* (1980) reported that taro flour mixed with 15 per cent winged bean flour or 15 per cent soya protein and extruded into rice, noodle and macaroni indicated they could be stored below 380C upto 12 months.

According to Bhattacharjee and Bhole (1989) 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. They studied the keeping quality of wheat in different packaging materials and recommended that it would be stored safely in polythene bags for a period upto 35 days, in polythene impregnated jute bag upto 21 days, and in jute bags only upto 14 days from the standpoint of insect infestation and the development of free fatty acid in stored wheat flour.

Choudhary and Kapoor (1984) found out that pearl millet flour could be stored at 20^0C and 70 per cent RH for 7, 8, 10 days respectively in gunny sacks, earthen pots, tin cans and polythene bags.

According to Nanda (1984) testing and evaluation of available packing materials for handling and storage of cassava products showed that an increase in moisture content was minimum for cassava chips stored in metal container and polythene lined jute bag the moisture content was within safe limits upto 60 days. The increase in moisture content of cassava flour stored in metal container and polythene lined jute bag was only 0.71 and 1.23 percent respectively after 120 days of storage.

According to Moy and Nip (1988) results of experiments on preparation and storage of dehydrated taro slices and flour in polythene bags at 21^0C, 38^0C and 60^0C showed that these products underwent small changes in acidity, some degradation of pigments, some increase in moisture contents and large decrease in catalase activity. In over all acceptability test results showed that these intermediate products were stable at 38^0C for one year or more.

Kulkarni *et al.*, (1992) reported that the quality of papads made from blends containing bengal gram or red gram was comparable to that of papads made from blackgram. Papad remained quite acceptable in 200 gauge LDPE and 120 gauge PP bags during four months storage without much change in quality.

The suitability of indigenously available glass containers have been studied for packing mango juice, banana puree, tomato puree and processed pear. Reduction of beta-carotene was found to be less in amber coloured bottles compared to colour less bottles (Purushotham *et al.*, 1992).

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 gauge. No significant change could be found in chemical attributes.

Results of experiment on the effect of storage duration on quality of potatoes used for production of chips showed that with the lapse of storage time, the starch content increased while the quantity of soluble sugars remained unchanged. The quality of chips produced was acceptable and did not change with the duration of storage (Mozolewski, 1999).

2.5 Acceptability studies

Scientific methods of sensory analysis of food are becoming increasingly important in evaluating the acceptability of the food product. When the quality of food is assessed by means of human sensory organs, the evaluation is said to be sensory analysis. Organoleptic qualities play an important role in evaluating the quality of food products. For judging consumer acceptability organoleptic evaluation of any food product is essential.

Organoleptic qualities such as colour, flavour, taste, texture and appearance are assessed with a panel of selected judges (Watts *et al.*, 1989). The combination which got the highest scores was selected for formulation of products.

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

MATERIALS AND METHODS

3. MATERIALS AND METHODS

The present investigation on "Value addition and evaluation of nutritional quality in elephant foot yam (*Amorphophallus paeoniifolius* (Dennst.))" was undertaken at the Department of Processing Technology, College of Agriculture, Vellayani, during the period 1999-2001.

The basic material for the study consisted of the following four cultivars of *Amorphophallus ie,*

V_1 -Sree Padma

V_2 - Vellayani local

V_3 - Pathanamthitta local

V_4 - Kottarakkara local

The cultivars were collected and multiplied to get tubers of sufficient quantity in the Instructional Farm, College of Agriculture, Vellayani.

3.1 Assessment of the nutritional quality of corms and petioles of Amorphophallus.

3.1.1 Corms

Corms after maturity were harvested and analysed to assess the nutritional quality. Nutritional aspects such as starch, protein, total sugars, vitamin C, crude fibre, calcium oxalate and organoleptic quality were analysed.

Starch

The starch content was estimated by using potassium ferricyanide method (A.O.A.C, 1984). The values were expressed as percentage on fresh weight basis.

Protein

Protein content was estimated using microkjeldhals method (Sadasivam and Manikam, 1992).

Total sugars

Total sugar content of corms was determined by the method of A.O.A.C. (1984).

Vitamin C

Vitamin C was estimated by the volumetric method (Sadasivam and Manikam, 1992).

Crude fibre

Crude fibre content of the corms was determined by the method of A.O.A.C. (1984).

Calcium oxalate

This is estimated by the method suggested by A.O.A.C. (1984) with slight modification. The procedure is given below.

Reagents

1. Tungsto phosphoric acid (2.5 g $Na_2WO_4 . 2H_2O$ dissolved in a mixture of 4 ml H_3PO_4 and 50 ml H_2O and diluted to 100 ml with water)

2. Wash liquid (dilute 12.5 ml HOAc to 250 ml with H_2O. Add a pinch of calcium oxalate. Shake and let it stand. Decant and filter.

3. Acetate Buffer (pH 4.5) Dissolve 2.5 g of anhydrous $CaCl_2$ in 50 ml acetic acid (1: 1 diluted) and add the solution to 33 g of sodium acetate diluted to 5 ml.

4. Potassium permanganate (0.01 N)

5. H_2SO_4 (2N)

6. HCl (0.25 N)

Procedure

One gram dried powder was extracted twice with 0.25 N HCl in a water bath for one hour each. The extract was centrifuged and the centrifugate was collected in a conical flask. This extract was precipitated by adding 5 ml tungsto phosphoric acid, kept overnight and centrifuged. This was neutralized with 1: 1 dilute ammonia solution, then precipitated by adding 5 ml acetate buffer with $CaCl_2$ (pH 4.5), centrifuged and washed the precipitate twice with wash liquid (6 ml each). The precipitate was then dissolved in 10-15 ml 2N H_2SO_4 and transferred into a 100 ml conical flask and titrated against 0.01 N $KMnO_4$ solution at 60^0C.

$$\text{Percentage oxalate in the sample} = \frac{0.063 \times V}{w}$$

where V =volume of $KMnO_4$ used

w =weight of the sample

Organoleptic quality

For organoleptic evaluation, the corms were peeled, sliced and boiled. Salt was added to taste, water drained off and the pieces were subjected to organoleptic assessment by a panel of judges selected from a group of students through triangle test as suggested by Mahony (1985).

For scoring, a scale of five to one was used, five representing the optimum for all quality characteristics. The major quality attributes included in the scorecard were colour, flavour, taste, texture, appearance and overall acceptability.

3.1.2 Petioles

Petioles in the tender stage were harvested and analysed to assess the nutritional quality. Nutritional aspects such as protein, total sugars, vitamin C, crude fibre, calcium oxalate and organoleptic quality were analysed using the same method as above.

3.2 Value addition in *Amorphophallus* through primary products

Corms were used to make primary products *viz.*, chips and flour, and both these primary products were subjected to physico chemical and organoleptic analysis as described below.

3.2.1 Chips

The corms after harvest were washed thoroughly with water to remove soil particles and dirt. Peeling was done manually with sharp knives. During chipping, the end portions of the tubers were discarded. Chips of uniform size of each cultivar (V) with three different thicknesses (K) were prepared using two techniques (T). Once the chips were sliced into different thicknesses, they were divided into two lots, one lot freshly fried and the other lot parboiled dried and then fried in coconut oil. Salt was added to taste.

Cultivars (V)

V_1 –Sree Padma

V_2 – Vellayani local

V_3 –Pathanamthitta local

V_4 –Kottarakkara local

Thickness of chips(K)

K_1 – 1 mm

K_2 – 2 mm

K_3 – 3 mm

Techniques (T)

T_1 – Freshly fried chips

T_2 – Parboiled dried and fried chips

The freshly fried chips and parboiled fried chips were then analysed for the following

Oil uptake

Oil uptake was estimated by extracting with hexane (Sadasivan and Manikam, 1992).

Moisture

Moisture content was measured by the oven drying method (Ranganna, 1977).

Starch

Starch content was estimated by potassium ferricyanide method (Ranganna, 1977).

Total sugars

Total sugars were estimated by the method suggested by A.O.A.C. (1984).

Organoleptic quality

Organoleptic qualities such as appearance, flavour, colour, texture, taste and overall acceptability were assessed with the panel of selected judges.

3.2.2 Flour

Chips of uniform size and thickness were made from corms of each cultivar (V) as described above and dried for four different drying periods

(H) at three different temperatures (T). The dried chips were ground and sieved through 40- mesh size sieve to get flour.

Cultivars (V)

V_1-Sree Padma

V_2-Vellayani local

V_3-Pathanamthitta local

V_4-Kottarakkara local

Drying periods (H)

H_1 - 6 hours

H_2- 12 hours

H_3- 18 hours

H_4- 24 hours

Temperatures (T)

T_1-55^{0}C

T_2-75^{0}C

T_3-95^{0}C

The flour obtained was analysed for the following.

Colour-was analysed on a five- point scale by a panel of judges.

Starch- analysed as above

Moisture- analysed as above

Total Sugars- analysed as above

3.3 Value addition through secondary products

The flour obtained from each cultivar was made into secondary products *viz*., murukku, wafers and pappads with standard blending material wherever necessary and were evaluated for organoleptic qualities like appearance, flavour, texture, taste, colour and overall acceptability.

3.3.1 Murukku

This is a traditional snack item of India. It is commonly made from rice flour. Dough was made by mixing black gram flour and Amorphophallus flour in equal proportion with sufficient water. Spices and salt were added. The dough was filled in a murukku mould and pressed down to make little round coils. This was deep fried in coconut oil and analysed for organoleptic quality.

3.3.2 Wafers

Wafers are one of the popular snack foods. Snack foods can be defined as ready-to-eat (RTE) foods consumed between the main meals of the day (Morgan, 1983).

Amorphophallus flour, blackgram flour and rice flour were mixed in a ratio of 50 : 25 : 25 and sieved. Water (five times volume of flour) was added and was cooked on a slow flame for 20 minutes. After cooling it was filled into an extruder, pressed out into thin long strips and spread on plastic sheets, cut into small pieces and sundried. Before consumption the wafers were deep fried in coconut oil and was evaluated for organoleptic quality by a panel of judges

3.3.3 Papads

These are thin wafers-like products prepared from a variety of base ingredients such as blackgram or blackgram plus other pulse combinations with or without spices. These are mostly prepared at homes or in cottage scale industry (Arya, 1992). A stiff dough was made from a mixture of black gram flour and amorphophallus flour in equal proportions with a little water. This was rolled into thin round discs by means of rolling pins and dried to a level so that it still remains pliable. The papads were deep fried in coconut oil before consumption and analysed for organoleptic quality.

3.4 To assess the storage life of primary and secondary products

The primary and secondary products of each cultivar (V) were packed in three different types of containers (C) which were stored for three months and observations were taken at different durations of storage (D) in duplicate. Products of each cultivar were tightly packed in different containers and observations were taken for three months at an interval of 15 days for starch, total sugars, moisture and organoleptic quality. These observations were taken as mentioned before. Sample size was 30 grams.

Cultivars (V)

V_1-Sree Padma

V_2-Vellayani local

V_3-Pathanamthitta local

V_4-Kottarakkara local

Containers (C)

C_1 – Glass bottles

C_2 – PET (Polyethylene terephthalate) jars

C_3 –LDPE (Low density polyethylene bags)

Duration of storage (D)

D_1 – 0 days

D_2 – 15 days

D_3 –30 days

D_4 – 45 days

D_5 – 60 days

D_6 – 75 days

D_7 – 90 days

Statistical Analysis

The data were analysed in the form of a CRD

RESULTS

4. RESULTS

The results of the investigation on "Value addition and evaluation of nutritional quality in elephant foot yam (*Amorphophallus paeoniifolius (Dennst.)*) were statistically analysed and are presented below.

4.1 Nutritional quality of corms and petioles

4.1.1 Corms

The quality characters like starch, protein, total sugars, vitamin C, crude fibre, calcium oxalate and organoleptic quality of four cultivars were analysed and is presented in Table 1.

V_3 was found to contain highest starch content (16.68 %) followed by V_2 (15.52 %). V_1 (12.20 %) was almost on par with V_4, (11.47 %) which had the lowest value.

Highest protein content of 3.7 per cent was recorded by V_3 followed by V_1 and V_4 both having a value of 3.3 percent. Lowest protein content was recorded by V_2 (2.18 %).

Among the cultivars, total sugar was found highest for V_1 (1.49 %) followed by V_3 (1.23 %), V_4 (0.92 %) and V_2 (0.64%).

Table 1. Nutritional quality of fresh corms

	Cultivar	Starch	Protein	Total sugars (%)	Vitamin C (mg/100 g)	Crude fibre	Calcium oxalate (%)	Organoleptic quality
1	V_1	12.20	3.30	1.49	5.17	0.61	0.09	4.48
2	V_2	15.52	2.18	0.64	2.64	0.78	0.22	3.65
3	V_3	16.68	3.70	1.23	5.20	0.60	0.15	4.58
4	V_4	11.47	3.30	0.92	5.14	0.84	0.25	2.35
CD (5%)		0.84	0.20	0.04	0.07	0.06	0.04	0.19

Nutritional quality of petioles

	Cultivar	Protein	Total sugars (%)	Vitamin C (mg/100 g)	Crude fibre	Calcium oxalate (%)	Organoleptic quality
1	V_1	1.25	2.51	18.56	3.00	1.79	4.48
2	V_2	1.25	2.37	15.68	3.18	2.11	3.55
3	V_3	2.28	2.26	20.67	2.70	1.59	4.58
4	V_4	1.23	2.08	22.23	3.38	2.08	3.05
CD (5%)		0.30	0.02	1.03	0.23	0.05	0.15

Vitamin C content was highest in V_3 (5.2 %) which was on par with V_1 (5.17 %) and V_4 (5.14%). Crude fibre content was highest in V_4 (0.84 %) and lowest in V_1 (0.61%) and V_3 (0.60 %), which were on par.

Calcium oxalate content was found highest in V_4 (0.25 %) which was on par with V_2 (0.22 %). It was lowest for V_1 (0.09 %).

Between the cultivars, organoleptic quality score was highest for V_3 (4.58) which was on par with V_1 (4.48) followed by V_2 (3.65) and lowest was found for V_4 (2.35).

4.1.2. Petioles

The quality characters like protein, total sugar, vitamin C, crude fibre, calcium oxalate and organoleptic qualities of the four cultivars were analysed and is presented in Table 1.

Protein content of V_3 was significantly higher than the rest (2.28 %). $V_1$and V_2 were on par having a value of 1.25 per cent.

Among the cultivars, V_1 was found to contain highest amount of total sugars which was 2.51 per cent while V_4 was found to be the lowest with 2.08 per cent.

Vitamin C content of petioles was found to be highest in V_4 (22.23 %) and lowest for V_2 (15.68 %).

Petioles of V_4 had the highest crude fibre content (3.38 %) which was on par with V_2 (3.18 %) and V_1 (3.00 %). It was found lowest in V_3 (2.70 %).

Calcium oxalate content was highest in V_2 (2.11 %) which is on par with V_4 (2.08 %). It was lowest in V_3 (1.59 %).

Organoleptic quality was found highest for V_3 (4.58) which was on par with V_1 (4.48). It was lowest for V_4 (3.05).

4.2. Value addition through primary products

4.2.1 Chips

4.2.1.1 Oil uptake

Oil uptake as influenced by cultivars, thickness of chips and techniques are presented in Table 2. Cultivars, thickness, techniques and their interaction effects had significant influence on oil uptake of chips.

Highest oil uptake was recorded by V_1 (14.01 %) and the lowest by V_3 (13.05 %). Oil uptake was highest for K_3 (14.16 %) level of thickness and lowest for K_1 (12.92 %). The oil uptake in technique T_1 (16.61 %) was found to be significantly higher as compared to T_2 (10.55 %).

Interaction of V x K significantly influenced oil uptake and treatment V_1K_3 (14.63 %) recorded highest oil uptake. Interaction effect of V x T had a significant influence on oil uptake and highest oil uptake was seen in

Table 2. Effect of cultivars, thickness and techniques and their interaction on oil uptake (%) of chips

	K_1	K_2	K_3	Mean	T_1	T_2
V_1	13.30	14.09	14.63	14.01	16.69	11.32
V_2	13.07	13.90	14.18	13.72	16.87	10.56
V_3	12.48	13.03	13.63	13.05	16.12	9.97
V_4	12.83	13.60	14.20	13.55	16.74	10.35
Mean	12.92	13.66	14.16		16.61	10.55

	T_1	T_2	Mean
K_1	16.24	9.60	12.92
K_2	16.60	10.71	13.66
K_3	16.98	11.34	14.16
Mean	16.61	10.55	

CD(5%) - (V) -0.06 (K)-0.05 (T)-0.04 (VK)-0.11 (VT)- 0.09 (KT)-0.08

Interaction effect of cultivar, thickness and techniques on oil uptake (%) of chips

	T_1			Mean	T_2			Mean
	K_1	K_2	K_3		K_1	K_2	K_3	
V_1	16.30	16.66	17.10	16.69	10.30	11.52	12.15	13.32
V_2	16.46	16.90	17.26	16.87	9.68	10.90	11.10	10.56
V_3	15.88	16.10	16.38	16.12	9.07	9.96	10.89	9.97
V_4	16.32	16.72	17.19	16.74	9.34	10.48	11.22	10.35
Mean	16.24	16.60	16.98		9.60	10.71	11.34	

CD (5 %) - (VKT)-0.15

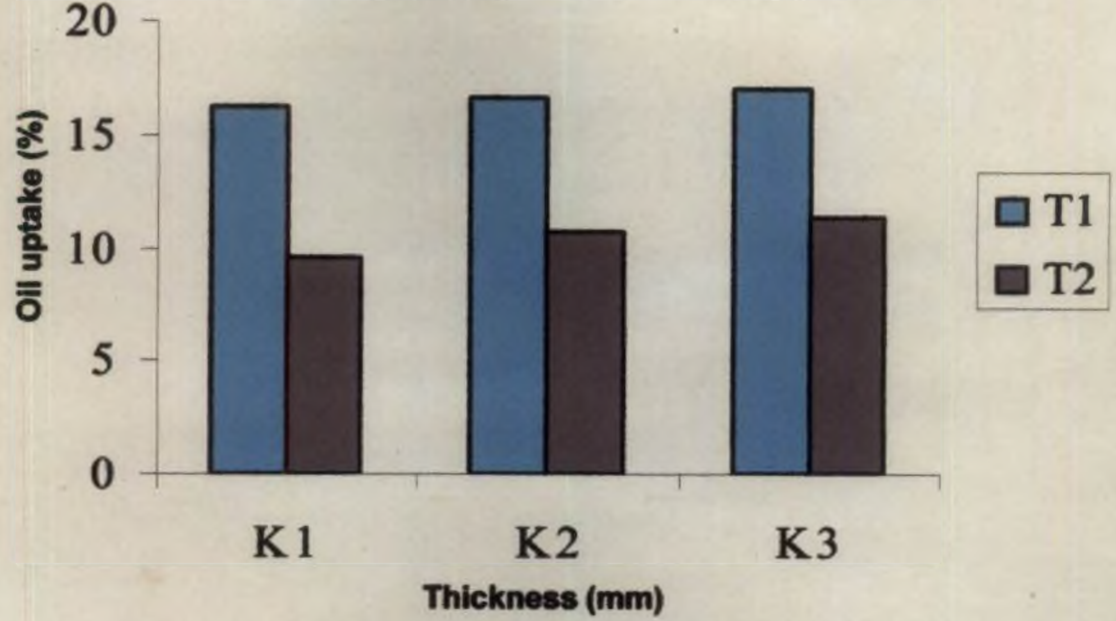

Fig 1. Effect of different techniques on oil uptake of chips at different thicknessess

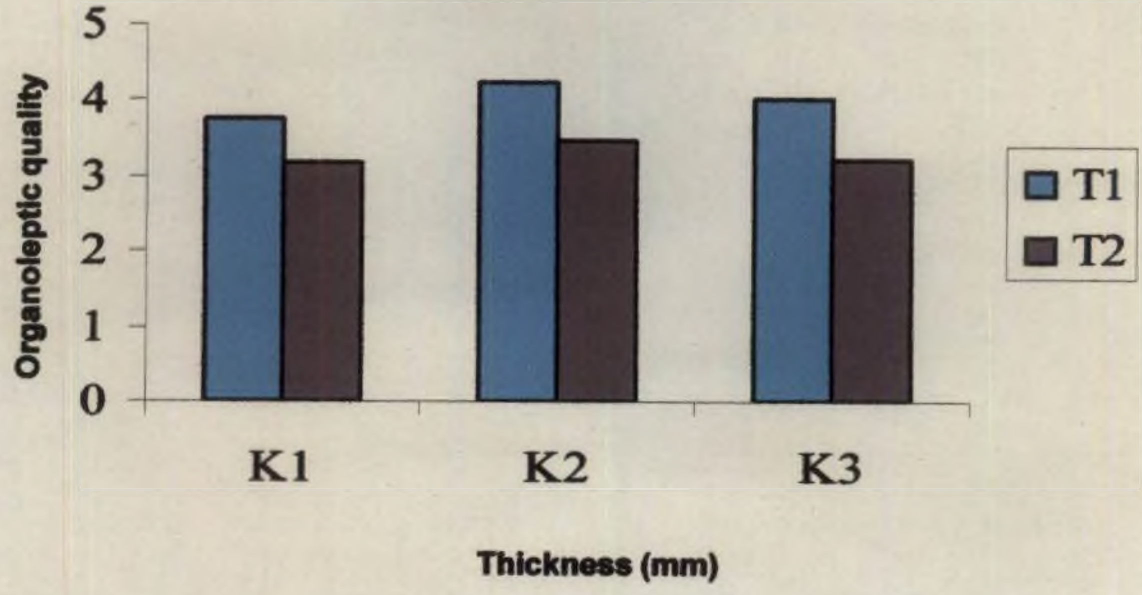

Fig 2. Effect of different techniques on organoleptic quality of chips at different thicknessess

V_2T_1 (16.87 %) and lowest in V_3T_2 (9.97 %). Interaction of K x T induced a significant influence on oil uptake K_3T_1 (16.98 %) recorded highest and K_1T_2 (9.60 %) the lowest oil uptake.

The interaction of all the three factors *viz*., V, K and T significantly influenced the oil uptake. The treatment $V_2K_3T_1$ (17.26 %) showed highest oil uptake. Lowest oil uptake was recorded by $V_3K_1T_2$ (9.07 %).

4.2.1. 2. Moisture

Moisture content as influenced by cultivars, thickness and techniques are presented in Table 3. Cultivars, thickness, techniques and their interaction effects had significant influence on moisture content of chips.

V_1 (5.39 %) recorded the highest moisture content while V_3 and V_1 (5.31 %) recorded lowest. K_3 (5.54 %) level of thickness had significantly higher moisture content than K_2 (5.30%) and K_1 (5.19 %). Technique T_1 (6.42 %) had significantly higher moisture content than T_2 (4.26 %).

Interaction V x K significantly influenced moisture content. V_4K_3 (5.56 %) recorded highest which was on par with V_3K_3 (5.55 %) and V_1K_3 (5.54 %). Lowest moisture content was recorded for V_3K_1 (5.11 %) which was on par with V_2K_1 (5.14%). Interaction between V x T significantly influenced moisture content and highest was recorded for V_1T_1 and V_4T_1

Table 3. Effect of cultivars, thickness, techniques on moisture content (%) of chips

	K_1	K_2	K_3	Mean	T_1	T_2
V_1	5.26	5.36	5.54	5.39	6.46	4.31
V_2	5.14	5.30	5.50	5.31	6.41	4.22
V_3	5.11	5.28	5.55	5.31	6.37	4.25
V_4	5.25	5.26	5.56	5.35	6.46	4.25
Mean	5.19	5.30	5.54		6.42	4.26

	T_1	T_2	Mean
K_1	6.25	4.13	5.19
K_2	6.40	4.19	5.30
K_3	6.62	4.46	5.54
Mean	6.42	4.26	

CD (5%) - (V)-0.02 (K)-0.02 (T)-0.02 (VK)-0.04 (VT)0.03 (KT)-0.03

Interaction effects of cultivars, thickness and techniques on moisture content (%) of chips

	T_1			Mean	T_2			Mean
	K_1	K_2	K_3		K_1	K_2	K_3	
V_1	6.30	6.44	6.63	6.46	4.22	4.27	4.45	4.31
V_2	6.23	6.44	6.56	6.41	4.05	4.15	4.45	4.22
V_3	6.21	6.29	6.60	6.37	4.01	4.26	4.49	4.25
V_4	6.27	6.44	6.67	6.46	4.22	4.07	4.45	4.25
Mean	6.25	6.40	6.61		4.13	4.19	4.46	

CD (5%) - (VKT)-0.06

(6.46 %). Interaction between K x T significantly influenced moisture content, highest was recorded for K_3T_1 (6.62 %). Lowest for K_1T_2 (4.13 %).

The combined effect of three factors *viz.*, V, K and T showed significant influence on moisture content. Highest moisture content was recorded by $V_4K_3T_1$ (6.67 %) which was on par with $V_1K_3T_1$ (6.63 %) and lowest was recorded by $V_3K_1T_2$ (4.01 %) which was on par with $V_2K_1T_2$ (4.05 %) and $V_4K_2T_2$ (4.07 %).

4.2.1. 3 Starch

Starch as influenced by cultivars, thickness and techniques are presented in Table 4.

Starch content was significantly influenced by all the main effects and also the interaction effect of V x K.

Highest starch was recorded for V_3 (52.65 %) and lowest for V_1 and V_4 (42.97 %). Among the thickness, K_3 (49.59 %) was significantly higher than K_1 (46.59 %). Technique T_1 (49.05 %) had higher starch content than T_2 (46.45 %).

Interaction of V x K induced a significant effect on starch content. Highest starch content was recorded by V_2K_3 (55.42 %) which was on par with V_3K_2 (54.60 %). Lowest was recorded for V_1K_2 and V_4K_1 (40.95 %).

Interaction effects of V x T, K x T and V x K x T were not significant.

Table 4. Effect of cultivars, thickness, techniques on starch content (%) of chips

	K_1	K_2	K_3	Mean	T_1	T_2
V_1	42.91	40.95	45.06	42.97	44.00	41.94
V_2	53.03	48.82	55.42	52.43	54.11	54.75
V_3	49.49	54.60	53.86	52.65	54.11	51.19
V_4	40.95	43.93	44.03	42.97	44.00	41.94
Mean	46.59	47.07	49.59		49.05	46.45

	T_1	T_2	Mean
K_1	47.97	45.22	46.59
K_2	47.97	46.18	47.00
K_3	51.22	47.97	49.59
Mean	49.05	46.45	

CD (5%) - (V)-1.54 (K)-1.33 (T)-1.09 (VK)-1.33 (VT)-ns (KT)-ns

[illegible] Total sugars

The influence of cultivars, thickness and techniques on total sugars is presented in Table 5 Cultivars, thickness, techniques and their interaction effects had significant influence on total sugar content of chips.

V_1 (2.03 %) recorded the highest total sugar content and V_2 (1.58 %) expressed the lowest. Level of thickness was found to significantly influence the total sugar content. Among the thickness, highest total sugar content was obtained with K_3 (1.91 %) and lowest with K_1 (1.62 %), The technique T_1 (2.02 %) had a significantly higher sugar content as compared to T_2 (1.48 %).

Interaction effects of V x K, V x T and K x T were found significant. The interaction V_1K_3 (2.20 %) having the highest total sugar content while V_4K_1 (1.42 %) recorded the lowest. Interaction effect V_1T_1 (2.33 %) was found significantly higher than the rest. K_3T_1 (2.03 %) recorded the highest total sugar content which was on par with K_1T_1 (2.00 %) and K_2T_1 (2.02 %).

Combined effect of all the three factors *viz.*, V, K and T significantly influenced total sugar content. Treatment $V_1K_3T_1$ (2.34 %) recorded higher value which was on par with $V_1K_2T_1$ (2.31 %) and $V_1K_1T_1$ (2.33 %).While $V_4K_1T_2$ (1.05 %) recorded the lowest value.

Table 5. Effect of cultivars, thickness, techniques on total sugar content (%) of chips

	K_1	K_2	K_3	Mean	T_1	T_2
V_1	1.95	1.93	2.20	2.03	2.33	1.73
V_2	1.46	1.56	1.73	1.58	1.84	1.32
V_3	1.66	1.76	1.95	1.79	2.05	1.53
V_4	1.42	1.63	1.75	1.60	1.85	1.35
Mean	1.62	1.72	1.91		2.02	1.48

	T_1	T_2	Mean
K_1	2.00	1.24	1.62
K_2	2.02	1.42	1.72
K_3	2.03	1.79	1.91
Mean	2.02	1.48	

CD (5%) - (V)-0.02 (K)-0.02 (T)-0.02 (VK)-0.04 (VT)-0.04 (KT)-0.03

Interaction effects of cultivars, thickness and techniques on total sugar content (%) of chips

	T_1			Mean	T_2			Mean
	K_1	K_2	K_3		K_1	K_2	K_3	
V_1	2.33	2.31	2.34	2.33	1.57	1.55	2.07	1.73
V_2	1.84	1.84	1.84	1.84	1.08	1.27	1.61	1.32
V_3	2.05	2.04	2.07	2.05	1.27	1.48	1.84	1.53
V_4	1.80	1.90	1.86	1.85	1.05	1.36	1.63	1.35
Mean	2.00	2.02	2.03		1.24	1.42	1.79	

CD (1 %) - (VKT)- 0.06

Plate 1. Freshly fried amorphophallus chips

Plate 2. Parboiled fried amorphophallus chips

4.2.1.5. Organoleptic quality

Organoleptic quality as influenced by cultivars, thickness and techniques is presented in Table 6 .The data revealed that main effects of cultivars, thickness, techniques and interaction effect of V x T had profound influence on organoleptic quality.

Organoleptic quality was significantly influenced by cultivars .V_3 gave the highest score of 4.25 and V_4 (3.04) had the lowest. Among the thickness of K_2 (3.85) was found to have a significantly higher score than others. Among the techniques, T_1 (4.01) was found to have significantly higher score than T_2 (3.27).

Interaction effect of V x T was found significant. The treatment V_3T_1 (4.48) recorded the highest score while V_4T_2 (2.62) recorded the lowest score for organoleptic quality.

4.2.2 Flour

4.2.2.1 Colour

Colour of flour as influenced by cultivars, drying periods and temperatures is presented in Table 7. The data revealed that main effects of drying periods and temperature and interaction effect of TH had profound influence on colour of flour. It was seen that colour of the flour decreased

Table 6 Effect of cultivars, thickness, techniques on organoleptic quality of chips

	K_1	K_2	K_3	Mean	T_1	T_2
V_1	3.82	4.28	4.00	4.03	4.33	3.73
V_2	3.15	3.40	3.18	3.24	3.75	2.73
V_3	4.13	4.48	4.15	4.25	4.48	4.02
V_4	2.78	3.25	3.10	3.04	3.47	2.62
Mean	3.47	3.85	3.61		4.01	3.27

	T_1	T_2	Mean
K_1	3.76	3.18	3.47
K_2	4.25	3.45	3.85
K_3	4.01	3.20	3.61
Mean	4.01	3.27	

CD (5%) - (V)-0.14 (K)-0.12 (T)-0.10 (VK)-ns (VT)-0.10 (KT)-ns

Table 7. Effect of cultivars, temperature and drying periods on colour of flour

	T_1	T_2	T_3	Mean	H_1	H_2	H_3	H_4
V_1	4.63	4.75	3.00	4.13	5.00	4.50	3.83	3.17
V_2	4.88	4.50	2.88	4.08	4.83	4.50	3.83	3.17
V_3	4.63	4.88	2.38	3.96	4.67	4.17	3.83	3.17
V_4	4.63	4.75	2.75	4.04	4.67	4.33	3.83	3.33
Mean	4.69	4.72	2.75		4.79	4.38	3.83	3.21

	H_1	H_2	H_3	H_4
T_1	5.00	5.00	4.63	4.13
T_2	5.00	5.00	4.63	4.25
T_3	4.38	3.13	2.25	1.25
Mean	4.79	4.38	3.83	3.21

CD(5%) - (V)-ns (T)-0.41(1%) (H)-0.25 (VT)-ns (VH)-ns (TH)-0.43(1%)

with increase in drying periods. Highest score of 4.79 was obtained for H_1 while lowest score was recorded for H_4 (3.21)

Temperature T_2 gave the highest score of 4.72 which was on par with T_1 (4.69) and was found significant.

Interaction effect of T x H has been found significant. Treatment combinations T_1H_1, T_1H_2, T_2H_1 and T_2H_2 were found to have highest score of 5.00 while, T_3H_3 recorded the lowest score of 2.25.

4.2.2.2 Starch

The data showing the effect of cultivars, drying periods and temperatures on starch content of flour are presented in Table 8

The main effects of cultivars, drying period and temperature had a significant influence on starch content of flour. The effect of interaction failed to express any significant variation in starch content of flour.

Among the cultivars, higher values of 46.20 percent and 44.82 percent were found for V_2 and V_3 respectively which were significantly higher.

Starch content was found to increase with temperature. T_3 gave a highest value of 45.38 percent which was significant.

Drying periods were found to significantly influence the starch content of flour. Starch content increased with drying periods. Higher values

Table 8. Effect of cultivars, temperature and drying periods on starch content (%) of flour

	T_1	T_2	T_3	Mean	H_1	H_2	H_3	H_4
V_1	35.30	38.56	44.04	39.30	31.57	37.12	42.82	45.68
V_2	39.70	47.85	51.06	46.20	37.72	44.12	49.99	52.96
V_3	40.56	44.48	49.43	44.82	37.67	42.87	47.86	50.91
V_4	29.09	35.43	37.01	33.84	26.00	31.42	37.89	40.05
Mean	36.16	41.58	45.38		33.24	38.88	44.64	47.40

	H_1	H_2	H_3	H_4
T_1	29.26	33.57	39.70	42.12
T_2	33.05	39.80	45.22	48.24
T_3	37.41	43.28	49.00	51.85
Mean	33.24	38.88	44.64	47.40

CD (5%)-(V)-0.97 (T)-0.84 (H)-1.09 (VT)-ns (VH)-ns (TH)-ns

Table 9. Effect of cultivars, temperature and drying periods on moisture content (%) of flour

	T_1	T_2	T_3	Mean	H_1	H_2	H_3	H_4
V_1	11.63	5.28	2.88	6.59	13.50	7.70	3.30	1.87
V_2	12.03	5.55	2.60	6.73	13.87	7.60	3.40	2.03
V_3	13.95	5.38	3.08	7.47	14.73	8.59	4.43	2.10
V_4	11.93	5.23	2.60	6.58	13.57	7.50	3.37	1.90
Mean	12.38	5.36	2.79		13.92	7.85	3.63	1.98

	H_1	H_2	H_3	H_4
T_1	23.48	14.73	7.65	3.68
T_2	11.65	6.60	2.03	1.15
T_3	6.63	2.23	1.20	1.10
Mean	13.92	7.85	3.63	1.98

CD (5%)- (V)-0.08 (T)-0.07 (H)-0.08 (VT)-0.14 (VH)-0.16 (TH)-0.14

were recorded for H_3 and H_4 which were 44.64 percent and 47.40 percent respectively.

4.2.2.3 Moisture

Moisture content of flour as influenced by cultivars, temperature and drying hours are presented in Table 9.

The main effects as well as the interaction effects had significant influence on moisture content. Main effect of V, T and H had significant influence on moisture content of flour. Among the cultivars, lower moisture content were recorded by V_1 (6.59%) and V_4 (6.58%) which were on par. Moisture content increased with increasing temperature ,as the temperature T_3 was found to have significantly lower moisture content of 2.79 percent as compared to others. Among the drying periods, the longest drying period brought about corresponding decrease in moisture content, H_4 having the least moisture content of 1.98 percent.

Interactions V x T, V x H, T x H exerted a significant influence on moisture content. In the case of V x T interaction, the effect of treatment combination V_2T_3 and V_4T_3 (2.60 %) were found significant to other combinations. With regard to V x H interaction, the treatment combinations V_1H_4 (1.87 %) had the least moisture content which was on par with V_4H_4

(1.90 %). Interaction T x H was found significant with T_3H_4 having the lowest moisture content of 1.10 %

4.2.2.4 Total Sugars

The data on total sugar content as influenced by cultivars, temperature and drying hours are shown in Table 10

The main effects of V, T and H had a profound influence on total sugar content of flour. Interaction effects were insignificant. Among the cultivars, V_1 had significantly higher value of 2.11 percent than V_2, V_3 and V_4. In the case of temperature, T_3 (1.63 %) had significantly higher total sugar content. Total sugar content was found to increase with drying periods Among drying periods, H_4 recorded highest value of 1.73 percent which was significantly higher.

4.3 Value addition through secondary products

4.3.1 Organoleptic quality evaluation of murukku, papad and wafers

Organoleptic quality of the secondary products *viz.* murukku, wafers and papad are presented in Table 11.

It was found that murukku made out of cultivar V_3 was significantly superior and recorded highest score of 4.87.

Table 10. Effect of cultivars, temperature and drying periods on total sugar content (%) of flour

	T_1	T_2	T_3	Mean	H_1	H_2	H_3	H_4
V_1	2.02	2.11	2.19	2.11	1.91	2.03	2.18	2.29
V_2	1.10	1.31	1.41	1.27	1.07	1.19	1.36	1.48
V_3	1.50	1.58	1.68	1.59	1.39	1.51	1.67	1.78
V_4	1.10	1.18	1.26	1.18	0.99	1.11	1.26	1.36
Mean	1.43	1.54	1.63		1.34	1.46	1.62	1.73

	H_1	H_2	H_3	H_4
T_1	1.18	1.34	1.53	1.67
T_2	1.35	1.47	1.62	1.74
T_3	1.48	1.58	1.70	1.77
Mean	1.34	1.46	1.62	1.73

CD (5%) -(V)-0.02 (T)-0.02 (H)0.01 (VT)-ns (VH)-ns (TH)-ns

Table11. Organoleptic quality of secondary products

	Murukku	Wafers	Pappad
V_1	4.47	4.47	3.73
V_2	4.53	4.13	3.53
V_3	4.87	4.67	3.33
V_4	4.27	4.13	3.20
CD (5%)	0.22	0.22	0.33 (1%)

Plate 3. Murukkus prepared using amorphophallus flour

Plate 4. Papads prepared using amorphophallus flour

Plate 5. Wafers prepared using amorphophallus flour

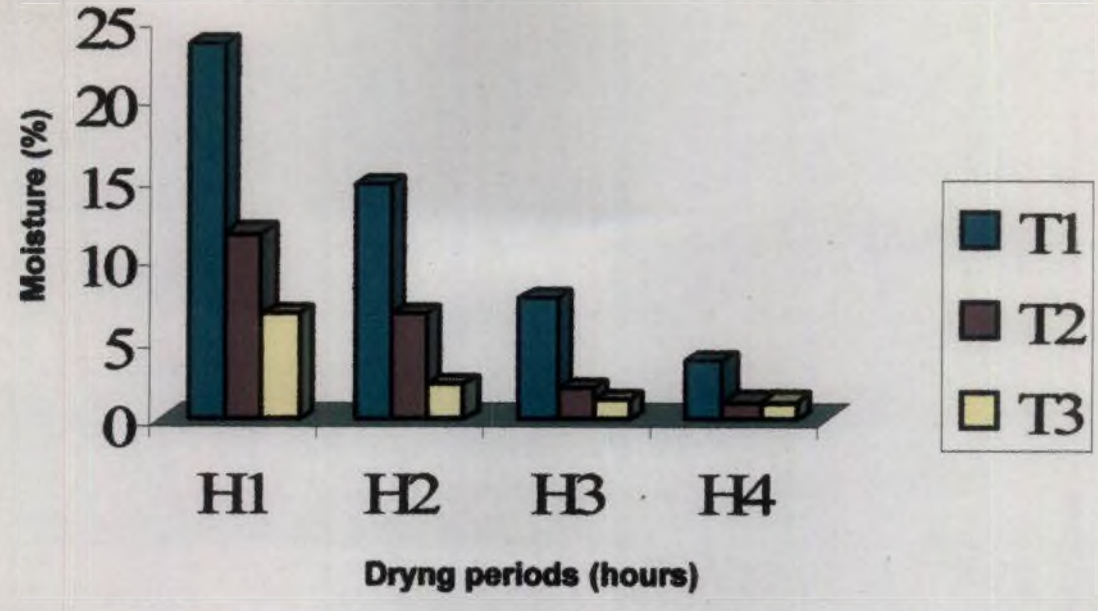

Fig 3. Effect of different temperatures on moisture content of flour at different drying periods

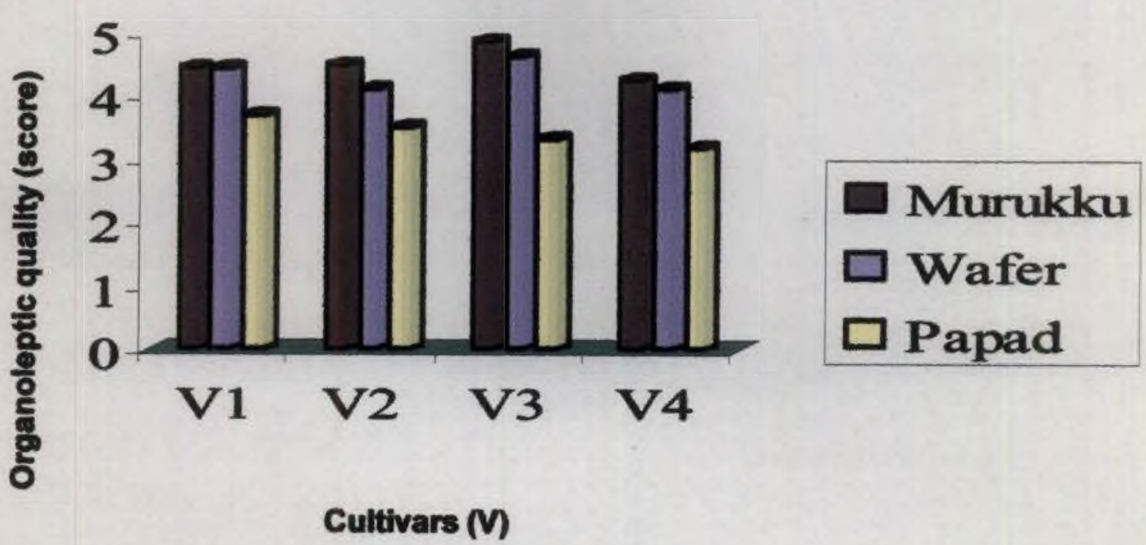

Fig 4. Organoleptic quality of secondary products

In the case of wafers V_3 was having the highest score of 4.67 which was on par with V_1 (4.47). V_2 and V_4 were on par and recorded the lowest score of 4.13 for organoleptic quality.

With regard to papad, cultivar V_1 was found significantly superior and recorded highest score of 3.73 while V_2 had the lowest score of 3.2.

4.4 Storage studies of primary products

4.4.1. Freshly fried chips

4.4.1.1. Starch

Starch content in freshly fried chips as influenced by cultivars, container and duration of storage is presented in Table 12. The results revealed that all the three treatments had significant influence on storage life of freshly fried chips. Among the cultivars, V_3 (52.72 %) recorded highest value while storage life of V_1 (41.09 %) was found to be the lowest. Starch content was found best in C_1 (47.97 %) which was on par with C_2 (47.09 %). Starch content was found to decrease with duration of storage from 47.97 per cent at D_1 days of storage to 45.34 per cent after D_7 days of storage.

Interaction effects had no statistical significant with respect to starch content of freshly fried chips.

Table 12. Effect of cultivars, containers, duration of storage on starch content (%) of freshly fried chips on storage

	C_1	C_2	C_3	Mean	D_1	D_2	D_3	D_4	D_5	D_6	D_7
V_1	41.89	41.13	40.27	41.09	41.89	41.89	41.59	41.59	40.70	40.17	39.85
V_2	51.47	51.09	48.47	50.34	51.47	51.47	51.47	50.09	50.09	48.90	48.90
V_3	54.60	52.92	50.63	52.72	54.60	54.60	53.66	53.11	52.45	50.30	50.30
V_4	43.93	43.23	41.67	42.94	43.93	43.93	42.92	42.92	42.30	42.30	42.30
Mean	47.97	47.09	45.26		47.97	47.97	47.41	46.93	46.39	45.42	45.34

	D_1	D_2	D_3	D_4	D_5	D_6	D_7
C_1	47.97	47.97	47.97	47.97	47.97	47.97	47.97
C_2	47.97	47.97	47.73	47.73	46.80	45.85	45.61
C_3	47.97	47.97	46.54	45.09	44.38	42.44	42.41

CD (5 %) - (V) – 1.12 (C)- 0.97 (VC)-ns (D)-1.49 (VD)-ns (CD)-ns

Table13. Effect of cultivars, containers, duration of storage on total sugar content (%) of freshly fried chips on storage

	C_1	C_2	C_3	Mean	D_1	D_2	D_3	D_4	D_5	D_6	D_7
V_1	2.42	2.43	2.46	2.44	2.31	2.33	2.37	2.42	2.47	2.53	2.61
V_2	1.96	1.96	2.00	1.97	1.84	1.87	1.92	1.95	2.00	2.07	2.15
V_3	2.16	2.16	2.20	2.17	2.04	2.07	2.11	2.16	2.21	2.28	2.35
V_4	2.02	2.02	2.05	2.03	1.90	1.92	1.97	2.01	2.07	2.15	2.21
Mean	2.14	2.14	2.18		2.02	2.05	2.09	2.13	2.19	2.26	2.33

	D_1	D_2	D_3	D_4	D_5	D_6	D_7
C_1	2.02	2.04	2.08	2.13	2.17	2.23	2.30
C_2	2.02	2.04	2.09	2.12	2.18	2.24	2.32
C_3	2.02	2.06	2.11	2.15	2.22	2.30	2.37

CD (5%) (V) – 0.02 (C) - 0.01 (V) – 0.02 (VC) – ns (VD) – ns (CD) - ns

4.4.1.2. Total Sugars

Total sugars of freshly fried chips as influenced by cultivars, container and duration of storage is presented in Table 13.

Total sugar content was significantly influenced by all the treatments. Cultivar V_1 (2.44 %) was found to have highest total sugar content while V_2 (1.97 %) recorded the lowest total sugar content. Total sugar content was found highest in C_3 (2.18 %) followed by C_1 and C_2 (2.14 %) which were on par. Total sugar content was found to increase with duration of storage progressively from 2.02 percent (D_1) to 2.33 percent (D_7).

4.4.1.3 Moisture

Moisture content during storage as influenced by cultivar, containers and duration of storage is presented in Table 14.

Moisture content was significantly influenced by cultivar. Lowest moisture content was recorded by V_3 (6.47 %). V_1, V_2 and V_3 were found to be on par (6.64 %). Maximum moisture content was recorded in chips stored in container C_3 (6.72 %) followed by C_2 (6.57 %) and C_1 (6.51 %). Moisture content was found to increase progressively during storage from an initial value of 6.40 percent (D_1) to a final value of 6.81 percent.

Table14. Effects of cultivars, containers, duration of storage on moisture content (%) of freshly fried chips on storage

	C_1	C_2	C_3	Mean	D_1	D_2	D_3	D_4	D_5	D_6	D_7
V_1	6.55	6.63	6.75	6.64	6.44	6.48	6.54	6.63	6.74	6.81	6.86
V_2	6.55	6.61	6.76	6.64	6.44	6.47	6.55	6.63	6.74	6.80	6.85
V_3	6.38	6.43	6.60	6.47	6.29	6.31	6.37	6.46	6.57	6.63	6.68
V_4	6.55	6.61	6.76	6.64	6.44	6.48	6.55	6.64	6.74	6.80	6.85
Mean	6.51	6.57	6.72		6.40	6.44	6.50	6.59	6.70	6.76	6.81

	D_1	D_2	D_3	D_4	D_5	D_6	D_7
C_1	6.40	6.42	6.45	6.49	6.55	6.61	6.65
C_2	6.40	6.44	6.51	6.57	6.65	6.69	6.73
C_3	6.40	6.45	6.55	6.71	6.88	6.98	7.01

CD (5 %) (V) -0.01 (C)- 0.01(D)-0.01 (VC)- ns (VD)-ns (CD)-ns

Table15. Effect of cultivars, containers, duration of storage on organoleptic quality of freshly fried chips on storage

	C_1	C_2	C_3	Mean	D_1	D_2	D_3	D_4	D_5	D_6	D_7
V_1	4.34	4.26	4.17	4.26	4.65	4.62	4.52	4.37	4.20	3.93	3.53
V_2	3.60	3.43	3.28	3.44	3.90	3.80	3.70	3.52	3.28	3.05	2.80
V_3	4.37	4.22	4.07	4.22	4.73	4.60	4.48	4.28	4.07	3.80	3.58
V_4	3.36	3.24	3.14	3.25	3.75	3.58	3.47	3.30	3.10	2.88	2.65
Mean	3.92	3.79	3.66		4.26	4.15	4.04	3.87	3.66	3.42	3.14

	D_1	D_2	D_3	D_4	D_5	D_6	D_7
C_1	4.25	4.20	4.13	4.01	3.81	3.63	3.41
C_2	4.25	4.14	4.06	3.88	3.66	3.39	3.15
C_3	4.28	4.11	3.94	3.71	3.51	3.24	2.86

CD (5%) (V) -0.07 (C)- 0.06 (D)-0.09 (VC) – ns (VD) – ns (CD) – 0.16

4.4.1.4 Organoleptic quality

Organoleptic quality of freshly fried chips as influenced by cultivar, type of containers and duration of storage is presented in Table 15.

Organoleptic quality was significantly influenced by cultivars, containers, duration of storage and interaction effect of C x D.

Organoleptic quality score was found highest in cultivar V_1 (4.26) which was on par with V_3 (4.22). Freshly fried chips stored in C_1 (3.92) recorded highest organoleptic quality score followed by C_2 (3.79). Organoleptic quality decreased consistently throughout the storage period from an initial score of 4.26 (D_1) to a final score of 3.14 (D_7)

Interaction effect of C x D was found significant. The treatment C_3D_1 (4.28) recorded the highest score of 4.28 and C_3D_7 recorded the lowest score of 2.86.

4.4.2. Parboiled fried chips

4.4.2.1. Starch

Starch content of parboiled, dried and fried chips as influenced by cultivars, type of containers and duration of storage is presented in Table 16.

Results revealed that starch content was significantly influenced by cultivars only. Cultivar V_3 (54.60 %) was found to have the highest starch content.

Table 16. Effect of cultivars, containers, duration of storage on starch content (%) of parboiled chips on storage

	C_1	C_2	C_3	Mean	D_1	D_2	D_3	D_4	D_5	D_6	D_7
V_1	39.96	40.02	39.06	39.68	40.02	40.02	40.02	40.02	39.45	39.18	39.04
V_2	46.17	46.00	45.22	45.80	46.17	46.17	46.17	45.81	45.81	45.42	45.03
V_3	54.60	54.60	54.60	54.60	54.60	54.60	54.60	54.60	54.60	54.60	54.60
V_4	43.93	43.93	42.93	43.60	43.93	43.93	43.93	43.61	43.01	43.25	42.92
Mean	46.16	46.14	45.45		46.18	46.18	46.18	46.01	45.87	45.61	45.40

	D_1	D_2	D_3	D_4	D_5	D_6	D_7
C_1	46.18	46.18	46.18	46.18	46.18	46.18	46.08
C_2	46.18	46.18	46.18	46.18	46.18	46.18	45.89
C_3	46.18	46.18	46.18	45.67	45.24	44.48	44.23

CD (5 %) (V) -0.78 (C)- ns (D)-ns (VC) – ns (VD) – ns (CD)- ns

Table 17. Effect of cultivars, containers, duration of storage on total sugar content (%) of parboiled chips on storage

V	C_1	C_2	C_3	Mean	D_1	D_2	D_3	D_4	D_5	D_6	D_7
V_1	1.61	1.63	1.64	1.63	1.55	1.56	1.58	1.60	1.66	1.71	1.73
V_2	1.34	1.35	1.38	1.35	1.27	1.28	1.31	1.34	1.39	1.43	1.46
V_3	1.55	1.56	1.57	1.56	1.48	1.49	1.52	1.54	1.59	1.64	1.65
V_4	1.42	1.43	4.48	1.44	1.36	1.37	1.39	1.43	1.49	1.52	1.55
Mean	1.48	1.49	1.52		1.42	1.43	1.45	1.48	1.53	1.58	1.60

	D_1	D_2	D_3	D_4	D_5	D_6	D_7
C_1	1.42	1.42	1.44	1.46	1.50	1.55	1.57
C_2	1.42	1.43	1.45	1.47	1.52	1.57	1.59
C_3	1.42	1.43	1.47	1.50	1.57	1.60	1.63

CD (5 %) (V) 0.01 (C)- 0.01 (D)-0.02 (VC) – ns (VD) – ns (CD) - ns

4.4.2.2. Total Sugars

Total sugars as influenced by cultivars containers and duration of storage is presented in Table 17

Total sugar content was significantly influenced by cultivars, types of containers and duration of storage. Among the cultivars V_1 (1.63 %) had the highest total sugar content while V_2 (1.35 %) had the lowest. Among the containers C_3 (1.52 %) was found to be superior. C_1 and C_2 were on par with each other Total sugar content was found to increase progressively during storage from an initial value of 1.42 per cent to 1.60 per cent at the end of the storage period.

Interactions did not have any statistical significance on total sugar content of parboiled chips on storage.

4.4.2.3 Moisture

Moisture content of parboiled, dried and fried chips as influenced by cultivars, containers and duration of storage is presented in Table 18

Cultivars, containers and duration of storage significantly influenced moisture content of chips. Parboiled chips made with cultivar V_3 (4.31 %) was found to be on par with V_1 (4.30 %) and had the highest moisture content. V_4 had the lowest moisture content (4.13 %). Chips stored in C_3 had highest moisture content (4.26 %) followed by C_2 (4.24 %) and lowest in C_1 (4.20 %).

The moisture content was found to increase with increasing storage period. Chips stored for D_7 days of storage had the highest moisture content.

4.4.2.4 Organoleptic quality

The influence of cultivar, containers and duration of storage on organoleptic quality is presented in Table 19.

Organoleptic quality of parboiled chips were significantly influenced by the main effects of cultivar, type of containers, duration of storage and interaction of C x D.

Among the cultivars, V_3 was found significantly superior over other cultivars and had the highest score of 3.95 followed by V_1 having a score of 3.62. Chips stored in C_1 (3.31) was significantly superior than C_2 and C_3.The data on storage period showed that organoleptic quality decreased with storage. Chips stored for period D_7 had the lowest score of 2.83 while highest score of 3.45 was recorded at D_1 days.

In the case of interaction, highest score was recorded by C_1D_1, C_2D_1 and C_3D_3 all having a score of 3.45.

Table 18. Effect of cultivars, containers, duration of storage on moisture content (%) of parboiled chips on storage

	C_1	C_2	C_3	Mean	D_1	D_2	D_3	D_4	D_5	D_6	D_7
V_1	4.23	4.32	4.34	4.30	4.27	4.27	4.29	4.15	4.34	4.37	4.39
V_2	4.18	4.21	4.23	4.20	4.15	4.15	4.17	4.20	4.23	4.25	4.27
V_3	4.29	4.31	4.33	4.31	4.26	4.26	4.28	4.31	4.34	4.36	4.36
V_4	4.10	4.12	4.15	4.13	4.07	4.07	4.09	4.12	4.15	4.18	4.19
Mean	4.20	4.24	4.26		4.19	4.19	4.20	4.24	4.26	4.29	4.30

	D_1	D_2	D_3	D_4	D_5	D_6	D_7
C_1	4.19	4.19	4.19	4.08	4.22	4.25	4.27
C_2	4.19	4.19	4.20	4.24	4.27	4.29	4.30
C_3	4.19	4.20	4.22	4.26	4.30	4.33	4.34

CD (5 %) (V) -0.04(C)- 0.03 (D)-0.05 (VC) – ns (VD) – ns (CD) – ns

Table 19. Effects of cultivars, containers, duration of storage on organoleptic quality of parboiled chips on storage

	C_1	C_2	C_3	Mean	D_1	D_2	D_3	D_4	D_5	D_6	D_7
V_1	3.77	3.69	3.41	3.62	3.90	3.83	3.78	3.68	3.55	3.40	3.22
V_2	2.76	2.71	2.53	2.67	2.90	2.87	2.80	2.72	2.60	2.47	2.32
V_3	4.10	4.01	3.75	3.95	4.25	4.17	4.07	3.98	3.77	3.82	3.62
V_4	2.62	2.46	2.29	2.46	2.75	2.67	2.58	2.45	2.33	2.27	2.15
Mean	3.31	3.22	2.99		3.45	3.38	3.31	3.21	3.06	2.99	2.83

	D_1	D_2	D_3	D_4	D_5	D_6	D_7
C_1	3.45	3.45	3.42	3.38	3.20	3.23	3.06
C_2	3.45	3.40	3.35	3.25	3.15	3.05	2.90
C_3	3.45	3.30	3.15	3.00	2.85	2.69	2.52

CD (5 %) (V) -0.06 (C)- 0.05 (D)-0.08 (VC) – ns (VD) – ns (CD) – 0.13

4.4.3 Storage studies of flour

4.4.3.1. Starch

The influence of cultivars, types of containers and duration of storage on starch content during storage of flour are presented in Table 20.

The data revealed that starch content was significantly influenced by cultivars. Higher values of 49.84 per cent and 47.20 per cent were recorded for V_2 and V_3 respectively which was significantly superior to V_1 and V_4.

Starch content of flour on storage was found highest for C_1 (45.22 %) which was found on par with C_2 (44.61%). Starch content was found to decrease with duration of storage and lower values were obtained at D_5 (44.16 %), D_6 (43.11 %) and D_7 (42.90 %) days of storage.

The interaction effect of C x D was found to have significant influence on starch content of flour. Starch content was lowest in C_3D_6 (40.90 %)and C_3D_7 (40.28 %).

4.4.3.2. Total sugars

Data showing the influence of cultivar, type of containers and duration of storage are given in Table 21

Cultivars significantly influenced total sugar content. Among the cultivars, V1 had significantly higher value of 2.30 percent. Type of container also had a significant influence on total sugar content. Flour

Table 20. Effect of cultivars, containers, duration of storage on starch content (%) of flour on storage

	C_1	C_2	C_3	Mean	D_1	D_2	D_3	D_4	D_5	D_6	D_7
V_1	41.89	41.12	39.90	40.97	41.89	41.89	41.89	41.56	40.99	39.28	39.28
V_2	51.47	50.31	47.75	49.84	51.47	51.47	51.47	50.29	48.97	47.78	47.46
V_3	47.50	47.21	46.90	47.20	47.50	47.50	47.50	47.50	47.50	46.46	46.46
V_4	40.02	39.79	38.73	39.51	40.02	40.02	40.02	40.02	39.18	38.91	38.41
Mean	45.22	44.61	43.32		45.22	45.22	45.22	44.84	44.16	43.11	42.90

	D_1	D_2	D_3	D_4	D_5	D_6	D_7
C_1	45.22	45.22	45.22	45.22	45.22	45.22	45.22
C_2	45.22	45.22	45.22	45.22	44.96	43.21	43.21
C_3	45.22	45.22	45.22	44.09	42.30	40.90	40.28

CD (5 %) (V) -0.97 (C)- 0.84 (D)- 1.28 (VC) – ns (VD) – ns (CD) -2.22 (1 %)

Table 21. Effect of cultivars, containers, duration of storage on total sugar content (%) of flour on storage

	C_1	C_2	C_3	Mean	D_1	D_2	D_3	D_4	D_5	D_6	D_7
V_1	2.27	2.29	2.33	2.30	2.19	2.20	2.23	2.27	2.35	2.40	2.44
V_2	1.49	1.52	1.55	1.52	1.40	1.42	1.46	1.51	1.57	1.62	1.65
V_3	1.75	1.76	1.79	1.77	1.66	1.68	1.71	1.75	1.81	1.87	1.90
V_4	1.32	1.35	1.40	1.36	1.25	1.27	1.30	1.34	1.41	1.45	1.48
Mean	1.71	1.73	1.77		1.62	1.64	1.68	1.72	1.79	1.84	1.86

	D_1	D_2	D_3	D_4	D_5	D_6	D_7
C_1	1.62	1.64	1.65	1.69	1.75	1.78	1.82
C_2	1.62	1.64	1.68	1.71	1.78	1.82	1.85
C_3	1.62	1.65	1.69	1.75	1.83	1.91	1.93

CD (5 %) (V) -0.01 (C)- 0.01(D)- 0.02 (CD) – 0.03 (VC) – ns (VD) - ns stored in container C_3 gave the highest value of 1.77 percent for starch while C_1 recorded the lowest value of 1.71 percent.

Duration of storage also had significant influence on total sugar content of flour during storage. Total sugar content was found to increase significantly with increasing days of storage, higher values of 1.86 percent and 1.84 percent were recorded at D_6 and D_7 days after storage respectively.

Interaction of treatment C x D was found to significantly influence total sugar content. Highest values were recorded for C_3D_7 (1.93 %) and C_3D_6 (1.91 %) and lowest value of 1.62 percent for C_1D_1, C_2D_1 and C_3D_1.

4.4.3.3. Moisture

Moisture content of flour as influenced by cultivars, type of containers and duration of storage is presented in Table 22.

The main effects V, C and D as well as their interactions had significant influence on moisture content of flour during storage.

The moisture content during storage of flour was found highest in cultivar V_3 (2.84 %) and least in V_4 (2.66 %). Moisture content was highest in flour stored in container C_3 (3.16 %) followed by C_2 (2.70 %) and C_1 (2.38 %). Duration of storage also had significant influence on moisture content. Moisture content of flour significantly increased with days of

Table 22. Effect of cultivars, containers, duration of storage on moisture content (%) of flour on storage

	C_1	C_2	C_3	Mean	D_1	D_2	D_3	D_4	D_5	D_6	D_7
V_1	2.44	2.75	3.19	2.79	2.05	2.21	2.45	2.71	3.06	3.38	3.69
V_2	2.35	2.62	3.10	2.69	1.90	2.11	2.33	2.60	2.97	3.33	3.61
V_3	2.51	2.76	3.26	2.84	2.20	2.29	2.47	2.74	3.09	3.39	3.71
V_4	2.21	2.67	3.11	2.66	1.80	2.00	2.28	2.85	2.90	3.23	3.58
Mean	2.38	2.70	3.16		1.99	2.15	2.38	2.72	3.01	3.33	3.65

	D_1	D_2	D_3	D_4	D_5	D_6	D_7
C_1	1.99	2.04	2.08	2.23	2.48	2.79	3.04
C_2	1.99	2.17	2.45	2.73	2.95	3.19	3.43
C_3	1.99	2.25	2.62	3.21	3.60	4.01	4.47

CD (5 %) (V) -0.03 (C)- 0.03 (D)- 0.04 (VC) – 0.06 (VD) – 0.09 (CD) – 0.08

Interactions effect of cultivars, containers, duration of storage on moisture content (%) of flour on storage

	C_1							Mean	C_2							Mean	C_3							Mean
	D_1	D_2	D_3	D_4	D_5	D_6	D_7		D_1	D_2	D_3	D_4	D_5	D_6	D_7		D_1	D_2	D_3	D_4	D_5	D_6	D_7	
V_1	2.05	2.09	2.20	2.34	2.55	2.82	3.06	2.44	2.05	2.22	2.48	2.76	2.99	3.24	3.50	2.75	2.05	2.32	2.68	3.03	3.66	4.07	4.51	3.19
V_2	1.90	1.98	2.04	2.18	2.45	2.86	3.06	2.35	1.90	2.12	2.37	2.66	2.88	3.12	3.30	2.62	1.90	2.22	2.58	2.95	3.57	4.01	4.46	3.10
V_3	2.20	2.22	2.23	2.36	2.59	2.85	3.10	2.51	2.20	2.32	2.47	2.75	2.96	3.20	3.46	2.76	2.20	2.34	2.72	3.10	3.74	4.14	4.57	3.26
V_4	1.80	1.86	1.87	2.02	2.32	2.65	2.96	2.21	1.80	2.03	2.48	2.76	2.97	3.20	3.46	2.67	1.80	2.11	2.50	3.78	3.41	3.84	4.33	3.11
Mean	1.99	2.04	2.08	2.23	2.48	2.79	3.04		1.99	2.17	2.45	2.73	2.95	3.19	3.43		1.99	2.25	2.62	3.21	3.60	4.01	4.47	

CD (5 %) (VCD) – 0.16

storage. Highest value was recorded after D_7 days of storage which was 3.65 percent.

Interaction effects of V x C, V x D and C x D had significant influence on moisture content of flour. The treatment combination C_3D_7 (4.47 %) recorded highest moisture content and lowest by C_1D_1, C_2D_1 and C3D1 which had a value of 1.99 percent.

Regarding V x C interaction, highest value of 3.26 per cent was recorded by V_3C_3 and lowest value of 2.21 per cent by V_4C_1. In the interaction of V x D, highest value was recorded by V_3D_7 (3.71 %) and V_1D_7 (3.69 %).

The interaction effect of V x C x D was found to be significant on moisture content. It was found to increase significantly and higher values were obtained for $V_1C_3D_7$ (4.51 %), $V_2C_3D_7$ (4.46 %), $V_3C_3D_7$ (4.57 %), $V_4C_3D_7$ (4.33 %).

4.5. Storage studies of secondary products

4.5.1.Murukku

4.5.1.1 Starch

Starch content of murukku as influenced by V, C and D is presented in Table 23.

The data revealed that different cultivars had significant influence on starch content during storage. V_3 recorded the highest value of 65.14 per cent which was significantly superior to V_2, V_4 and V_1. The different containers used appreciably influenced starch content on storage. Highest value of 60.25 per cent was noticed in C_1 and lowest value of 57.77 per cent in C_3. Duration of storage had significant influence on starch content. Starch content was found to decrease with days of storage. The starch content remained almost steady during the first month of storage after which it was found to decrease gradually. The highest value of 60.25 percent was recorded in D_1 and D_2 and the lowest value of 57.85 percent was recorded at the end of the storage period (D_6 and D_7).

The effect of interactions failed to express any significant variation in starch content of murukku during storage.

4.5.1.2.Total sugars

Total sugar content as influenced by V, C, D is given in Table 24.

The main effects of V and D had a significant influence on total sugar content. Among the cultivars, V_3 recorded highest value of 2.41 per cent which was significantly higher as compared to other cultivars. In the case of duration of storage, total sugar content increased significantly with

Table 23. Effect of cultivars, containers, duration of storage on starch content (%) of murukku on storage

	C_1	C_2	C_3	Mean	D_1	D_2	D_3	D_4	D_5	D_6	D_7
V_1	54.50	53.21	52.00	53.24	54.50	54.50	54.50	53.50	52.50	51.58	51.58
V_2	62.00	60.57	59.71	60.76	62.00	62.00	62.00	60.67	60.00	59.33	59.33
V_3	66.50	65.29	63.64	65.14	66.50	66.50	65.83	65.00	63.50	64.33	64.33
V_4	58.00	57.43	55.71	57.05	58.00	58.00	57.33	56.83	56.83	56.17	56.17
Mean	60.25	59.13	57.77		60.25	60.25	59.92	59.00	58.21	57.85	57.85

	D_1	D_2	D_3	D_4	D_5	D_6	D_7
C_1	60.25	60.25	60.25	60.25	60.25	60.25	60.25
C_2	60.25	60.25	60.25	60.25	57.88	57.50	57.50
C_3	60.25	60.25	59.25	56.50	56.50	55.81	55.81

CD (0.05) (V) –1.26 (C)- 1.09 (D)- 1.67 (VC) – ns (VD) – ns (CD) – ns

Table 24. Effect of cultivars, containers, duration of storage on total sugar content (%) of murukku on storage

	C_1	C_2	C_3	Mean	D_1	D_2	D_3	D_4	D_5	D_6	D_7
V_1	2.38	2.38	2.39	2.38	2.23	2.27	2.32	2.39	2.45	2.49	2.54
V_2	2.26	2.26	2.27	2.26	2.11	2.15	2.21	2.27	2.32	2.37	2.41
V_3	2.40	2.40	2.41	2.41	2.25	2.29	2.35	2.42	2.47	2.51	2.55
V_4	2.22	2.22	2.22	2.22	2.07	2.11	2.17	2.22	2.27	2.32	2.36
Mean	2.31	2.31	2.32		2.16	2.20	2.26	2.32	2.38	2.42	2.47

	D_1	D_2	D_3	D_4	D_5	D_6	D_7
C_1	2.16	2.20	2.26	2.32	2.38	2.42	2.46
C_2	2.16	2.20	2.26	2.32	2.37	2.42	2.46
C_3	2.16	2.21	2.27	2.33	2.38	2.43	2.48

CD (5 %) (V) –1.01 (C)- ns (D)- 0.01 (VC) – ns (VD) – ns (CD) -ns increasing days of storage. Highest value of 2.47 per cent was recorded after D_7 days of storage.

No significant variation in total sugar content was observed due to interactions during storage.

4.5.1.3 Moisture

The data on moisture content of murukku during storage as influenced by treatments V,C,D are shown in Table 25.

The main effects of V, C and D had profound influence on moisture content. Among the cultivars, V_4 recorded the highest value of 9.92 per cent which was significantly high as compared to other cultivars. The lowest value of 9.3 per cent was recorded highest value of 9.72 per cent followed by C_2 and C_1 which were on par. With regard to duration of storage, moisture content was found to increase with storage. Highest value of 9.89 per cent was recorded after D_7 days of storage.

The C x D interaction exerted a significant influence on moisture content. The effect of the treatment combination C_3D_7 was highest and was significantly superior from all other combination.

All the other interactions failed to express any significant variation on moisture content of murukku during storage.

Table 25. Effect of cultivars, containers, duration of storage on moisture content (%) of murukku on storage

	C_1	C_2	C_3	Mean	D_1	D_2	D_3	D_4	D_5	D_6	D_7
V_1	9.51	9.52	9.74	9.59	9.30	9.37	9.47	9.59	9.69	9.78	9.95
V_2	9.23	9.24	9.43	9.30	9.00	9.08	9.19	9.31	9.43	9.50	9.58
V_3	9.52	9.53	9.70	9.58	9.30	9.37	9.47	9.60	9.71	9.79	9.85
V_4	9.86	9.88	10.02	9.92	9.65	9.73	9.83	9.94	10.02	10.11	10.17
Mean	9.53	9.54	9.72		9.31	9.39	9.49	9.61	9.71	9.79	9.89

	D_1	D_2	D_3	D_4	D_5	D_6	D_7
C_1	9.31	9.38	9.44	9.52	9.63	9.69	9.74
C_2	9.31	9.39	9.45	9.54	9.64	9.70	9.76
C_3	9.31	9.39	9.57	9.77	9.87	9.99	10.16

CD (5 %) (V) –0.06 (C)- 0.05 (D)- 0.07 (VC) – ns (VD) – ns (CD) – 0.13

Table 26. Effect of cultivars, containers, duration of storage on organoleptic quality of murukku on storage

V	C_1	C_2	C_3	Mean	D_1	D_2	D_3	D_4	D_5	D_6	D_7
V_1	4.39	4.31	3.96	4.22	4.65	4.60	4.48	4.33	4.12	3.82	3.53
V_2	3.98	3.89	3.63	3.83	4.25	4.22	4.07	3.93	3.73	3.42	3.22
V_3	4.30	4.24	3.98	4.18	4.70	4.63	4.48	4.32	4.13	3.58	3.40
V_4	3.81	3.69	3.44	3.65	4.05	4.02	3.85	3.72	3.57	3.33	3.02
Mean	4.12	4.04	3.75		4.41	4.37	4.22	4.08	3.89	3.54	3.29

	D_1	D_2	D_3	D_4	D_5	D_6	D_7
C_1	4.41	4.35	4.33	4.30	4.17	3.75	3.54
C_2	4.41	4.34	4.20	4.18	4.01	3.68	3.45
C_3	4.41	4.41	4.14	3.75	3.48	3.19	2.89

CD (5 %) (V) –0.05 (C)- 0.04 (D)- 0.06 (VC) – ns (VD) – 0.12 (CD) – 0.10

4.5.1.4. Organoleptic quality

The influence of V, C and D and their interactions on organoleptic quality of murukku during storage are given in Table 26.

Cultivar V_1 recorded the highest score of 4.22 which was on par with V_3 (4.18). Highest organoleptic quality was obtained for murukku stored in container C_1 (4.12) followed by C_2 (4.04). Organoleptic quality was found to decrease with increase in duration of storage and lowest value was obtained after D_7 days of storage (3.29).

The interactions of V x D and C x D were found to have significant effect on organoleptic quality. Higher scores were obtained for V_3D_1 (4.70), V_3D_2 (4.63), V_1D_1 (4.65) and V_1D_2 (4.60) which were significantly superior from other combinations. In the case of C x D interactions C_1D_1, C_2D_1, $C_3D_1$and C_3D_2 recorded highest score of 4.41 which was significantly superior from other combinations.

The combined effect of three factors *viz.*, V, C and D failed to show any profound influence on organoleptic quality of murukku during storage.

4.5.2. Wafers

4.5.2.1. Starch

Starch content of wafers as influenced by V, C and D and their interaction is shown in Table 27.

The data revealed that main effects of V and C had significant effect on starch content of wafers during storage. Among the cultivars, highest starch content was recorded by V_3 (61.44 %). Among the containers, the highest starch content was recorded in C_1 (54.88 %) which was on par with C_2 (54.3 %). Duration of storage did not show any significant influence on starch content of wafers.

The interactions failed to show any significant influence on starch content of wafers during storage.

4.5.2.2 Total sugars

The influence of V, C and D and their interactions on total sugar content of wafers is presented in Table 28.

The main effects of V, C and D had a significant influence on total sugar content. Cultivar V_1 recorded the highest total sugar content of 2.18 percent .The different containers used appreciably influenced total sugar content on storage. Highest value of 2.17 per cent was noticed in C_3 and lowest in C_1 (2.12 %). Duration of storage had significant influence on total sugar content. Total sugar content was found to increase significantly with days of storage. Highest total sugar content was recorded after D_7 days of storage (2.28 %).

Among the interactions, C x D interaction was found significant. The effect of treatment combination C_3D_7 (2.32 %) was highest among the

Table 27. Effect of cultivars, containers, duration of storage on starch content (%) of wafers on storage

	C_1	C_2	C_3	Mean	D_1	D_2	D_3	D_4	D_5	D_6	D_7
V_1	54.50	53.86	53.21	53.86	54.50	54.50	54.50	54.50	53.50	53.00	52.50
V_2	51.50	51.50	50.32	51.11	51.50	51.50	51.50	51.50	50.58	50.58	50.58
V_3	62.00	61.54	60.79	61.44	62.00	62.00	62.00	62.00	61.33	60.92	59.83
V_4	51.50	51.50	50.32	51.11	51.50	51.50	51.50	51.50	50.58	50.58	50.58
Mean	54.88	54.6	53.66		54.88	54.88	54.88	54.88	54.00	53.77	53.38

	D_1	D_2	D_3	D_4	D_5	D_6	D_7
C_1	54.88	54.88	54.88	54.88	54.88	54.88	54.88
C_2	54.88	54.88	54.88	54.88	54.88	54.50	53.31
C_3	54.88	54.88	54.88	54.88	52.25	51.94	51.94

CD (5 %) (V) -0.97 (C)-0.84 (1 %) (D) –ns (VC) – ns (VD) – ns (CD) - ns

Table 28. Effect of cultivars, containers, duration of storage on total sugar content (%) of wafers on storage

	C_1	C_2	C_3	Mean	D_1	D_2	D_3	D_4	D_5	D_6	D_7
V_1	2.16	2.18	2.21	2.18	2.05	2.08	2.12	2.18	2.23	2.28	2.33
V_2	2.09	2.11	2.14	2.12	1.98	2.00	2.05	2.12	2.18	2.21	2.26
V_3	2.14	2.15	2.18	2.15	2.02	2.04	2.09	2.16	2.22	2.26	2.30
V_4	2.10	2.11	2.14	2.12	1.98	2.00	2.05	2.13	2.19	2.23	2.25
Mean	2.12	2.14	2.17		2.01	2.03	2.08	2.15	2.21	2.24	2.28

	D_1	D_2	D_3	D_4	D_5	D_6	D_7
C_1	2.01	2.03	2.07	2.13	2.18	2.21	2.24
C_2	2.01	2.03	2.07	2.14	2.20	2.23	2.28
C_3	2.01	2.04	2.10	2.17	2.23	2.29	2.32

CD (5 %) (V) –0.01 (C)- 0.00 (D)- 0.01 (VC) – ns (VD) – ns (CD) – 0.01

treatment combinations. All the other interactions failed to express any significant variation on total sugar content of wafers during storage.

4.5.2.3. Moisture

The data on moisture content of wafers during storage as influenced by various treatments are shown in Table 29.

The main effects of V, C and D had significant influence on moisture content during storage. Among the cultivars highest value of 8.45 per cent was recorded in V_1 and lowest value of 8.28 per cent in V_4. In the case of containers highest moisture content was recorded in C_3 (8.41 %) and lowest moisture content of 8.29 per cent was recorded in C_1. With regard to duration of storage, moisture content was found to increase with storage. Highest value of 8.56 per cent was recorded after D_7 days of storage which was on par with D_6 (8.55%).

Among the interactions V x D, C x D interactions were found significant. In case of V x D interaction, highest value was recorded for V_1D_7 (8.73 %) and lowest value for V_4D_1 (8.04 %)

With regard to C x D interaction highest moisture content was recorded in C_3D_7 (8.71%) and lowest in C_1D_1, C_2D_1 and C_3D_3 having a value of 8.10 per cent.

Table 29. Effect of cultivars, containers, duration of storage on moisture content (%) of wafers on storage

	C_1	C_2	C_3	Mean	D_1	D_2	D_3	D_4	D_5	D_6	D_7
V_1	8.39	8.42	8.54	8.45	8.19	8.25	8.33	8.44	8.57	8.67	8.73
V_2	8.28	8.30	8.40	8.33	8.09	8.14	8.21	8.31	8.46	8.54	8.55
V_3	8.26	8.27	8.36	8.30	8.07	8.12	8.20	8.30	8.40	8.49	8.51
V_4	8.23	8.25	8.35	8.28	8.04	8.09	8.17	8.27	8.41	8.50	8.47
Mean	8.29	8.31	8.41		8.10	8.15	8.22	8.33	8.46	8.55	8.56

	D_1	D_2	D_3	D_4	D_5	D_6	D_7
C_1	8.10	8.14	8.21	8.29	8.37	8.45	8.49
C_2	8.10	8.15	8.22	8.30	8.40	8.49	8.54
C_3	8.10	8.15	8.25	8.42	8.61	8.66	8.71

CD (5 %) (V) - 0.01 (C)- 0.01 (D)- 0.02 (VC) – ns (VD) – 0.03 (CD) – 0.03

Interactions effect of cultivars, containers, duration of storage on moisture content (%) of wafers on storage

	C_1							Mean	C_2							Mean	C_3							Mean
V	D_1	D_2	D_3	D_4	D_5	D_6	D_7		D_1	D_2	D_3	D_4	D_5	D_6	D_7		D_1	D_2	D_3	D_4	D_5	D_6	D_7	
V_1	8.19	8.23	8.31	8.39	8.47	8.55	8.60	8.39	8.19	8.25	8.32	8.40	8.50	8.63	8.68	8.42	8.19	8.25	8.35	8.53	8.73	8.82	8.93	8.54
V_2	8.09	8.13	8.20	8.27	8.35	8.43	8.48	8.28	8.09	8.14	8.21	8.29	8.39	8.48	8.54	8.30	8.09	8.15	8.24	8.39	8.63	8.72	8.62	8.40
V_3	8.07	8.11	8.18	8.26	8.35	8.42	8.44	8.26	8.07	8.12	8.18	8.26	8.36	8.43	8.50	8.27	8.07	8.13	8.23	8.39	8.51	8.60	8.58	8.36
V_4	8.04	8.09	8.15	8.23	8.30	8.39	8.45	8.23	8.04	8.09	8.16	8.24	8.35	8.42	8.44	8.25	8.04	8.09	8.19	8.36	8.57	8.68	8.54	8.35
Mean	8.10	8.14	8.21	8.29	8.37	8.45	8.49		8.10	8.15	8.22	8.30	8.40	8.49	8.54		8.10	8.15	8.25	8.42	8.61	8.66	8.71	

CD (5 %) (VCD) – 0.06

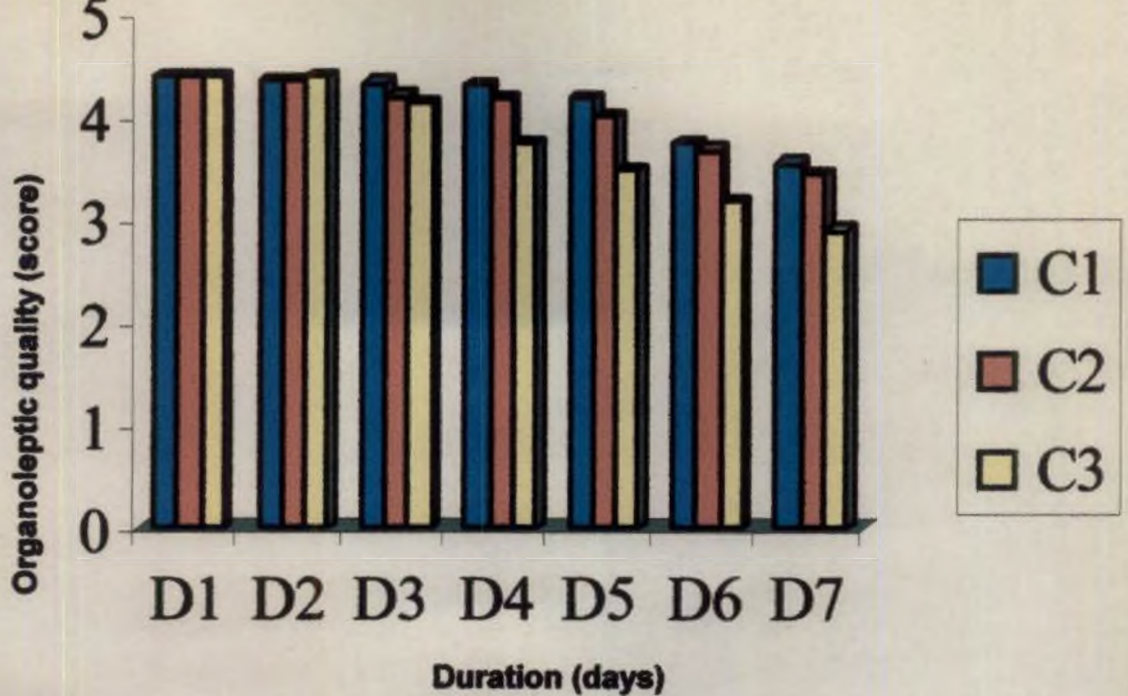

Fig 5. Effect of three types of containers on organoleptic quality of murukku for a period of 90 days

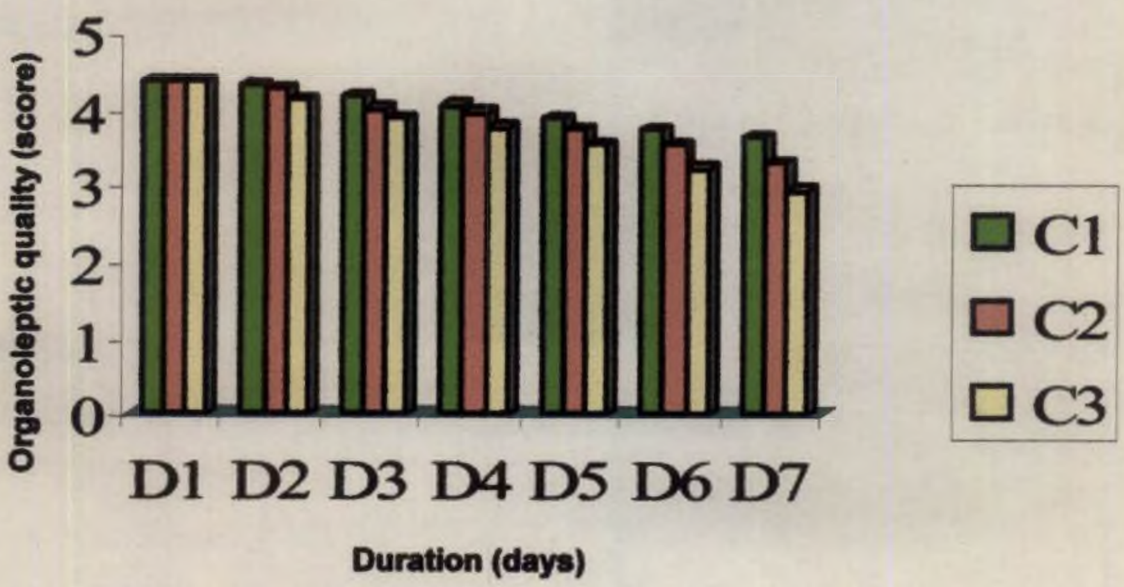

Fig 6. Effect of three types of containers on organoleptic quality of wafer for a period of 90 days.

Significant variation in moisture content was noticed due to the effect of V x C x D interaction. Highest values were recorded for $V_1C_3D_7$ (8.93 %) and lowest value for $V_4C_1D_1$ (8.04 %).

4.5.2.4.Organoleptic quality

The data on organoleptic quality as influenced by various treatments are shown in Table 30.

Cultivar V_1 recorded the highest score of 4.13. Highest organoleptic quality score was obtained for wafers stored in container C_1 (4.02) and lowest in C_3 (3.69). Organoleptic quality was found to decrease with increase in duration of storage. Lowest score of 3.29 was obtained after D_7 days of storage.

Interactions V x D and C x D were found significant. In the case of V x D interaction, higher scores were obtained for V_1D_1 (4.52 %) and V_3D_1 (4.42 %). With regard to C x D interaction, higher scores were obtained for C_1D_1, C_2D_1, C_3D_1 which were on par and had a score of 4.35.

4.5.3 Papad

4.5 3.1 Starch

Starch content of papads as influenced by V, C and D and their interaction is shown in Table 31.

Table 30. Effect of cultivars, containers, duration of storage on organoleptic quality of wafers on storage

	C_1	C_2	C_3	Mean	D_1	D_2	D_3	D_4	D_5	D_6	D_7
V_1	4.29	4.14	3.96	4.13	4.65	4.52	4.27	4.22	4.03	3.75	3.48
V_2	3.84	3.74	3.57	3.71	4.15	4.07	3.83	3.73	3.55	3.42	3.25
V_3	4.14	3.96	3.76	3.95	4.55	4.42	4.15	4.03	3.80	3.47	3.25
V_4	3.81	3.64	3.46	3.64	4.05	3.92	3.80	3.68	3.50	3.33	3.17
Mean	4.02	3.87	3.69		4.35	4.23	4.01	3.92	3.72	3.49	3.29

	D_1	D_2	D_3	D_4	D_5	D_6	D_7
C_1	4.35	4.31	4.16	4.05	3.89	3.73	3.63
C_2	4.35	4.25	4.00	3.94	3.74	3.53	3.30
C_3	4.35	4.13	3.88	3.76	3.54	3.23	2.94

CD (5 %) (V) –0.04 (C)- 0.03 (D)- 0.05 (VC) – ns (VD) – 0.09 (CD) – 0.08

Interactions effect of cultivars, containers, duration of storage on organoleptic quality of wafers on storage

	C_1							Mean	C_2							Mean	C_3							Mean
	D_1	D_2	D_3	D_4	D_5	D_6	D_7		D_1	D_2	D_3	D_4	D_5	D_6	D_7		D_1	D_2	D_3	D_4	D_5	D_6	D_7	
V_1	4.65	4.55	4.40	4.35	4.20	4.00	3.85	4.29	4.65	4.55	4.25	4.20	4.00	3.80	3.55	4.14	4.65	4.45	4.15	4.10	3.90	3.45	3.05	3.96
V_2	4.15	4.15	4.00	3.85	3.70	3.55	3.45	3.84	4.15	4.05	3.85	3.80	3.60	3.45	3.25	3.74	4.15	4.00	3.65	3.55	3.35	3.25	3.05	3.57
V_3	4.55	4.50	4.25	4.15	3.95	3.80	3.75	4.14	4.55	4.45	4.15	4.10	3.85	3.45	3.20	3.96	4.55	4.30	4.05	3.85	3.60	3.15	2.80	3.76
V_4	4.05	4.05	4.00	3.85	3.70	3.55	3.45	3.81	4.05	3.95	3.75	3.65	3.50	3.40	3.20	3.64	4.05	3.75	3.65	3.55	3.30	3.05	2.85	3.46
Mean	4.35	4.31	4.16	4.05	3.89	3.73	3.63		4.35	4.25	4.00	3.94	3.74	3.53	3.30		4.35	4.13	3.88	3.76	3.54	3.23	2.94	

CD (5 %) (VCD) – 0.06

The main effect of only V was found significant. Among the varieties, V_1 was found to have significantly higher value of 61.56 per cent. Interaction of treatments failed to express significant variation in the starch content of papad.

4.5.3.2.Total sugars

The influence of V, C and D and their interaction on total sugar content of papads is given in Table 32.

The main effect of V and D was found significant. Among the cultivars, V_3 (2.33 %) was found significantly higher . In the case of duration of storage, total sugar content was found to increase with storage. Highest total sugar content was found after D_3 days of storage (2.19 %).

Interaction of treatments was found insignificant.

4.5.3.3 Moisture

The data on moisture content of papads as influenced by V, C and D and their interactions are presented in Table 33.

The main effect of V, C and D were found significant. Highest value for V being recorded in V_1 (17.53 %) and lowest by V_2 (16.92%) and V_4 (16.93%) which were on par. Among the containers, C_3 recorded the highest value of 17.47 per cent and lowest by C_1 (16.70 %). Duration of storage significantly influenced the moisture content. Moisture content increased

Table 31. Effect of cultivars, containers, duration of storage on starch content (%) of papad on storage

	C_1	C_2	C_3	Mean	D_1	D_2	D_3		D_1	D_2	D_3
V_1	62.00	62.00	60.67	61.56	62.00	62.00	60.67	C_1	54.19	54.19	54.19
V_2	54.50	54.50	54.50	54.50	54.50	54.50	54.50	C_2	54.19	54.19	54.19
V_3	51.5	51.5	51.08	51.36	51.50	51.50	51.08	C_3	54.19	54.19	54.19
V_4	48.75	48.75	48.33	48.61	48.75	48.75	48.33	Mean	54.19	54.19	52.56
Mean	54.19	54.19	53.65		54.19	54.19	53.65	CD			

CD (5 %) (V) –1.55 (C) – ns (D) – ns (VC) –ns (VD) – ns (CD) -ns

Table 32. Effect of cultivars, containers, duration of storage on total sugar content (%) of papad on storage

	C_1	C_2	C_3	Mean	D_1	D_2	D_3		D_1	D_2	D_3
V_1	2.25	2.24	2.25	2.25	2.24	2.24	2.26	C_1	2.17	2.18	2.19
V_2	2.05	2.05	2.05	2.05	2.04	2.05	2.06	C_2	2.17	2.18	2.19
V_3	2.33	2.33	2.33	2.33	2.32	2.33	2.34	C_3	2.17	2.18	2.20
V_4	2.10	2.10	2.10	2.10	2.09	2.10	2.11				
Mean	2.18	2.18	2.18		2.17	2.18	2.19				

CD (5 %) (V) –0.01 (C) – ns (D) – 0.01 (VC) – ns (VD) – ns (CD) - ns

Table 33. Effect of cultivars, containers, duration of storage on moisture content (%) of papad on storage

	C1	C2	C3	Mean	D1	D2	D3
V1	16.78	16.81	17.53	17.04	16.21	17.03	17.89
V2	16.65	16.70	17.42	16.92	16.09	16.91	17.77
V3	16.73	16.77	17.50	17.00	16.17	16.98	17.85
V4	16.65	16.70	17.43	16.93	16.09	16.91	17.78
Mean	16.70	16.74	17.47		16.14	16.96	17.82

	D1	D2	D3
C1	16.14	16.69	17.28
C2	16.14	16.73	17.36
C3	16.14	17.46	18.82

CD (5 %) (V) –0.02 (C) – 0.01(D) – 0.01 (VC) – ns (VD) – ns (CD) – 0.03

Table 34. Effect of cultivars, containers, duration of storage on organoleptic quality of papad on storage

	C1	C2	C3	Mean	D1	D2	D3
V1	3.35	3.30	3.17	3.27	3.50	3.38	2.93
V2	3.52	3.38	3.27	3.39	3.70	3.50	2.97
V3	3.68	3.57	3.27	3.51	3.90	3.62	3.00
V4	3.33	3.27	3.10	3.23	3.50	3.27	3.93
Mean	3.47	3.38	3.20		3.65	3.44	2.96

	D1	D2	D3
C1	3.65	3.59	3.18
C2	3.65	3.51	2.98
C3	3.65	3.23	2.73

CD (5 %) (V) –0.11 (C) – 0.10 (D) – 0.10 (VC) – ns (VD) – ns (CD) – 0.17

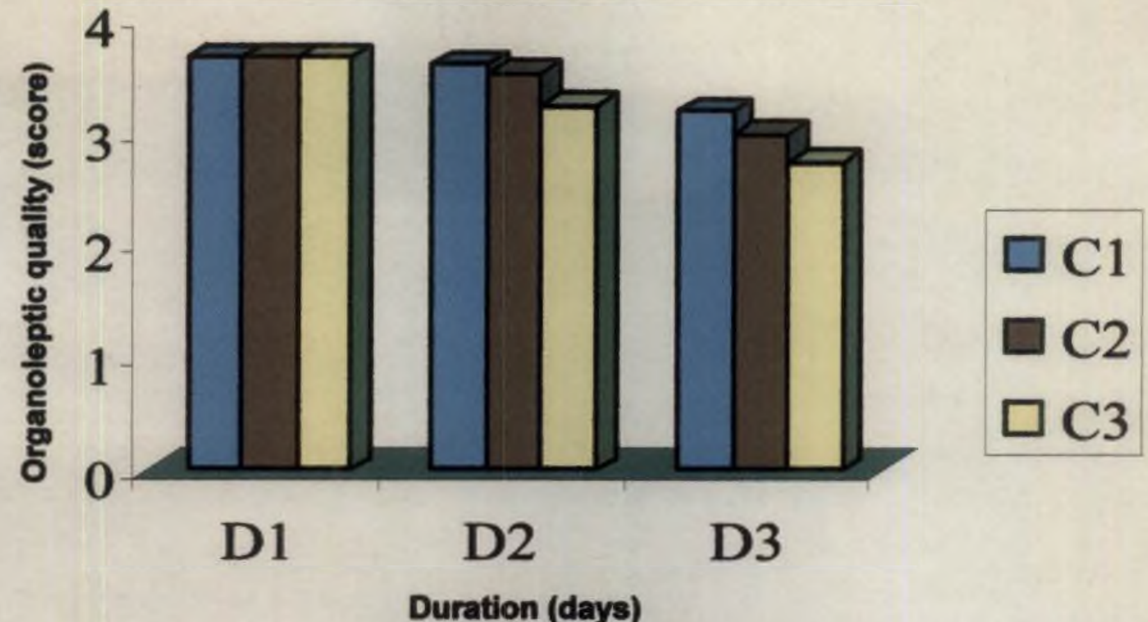

Fig 7. Effect of three types of containers on organoleptic quality of papad for a period of 90 days.

significantly with days of storage. Highest value was obtained for D_3 days after storage (17.82 %) after which the papads could not be stored due to mould growth..

Among the interactions C X D was found significant. The treatment combination C_3D_3 (18.82 %) was found to *have highest moisture while* C_1D_1, C_2D_1 and C_3D_1 were found to record lowest moisture content of 16.14 per cent.

4.5.3.4. Organoleptic quality

The data presented in Table 34 revealed that cultivars V_3 was significantly superior to other cultivars in organoleptic quality and had the highest score of 3.51 followed by V_2 (3.39).

In the case of *containers* C_1 *and* C_2 were found *superior* than C_3 and recorded the scores 3.47 and 3.38 respectively. Organoleptic quality was found to decrease with duration of storage.

Among the interactions C x D was found significant. The treatment combinations C_1D_1, C_2D_1 and C_3D_1 *were found to be on par and had a score of* 3.65 which was significantly higher than other combinations.

DISCUSSION

5. DISCUSSION

The results of the investigation on " Value addition and evaluation of nutritional quality in Elephant foot yam (*Amorphaphallus paeoniifolius (*Dennst.)) are discussed and are presented under the following headings.

5.1 Nutritional quality of corms and leaves of elephant foot yam

Among the four cultivars evaluated, Pathanamthitta local was found to contain highest starch content of about 16.68 percent. This is in conformity with the findings reported by Lila (2000) who stated that starch in the amorphaphallus corm ranges from 15 - 20 per cent of fresh weight. The starch content in Sree Padma (12.20%) was found to be similar to the value reported by CTCRI (1999) stating that starch content in Sree Padma to be 12 percent. From the findings it is seen that the starch content in amorphophallus is sufficiently high to make an important contribution to our daily diets.

Among the four cultivars evaluated, protein content was highest in corms and petioles of Pathanamthitta local. The protein content in corms of Pathanamthitta local was 3.7 percent which was in accordance with the values reported by Balagopalan (2000) and Ghosh (1988) which was in the range of one to four percent, but was lesser than the value reported by Lila *et al.* (1990)

which was 3.2 per cent. The protein content in corms was however higher than the value reported by Seralathan and Thirumaran (1999) which was two per cent. The protein content in petioles was 2 to 3 per cent which was also in agreement with the values reported by Ghosh *et al.* (1988).

The evaluation of corms and leaves of four cultivars revealed that corms and petioles of Sree Padma had the highest total sugar content. Maga (1992) stated that data on sugar cannot be taken as absolute since starch or sugar conversion is a very active metabolic process in most root crops with factors such as maturity and storage temperature significantly influencing sugar content.

The evaluation revealed that among the four cultivars, corms of Sree Padma (5.17%), Pathanamthitta local (5.20%) and petioles of Kottarakkara local recorded highest vitamin C content. The values of vitamin C content in corms (5.2 %) were however similar to the finding of Kays (1992) who reported the vitamin C content to be 6 mg per 100 gm of corm. The vitamin C content in corm was however higher than the values of vitamin C reported by Lila (1990) and Seralathan and Thirimaran (1999).

Crude fibre content was found to be highest in corm and petioles of Kottarakara local which were 0.84 percent and 3.38 percent respectively. The values of 3.38 percent was however lower than the value reported by Ghosh (1988) which was four to seven percent.

The calcium oxalate content was highest in the corms of Kottarakara local and Vellayani local while lowest in Sree Padma and Pathanamthitta local. Petioles of Vellayani local and Kottarakara local had the highest calcium oxalate content, while Pathanamthitta local had the least. The value of calcium oxalate content in corm was in accordance with the findings of Lila (1990) who reported that calcium oxalate content to be in the range of 0.08 - 0.28 per cent dry weight.

Lila (2000) states that the presence of calcium oxalate crystals has been attributed to be the major cause for acridity. She also stated that cooking the tuber either by cutting into small pieces or by cooking with tamarind or citric acid helped in reducing calcium oxalate levels.

Organoleptic quality was highest for petioles and corms of Sree Padma and Pathanamthitta local. This could be attributed to the low calcium oxalate content in these cultivars.

The evaluation on nutritional quality revealed that the corm and petioles of amorphophallus are fairly good sources of starch and contain some amount of protein and vitamin C. They have good organoleptic quality and can be utilized for culinary purpose though some amount of acridity is found in certain cultivars.

5.2 Value addition through primary products

The chips made were evaluated for oil uptake, moisture content, starch, total sugars and organoleptic quality. Oil uptake was highest in Sree Padma and the lowest in Pathanamthitta local. It was also found that oil uptake increased with increasing thickness as one mm chips had least oil uptake and three mm chips had the highest. Parboiling helped to reduce the oil uptake significantly.

Parboiling drying and frying of chips in an effective method for reducing oil uptake and chips of one mm thickness had lowest oil uptake. Compared to potato chips where oil uptake is as high as 30 - 40 per cent, elephant foot yam chips have a relatively low oil uptake of only about 15 per cent.

Mottur (1989) reported that the quality of potato chips is affected by variety, storage condition prior to processing, slice thickness, blanching time and temperature, nature of oil used, temperature and period of frying.

Moisture content was found to be influenced by the cultivars, thickness of chips and technique. Chips made from Sree Padma recorded maximum moisture content. With increasing thickness, moisture content also increased as 3 mm chips had maximum moisture content compared to 1 mm chips. This could be probably because increasing thickness makes it difficult for the moisture to escape from the chips. Freshly fried chips had a higher moisture content that parboiled fried chips. This can be explained by the fact that parboiled chips are dried first and then fried, as at the time of frying they already have lower moisture content whereas freshly fried chips are not dried before frying thereby having more initial moisture content.

Highest starch content in chips was recorded by Pathanamthitta local. Increasing thickness showed increasing starch content as three mm thick chips had higher starch content. It may be a possibility that some starch may be lost from thinner chips on frying. Parboiled chips had lesser starch content than freshly fried chips possibly because some starch may have leached out on parboiling.

According to Padmaja (1994) parboiled cassava chips are harder than plain chips due to partial gelatinisation and fusion of starch granules.

In case of total sugar content, chips made from Sree Padma recorded the maximum sugar content. Three mm thick chips had higher sugar content than two and one mm chips probably due to loss of sugars from two and one mm chips during frying. Parboiled chips had lesser sugar content than freshly fried chips probably due to leaching of sugars on parboiling. This statement is supported by Raja and Ramakrishna (1990) who reported that the percent of reducing sugars was reduced from 0.99 to 0.23 per cent during parboiling for five minutes.

Pathanamthitta local scored the highest for organoleptic quality. Two mm chips were preferred ones than one and three mm chips. It is seen that freshly fried chips scored over parboiled chips, thus parboiling cannot be recommended for making elephant foot yam chips.

Chips made from amorphophallus contain a good amount of starch and have low oil uptake. They have also fairly good scores for organoleptic quality. Thus they can be included as an everyday snack item in our house hold. As freshly fried chips are scored better than parboiled fried chips, it is a matter of ease to prepare these chips.

The chips used for making flour was dried at different temperatures for different drying periods. Starch and total sugar content was found to increase with temperature and drying periods. The variation in starch and total sugar contents could be the result of variation in moisture content at different temperatures. Thus we have different value for starch and total sugar at the various temperatures and drying periods. However the starch and total sugar content means for cultivars were more or less in the same proportion as seen in the fresh corm.

The evaluation of moisture content in flour revealed that with increasing temperatures and drying periods, moisture content decreased. Though the 95^0C temperature and 24 hr drying period reported the least moisture content in flour, it also brought about browning of the flour which could be due to charring. Moisture content was higher in flour dried at 55^0C than that of flour dried at 75^0C. Thus flour dried at 75^0C for 18 hrs could be judged as best because it had fairly low moisture content and good colour.

5.3 Value addition through secondary products

Secondary products *viz.*, murukkus, wafers, papads were prepared from amorphophallus flour for evaluation of organoleptic quality. The organoleptic evaluation revealed that murukkus and wafers made from flour of Pathanamthitta local had highest organoleptic quality while in case of papads, those made from Sree Padma scored the highest. All the products received fairly good scores indicating a good possibility for the usage of elephant foot yam flour in preparing snack items. Similar findings are reported by Ghosh *et al.* (1988) wherein they have stated that flour prepared from aroids like taro has been used to produce noodles, flakes, cookies, biscuits, infant food and puddings.

5.4 Storage studies of primary products

The starch and total sugar contents of the different cultivars varied more or less in the same proportion as that in the fresh corm. Starch content in freshly fried chips declined on storage while the total sugar content increased. Starch content remained fairly constant in glass and PET bottles but declined more sharply in LDPE bags. Chips stored in LDPE bags showed higher increase in total sugar content than glass and PET bottles. The increase in total sugar content was probably due to conversion of starch to sugars. This is supported by Chellamal (1995) who opined that the conversion of starch to sugars during storage may be the reason for the increase in sugar content of stored products. It was found that moisture content increased over the period of storage,and the increase was more in LDPE bags. Glass and PET bottles were found to be better for storage of chips than LDPE bags. The chips when stored in LDPE bags lost their crisp texture gradually due to the absorption of moisture and also turned rancid towards the later storage periods of 75 and 90 days.

For organoleptic quality, cultivars Sree Padma and Pathanamthitta local scored the highest. Chips stored in glass bottles scored highest for organoleptic quality. The organoleptic quality score remained high upto 45 days and then declined.

The starch content in parboiled fried chips was only affected by the cultivars. This starch and total sugar content of the various cultivars varied more or less in the same proportion as that in the fresh corm. Total sugar content increased progressively during storage. Among the containers, LDPE bags caused greater increase in total sugar content of the chips than glass and PET bottles. Moisture content of chips was found to increase over period of storage and polyethylene bags caused greater increase in moisture content. It does appear that glass and PET bottles exposed the products less to the outer environment. This has been supported by Seth and Rathore (1993) who stated that regarding storage of snack food stored in different containers, glass containers exhibited a lower increase in moisture content when compared to tin and polyethylene bags. In regard to moisture absorption by chips, Kumar and Ananthaswamy (1984) reported that to retard effect of pickup of moisture from tapioca chips during storage, polyethylene lined gunny sacks or laminated bitumen and polyethylene lined gunny sack or high density polyethylene or polypropylene wooden sack could be used.

The organoleptic quality of chips declined over the period of storage. Chips stored in glass bottles had higher organoleptic quality than those stored in plastic or LDPE bags. This was because the scores of organoleptic quality for chips stored in glass bottles were high upto 60 days while scores of chips stored in PET bottles and LDPE bags were high only upto 45 days

The starch and total sugar content of flour or various cultivars differed from each other more or less in the same proportion as that in fresh corms. Starch content was found to decline in flours stored in LDPE bags towards the end of storage but there was no significant change. The total sugar content and moisture content was found to increase over the period of storage. This increase was found to be more profound in LDPE bags and was significant. The LDPE bags appeared to have allowed the flour to absorb more moisture. This is in agreement with the report of Augustine (1999) who stated that the moisture content of sweet potato flour stored polyethylene bag was higher than other container during the storage period. It seems that glass bottles and PET jars can provide longer shelf life for amorphophallus flour than LDPE bags, as they did not allow moisture content in flour to increase much.

5.5 Storage studies of secondary products

Murukku stored in LDPE bags showed a decrease in starch content towards the end of the storage period. Starch content remained high for initial 45 days then declined. Total sugar content and moisture content increased over the period of storage and was highest in murukku stored in LDPE bags. This indicated that LDPE bags by allowing absorption of moisture caused some deteriorative changes. This is in agreement with the finding of Beerah *et al.* (1990) who reported highest moisture content in wafers stored in polyethylene bags from a study on the preparation, packing and storage of potato snacks. The murukku in glass bottles has high scores for organoleptic quality upto 45 days of storage while those in LDPE bags had good scores upto 30 days of storage.

The starch content in wafers stored in all containers declined towards the end of storage but was not significant. Starch content decreased more in wafers stored in LDPE bags. Total sugar content of wafers increased in all containers but increase was more severe in those stored in LDPE bags. Over the period of storage, the total sugar increased indicating some chemical or deteriorative changes. The moisture content increased over the period of storage. Those stored in glass bottles had least moisture content, while those stored in LDPE bags had highest moisture content. For organoleptic quality wafers stored in glass bottles gave the best scores while those stored in LDPE bags gave the least scores. The organoleptic quality was found to decrease over the period of storage. The organoleptic quality remained high upto 45 days of storage in glass bottles, 30 days of storage in PET bottles and 15 days of storage in LDPE bags, then declined.

The observation for papads were taken only upto 30 days of storage as after this they were subject to mould attack. There was not much variation in starch content over the period of storage. The total sugar content increased slightly. The moisture content increased in all the three containers though papads stored in LDPE bags had the highest moisture content at the end of 30 days. The organoleptic quality remained good upto 30 days of storage. The high moisture content in the papads could have been the cause of the short storage life. This has been supported by the findings of Arya (1992) who stated that the moisture content in the papads is around 14-18 per cent and their water activity is quite near to critical limit of mould growth.

SUMMARY

SUMMARY

The present investigation entitled "Value addition and evaluation of nutritional quality in elephant foot yam (*Amorphophallus Paeoniifolius* (Dennst.))" was carried out to evaluate the nutritional quality of *Amorphophallus* cultivars and to examine the potentiality of developing value added products using elephant foot yam. The experiment was carried out at the Department of Processing Technology, College of Agriculture, Vellayani, Thriruvananthapuram during the period 1999-2001. Major findings of the study are summarized below.

The study on nutritional quality of the corms revealed that, among the four cultivars, Pathanamthitta local had the highest starch, vitamin C and protein content. Total sugar and crude fibre was highest in Sree Padma. The calcium oxalate content was higher in corms of Kottarakkara local and Vellayani local. Pathanamthitta local followed by Sree Padma recorded highest organoleptic quality.

In case of petioles, protein content was highest in Pathanamthitta local while total sugar content was highest in Sree Padma. Vitamin C and crude fibre content was highest in the petioles of Vellayani local. Calcium oxalate content was highest in the petioles of Vellayani local, while Pathanamthitta local had the highest organoleptic quality score for petioles.

The chips made from amorphophallus with two techniques were evaluated for oil uptake, moisture content, starch, total sugars and organoleptic quality. The two techniques used to prepare chips were by freshly frying them and the other by parboiling and frying. Oil uptake was highest in Sree Padma and lowest in Pathanamthitta local. It was found that oil uptake increased with increasing thickness. Chips with a thickness of one mm had the lowest oil uptake while that with three mm thickness had the highest. Parboiling was an effective method to reduce oil uptake. Moisture content was found to be influenced by the cultivars, thickness of chips and by technique. Chips made from Sree Padma recorded the highest moisture content. With increasing thickness moisture content also increased. Three mm chips had maximum moisture content compared to one mm chips. Freshly fried chips had a higher moisture content than parboiled, fried chips.

Pathanamthitta local recorded highest starch content in chips. Increasing thickness showed increasing starch content. In case of total sugar content, chips made from Sree Padma recorded the highest. Three mm thick chips had higher total sugar content than two mm and one mm chips. Parboiled chips had lesser total sugar content than freshly fried chips probably due to leaching of sugar on parboiling. Chips made from Pathanamthitta local scored the highest for organoleptic quality. Two mm chips were the preferred ones than one mm and three mm chips, while freshly fried chips had maximum points than parboiled chips.

The chips used for making flour were dried at different temperatures for different drying periods and was analysed for starch, total sugars, moisture and colour. The starch and total sugar contents among the cultivars were more or less in the same proportion as that in the fresh corm. The evaluation of moisture content in the flour revealed that with increasing temperatures and drying periods, moisture content decreased. Flour dried at 95^{0}C temperature and 24 hour drying reported the lowest moisture content but was unsuitable due to charring. The flour dried at 75^{0}C for 18 hours was judged as the best because it had low moisture content and good colour.

Secondary products *viz*., murukku, wafers and papads were prepared from amorphophallus flour. The organoleptic evaluation revealed that murukkus and wafers made from flour of Pathanamthitta local had the highest score, while papads made from flour of Sree Padma scored the highest.

Storage studies of the primary and secondary products evaluated the changes in starch, total sugars, moisture content and organoleptic quality. In the case of chips, starch content declined on storage while the total sugar and moisture content increased gradually. Starch content remained fairly the same in LDPE bags. Chips stored in LDPE bags showed a higher increase in total sugar and moisture content than glass or PET bottles. Chips stored in glass bottles scored the highest for organoleptic quality and the score declined on prolonged storage.

In case of flour, total sugar content and moisture content was found to increase over the period of storage. The increase was more profound in LDPE bags, than in glass or PET bottles.

Murukku and wafers stored in LDPE bags showed a decrease in starch content towards end of the storage period. The total sugar and moisture content of murukku and wafers increased over the period of storage in all containers, though those in LDPE bags expressed a greater increase compared to glass and plastic bottles. Murukku and wafers stored in glass and PET bottles had higher organoleptic score compared to LDPE bags. Papads exhibited a shelf life of only thirty days after which they were subjected to mould attack. There was not much variation in starch content. Total sugar and moisture content increased slightly while the organoleptic quality remained good up to 30 days of storage.

From the above study it can be concluded that the corms and petioles of *Amorphophallus* can be used for culinary preparations, as it is a good source of starch and some nutrients. Chips prepared from *Amorphophallus* received fairly good scores for organoleptic quality indicating the possibility of developing them as a snack item. *Amorphophallus* flour can also be used in the preparation of some traditional snack item like murukku and wafers. These products also had a satisfactory storage life.

REFERENCES

REFERENCES

*Affran, D.K. 1968. Cassava and its economic importance. *Ghana Fmr.* **5** :172-178

Allen, O.N. and Allen, E.K. 1933. The manufacture of poi from taro in Hawaii with special emphasis upon its fermentation. *Bull. Hawaii Agric. Exp. Sta.* **70** : 34-71

Anonymous. 1975. Uses of tapioca. *J. Root Crops* **1** : 12

Anonymous. 1999. Konjac-mannan (glucomannan) improves glycemia and other associated risk factors for coronary heart disease in type 2 diabetes. *Diabetes Care.* **22** (6) : 913-919

AOAC. 1984. Official methods of analysis, 14th edn. Association of official analytical chemists, Washington DC

Arya, S. S. 1992. Convenience foods - Emerging scenario. *Indian Fd. Ind.* **2** : 54 - 56

Augustine, E. 1999. *Developing baked and confectionary products based on sweet potato.* M.Sc. thesis, Kerala Agricultural University, Thrissur, p.101 - 125

Babu, L. 1977. Biochemical aspects of sweet potato. *3rd International Training Course of Sweet Potato Production.* Central Tuber Crops Research Institute, Thiruvananthapuram, p. 85-89

Balagopalan, C. and Padmaja, G. 1988. Biochemical changes during the solid state fermentation of cassava under uncontrolled condition. *J. Root Crops* **15** : 1-6

Balagopalan, C., Padmaja, G., Nanda, S.K. and Moorthy, S.N. 1988. "Cassava in food and feed industry" *Proceedings of the National Symposium on the Production and Utilization of Tropical Tuber Crops*. Central Tuber Crops Research Institute, Thiruvananthapuram, p. 65-72

Balagopalan. 2000. *Integrated technologies for value addition and post harvest management in tropical tuber crops*. The Director. Central Tuber Crops Research Institute, Thiruvananthapuram, p. 57-65

Beerah, O.P., Manon, J.K., Berry, S.K. and Joshi, G.J. 1990. The quality of potato wafers made from cold stored potatoes of different varieties grown in Punjab plains. *Indian Fd. Packer* **44** : 23-27

Bhattachargee, M. and Bhole, N.G. 1989. The keeping quality of wheat flour in different packaging materials. *Fd. Nutr. Bull.* **6** : 81-83

Bouwkamp, J.C. 1985. *Sweet potato products - A natural resource for the tropics*. CRC press, Inc., Boca Raton, Florida, USA, p. 25-27

Chaudhary, P. and Kapoor, S.C. 1984. Changes in the nutritive value of pearl millet flour during storage. *J. Sci. Fd. Agric.* **35** : 1219-1224

Chellamal, S. 1995. *Developing complementary food products based on cassava and sweet potato*. Ph.D. thesis. Kerala Agricultural University, Thrissur, p. 236 - 247

Chellamal, S. and Prema, L. 1994. Nutritional enrichment of cassava flour. Paper presented at the 3rd Swadeshi, Science congress, Ernakulam. p.15-16

Chibber, R.C and Choudhary, K. 1959. "Elephant foot yam". *Indian Hort.* **3** : 5

CSIR. 1950. "Colocasia" *Wealth of India - Raw materials Vol II*; Council of Scientific and Industrial Research, Govt. Press. New Delhi, p. 310-311

CTCRI. 1999. Tuber crop varieties released by Central tuber crops research Institute. *Tech. Bull. Series* 24. Central Tuber Crops Research Institute, Thiruvananthapuram, India, p. 37

CTCRI. 2000. *Annual Report 1999-2000*. Central Tuber Crops Research Institute, Thiruvananthapuram, p. 77 -78

Edison, S. 1999. Foreword. *Tropical Tuber Crops in Food Security and Nutrition*. Balagopalan, C., Nayar, T.V.R., Sunderasan, S., Premkumar, T and Lakshmi, K.R. (Eds.). Oxford and IBH Publishing Co., New Delhi, p.1

*El Dash, A.A. and Chang, Y.K. 1990. Meeting the demand for the future, cassava in convenience foods. *Proceedings of the 8th International. Symposium for Tropical Root crops.* Centro International de Agricultural Tropical, Nigeria, p.61-65

Gaillard, J. 1984. Foreword. *Edible aroids*. Chandra. S. (Ed.). Clarendon Press, Oxford, p.1

Ghosh, S.P., Ramanujan, T., Jos, J.S., Moorthy, S.N. and Nair, R.G. 1988. 'Edible aroids'. *Tuber Crops*. Oxford and IBH Publishing Co. Pvt Ltd., New Delhi, p.280-285

*Greenwell, A.B.H. 1947. Taro-with special reference to its culture and uses in Hawaii. *Econ. Bot.* **1** : 276

Griffin, G.L.L. 1979. Non food application of starch with special reference to potential uses of taro. *Small scale processing and storage of tropical root crops.* Plucknett, D.L. (Ed). West View Press, Colorado, p.75

*Gubag, R., Omoloso, D.A. and Owens, J.D. 1996. Sapal- a traditional fermented taro. *Int. J. Fd. Microbiol.* **3** : 361-367

*Hiranandani, G.J. and Advani, K.H. 1955. Report on the marketing of tapioca in India. Mark. Ser. No. 88. *Directorate Mark. Inspect. Minist. Fd. Agric.*, India, p. 30-32

*Kasasian, R. and Dendy, D.A.V. 1977. Composite flour Technology. *Bibliography Report* **6**. Tropical Products Institute, London. p.70

Kays, S.J. 1992. The chemical composition of the sweet potato. *Sweet potato technology for the 21st century.* Tuskegee University, Alabama, USA. p. 201-211

Kulkarni, S.G., Manan, J.K. and Shukla, I.C. 1992. Preparation, evaluation and storage of papads made from rice flakes and flour. *Beverage Fd. Wld.* **19** : 13-15

Kumar, K.R. and Anandaswamy, B. 1984. Packaging and storage of dry tapioca products. *Proceedings of the Seminar on the Post Harvest Technology of Cassava.* Association of Food Scientists and Technologists, India, p. 74 –78

Lila, B. 2000. Nutritive value of tuber crops. *Short course on Advancements in Production, Processing and Utilization of Tropical tuber crops.* Central Tuber Crops Research Institute, Thiruvananthapuram, p. 219-223

Lila, B. Nambisan, B. and Sunderasan, S. 1990. Comparative evaluation of biochemical constituents of selected tuber crop cultivars. *Abstract on the National Symposium on Tuber Crops*. Central Tuber Crops Research Institute, Thiruvananthapuram, p.37-39

*Lyonga, S.N. 1980. Cocoyam production in Cameroon. *Provisional Report 5* International Foundation for Science, Stockholm, p. 64-65

Maga, J.A. 1992. Taro: Composition and food uses. *Fd. Rev. Int.* **8** : 443-473

Mahony, M. 1985. *A Textbook on Sensory Evaluation of Food*. Marcel Dekker. Inc., New York, p.30-39

Manan, J.K., Kalra, C.L., Kulkarni, S.G., Joshi, C.J. and Berry, S.K. 1991. Studies on the preparation, packaging and storage of colocasia, snack products. *Indian Fd. Packer* **45** : 49-54

*Massal, E. and Barrau, J. 1955. Pacific subsistence crops- Taro. *S. Pacif. Commn. Q. Bull.* **5** :17-21

*Mc Dermott, J. 1992. The importance of sensory analysis for evaluation of quality. *Fd. Technol. Abstr.* **27**: 167

*Morgan, K.J. 1983. The role of snacking in the American diet. *Cereal Fd. Wld.* **28** : 305

*Motte, J. 1932. Le konnyaku du Japon. *Ann. Mus. Colon.* **10** : 1-22

Mottur, G.P. 1989. A scientific look at potato chips - the original savoury snack. *Cereal Fd. Wld.* **34** : 620-666

*Moy J. H. and Nip, W. K.1988. Increased utilization of taro through process and product development. *Proc. 8th Symp. Int. Trop. Root Crops*. Bangkok, Thailand, p.680

*Moy, J.G., N.P.W.K., Tsai, J.V.W. and Hai, A.D. 1979. Storage qualities of extruded taro products. *Proc. 5th Symp. Int. Soc. Trop. Root Crops*. Manila, Philippines, p.145-147

*Moy, J.H. and Nip, W.K. 1983. Processed food. *Taro*. Wang, J.K. (Ed.). University of Hawaii press, Honolulu, p. 267-300

*Moy, J.H., Nip, W.K., Hai, A.O., Tsai, W.J.J. and Nakayama, T.O.M. 1980. Development of extruded taro products. *J. Fd. Sci.* **45** : 652-655

*Mozolewski, W. 1999. The usefulness of potato cultivars to processing in relation to the time of storage. *Proc. Conf. Table and Food Processing Potatoes - Agro Technical and Storage Factors Conditioning Quality*. Radzikow, Inc., Poland, p.173-174

Murray, B.K. 1977. Food uses of taro. *Fd. Prod. Dev.* **11** : 30

Nanda, S.K. 1984. Post harvest practices of tuber crops. *Indian Fmg.* **33** : 64 -66

*Nip, W.K. 1978. Food uses of taro. *J. Fd. Sci.* **44** : 222

Padmaja, G. 1994. Utilization of tuber crops. *Advances in Horticulture, Vol. 8*. Chadha, K.L, Nayar C.G. (Eds.). Malhothra Publishing House, New Delhi, p. 607-676

Padmaja, G., Moorthy, S.N. and Nanda, S.K. 1999. Production technology for flour flakes and fried food. *Annual Report*. Central Tuber Crops Research Institute, Thiruvananthapuram, India, p.74-75

Parkinson, S. 1984. The contribution of aroids in the nutrition of people in the South Pacific *Edible Aroids*. Chandra. S. (Ed.). Clarendon Press Oxford, New Delhi, p. 215-223

*Pena, R.S. 1970. The edible aroids in the Asian Pacific area. *Proc. 2nd Int. Symp. Trop. Root and Tuber crops*. University of Hawaii Press, Honolulu, p.136-140

Purushotham, V., Mahadevian, M., Gowaramma, R. V. and Naresh, R. 1992. Packaging of some fruits and vegetables in glass containers. *J. Fd. Sci. Technol.* **29** : 368-370

Raghu. A., Deepa. V.C. and Sundaran, K. 1999. A study on Soorana. *Tropical Tuber Crops in Food Security and Nutrition*. Balagopalan, C., Nayar. T.V.R., Sunderasan, S., Premkumar, T. and Lakshmi, K.R. (Eds.) Oxford and IBH publishing Co. New Delhi, p. 10-14

*Raja, K.C.M. and Ramakrishna, S.V. 1990. Compositional and pasting characteristics of plain dried and parboiled cassava. *Fd. Chem.* **38** : 79 - 88

Ranganna, S. 1977. *Mannual of analysis of fruit and vegetable products*. Tata Mc Graw Hill Publishing Co. Ltd., New Delhi, p. 12-35

Sadasivam, S and Manikam, A. 1992. *Biochemical Methods for Agricultural Sciences*. Wiley Eastern Ltd., New Delhi. p. 65-71

Sakai, W. S. 1979. Aroid root crops, acridity and raphides. *Tropical Foods-Chemistry and Nutrition*. Englett, G.E. and Charanlabous, G. (Eds.). Academic Press, New York, London, p. 265-278

Seralathan, M.A. and Thirumaran, A.S. 1988. Utilization of sweet potato flour in South Indian dishes. *Proc. 8th Symp. Int. Soc. Trop. Root Crops*. Bangkok, Thailand, p. 600

Seralathan, M.A. and Thirumaran, A.S. 1999. Acceptability of recipes with minor tubers. *Tropical Tuber Crops in Food Security and Nutrition*. Balagopalan, C., Nayar, T.V.R., Sunderasan, S., Premkumar, T. and Lakshmi, K.R. (Eds.). Oxford and IBH Publishing Co. New Delhi, p. 20-26

Seth, P. and Rathore, J.S. 1993. Studies on self life of snack products made from bajra. *Proc. 3rd Int. Food Convention*, Central Food Technology Research Institute, Mysore, p.187

Shanmugavelu, K.G., Thamburaj, S. and Abdul Khader, J.B.M. 1987. New varieties of horticultural crops. *S. Indian Hort.* **35** : 12

*Siviero, M.L., Ferrera, V.L.P., Vitti, P. and Silviera, E.T.F. 1984. *Bol. Inst. Techn.* **21** : 355

*Tallantire, A.G. and Goode, P.M. 1975. A preliminary study of the food plants of the West Nile and Madi districts of Uganda. The utilization of leaves and fruits of local mainly indigenous plants in supplementing the staple foods. *E. Afr. Agric. J.* **40** : 233-255

Thirumaran, A.S. and Seralathan, M.A. 1988. Studies on the nutritive value and utilization of tubers of *D. alata* and *D. esculenta*. *Proc. 8th Symp. Int. Soc. Trop. Root Crops*, Bangkok, Thailand, p.564

Wang, J.K. 1983. *Taro*. University of Hawaii press, Honolulu, p.104

*Warid. W.A. 1970. Trends in production of taro in Egypt in Tropical Root and tuber crops tomorrow. *Proc. 2nd Int. Symp. Trop. Root and Tuber crops*. University of Hawaii Press, Honolulu, p.141-142

Watts, B.M., Jalmohi, C.L., Jeffery, L.F and Elias, L.C 1989. *Basic Sensory Methods for Food Evaluation.* IDRC, International Development Research Centre, Ottawa, Canada, p. 12 - 14

*Yen, D.E. 1973. Anutan Agriculture in Anuta: A Polynesian outier in Solomon islands. Yen, D.E. and Gordon, J. (Eds.). *Pacif. Anthropol. Records,* University of Hawaii press, Honolulu, p. 23-25

*Yen, D.E. 1974. The sweet potato and Oceania. *Bull. 236*, Bernice P. Bishop Museum. Bishop Museum Press. Honolulu, p. 16-18

Zoizima, H. 1992. The use of sweet potato in bread making. *Sweet Potato Technology for the 21st Century.* Tuskegee University, Alabama, USA, p. 460

* Original not seen

APPENDIX - I

KERALA AGRICULTURAL UNIVERSITY

Department of Processing Technology, College of Agriculture, Vellayani

Score card for evaluation of cooked amorphophallus corm

			V_1	V_2	V_3	V_4
Appearance						
	Excellent	5				
	Good	4				
	Fair	3				
	Poor	2				
	Very poor	1				
Colour						
	Creamy brown	5				
	Light brown	4				
	Brown	3				
	Dark brown	2				
	Blackish brown	1				
Flavour						
	Highly acceptable	5				
	More acceptable	4				
	Acceptable to a certain extent	3				
	Less acceptable	2				
	Not acceptable	1				
Taste						
	Not acrid	5				
	Slightly acrid	4				
	Acrid	3				
	Very acrid	2				
	Extremely acrid	1				
Texture						
	Very soft	5				
	Soft	4				
	Slightly Hard	3				
	Hard	2				
	Very hard	1				
Overall acceptability						
	Like extremely	5				
	Like very much	4				
	Like moderately	3				
	Dislike slightly	2				
	Dislike extremely	1				

KERALA AGRICULTURAL UNIVERSITY
Department of Processing Technology, College of Agriculture, Vellayani

Score card for evaluation of cooked amorphophallus leaves

			V_1	V_2	V_3	V_4
Appearance						
	Excellent	5				
	Good	4				
	Fair	3				
	Poor	2				
	Very poor	1				
Colour						
	Light green	5				
	Green	4				
	Dark green	3				
	Brownish green	2				
	Brown	1				
Flavour						
	Highly acceptable	5				
	More acceptable	4				
	Acceptable to a certain extent	3				
	Less acceptable	2				
	Not acceptable	1				
Taste						
	Not acrid	5				
	Slightly acrid	4				
	Acrid	3				
	Very acrid	2				
	Extremely acrid	1				
Texture						
	Very soft	5				
	Soft	4				
	Slightly fibrous	3				
	Fibrous	2				
	Very fibrous	1				
Overall acceptability						
	Like extremely	5				
	Like very much	4				
	Like moderately	3				
	Dislike slightly	2				
	Dislike extremely	1				

KERALA AGRICULTURAL UNIVERSITY
Department of Processing Technology, College of Agriculture, Vellayani

Score card for evaluation of amorphophallus chips

				V_1	V_2	V_3	V_4
Appearance							
	Excellent	5					
	Good	4	FFC				
	Fair	3	PFC				
	Poor	2					
	Very poor	1					
Colour							
	Creamy brown	5					
	Light brown	4	FFC				
	Dull brown	3	PFC				
	Brown	2					
	Dark brown	1					
Flavour							
	Highly acceptable	5					
	More acceptable	4	FFC				
	Acceptable to a certain extent	3	PFC				
	Less acceptable	2					
	Not acceptable	1					
Taste							
	Not acrid	5					
	Slightly acrid	4	FFC				
	Acrid	3	PFC				
	Very acrid	2					
	Extremely acrid	1					
Texture							
	Very crisp	5					
	Crisp	4	FFC				
	Slightly crisp	3	PFC				
	Slightly soft	2					
	Soft	1					
Overall acceptability							
	Like extremely	5					
	Like very much	4	FFC				
	Like moderately	3	PFC				
	Dislike slightly	2					
	Dislike extremely	1					

FFC – Freshly fried chips   PFC – Parboiled fried chips

KERALA AGRICULTURAL UNIVERSITY
Department of Processing Technology, College of Agriculture, Vellayani

Score card for evaluation of murukkus

			V_1	V_2	V_3	V_4
Appearance						
	Excellent	5				
	Good	4				
	Fair	3				
	Poor	2				
	Very poor	1				
Colour						
	Creamy brown	5				
	Light brown	4				
	Dull brown	3				
	Brown	2				
	Dark brown	1				
Flavour						
	Highly acceptable	5				
	More acceptable	4				
	Acceptable to a certain extent	3				
	Less acceptable	2				
	Not acceptable	1				
Taste						
	Not acrid	5				
	Slightly acrid	4				
	Acrid	3				
	Very acrid	2				
	Extremely acrid	1				
Texture						
	Very crisp	5				
	Crisp	4				
	Slightly Hard	3				
	Hard	2				
	Very hard	1				
Overall acceptability						
	Like extremely	5				
	Like very much	4				
	Like moderately	3				
	Dislike slightly	2				
	Dislike extremely	1				

KERALA AGRICULTURAL UNIVERSITY

Department of Processing Technology, College of Agriculture, Vellayani

Score card for evaluation of wafers

			V_1	V_2	V_3	V_4
Appearance						
	Excellent	5				
	Good	4				
	Fair	3				
	Poor	2				
	Very poor	1				
Colour						
	Creamy brown	5				
	Light brown	4				
	Dull brown	3				
	Brown	2				
	Dark brown	1				
Flavour						
	Highly acceptable	5				
	More acceptable	4				
	Acceptable to a certain extent	3				
	Less acceptable	2				
	Not acceptable	1				
Taste						
	Not acrid	5				
	Slightly acrid	4				
	Acrid	3				
	Very acrid	2				
	Extremely acrid	1				
Texture						
	Very crisp	5				
	Crisp	4				
	Slightly hard	3				
	Hard	2				
	Very hard	1				
Overall acceptability						
	Like extremely	5				
	Like very much	4				
	Like moderately	3				
	Dislike slightly	2				
	Dislike extremely	1				

KERALA AGRICULTURAL UNIVERSITY

Department of Processing Technology, College of Agriculture, Vellayani

Score card for evaluation of papads

			V_1	V_2	V_3	V_4
Appearance						
	Excellent	5				
	Good	4				
	Fair	3				
	Poor	2				
	Very poor	1				
Colour						
	Creamy brown	5				
	Light brown	4				
	Dull brown	3				
	Brown	2				
	Dark brown	1				
Flavour						
	Highly acceptable	5				
	More acceptable	4				
	Acceptable to a certain extent	3				
	Less acceptable	2				
	Not acceptable	1				
Taste						
	Not acrid	5				
	Slightly acrid	4				
	Acrid	3				
	Very acrid	2				
	Extremely acrid	1				
Texture						
	Very crisp	5				
	Crisp	4				
	Slightly soft	3				
	Soft	2				
	Very soft	1				
Overall acceptability						
	Like extremely	5				
	Like very much	4				
	Like moderately	3				
	Dislike slightly	2				
	Dislike extremely	1				

APPENDIX - II

KERALA AGRICULTURAL UNIVERSITY

Department of Processing Technology, College of Agriculture, Vellayani

Score card for evaluation of colour of amorphophallus flour

Colour

Whitish cream	5
Cream	4
Creamy brown	3
Dull brown	2
Brown	1

VALUE ADDITION AND EVALUATION OF NUTRITIONAL QUALITY IN ELEPHANT FOOT YAM
(*Amorphophallus paeoniifolius* (Dennst.))

BY

SINI. S

ABSTRACT OF THE THESIS
submitted in partial fulfilment of the requirement for the degree
MASTER OF SCIENCE IN HORTICULTURE
Faculty of Agriculture
Kerala Agricultural University

Department of Processing Technology
COLLEGE OF AGRICULTURE
Vellayani
Thiruvananthapuram

2002

ABSTRACT

A study on "Value addition and evaluation of nutritional quality in elephant foot yam (*Amorphophallus paeoniifolius* (Dennst))" was carried out at the Department of Processing Technology, College of Agriculture, Vellayani, Thiruvananthapuram during the period 1999-2001.

The objective of the study was to evaluate nutritional qualities of amorphophallus cultivars, examine the potentiality of developing value added products, to assess the storage and shelf life of prepared products.

The nutritional quality of corms and petioles of four cultivars *ie*., Sree Padma, Vellayani local, Pathanamthitta local and Kottarakkara local were evaluated. Corms of Pathanamthitta local had highest starch, vitamin C and protein content. Sree Padma recorded the maximum total sugar and crude fibre. Calcium oxalate content was least in the corms of Sree Padma and Pathanamthitta local. Organoleptic quality score was highest in Pathanamthitta local. In case of petioles, Pathanamthitta local had highest protein content and organoleptic score. Sree Padma recorded the highest total sugar content while Kottarakkara local had the maximum vitamin C and crude fibre content.

Value added products like chips and traditional snack items *viz*., murukku, wafers and papads were prepared. Chips were prepared by two techniques *ie*. frying of fresh slices ,parboiling and frying.

It was found that oil uptake increased with increasing thickness and parboiling was an effective method to reduce oil uptake. Oil intake was lowest in Pathanamthitta local. Moisture content increased with thickness. Freshly fried chips had higher moisture content than parboiled chips. Starch and total sugar content increased with increasing thickness. Parboiled chips had lesser total sugar content. Highest scores for organoleptic quality was recorded in chips made from Pathanamthitta local. Two mm thick chips were the most preferred while, freshly fried chips had higher organoleptic score than parboiled chips.

The evaluation of flour prepared from *Amorphophallus* revealed that, with increasing temperatures and drying periods, moisture content decreased. Flour dried at 75°C for 18 hours was judged as the best due to low moisture content and good colour.

The evaluation of secondary products *viz.*, murukku, wafers and papads revealed that murukku and wafers prepared from the flour of Pathanamthitta local had the highest score while papads made from flour of Sree Padma scored the highest.

Storage studies of the products revealed the changes in starch, total sugars, moisture content and organoleptic quality. Starch content declined on storage while total sugar and moisture content increased slightly. Glass and PET bottles gave better storage results than LDPE bags. The moisture and total sugar content increased more rapidly in LDPE bags than glass and

PET bottles during storage. Papads exhibited a shelf life of only 30 days after which they were subjected to mould attack. Organoleptic quality score was highest for all the products stored in glass bottles than PET bottles and LDPE bags.