VALUE ADDITION AND EVALUATION OF NUTRITIONAL QUALITY IN TARO (*Colocasia esculenta* (L.) Schott)

BY

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THESIS
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DECLARATION

I hereby declare that this thesis entitled **"Value Addition and Evaluation of Nutritional Quality in Taro (*Colocasia esculenta* (L.) Schott)"** is a bonafide record of research work done by me during the course of research and that the thesis has not previously formed the basis for the award of any degree, diploma, associateship, fellowship or other similar title, of any other university or society.

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Certified that this thesis entitled **"Value Addition and Evaluation of Nutritional Quality in Taro (*Colocasia esculenta* (L.) Schott)"** is a record of research work done independently by Ms. Shamsudeen Liya (99-12-24) under my guidance and supervision and that it has not previously formed the basis for the award of any degree. fellowship or associateship to her.

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INTRODUCTION

1. INTRODUCTION

Taro (*Colocasia esculenta* (L.) Schott), also known as Colocasia is one of the important edible aroids cultivated as an intercrop in coconut gardens of Kerala. Taro is adapted to a wide range of soil and climatic conditions and has been the staple food in many areas of the tropical and subtropical world since ancient times. In addition to its corms, many cultures consume its leaves and petioles. Areas and countries that heavily utilize taro include The Caribbean, Hawaii, The Solomon Islands, American Samoa, West Samoa, The Philippines, Fiji and Sri Lanka.

All parts of the crop are edible and rich in carbohydrates, proteins and minerals. Steamed corms constitute a high energy food and its flour can be prepared from raw or precooked tuber for preparing soups and gruels (Aggarwal *et al.*, 1999). Taro can be used as such for preparation of snack items like chips, while the flour can be used as a substitute for cereal or pulse flour in many traditional snack items like murukku, papad etc. The utilization of taro is restricted to its use as a vegetable in India. Unlike in countries like Philippines and Hawaiian Islands where taro is processed into a number of extruded products, such products are not available in India (Padmaja, 1994). Throughout the years research interest in taro has undergone an apparent decline, primarily due to strong national and international research programmes that have developed around other root crops such as cassava, sweet potato and potato. The lack of research effort in this line is mainly due to low spread of the crop in India.

This crop with a potential yield of 15 tonnes per hectare has tremendous scope to be used for preparation of commercial food products which can be distributed on a wide scale. If this concept becomes a reality, wide range of stable products could expand the production and use of taro thereby increasing the economic base in many parts of the world. Today the uses of taro other than food are in the industrial sector for the preparation of fructose syrups, alcohol, cosmetic powders and biodegradable plastics.

Even though taro has been an important part of the Keralite cuisine for centuries, there has been a sharp decline in its consumption pattern in recent years possibly due to higher living standards and an influx of other vegetable crops.

Thus a study which explores, not only the nutritional quality but also the possibility of developing various food products using taro is a necessity. This can provide a variety to the consumer and also help in consumer acceptance ultimately leading to an increase in taro production. It is about time that minor tuber crops like taro with its many uses should be brought out of their present state of ignominy towards a brighter future of proper utilization and management. With this background this investigation entitled "Value addition and evaluation of nutritional quality in taro (*Colocasia esculenta* (L.) Schott) was carried out with the following objectives.

To evaluate four cultivars of colocasia for nutritional quality

To examine the potentiality of developing value added products using colocasia.

To assess the storage and shelf life of the colocasia products.

REVIEW OF LITERATURE

2. REVIEW OF LITERATURE

Research work on Colocasia 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 Colocasia in particular and whatever information is lacking, relevant work on other tuber crops have been reviewed.

1 Importance and nutritional significance

2. Traditional food uses of Colocasia

3. Value addition and product development

4. Storage and shelf life of Colocasia products

2.1 Importance and nutritional significance

2.1.1 Importance of colocasia

Taro has played an important role in the food habits and economy of many countries.

Massal and Barrau (1955) reported that 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, South Africa and in many parts of Asia. According to Gaillard (1984) in recent years there has been a marked decline in the cultivation and utilization of edible aroids. Part of this decline has been due to storable convenience foods such as cereal and cereal based products. 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) reported that minor tuber crops have some quality of protein besides carbohydrates. Minor tuber crops are low cost, calorie dense foods which are suitable in the Indian situation to alleviate calorific malnutrition. Ghosh *et al.* (1988) reported that taro is grown mostly as staple or subsistence crop throughout the tropics and subtropics and in many warmer regions of the tropical zone. Several varieties of taro are cultivated in India and form an important part of the diet.

Being concentrated sources of energy, tuber crops are utilized as a component of human food in almost all countries where these are cultivated. Extensive work has been conducted on processing and utilization of cassava and sweet potato (Balagopalan *et al.*, 1988).

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

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

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

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 the 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.

According to Lila Babu (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.

2.1.2 Nutritional significance

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

Steamed corms of Colocasia which contain 30 per cent 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 between 78.1 and 90.1 per cent on dry weight basis. The protein content of cassava was reported to be as low as 1.6 to 2.6 per cent (Anon 1975).

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* species.

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 per cent 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 1 and 5 per cent and fat upto 2 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 ranges between 4 and 12 per cent. Leaves of Amorphophallus contain 2 to 3 per cent protein, 3 per cent carbohydrate and 4 to 7 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.

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.

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 β- 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.

It cures piles, increased 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. (Raghu *et al.*, 1999).

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 olocasia and morphophallus (1.2mg) and all aroids have high amounts of phosphorous (49-60 mg). Also the leaves of Colocasia are exceptionally rich in minerals, vitamins and protein. Leaves contain between 3.9 to 7g protein, 225 to 460 mg calcium, 82 to 125 mg phosphorous, 10 to 12 mg carotene 0.26 to 0.45 mg riboflavin and 12.6 mg Vitamin C per 100g fresh tissue.

According to Lila Babu (2000) all plant parts of xanthosoma 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 between 3.9 to 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 sweet potato, 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

Colocasia 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

Payne *et al.* (1941) made a meal or a grit type product by roasting sequentially slices or shreds of corms at 121^0, 150^0 and 177^0C and grading. This could be converted to mash by adding hot water.

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 Choudhary (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 in 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 (1973) in the Anuta Islands, Colocasia is made into the fermented ma by planning grated corms in leaf lined pits which are sealed over and the material left to ferment.

According to Yen (1974) in the Philippines, dried flakes of sweet potato are prepared for storage and pounded into a flour as required for one 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.

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. It has good shelf life.

Esubaka – also called fufu and is boiled tuber pounded to a soft pulp, eaten with same.

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.

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).

In Fiji and other pacific islands, colocasia is often grated and mixed with coconut milk and then wrapped in leaves before boiling or peeled corns may be boiled or steamed and then pounded and made into balls to be eaten with coconut milk and sugar. A fermented product known as poi is prepared in Hawaii from colocasia. Traditionally corms are first baked or steamed, then peeled and pounded with a stone pestle in a long shallowly, hollowed out board or stone. Water is added gradually until the correct consistency is obtained after which time the dough is placed in a calabash and left to ferment for several days (Allen and Allen, 1933).

Padmaja (1994) reported that traditionally in many Indian families, yam tubers are consumed after cooking and peeling. The utilization of taro and tannia is restricted to its use as a vegetable in India. Unlike in countries like Philippines and Hawaiian Islands where taro is processed into a number of extruded products, information on such products is not available in India.

She also 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. The same author has opined that cassava flour is used in a number of Indian 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, a curry of northern Kerala is made with elephant foot yam and butter milk.

2.2.2 Leaves as food

According to Greenwell (1947) young leaves and stalks of taro are edible and can be cooked and used like spinach on sag. They are cooked in the same way as other green, but a pinch of baking soda is added to remove acridity, which increase with age.

Tender petioles 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). Also the fried pieces of the tuber are 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) stated 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 and chips are also made by slicing tubers and frying in oil.

2.3 Value addition and product development

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 from the flour are said to form good infant and invalid foods.

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 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 is produced in Hawaii, which consists of taro flour, cocoa milk, unrefined cane juice and sodium chloride.

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.

Bouwkamp (1985) reviewed the sweet potato flour as raw materials for the preparation of candy drops, ice cream, jams, sausage, bread, biscuits, cake and juice.

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 5 minutes at 5 psi or immersion in boiling water upto 5 minutes are necessary for obtaining good quality cassava rava.

Ghosh *et al.* (1988) has described a process developed by CFTRI, Mysore, India where taro corms are washed, peeled, cut into 6 mm thick slices, washed thoroughly to remove mucilage and kept immersed overnight in water, washed again, immersed in 0.75 per cent potassium bisulphite solution for 3 hrs. The slices are then blanched in hot water for 5 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. Nayar and Rajendran (1988) reported that sweet potato flour can be used as a dough conditions in bread making and stabilizer in ice creams. Thirumaran and Seralathan (1988) have also found that novel recipes like tuber mash, bitsoy and sweet stuffed parathas could be prepared from fresh tubers of both the *Dioscorea* sp. Wafers, cripples and biscuits made out of *D. alata* tubers were found to have good acceptability.

Pillai (1990) explained the utilization of cassava in food item like rava, which, could be used as a breakfast item, and 'vattal' which can be used as a snack item.

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

Palomar (1992) reported that based on cost analysis root crop flour is a good substitute for wheat flour (20 per cent). He explained substitution with cassava flour in bread making.

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.

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. She also reported that fried chips were prepared using brightened sweet potato flour and refined wheat flour (Maida) in varying proportion which were of excellent quality.

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).

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.

2.4 Shelf life studies

Moy *et al.* (1980) reported that taro flour mixed with 15 per cent winged bean flour or 15 per cent soy protein and extruded into rice, noodle and macaroni indicated they could be stored below 38^0C upto 12 months.

According to Bhattacharjee and Bhole (1984) food packaging and storage is the vital step to ensure product quality because it provides protection against deterioration and damage during storage, transportation and distribution. 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^{0}C and 70 per cent RH for 6, 7, 8 & 10 days in gunny sacks, earthen pots, tin cans and polythene bags respectively.

According to Nanda (1984) results, 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 and in plastic 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.

Kulkarni *et al.* (1992) reported that the quality of pappads made from blends containing bengal gram or red gram was comparable to that of pappads made from blackgram. Pappad remained quite acceptable in 200 gauge LDPE and 120 gauge PP bags during 4 months storage without much change in quality.

According to Moy and Nip (1988) results of experiments 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 1 year or more.

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 colourless 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, ten, 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.

According to Mc Dermott (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.

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.

MATERIALS AND METHODS

3. MATERIALS AND METHODS

The present investigation on "Value Addition and evaluation of nutritional quality in taro (*Colocasia escculenta* (L.) Schott)" 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 4 cultivars of Colocasia *ie.* Pathanamthitta local, Vellayani local, Thamarakannan and Sree Rashmi. The cultivars were collected and multiplied to get sufficient quantity in the Instructional Farm, Vellayani, the investigation was undertaken under the following heads.

Experiment 1 –Assessment of the nutritional quality of corms and leaves of Colocasia.

Experiment 2 – Value addition in Colocasia through primary and secondary products.

Experiment 3 Assessment of the storage life of primary and secondary products.

Experiment I- Assessment of the nutritional quality of corms and leaves of Colocasia

Leaves in the tender stage and 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. Four replications were carried out.*

3.1 Nutritional quality of corms and leaves

3.1.1 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.

3.1.2 Protein

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

3.1.3 Total sugars

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

3.1.4 Vitamin C

Vitamin C (mg per 100 g) was estimated by the volumetric method (Sadsivam and Manikam, 1992).

3.1.5 Crude fibre

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

3.1.6 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 of 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.

$$\text{Percentage oxalate in the sample} = \frac{0.063 \times V}{1g}$$

1.1.7 Organoleptic quality

Organoleptic qualities of corms and leaves were assessed (*ie.,* after cooking). In case of leaves except for starch all other parameters were analysed. The judges for the organoleptic evaluation were 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 score card were colour, flavour, taste, texture, appearance and overall acceptability. The above said method was used for organoleptic evaluation of corms, leaves and the primary and secondary products.

Experiment 2. Value addition in Taro through primary and secondary products

3.2 Primary products

Corms were used to make primary products *viz.*, chips and flour. The flour was used to make secondary products like murukku, pappads and wafers. The chips were analysed for oil uptake, moisture, starch, total sugars and organoleptic quality. The secondary products were analysed for organoleptic quality only.

3.2.1 Chips

The corms after harvest were washed thoroughly with water to remove solid particles and dirt. Peeling was done manually with sharp knives. During chipping, the end portions of the tubers were discarded. Chips of uniform size with different thickness (K) were prepared using two techniques (T). Once the chips were sliced into the three 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_1 – Pathanamthitta local

V_2 – Vellayani local

V_3 - Thamarakannan

V_4 – Sree Rashmi

Thickness of chips

K_1 – 1mm

K_2 – 2mm

K_3 – 3mm

Techniques

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

3.2.1.1 Oil uptake

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

3.2.1.2 Moisture

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

3.2.1.3 Starch

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

3.2.1.4 Total sugars

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

3.2.1.5 Organoleptic quality

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

3.2.2 Flour

Corms after harvest were washed thoroughly with water to remove solid particles and dirt. Peeling was done manually with sharp knife. Chips of uniform size and thickness were made from corms and dried for different drying period (H) at different temperatures (T). The dried chips were ground and sieved through 40 mesh size sieve to get flour. The four cultivars are as mentioned above

Drying periods (H)

$\mathbf{H_1}$ – 6 hours

$\mathbf{H_2}$ – 12 hours

$\mathbf{H_3}$ – 18 hours

$\mathbf{H_4}$ - 24 hours

Temperatures (T)

$\mathbf{T_1}$ – 55^0c

$\mathbf{T_2}$ 75^0C

$\mathbf{T_3}$ –95^0C

The flour obtained was analysed for colour, moisture, starch and total sugars. Colour was analysed on a five point scale by a panel of judges while the rest was 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 is 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 Taro 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 stored.

3.3.2 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 colocasia 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.

3.3.3 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).

Organoleptic qualities were assessed by a panel of judges using a five point scale based on colour, crispness, flavour, rancidity and overall acceptability.

Taro 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 spread thinly on plastic sheets and sundried. Before consumption the wafers were deep fried in coconut oil.

All these products were evaluated for organoleptic quality by a panel of judges.

Experiment 3:To assess the storage life of primary and secondary products

3.4 Storage life of taro products

The primary and secondary products of each cultivar were packed in three different types of containers (C) which were stored for three months and observations will be 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 moisture, starch, total sugars and organoleptic quality. These observations were taken as mentioned before. Sample size was 30 gms.

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

3.5 *Statistical Analysis*

Experiment 1 – The experimental design used was CRD with four replications.

Experiment 2

Chips – Three factor CRD in two replications with cultivar as the first factor, thickness of chips as the second factor and technique as the third factor.

Flour – Three factor CRD in two replications with cultivar as the first factor, temperature as the second factor and hours as the third factor.

Organoleptic quality of secondary products – The experimental design was CRD with three replications

Experiment 3 – Three factor CRD in two replications with cultivar as the first factor, container as the second factor and duration as the third factor.

RESULTS

4. RESULTS

The results of the investigation on "Value addition and evaluation of nutritional quality in Taro (*Colocasia esculenta* (L.) Schott)" were statistically analysed and are presented below.

4.1 Nutritional quality of corms and leaves of taro

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 presented in Table 1. Among the cultivars V_1 was found having highest starch content (18.25 %) while V_4 expressed the lowest (15.35 %), which was on par with V_3 (15.65 %). Between the cultivars V_2 exhibited the highest protein content (2.65 %) while V_1 showed the least (2.32 %). The protein content of V_4 (2.45 %) and V_3 (2.50 %) were on par. The cultivar V_3 exhibited the highest total sugar content (1.03 %) while V_1 had the least (0.78 %). In the case of vitamin C, V_2 had the highest vitamin content (17.28 %) while V_3 had the least (12.16 %). V_4 (15.68 %) and V_1 (16.00 %) were on par.

The crude fibre contents of all the four cultivar were found to be on par with each other wherein the cultivar V_2 had the highest (0.85 %) and V_3 the least (0.75 %). The calcium oxalate content was found to be highest in the

Table 1. Nutritional quality of fresh corms and leaves of colocasia

Cultivars (Corms)	Starch (% fresh weight)	Protein (% fresh weight)	Total sugar (% fresh weight)	Vitamin C (mg / 100 g fresh weight)	Crude fibre (% fresh weight)	Calcium oxalate (% dry weight)	Organoleptic quality
V_1	18.25	2.32	0.78	16.00	0.80	0.16	4.25
V_2	17.27	2.65	0.85	17.28	0.85	0.12	4.32
V_3	15.65	2.50	1.03	12.16	0.75	0.77	4.65
V_4	15.35	2.45	9.32	15.68	0.75	0.03	4.90
CD (1 %)	0.91	0.12	0.05	1.10	NS	0.006	0.16

Cultivars (Leaves)	Protein (% fresh weight)	Total sugar (% fresh weight)	Vitamin C mg / 100 g fresh weight	Crude fibre (% fresh weight)	Calcium oxalate (% dry weight)	Organoleptic quality
V_1	3.62	2.71	11.84	2.80	1.91	4.01
V_2	3.67	2.46	10.25	2.72	2.18	4.32
V_3	3.55	2.50	12.16	2.65	2.07	4.20
V_4	3.75	2.37	11.84	2.57	1.79	4.32
CD (1 %)	NS	0.07	NS	0.11	0.06	0.21 (5 %)

cultivar V_1 (0.16 %) and the least in V_4 (0.03 %). Organoleptic quality was found to be the highest for V_4 (4.90 %) and the least for V_1 (4.25 %) which was on par with V_2 (4.32 %).

4.1.2 Leaves

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

The protein content was found to be the highest in the cultivar V_4 (3.75 %) while the least in V_3 (3.55 %). The total sugar content was found to be highest in V_1 (2.71 %) and least in leaves of V_4 (2.37 %). The vitamin C content was found to be the highest in leaves of the cultivar V_3 (12.16 %) and the least in V_2 (10.25 %). The crude fibre content was found to be maximum in leaves of V_1 while minimum in V_4 (2.57 %). The calcium oxalate content was highest in leaves of V_2 (2.18 %) and least in leaves of V_4 (1.79 %). The organoleptic quality was maximum for V_4 (4.32 %) which was on par with V_2 (4.32 %) and minimum for V_1.

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 all had significant influence on oil uptake of chips.

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**		**T_1**	**T_2**	**Mean**
V_1	11.40	12.30	15.85	13.08	17.65	8.50	**K_1**	14.63	8.3	11.46
V_2	11.80	12.85	16.35	13.67	18.97	8.37	**K_2**	16.55	8.43	12.49
V_3	11.45	12.50	15.40	13.12	17.67	8.57	**K_3**	22.7	8.65	15.68
V_4	11.20	12.30	15.45	12.98	17.57	8.40				
Mean	11.46	12.49	15.68		16.29	8.46				
CD (1 %) (V) – 0.16 (T) – 0.11 (VT) – ns (VK) – 0.28 (K) –0.14 (KT)- 0.2										

Interaction effect of V x K x T

	T_1			**Mean**	**T_2**			**Mean**
	K_1	**K_2**	**K_3**		**K_1**	**K_2**	**K_3**	
V_1	14.50	16.10	22.30	10.97	8.30	8.50	8.70	8.50
V_2	15.30	17.50	24.10	18.97	8.30	8.20	8.60	8.37
V_3	14.50	16.30	22.20	17.67	8.40	8.70	8.60	8.57
V_4	14.20	16.30	22.20	17.57	8.20	8.30	8.70	8.40
Mean	14.63	16.55	22.70		8.30	8.43	8.65	
CD (1 %) - 0.4								

Plate 1. Freshly fried colocasia chips

Plate 2. Parboiled fried colocasia chips

Maximum oil uptake was recorded by V_2 (13.67 %) and minimum by V_4 (12.98 %). Oil uptake was high for thickness K_3 (15.68 %) and low for K_1 (11.46 %). The oil uptake was higher for technique T_1 (17.96 %) which is significantly higher than T_2 (8.5 %). The interaction VK was found to be significantly different and influenced oil uptake. The treatment V_2K_3 had the had the highest oil uptake. Interaction effect of V x T was significant and highest oil uptake was seen in V_2T_1 (18.97 %) and minimum in V_2T_2 (8.37 %).

Interaction KT was also significant in oil uptake. While K_3T_1 (22.70 %) recorded maximum oil uptake, K_1T_2 (8.30 %) recorded the minimum. The interaction of all the three factors. *viz.*, V, K and T significantly influenced oil uptake. The treatment $V_2K_1T_2$ (8.20 %) recorded the least.

4.2.1.2 Moisture

The moisture content of chips as influenced by cultivars, thickness of chips and techniques are presented in Table 3. The moisture content in the chips was found to be significantly influenced by the technique used. Technique T_1 showed a higher moisture content (6.34 %) which was significantly different than the moisture content by T_2 (2.29 %). The moisture content was not influenced by cultivar and thickness of chips and also the interaction of V x K x T.

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

	K_1	K_2	K_3	Mean	T_1	T_2		T_1	T_2	Mean
V_1	4.40	4.22	4.35	4.32	6.44	2.20	K_1	6.40	2.28	
V_2	4.25	4.32	4.30	4.29	6.24	2.33	K_2	6.27	2.30	
V_3	4.35	4.26	4.25	4.49	6.34	2.23	K_3	6.35	2.30	
V_4	4.35	4.35	4.40	4.37	6.33	2.40				
Mean	4.34	4.29	4.37		6.34	2.29				
CD (1 %)	(V) – ns (T) – 0.12 (VT) – ns (VK) – ns (K)-ns (KT)- ns									

Interaction effect of V x K x T

	T_1			Mean	T_2			Mean
	K_1	K_2	K_3		K_1	K_2	K_3	
V_1	6.50	6.33	6.50	6.44	2.30	2.10	2.20	2.20
V_2	6.30	6.13	6.30	6.24	2.20	2.50	2.30	2.33
V_3	6.40	6.32	6.30	6.34	2.30	2.20	2.20	2.23
V_4	6.40	6.30	6.30	6.33	2.30	2.40	2.50	2.40
Mean	6.40	6.27	6.35		2.28	2.30	2.30	
CD (1 %)	ns							

4.2.1.3 Starch

The starch content of chips as influenced by the cultivar, thickness, techniques and their interaction are presented in Table 4. The starch content in the chips was influenced only by the variety, but the thickness, techniques their interaction and the V x K x T interaction exhibited no significant effect. Among the cultivars, V_1 (57.33 %) recorded the highest starch content while V_4 (50.33 %) recorded the least.

4.2.1.4 Total sugars

The total sugar content of the chips was found to be influenced by cultivar, thickness and technique and is presented in Table 5.

Cultivars significantly influenced total sugar content with the cultivar V_3 (1.85 %) recording the maximum content and V_1 (1.69 %) expressed the minimum value. Among the thickness K_3 (1.80 %) recorded maximum sugar content which was on par with K_1 (1.79 %) while K_2 recorded the least sugar content (1.73 %). The V x K interaction did not significantly affect the total sugar content. The technique T_1 (1.83 %) had a significantly higher sugar content as compared to T_2 (1.72 %). The interaction VT was found to significantly influence sugar content with the interaction V_3T_1 (1.92 %) having the highest sugar content which was on par with V_4T_1 (1.91 %) and the least sugar content seen in V_4T_2 which is on par with V_1T_2.

Of the interactions, K_2T_1 (1.84 %) and K_3T_1 (1.84 %) recorded the maximum sugar content which is on par with K_1T_1 (1.81 %) while the

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

	K_1	K_2	K_3	Mean	T_1	T_2		T_1	T_2	Mean
V_1	57.00	58.00	57.00	57.33	57.33	57.33	K_1	52.41	52.29	52.35
V_2	51.50	51.50	54.50	52.50	52.50	52.50	K_2	53.13	52.41	52.77
V_3	51.50	51.50	52.25	51.75	51.50	52.00	K_3	53.38	54.25	53.81
V_4	49.40	50.08	51.50	50.33	50.55	50.10				
Mean	52.35	52.77	53.81		52.97	52.98				
CD (1 %)(V) – 2.01 (T) – ns (VT) – ns (VK) – ns (K)-ns (KT)-ns										

Interaction effect of V x K x T

	T_1			Mean	T_2			Mean
	K_1	K_2	K_3		K_1	K_2	K_3	
V_1	58.00	58.00	56.00	57.33	56.00	58.00	58.00	57.33
V_2	51.50	51.50	51.50	51.50	51.50	51.50	54.50	52.00
V_3	51.50	51.50	51.50	51.50	51.50	51.50	53.00	52.00
V_4	48.65	51.50	51.50	50.55	50.15	48.65	51.50	50.10
Mean	52.41	53.13	63.38		52.29	52.41	54.25	
CD (1 %)	ns							

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

	K_1	K_2	K_3	Mean	T_1	T_2		T_1	T_2	Mean
V_1	1.70	1.63	1.75	1.69	1.71	1.68	K_1	1.81	1.78	1.79
V_2	1.78	1.70	1.80	1.76	1.77	1.74	K_2	1.84	1.62	1.73
V_3	1.25	1.86	1.85	1.85	1.92	1.78	K_3	1.84	1.76	1.80
V_4	1.84	1.74	1.80	1.79	1.91	1.67	CD	(KT)-0.06 (K)- 0.04		
Mean	1.79	1.73	1.80		1.83	1.72				
CD 1 %)	(V) – 0.05 (T) – 0.04 (VT) – 0.07 (VK) – ns (K)-0.04 (KT)-0.06									

Interaction effect of V x K x T

	T_1			Mean	T_2			Mean
	K_1	K_2	K_3		K_1	K_2	K_3	
V_1	1.66	1.72	1.75	1.11	1.75	1.54	1.75	1.68
V_2	1.75	1.75	1.82	1.77	1.82	1.64	1.78	1.74
V_3	1.88	1.96	1.92	1.92	1.82	1.76	1.78	1.78
V_4	1.92	1.92	1.88	1.91	1.75	1.55	1.72	1.67
Mean	1.81	1.84	1.84		1.78	1.62	1.76	
CD (1 %)	ns							

Table 6. Effect of cultivars, thickness and techniques and their interactions on the organoleptic quality of chips

	K_1	K_2	K_3	Mean	T_1	T_2
V_1	4.60	4.65	4.53	4.59	4.35	4.83
V_2	4.78	4.63	4.48	4.63	4.45	4.80
V_3	4.80	4.80	4.60	4.73	4.80	4.67
V_4	4.90	4.80	4.80	4.83	4.77	4.90
Mean	4.77	4.72	4.60		4.59	4.80
CD (1 %)	(V) – 0.15 (T) – 0.10 (VT) – 0.21 (VK) – ns (K)-0.13 (5%) (KT)-ns					

	T_1	T_2	Mean
K_1	4.69	4.85	4.77
K_2	4.59	4.85	4.72
K_3	4.50	4.70	4.60
CD	(KT)-ns (K)- 0.13		

Interaction effect of V x K x T

	T_1			Mean	T_2			Mean
	K_1	K_2	K_3		K_1	K_2	K_3	
V_1	4.40	4.40	4.25	4.35	4.80	4.90	4.80	4.83
V_2	4.55	4.55	4.25	4.45	5.00	4.70	4.70	4.80
V_3	4.90	4.70	4.80	4.80	4.70	4.90	4.40	4.67
V_4	4.90	4.7	4.70	4.77	4.90	4.90	4.90	4.90
Mean	4.69	4.59	4.50		4.85	4.85	4.70	
CD (1 %)	ns							

minimum was recorded by K_2T_2 (1.62 %). The V x K x T interaction was not found to be significant.

4.2.1.4 Organoleptic quality

Here the cultivar, thickness and technique had significant influence on organoleptic quality and is presented in Table 6.

Among the cultivars, V_4 recorded the maximum (4.83) while V_1 (4.59) exhibited the least. Among thicknesses K_1 (4.77) showed maximum score while K_3 (4.60) expressed the least. The interaction VK did not have any significant effect. Among the techniques T_2 (4.80) was found to have a significantly higher score than T_1 (4.59). The interaction effect of VT was found to be significant on organoleptic quality with V_4T_2 (4.9 having the maximum and V_1T_1 (4.35) the minimum. The interactions K x T and V x K x T did not have a significant influence on the organoleptic quality.

4.2.1 Flour

4.2.1.1 Starch

The data showing the effect of cultivar, drying periods and temperatures on starch content of flour are presented in Table 7.

The data revealed that main effect of cultivar, temperature and drying periods had significant effect on the starch contents of the flour. Higher values 50.18 per cent (V_1) and 47.48 per cent (V_2) were found which was significantly superior over V_3 and V_4. Starch content was found to increase with temperature. T_3 was found significantly superior with a higher value of

Table 7. Effect of cultivars, temperatures, drying periods and their interaction on the starch content (%) of flour

	T1	T2	T3	Mean	H1	H2	H3	H4		H1	H2	H3	H4
V1	42.75	52.55	55.26	50.19	41.506	48.50	54.95	55.90	**T1**	31.26	35.55	44.95	47.84
V2	41.03	49.46	51.97	47.49	39.956	46.13	51.78	52.08	**T2**	40.69	47.55	52.87	53.21
V3	38.02	46.14	48.29	44.15	38.19	42.42	47.71	48.27	**T3**	45.49	51.96	54.30	52.47
V4	37.80	46.17	48.70	44.23	36.94	43.13	48.38	48.45					
Mean	39.90	48.58	51.06		39.15	45.02	50.71	51.17					
CD (1 %)	(V) – 1.802 (T) – 1.561 (VT) – ns (H) – 1.196 (VH) – ns (TH) – 2.071 (5 %)												

Interaction effect of V x H x T

	T1					T2					T3				
	H1	**H2**	**H3**	**H4**	**Mean**	**H1**	**H2**	**H3**	**H4**	**Mean**	**H1**	**H2**	**H3**	**H4**	**Mean**
V1	33.37	37.50	48.65	51.50	42.75	42.50	51.50	58.10	58.10	52.55	48.65	56.20	58.10	58.10	55.26
V2	32.57	36.75	46.15	48.65	41.03	40.00	48.65	54.60	54.60	49.46	47.30	53.30	54.60	53.00	51.97
V3	29.56	33.37	43.00	46.15	38.02	42.00	43.90	48.65	50.00	46.14	43.00	50.00	51.50	48.65	48.28
V4	29.56	34.60	42.00	45.05	37.80	38.25	46.15	50.15	50.15	46.17	43.00	48.65	53.00	50.15	48.70
Mean	31.26	35.55	44.93	47.84		40.69	47.55	52.87	53.21		45.48	51.96	54.30	52.47	

CD - ns

51.05 per cent. Drying periods were found to significantly influence starch content with H_3 (53.70 %) and H_4 (51.17 %) being superior and on par with each other.

The effect of interactions failed to express any significant variation in starch content of flour.

4.2.1.2 Total sugars

The total sugar content of the flour was significantly influenced by cultivar, drying period and temperature. The data is presented in Table 8.

Among the cultivars V_3 (1.58 %) had significantly higher total sugar content as compared to other cultivars. In case of temperature, T_3 (1.69 %) had significantly higher total sugar content. Among the drying periods, H_4 (1.72 %) was superior to the others. Among the interactions, only T x H was significant with T_2H_3 (1.84 %) being significantly superior. The other interactions did not show significant variation.

4.2.1.3 Moisture

The influence of cultivar, temperature and drying periods are presented in Table 9. The data showed that moisture content in flour was significantly influenced by temperature, drying period and its interaction. Moisture content decreased with increasing temperature as the temperature T_3 was found to have significantly lower moisture content of 2.53 per cent as compared to the other.

Table 8. Effect of cultivars, temperatures, drying periods and their interaction on the sugar content (%) of flour

	T_1	T_2	T_3	Mean	H_1	H_2	H_3	H_4		H_1	H_2	H_3	H_4
V_1	1.27	1.56	1.67	1.50	1.20	1.45	1.63	1.71	T_1	0.82	1.24	1.48	1.61
V_2	1.30	1.58	1.68	1.52	1.21	1.47	1.68	1.73	T_2	1.34	1.46	1.84	1.76
V_3	1.33	1.66	1.76	1.58	1.23	1.56	1.78	1.77	T_3	1.46	1.75	1.77	1.78
V_4	1.24	1.60	1.65	1.50	1.19	1.45	1.70	1.66					
Mean	1.29	1.60	1.69		1.21	1.48	1.70	1.72					
CD (1 %)	(V) – 0.028 (5 %) (T) – 0.024 (VT) – ns (H) – 0.022 (VH) – ns (TH) – 0.038												

Interaction effect of V x H x T

	T_1					T_2					T_3				
	H_1	H_2	H_3	H_4	Mean	H_1	H_2	H_3	H_4	Mean	H_1	H_2	H_3	H_4	Mean
V_1	0.81	1.20	1.45	1.63	1.27	1.34	1.45	1.72	1.74	1.56	1.44	1.72	1.74	1.77	1.67
V_2	0.81	1.23	1.53	1.65	1.30	1.37	1.45	1.75	1.77	1.58	1.45	1.74	1.77	1.78	1.63
V_3	0.86	1.33	1.52	1.64	1.33	1.33	1.51	1.96	1.83	1.66	1.51	1.83	1.86	1.83	1.76
V_4	0.81	1.20	1.45	1.52	1.24	1.33	1.44	1.92	1.73	1.60	1.43	1.72	1.725	1.73	1.65
Mean	0.82	1.24	1.48	1.61		1.34	1.46	1.84	1.76		1.46	1.75	1.773	1.78	

CD - ns

Table 9. Effect of cultivars, temperatures, drying periods and their interaction on the moisture content (%) of flour

	T_1	T_2	T_3	Mean	H_1	H_2	H_3	H_4
V_1	12.82	5.85	2.49	7.05	13.53	8.08	4.03	2.57
V_2	12.65	5.85	2.50	7.00	13.50	8.03	3.97	2.50
V_3	12.55	5.87	2.64	7.02	13.6	7.88	4.07	2.53
V_4	12.72	5.92	2.52	7.06	18.83	8.03	4.13	2.53
Mean	12.69	5.87	2.53		13.54	8.00	4.05	2.53
CD (5%)	(V)–ns (T)- 0.109 (VT)–ns (H)–0.090 (VH)–ns (TH)–0.156							

	H_1	H_2	H_3	H_4
T_1	22.17	16.07	8.37	4.12
T_2	12.17	6.50	2.50	2.32
T_3	6.27	1.45	1.27	1.15

Interaction effect of V x H x T

	T_1					T_2					T_3				
	H_1	H_2	H_3	H_4	Mean	H_1	H_2	H_3	H_4	Mean	H_1	H_2	H_3	H_4	Mean
V_1	22.50	16.30	8.30	4.20	12.82	12.00	6.50	2.50	2.30	5.85	6.10	1.45	1.30	1.10	2.487
V_2	22.10	16.10	8.30	4.10	12.65	12.10	6.50	2.50	2.30	5.85	6.30	1.50	1.10	1.10	2.50
V_3	21.90	15.80	8.50	4.00	12.55	12.50	6.30	2.40	2.30	5.87	6.40	1.55	1.30	1.30	2.637
V_4	22.20	16.10	8.40	4.20	12.72	12.10	6.70	2.60	2.30	5.92	6.30	1.30	1.40	1.10	2.525
Mean	22.17	16.07	8.37	4.12		12.17	6.50	2.50	2.32		6.27	1.45	1.275	1.15	

CD ns

Table 10. Effect of cultivars, temperatures, drying periods and their interaction on the colour of flour

	T_1	T_2	T_3	Mean	H_1	H_2	H_3	H_4		H_1	H_2	H_3	H_4
V_1	4.62	4.87	3.25	4.25	5.00	4.66	4.00	3.33	T_1	5.00	5.00	4.87	4.37
V_2	4.87	4.87	3.25	4.33	5.00	4.50	4.33	3.50	T_2	5.00	5.00	5.00	4.50
V_3	4.87	4.87	3.62	4.46	5.00	4.50	4.50	3.83	T_3	5.00	3.50	2.87	1.87
V_4	4.87	4.87	3.12	4.29	5.00	4.33	4.17	3.67					
Mean	4.81	4.87	3.31		5.00	4.50	4.25	3.58					
CD	(V)–ns (T)–0.283 (5%) (VT)–ns (H)–0.289 (1%) (VH) ns (TH)–0.500 (5%)												

Interaction effect of V x H x T

	T_1					T_2					T_3				
	H_1	H_2	H_3	H_4	Mean	H_1	H_2	H_3	H_4	Mean	H_1	H_2	H_3	H_4	Mean
V_1	5.00	5.00	4.50	4.00	4.62	5.00	5.00	5.00	4.50	4.87	5.00	4.00	2.50	1.50	3.25
V_2	5.00	5.00	5.00	4.50	4.87	5.00	5.00	5.00	4.50	4.87	5.00	3.50	3.00	1.50	3.25
V_3	5.00	5.00	5.00	4.50	4.87	5.00	5.00	5.00	4.50	4.87	5.00	3.50	3.50	2.50	3.62
V_4	5.00	5.00	5.00	4.50	4.87	5.00	5.00	5.00	4.50	4.87	5.00	3.00	2.50	2.00	3.12
Mean	5.00	5.00	4.87	4.37		5.00	5.00	5.00	4.50		5.00	3.50	2.87	1.87	

CD – ns

Among drying periods also, the longest drying periods brought about corresponding decrease in moisture content, with H_4 (2.53 %) having the maximum reduction in moisture. The interaction T x H was found significant with T_3H_4 having the least moisture content (1.15 %). The cultivars and other interactions did not show significant variation.

4.2.1.4 Colour

The influence of cultivar, temperature and drying periods are presented in Table 10.

The data revealed that the main effects of temperature and drying period had significant influence on the colour of flour. Among the temperatures T_2 (4.88) scored the highest which was on par with T_1 (4.81) while T_3 scored the least (3.31). Among the drying periods H_1 (5.00) scored maximum while H_4 (3.58) scored minimum. Among the interaction only the T x H interaction was significant with T_1H_1, T_1H_2, T_2H_1, T_2H_2, T_2H_3, and T_3H_1 scoring maximum of five which is on par with T_2H_4 (4.50) and T_1H_3 (4.87). T_3H_4 (1.87) had minimum scoring.

4.3 Value addition through secondary products

4.3.1 Organoleptic quality evaluation of murukku, papad and wafer

The results of the organoleptic evaluation of the secondary products are presented in Table 11. For murukku, those made from the cultivar V_4 (4.86) had the highest value for organoleptic quality which was on par with

V_3 (4.80) while V_1 had the least value of 4.46 which was on par with V_2 (4.53).

In case of papad, the highest value of 4.93 was obtained by papads made from the cultivar V_3 which was on par with V_4. While V_2 (4.46) recorded the minimum value which was on par with V_1 (4.53).

In case of wafer V_3 (4.93) expressed the highest value and was on par with V_4 (4.86) while V_2 (4.46) had the minimum value and was on par with V_1 (4.53).

Table 11. Organoleptic quality of the secondary products

Cultivars	Murukku	Papads	Wafer
V_1	4.46	4.53	4.53
V_2	4.53	4.46	4.46
V_3	4.80	4.93	4.93
V_4	4.86	4.86	4.86
CD	0.266 (5 %)	0.217 (1 %)	0.217 (1 %)

4.4 Storage studies of primary products

4.4.1 Freshly fried chips

4.4.1.1 Starch

The influence of cultivar type of container and duration of storage on the starch content of freshly fried chips is presented in Table 12.

Table 12. Effect of cultivars, containers, duration of storage and their interactions on the starch content (%) of freshly fried 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	58.00	58.00	57.21	57.74	58.00	58.00	58.00	58.00	58.00	57.33	56.83
V_2	51.50	51.50	50.88	51.29	51.50	51.50	51.50	51.50	51.50	51.00	50.55
V_3	51.50	51.50	50.28	51.29	51.50	51.50	51.50	51.50	51.50	51.00	50.55
V_4	51.50	51.50	50.90	51.30	51.50	51.50	51.50	51.50	51.50	51.00	51.55
Mean	53.13	53.13	52.47		53.13	53.13	53.13	53.13	53.13	52.60	52.12
CD (1 %)	(V) – 1.00 (VC) – ns (VD) – ns (D) – ns (CD) – ns (C) – ns										

	D_1	D_2	D_3	D_4	D_5	D_6	D_7
C_1	53.13	53.13	53.13	53.13	53.13	53.13	53.13
C_2	53.13	53.13	53.13	53.13	53.13	53.13	53.13
C_3	53.13	53.13	53.13	53.13	53.13	51.54	50.11

Interaction effect of V x C x D

	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	58.00	58.00	58.00	58.00	58.00	58.00	58.00	58.00	58.00	58.00	58.00	58.00	58.00	58.00	58.00	58.00	58.00	58.00	58.00	58.00	58.00	56.00	54.50	57.21
V_2	51.50	51.50	51.50	51.50	51.50	51.50	51.50	51.50	51.50	51.50	51.50	51.50	51.50	51.50	51.50	51.50	51.50	51.50	51.50	51.50	51.50	50.00	48.65	50.88
V_3	51.50	51.50	51.50	51.50	51.50	51.50	51.50	51.50	51.50	51.50	51.50	51.50	51.50	51.50	51.50	51.50	51.50	51.50	51.50	51.50	51.50	50.00	48.65	50.88
V_4	51.50	51.50	51.50	51.50	51.50	51.50	51.50	51.50	51.50	51.50	51.50	51.50	51.50	51.50	51.50	51.50	51.50	51.50	51.50	51.50	51.50	50.10	48.65	50.90
Mean	53.13	53.13	53.13	53.13	53.13	53.13	53.13		53.13	53.13	53.13	53.13	53.13	53.13	53.13		53.13	53.13	53.13	53.13	53.13	53.13	53.13	

CD - ns

The data revealed that of the three main effect only the cultivars showed significant variation with V_1 (57.74 %) showing the highest value and V_2, V_3 x V_4 on par (51.3 %). The interaction effects also did not show significant variation.

4.4.1.2 Total sugars

The influence of cultivar type of containers and duration of storage on the total sugar content of freshly fried chips is presented in Table 13.

The results revealed that the cultivar and number of days had significant influence on the total sugar content. V_3 (2.07 %) showed the maximum which was on par with V_4 (2.06 %).

The total sugar content was found to increase with duration of five days. Among the duration D_7 (2.10 %) showed the maximum total sugar content while D_1 (1.84 %) showed the minimum which was on par with D_2, D_3 and D_4. Interaction effects did not show any statistical significance with respect to total sugar content. The main effect of container also did not show statistical significance.

4.4.1.3 Moisture

The moisture content of freshly fried chips was influenced by cultivars, type of containers and duration of storage and are presented in Table 14.

The moisture content was significantly influenced by cultivar, container and storage period. Moisture was higher in cultivars V_1 (6.49 %) V_3 (6.48 %) and V_4 (6.48 %) which were on par while V_2 (6.30 %) expressed the

Table 13. Effect of cultivars, containers, duration of storage and their interactions on the total sugar content (%) of freshly fried 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	1.82	1.82	1.84	1.83	1.72	1.75	1.79	1.81	1.86	1.90	1.95
V_2	1.84	1.84	1.87	1.85	1.75	1.78	1.81	1.83	1.88	1.93	1.98
V_3	2.07	2.01	2.13	2.07	1.96	1.99	2.04	1.91	2.15	2.20	2.25
V_4	2.04	2.05	2.08	2.06	1.92	1.96	1.99	2.04	2.11	2.16	2.22
Mean	1.94	1.93	1.93		1.84	1.87	1.91	1.90	2.00	2.05	2.10
CD (1 %)	(V) – 0.05 (C) – ns (D) – 0.07 (VC) – ns (VD) – ns (CD) – ns										

	D_1	D_2	D_3	D_4	D_5	D_6	D_7
C_1	1.84	1.87	1.89	1.92	1.98	2.03	2.08
C_2	1.84	1.87	1.90	1.81	1.98	2.03	2.08
C_3	1.84	1.87	1.92	1.97	2.03	2.08	2.14

Interaction effect of V x C x D

	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	1.72	1.75	1.78	1.81	1.88	1.89	1.93	1.82	1.72	1.75	1.78	1.81	1.84	1.89	1.94	1.82	1.72	1.76	1.80	1.83	1.87	1.94	1.99	1.84
V_2	1.75	1.77	1.80	1.82	1.86	1.92	1.96	1.84	1.75	1.79	1.81	1.84	1.87	1.91	1.95	1.84	1.75	1.77	1.81	1.85	1.91	1.96	2.02	1.87
V_3	1.96	1.99	2.02	2.04	2.12	2.17	2.22	2.07	1.96	2.00	2.02	1.56	2.13	2.18	2.24	2.01	1.96	1.99	2.08	2.13	2.19	2.24	2.30	2.13
V_4	1.93	1.95	1.97	2.00	2.08	2.11	2.21	2.04	1.93	1.96	1.99	2.03	2.11	2.15	2.20	2.05	1.93	1.97	2.01	2.07	2.14	2.19	2.25	2.08
Mean	1.84	1.87	1.89	1.92	1.98	2.03	2.08		1.84	1.87	1.90	1.81	1.98	2.03	2.08		1.84	1.87	1.92	1.97	2.03	2.08	2.14	

CD - ns

Table 14. Effect of cultivars, containers, duration of storage and their interactions on the moisture content (%) of freshly fried 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	6.41	6.41	6.63	6.49	6.33	6.36	6.42	6.48	6.53	6.61	6.69
V_2	6.24	6.24	6.41	6.30	6.13	6.17	6.21	6.28	6.35	6.44	6.50
V_3	6.43	6.42	6.60	6.48	6.32	6.36	6.37	6.46	6.54	6.62	6.69
V_4	6.42	6.42	6.60	6.48	6.32	6.35	6.40	6.46	6.53	6.60	6.68
Mean	6.38	6.37	6.56		6.27	6.31	6.35	6.42	6.49	6.57	6.64
CD (1 %)	(V) – 0.06 (C) – 0.05 (D) – 0.08 (VC) – ns (VD) – ns (CD) – 0.14										

	D_1	D_2	D_3	D_4	D_5	D_6	D_7
C_1	6.27	6.30	6.33	6.36	6.41	6.46	6.50
C_2	6.27	6.29	6.30	6.37	6.40	6.46	6.50
C_3	6.27	6.35	6.43	6.53	6.65	6.78	6.91

Interaction effect of V x C x D

	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	6.33	6.34	6.37	6.40	6.43	6.49	6.54	6.41	6.33	6.34	6.38	6.42	6.42	6.47	6.54	6.41	6.33	6.40	6.65	6.62	6.73	6.87	6.93	6.63
V_2	6.13	6.16	6.19	6.23	6.28	6.33	6.37	6.24	6.13	6.15	6.17	6.22	6.27	6.36	6.37	6.24	6.13	6.20	6.28	6.38	6.50	6.62	6.75	6.41
V_3	6.32	6.34	6.37	6.41	6.47	6.53	6.55	6.43	6.32	6.35	6.29	6.42	6.46	6.52	6.55	6.42	6.32	6.39	6.46	6.55	6.70	6.82	6.97	6.60
V_4	6.32	6.34	6.37	6.40	6.46	6.51	6.55	6.42	6.32	6.33	6.37	6.41	6.46	6.49	6.55	6.42	6.32	6.39	6.47	6.57	6.67	6.80	6.95	6.60
Mean	6.27	6.30	6.33	6.36	6.41	6.46	6.50		6.27	6.29	6.30	6.37	6.40	6.46	6.80		6.27	6.35	6.43	6.53	6.65	6.78	6.91	

CD - ns

least moisture content. Among the containers C_2 (6.51 %) showed the least moisture content which was on par with C_1 (6.38 %) while C_3 (6.56 %) showed the maximum.

In storage duration D_7 recorded the highest value of 6.64 per cent which was on par with D_6. While D_1 recorded the lowest (6.27 %) which is on par with D_2 x D_3 showing that moisture content increased with longer storage periods. The interaction C x D was also statistically significant with C_3D_7 (6.91 %) having the maximum value and this is while C_1D_1, C_2D_1 and C_3D_1 had the minimum at 6.27 per cent which is on par with all except C_1D_6, C_1D_7, C_2D_6, C_2D_7, C_3D_3, C_3D_4, C_3D_5, C_3D_6 x C_3D_7. The other interaction effective had no statistical significance.

4.4.1.4 Organoleptic quality

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

Organoleptic quality was significantly influenced by cultivar, container, storage period and interaction effect of C x D. Organoleptic quality was found the highest in the cultivar V_3 (4.59) which is on par with V_4 (4.53) while V_1 (4.04) was found to have the least. Among the container, C_1 (4.39) had the highest value which was on par with C_2 (4.35) while C_3 (4.21) had the lowest value. The storage duration D_1 (4.66) had the highest value which was on par with D_2 (4.58) while D_7 (3.69) had the lowest value, showing that organoleptic quality decreased with prolonged storage. *On the interaction*

Table 15. Effect of cultivars, containers, duration of storage and their interactions on the organoleptic quality of freshly fried 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	4.13	4.06	3.94	4.04	4.40	4.35	4.30	4.13	3.98	3.70	3.42
V_2	4.18	4.14	3.99	4.10	4.45	4.38	4.40	4.30	4.00	3.82	3.37
V_3	4.69	4.60	4.48	4.59	4.90	4.83	4.80	4.78	4.58	4.55	4.03
V_4	4.57	4.59	4.42	4.53	4.90	4.73	4.83	4.72	4.45	4.13	3.93
Mean	4.39	4.35	4.21		4.66	4.58	4.58	4.42	4.24	3.98	3.69
CD (1 %)	(V) – 0.07 (C) – 0.06 (D) – 0.09 (VC) – ns (VD) – ns (CD) – 0.15										

	D_1	D_2	D_3	D_4	D_5	D_6	D_7
C_1	4.69	4.58	4.56	4.59	4.34	4.07	3.93
C_2	4.65	4.58	4.54	4.61	4.31	4.06	3.71
C_3	4.65	4.58	4.65	4.25	4.07	3.81	3.43

Interaction effect of V x C x D

	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	4.40	4.40	4.40	4.25	4.10	3.75	3.60	4.13	4.40	4.40	4.10	4.25	4.10	3.75	3.40	4.06	4.40	4.25	4.40	3.90	3.75	3.60	3.25	3.94
V_2	4.55	4.40	4.35	4.40	3.90	3.90	3.75	4.18	4.40	4.40	4.45	4.40	4.20	3.90	3.25	4.19	4.40	4.35	4.40	4.10	3.90	3.65	3.10	3.99
V_3	4.90	4.80	4.80	4.90	4.80	4.40	4.25	4.69	4.90	4.80	4.70	4.90	4.55	4.25	4.10	4.60	4.90	4.90	4.90	4.55	4.25	4.10	3.75	4.48
V_4	4.90	4.70	4.70	4.80	4.55	4.25	4.10	4.57	4.90	4.70	4.90	4.90	4.40	4.25	4.10	4.59	4.90	4.80	4.90	4.45	4.40	3.90	3.60	4.42
Mean	4.69	4.58	4.56	4.59	4.34	4.07	3.93		4.65	4.58	4.84	4.61	4.31	4.06	3.71		4.65	4.58	4.65	4.25	4.07	3.81	3.43	

CD -ns

effect C x D, C_1D_1 (4.69) had the maximum value which was on par with C_2D_1, C_3D_1, C_1D_2, C_1D_3, C_1D_4, C_2D_2, C_2D_3, C_2D_4, C_3D_2, C_3D_3 where C_3D_7 (3.43) had the least value. The other interaction effects did not show statistical significance.

4.4.2 Parboiled fried chips

4.4.2.1 Starch

Starch content of parboiled, dried and fried chips as influenced by cultivar, type of container and duration of shortage is presented in Table 16.

Only the main effect of cultivar was found to have significant effect on starch content with V_1 (57.93 %) having the highest value and V_4 (48.65 %) having the lowest value. The interaction effects also did not show any statistical significance.

4.4.2.2 Total sugars

Total sugars as influenced by cultivars, type of container and duration of storage is presented in Table 17.

Total sugar content was found to be influenced by cultivars type of container, duration of storage and the interaction effect of C x D. Among cultivar V_3 (1.83 %) was found to have the highest sugar content while V_1 (1.61) had the least. Among the type of container C_3 (1.73 %) scored the maximum value while C_1 (1.68 %) x C_2 (1.68 %) obtained the minimum value. In storage duration D_7 (1.82 %) had the maximum value while D_1 (1.62 %) had minimum value which was on par with D_2 (1.63 %).

Table 16. Effect of cultivars, containers, duration of storage and their interactions on the starch content (%) of parboiled fried 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	58.00	58.00	57.79	57.93	58.00	58.00	58.00	58.00	58.00	58.00	58.00
V_2	51.50	51.50	51.29	51.43	51.50	51.50	51.50	51.50	51.50	51.50	51.50
V_3	51.50	51.50	51.31	51.44	51.50	51.50	51.50	51.50	51.50	51.15	51.05
V_4	48.65	48.65	48.46	48.65	48.65	48.65	48.65	48.65	48.65	48.65	48.20
Mean	52.41	52.41	52.21		52.41	52.41	52.41	52.41	52.41	52.41	51.94
CD (1 %)	(V) – 1.01 (VC) – ns (VD) – ns (D) – ns (CD) – ns (C) – ns										

	D_1	D_2	D_3	D_4	D_5	D_6	D_7
C_1	52.41	52.41	52.41	52.41	52.41	52.41	52.41
C_2	52.41	52.41	52.41	52.41	52.41	52.41	52.41
C_3	52.41	52.41	52.41	52.41	52.41	52.41	50.99

Interaction effect of V x C x D

	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	58.00	58.00	58.00	58.00	58.00	58.00	58.00	58.00	58.00	58.00	58.00	58.00	58.00	58.00	58.00	58.00	58.00	58.00	58.00	58.00	58.00	58.00	5650	57.79
V_2	51.50	51.50	51.50	51.50	51.50	51.50	51.50	51.50	51.50	51.50	51.50	51.50	51.50	51.50	51.50	51.50	51.50	51.50	51.50	51.50	51.50	51.50	50.00	51.29
V_3	51.50	51.50	51.50	51.50	51.50	51.50	51.50	51.50	51.50	51.50	51.50	51.50	51.50	51.50	51.50	51.50	51.50	51.50	51.50	51.50	51.50	51.50	50.15	51.33
V_4	48.65	48.65	48.65	48.65	48.65	48.65	48.65	48.65	48.65	48.65	48.65	48.65	48.65	48.65	48.65	48.65	48.65	48.65	48.65	48.65	48.65	48.65	47.50	48.46
Mean	52.41	52.41	52.41	52.41	52.41	52.41	52.41		52.41	52.41	52.41	52.41	52.41	52.41	52.41		52.41	52.41	52.41	52.41	52.41	52.41	50.99	

CD – ns

Table 17. Effect of cultivars, containers, duration of storage and their interactions on the total sugar content (%) of parboiled fried 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	1.59	1.60	1.65	1.61	1.54	1.54	1.57	1.59	1.63	1.68	1.73
V_2	1.70	1.71	1.74	1.72	1.64	1.65	1.67	1.69	1.74	1.79	1.85
V_3	1.81	1.82	1.87	1.83	1.76	1.77	1.79	1.81	1.85	1.90	1.96
V_4	1.60	1.61	1.65	1.62	1.55	1.56	1.57	1.60	1.64	1.69	1.75
Mean	1.68	1.68	1.73		1.62	1.63	1.65	1.67	1.71	1.77	1.82
CD (1 %)	(V) – 0.02 (C) – 0.02 (D) – 0.02 (VC) – ns (VD) – ns (CD) – 0.04(5%)										

	D_1	D_2	D_3	D_4	D_5	D_6	D_7
C_1	1.62	1.63	1.64	1.65	1.69	1.73	1.78
C_2	1.62	1.63	1.64	1.66	1.70	1.75	1.80
C_3	1.62	1.64	1.66	1.71	1.76	1.82	1.89

Interaction effect of V x C x D

	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	1.54	1.54	1.55	1.56	1.50	1.64	1.69	1.59	1.64	1.54	1.55	1.57	1.62	1.67	1.71	1.60	1.54	1.56	1.59	1.64	1.68	1.74	1.79	1.65
V_2	1.64	1.65	1.66	1.68	1.71	1.77	1.82	1.70	1.64	1.64	1.66	1.69	1.72	1.78	1.84	1.71	1.64	1.66	1.68	1.72	1.77	1.83	1.89	1.74
V_3	1.76	1.77	1.77	1.79	1.83	1.87	1.92	1.81	1.76	1.77	1.79	1.80	1.83	1.87	1.91	1.82	1.76	1.77	1.80	1.85	1.90	1.96	2.03	1.87
V_4	1.55	1.56	1.57	1.59	1.61	1.65	1.71	1.60	1.55	1.56	1.57	1.59	1.62	1.66	1.72	1.61	1.55	1.57	1.59	1.63	1.69	1.75	1.82	1.65
Mean	1.62	1.63	1.64	1.65	1.69	1.73	1.78		1.62	1.63	1.64	1.66	1.70	1.75	1.80		1.62	1.64	1.66	1.71	1.76	1.82	1.89	

CD – ns

Among the interaction effect, only C x D interaction was significant with C_3D_7 (1.89 %) having the maximum value and C_1D_1 (1.62 %) having the minimum which is on par with C_1D_2 (1.63 %), C_1D_3 (1.64 %), C_1D_4 (1.65 %), C_2D_1 (1.62 %), C_2D_2 (1.63 %), C_2D_3 (1.64 %), C_2D_4 (1.66 %), C_3D_1 (1.62 %), C_3D_2 (1.64 %) and C_5D_3 (1.66 %).

4.4.2.3 Moisture

Moisture content of parboiled, dried and tried chips as influenced by cultivar, type of container and duration of storage is presented in Table 18.

The main effects of cultivar and storage period were found to influence the moisture content of parboiled fried chips. Among the cultivars V_2 was found to have maximum value of 2.59 per cent while V_3 had minimum value of 2.23 per cent, which was on par with V_1 (2.25 %).

The moisture content was found to increase with increasing storage period as chips stored for duration D_7 had the maximum value of 2.45 per cent, which was on par with D_4 (2.36 %), D_5 (2.38 %) and D_6 (2.41 %) while D_1 (2.32 %) had the minimum value. The interaction effects and effect of type of container are not statistically significant.

4.4.2.4 Organoleptic quality

The influence of cultivar, type of container and duration of storage on the organoleptic quality in presented in Table 19.

Organoleptic quality was significantly influenced by type of container, storage duration, the interaction effect of V x D and C x D. Chips stored in

Table 18. Effect of cultivars, containers, duration of storage and their interactions on the moisture content (%) of parboiled fried 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	2.24	2.24	2.28	2.25	2.20	2.21	2.22	2.24	2.27	2.29	2.34
V_2	2.57	2.57	2.62	2.59	2.53	2.59	2.56	2.57	2.60	2.63	2.67
V_3	2.21	2.21	2.27	2.23	2.17	2.18	2.20	2.22	2.24	2.27	2.31
V_4	2.40	2.39	2.43	2.41	2.36	2.37	2.38	2.40	2.42	2.45	2.49
Mean	2.35	2.35	2.40		2.32	2.32	2.34	2.36	2.38	2.41	2.45
CD (1 %)	(V) – 0.07 (1%) (C) – ns (D) – 0.09 (5 %) (VC) – ns (VD) – ns (CD) – ns										

	D_1	D_2	D_3	D_4	D_5	D_6	D_7
C_1	2.32	2.32	2.33	2.34	2.36	2.38	2.42
C_2	2.32	2.32	2.33	2.34	2.36	2.39	2.43
C_3	2.32	2.33	2.36	2.39	2.43	2.46	2.51

Interaction effect of V x C x D

	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	2.20	2.21	2.22	2.23	2.25	2.26	2.31	2.24	2.20	2.21	2.21	2.22	2.25	2.27	2.31	2.24	2.20	2.22	2.24	2.27	2.30	2.35	2.40	2.28
V_2	2.53	2.53	2.55	2.55	2.57	2.61	2.64	2.57	2.33	2.53	2.55	2.56	2.59	2.62	2.65	2.57	2.53	2.55	2.58	2.61	2.64	2.68	2.73	2.62
V_3	2.18	2.18	2.19	2.20	2.21	2.24	2.27	2.21	2.18	2.18	2.18	2.19	2.21	2.24	2.28	2.21	2.18	2.19	2.23	2.26	2.31	2.34	2.39	2.27
V_4	2.36	2.36	2.37	2.40	2.41	2.43	2.47	2.40	2.36	2.37	2.37	2.39	2.40	2.42	2.46	2.39	2.36	2.38	2.39	2.42	2.46	2.52	2.55	2.43
Mean	2.32	2.32	2.33	2.34	2.36	2.38	2.42		2.32	2.32	2.33	2.34	2.36	2.39	2.43		2.32	2.33	2.36	2.39	2.43	2.46	2.51	

CD – ns

Table 19. Effect of cultivars, containers, duration of storage and their interactions on the organoleptic quality of parboiled fried 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	4.63	4.61	4.39	4.55	4.80	4.83	4.67	4.53	4.55	4.35	4.08
V_2	4.66	4.64	4.38	4.56	5.00	4.83	4.60	4.50	4.45	4.38	4.35
V_3	4.71	4.66	4.26	4.55	4.70	4.75	4.87	4.63	4.57	4.37	3.95
V_4	4.74	4.61	4.36	4.57	4.90	4.80	4.80	4.68	4.55	4.35	3.88
Mean	4.68	4.63	4.35		4.85	4.80	4.73	4.59	4.53	4.36	4.02
CD (1 %)	(V) – ns (C) – 0.06 (D) – 0.09 (VC) – ns (VD) – 18 (CD) – 0.15										

	D_1	D_2	D_3	D_4	D_5	D_6	D_7
C_1	4.85	4.78	4.77	4.78	4.71	4.68	4.23
C_2	4.85	4.85	4.71	4.76	4.74	4.41	4.10
C_3	4.85	4.79	4.71	4.23	4.14	4.00	3.73

Interaction effect of V x C x D

	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	4.80	4.70	4.60	4.65	4.70	4.55	4.40	4.63	4.80	4.90	4.70	4.70	4.70	4.40	4.10	4.61	4.80	4.90	4.70	4.25	4.25	4.10	3.75	4.39
V_2	5.00	4.70	4.70	4.70	4.55	4.70	4.25	4.66	5.00	4.90	4.55	4.55	4.65	4.55	4.30	4.64	5.03	4.90	4.55	4.25	4.15	3.90	3.90	4.38
V_3	4.70	4.80	4.90	4.85	4.90	4.75	4.10	4.71	4.70	4.80	4.80	4.90	4.90	4.45	4.10	4.66	4.70	4.65	4.90	4.15	3.90	3.90	3.65	4.26
V_4	4.90	4.90	4.90	4.90	4.70	4.70	4.15	4.74	4.90	4.80	4.80	4.90	4.70	4.25	3.90	4.61	4.90	4.70	4.70	4.25	4.25	4.10	3.60	4.36
Mean	4.85	4.78	4.77	4.78	4.71	4.61	4.23		4.85	4.85	4.71	4.76	4.74	4.91	4.10		4.85	4.79	4.71	4.23	4.14	4.00	3.73	

CD – ns

container C_1 had the maximum value of 4.68 which was on par with C_2 (4.63) while C_3 (4.35) had the least value. The data on storage period showed that chips stored for duration had maximum value which was on par with D_2 (4.80) while D_7 (4.02) had the least value showing organoleptic quality decreased with increasing storage. On the interaction effect of V x D, V_2D_1 (5.00) recorded the highest value which was on par with V_4D_1 (4.90), V_1D_2 (4.83) and V_2D_2 (4.83) and the minimum value shown by V_4D_7 (3.88).

In the interaction effect of C x D, the maximum value was given by C_1D_1, C_2D_2 x C_3D_3 at 4.85 which was on par with all except C_1D6, C_1D_7, C_2D_6, C_2D_7, C_3D_4, C_3D_5, C_3D_6 x C_3D_7, C_3D_7 recorded the minimum value.

4.4.3 Storage studies of flour

4.4.3.1 Starch

The influence of cultivar, type of container and duration of storage on the starch content of Colocasia flour is presented in Table 20.

The main effect of cultivar showed significant influence on the starch content with the cultivar V_1 (57.60 %) having the maximum value and V_3 (48.65 %) having the least. The other main effects and interaction effects did not show any statistical significance.

4.4.3.2 Total sugars

The influence of cultivar, type of container and duration of storage on the total sugar content of Colocasia flour is presented in Table 21.

Table 20. Effect of cultivars, containers, duration of storage and their interactions on the starch content (%) of flour 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	58.00	58.00	56.79	57.60	58.00	58.00	58.00	58.00	57.5	56.83	56.83
V_2	54.5	54.07	53.64	54.07	54.50	54.50	54.50	54.50	53.50	53.50	53.50
V_3	48.65	48.65	48.10	48.47	48.65	48.65	48.65	48.65	48.65	48.2	47.82
V_4	50.15	50.15	49.18	49.83	50.15	50.15	50.15	50.15	49.65	49.27	49.27
Mean	52.83	52.72	51.93		52.83	52.83	52.83	52.83	52.33	51.95	51.85
CD (1 %)	(V) - 1.22 (C)-ns (VC)-ns (D)-ns (VD)-ns (CD)-ns										

	D_1	D_2	D_3	D_4	D_5	D_6	D_7
C_1	52.82	52.82	52.82	52.82	52.82	56.82	56.82
C_2	52.82	52.82	52.82	52.82	52.07	52.82	52.82
C_3	58.82	52.82	52.82	52.82	52.07	50.20	49.91

Interaction effect of V x C x D

	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	58.00	58.00	58.00	58.00	58.00	58.00	58.00	58.00	58.00	58.00	58.00	58.00	58.00	58.00	58.00	58.00	58.00	58.00	58.00	58.00	56.50	54.50	54.50	56.79
V_2	54.50	54.50	54.50	54.50	54.50	54.50	54.50	54.50	54.50	54.50	54.50	54.50	54.50	54.50	54.50	54.07	54.50	54.50	54.50	54.50	54.50	51.50	51.50	53.64
V_3	48.65	48.65	48.65	48.65	48.65	48.65	48.65	48.65	48.65	48.65	48.65	48.65	48.65	48.65	48.65	48.65	48.65	48.65	48.65	48.65	48.65	47.30	46.15	48.10
V_4	50.15	50.15	50.15	50.15	50.15	50.15	50.15	50.15	50.15	50.15	50.15	50.15	50.15	50.15	50.15	50.15	50.15	50.15	50.15	50.15	48.65	47.50	47.5	49.18
Mean	52.82	52.82	52.82	52.82	52.82	52.82	52.82		52.82	52.82	52.82	52.82	52.82	52.82	52.82		52.82	52.82	52.82	52.82	52.07	50.20	49.91	

CD - ns

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

V	C1	C2	C3	Mean	D1	D2	D3	D4	D5	D6	D7		D1	D2	D3	D4	D5	D6	D7
V1	1.81	1.82	1.85	1.83	1.72	1.74	1.77	1.80	1.86	1.92	1.99	C1	1.84	1.85	1.88	1.91	1.95	1.98	2.07
V2	1.83	1.84	1.89	1.85	1.75	1.76	1.79	1.83	1.87	1.94	2.02	C2	1.84	1.86	1.88	2.04	1.94	1.88	2.08
V3	2.05	2.13	2.09	2.09	1.96	1.98	2.01	2.22	2.08	2.15	2.22	C3	1.84	1.86	1.90	1.94	2.00	2.08	2.16
V4	2.01	1.94	2.04	2.00	1.92	1.94	1.96	2.00	2.04	1.92	2.18								
Mean	1.93	1.93	1.97		1.34	1.86	1.88	1.96	1.96	1.98	2.10								
CD (1 %)	(V) – 0.06 (C) – ns (VC) –ns (D) – 0.08 (VD) – ns (CD) – ns																		

Interaction effect of V x C x D

	C1							Mean	C2							Mean	C3							Mean
V	D1	D2	D3	D4	D5	D6	D7		D1	D2	D3	D4	D5	D6	D7		D1	D2	D3	D4	D5	D6	D7	
V1	1.72	1.73	1.77	1.80	1.84	1.89	1.96	1.81	1.72	1.75	1.77	1.79	1.85	1.90	1.96	1.82	1.72	1.74	1.78	1.83	1.89	1.97	2.05	1.85
V2	1.75	1.76	1.77	1.81	1.84	1.90	1.98	1.83	1.75	1.76	1.79	1.82	1.84	1.90	2.00	1.84	1.75	1.77	1.82	1.87	1.93	2.01	2.09	1.89
V3	1.96	1.98	2.00	2.04	2.08	2.12	2.18	2.05	1.96	1.97	2.00	2.55	2.05	2.13	2.21	2.13	1.96	1.99	2.02	2.06	2.12	2.20	2.28	2.09
V4	1.93	1.94	1.96	2.10	2.03	2.03	2.16	2.01	1.93	1.94	1.96	2.00	2.01	1.59	2.17	1.94	1.93	1.94	1.97	2.01	2.08	2.15	2.23	2.04
Mean	1.84	1.85	1.88	1.91	1.95	1.98	2.07		1.84	1.86	1.88	2.04	1.94	1.88	2.08		1.84	1.86	1.90	1.94	2.00	2.08	2.16	

CD – ns

The data revealed that only the main effects of cultivar and duration of storage significantly influenced the total sugar content. Among the cultivars V_3 (2.09 %) recorded the highest value while V_1 (1.83 %) showed the minimum which was on par with V_2 (1.85 %). For duration of storage, data indicated that total sugar content increased with storage as D_7 (2.10 %) exhibited the maximum value and it was on par with D_4, D_5 and D_6. D_1 showed the minimum of 1.84 per cent and was on par with D_2 and D_3. The interaction effects were not statistically significant.

4.4.3.3 Moisture

The moisture content of Colocasia flour as influenced by cultivar, type of container and shortage duration is presented in Table 22.

Moisture content of Colocasia flour was significantly influenced by cultivar, type of container, storage duration and the interaction effect of C x D. Among the cultivars V_1 (3.04 %) recorded the maximum moisture content while V_2, V_3 and V_4 were on par with V_3 (2.84 %) having the minimum value. Among the type of containers, flour stored in C_3 (3.08 %) recorded the maximum while C_1 (2.81 %) and C_2 (2.83 %) were on par with lower values. Among the durations of storage, flour stored at D_7 recorded the maximum value of 3.62 per cent while D_1 recorded the minimum value (2.39 %).

The interaction effect of C x D showed that C_3D_7 (4.21 %) recorded the highest moisture content. While C_1D_1, C_2D_1 and C_3D_1 (all at 2.39 %) recorded minimum and was on par with C_1D_2, C_2D_2 and C_3D_2.

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

V	C_1	C_2	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
V_1	2.96	2.96	3.20	3.04	2.53	2.71	2.83	2.96	3.14	3.42	3.70	C_1	2.39	2.51	2.63	2.77	2.92	3.11	3.31
V_2	2.72	2.80	3.03	2.85	2.33	2.44	2.58	2.73	2.92	3.39	3.58	C_2	2.39	2.52	2.64	2.77	2.92	3.24	3.34
V_3	2.75	2.75	3.04	2.84	2.36	2.46	2.60	2.74	2.93	3.25	3.58	C_3	2.39	2.55	2.71	2.88	3.15	3.68	4.21
V_4	2.80	2.81	3.05	2.89	2.34	2.50	2.64	2.79	3.01	3.32	3.63								
Mean	2.81	2.83	3.08		2.39	2.53	2.66	2.80	3.00	3.34	3.62								
CD (1 %)	(V) – 0.07 (C) – 0.06 (VC) – ns (D) –0.09 (VD) – ns (CD) – 0.16																		

Interaction effect of V x C x D

	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	2.53	2.69	2.82	2.95	3.08	3.24	3.41	2.96	2.53	2.71	2.81	2.95	3.06	3.25	3.41	2.96	2.53	2.73	2.86	3.00	3.25	3.78	4.29	3.20
V_2	2.33	2.43	2.55	2.62	2.82	3.01	3.22	2.72	2.33	2.44	2.55	2.66	2.83	3.51	3.33	2.80	2.33	2.46	2.64	2.84	3.13	3.65	4.20	3.03
V_3	2.36	2.44	2.57	2.69	2.84	3.05	3.26	2.75	2.36	2.44	2.59	2.69	2.84	3.05	3.26	2.75	2.36	2.49	2.64	2.83	3.10	3.65	4.21	3.04
V_4	2.34	2.47	2.61	2.77	2.94	3.15	3.35	2.80	2.34	2.49	2.62	2.77	2.95	3.15	3.37	2.81	2.34	2.55	2.69	2.84	3.13	3.66	4.17	3.05
Mean	2.39	2.51	2.63	2.77	2.92	3.11	3.31		2.39	2.52	2.64	2.77	2.92	3.24	3.34		2.39	2.55	2.71	2.88	3.15	3.68	4.21	

CD - ns

Plate 3. Murukkus prepared using colocasia flour

Plate 4. Wafers prepared using colocasia flour

4.5 Storage studies of secondary products

4.5.1 Murukku

4.5.1.1 Starch

The influence of cultivar, type of container and storage period on the starch content of *murukku made from Colocasia flour is presented* in Table 23.

The main effects of cultivar and type of container were found to significantly influence the starch content. The cultivar V_4 (66.20 %) recorded the maximum while V_2 (57.74 %) recorded the minimum. Among the containers murukku stored in C_3 (60.71 %) recorded the minimum while C_1 and C_2 were on par with each other at 62.30 per cent and had the maximum values. The interaction effects were not statistically significant.

4.5.1.2 Total sugars

The influence of cultivar type of container and storage duration on the total sugar content of murukku is presented in Table 24.

The data revealed that the cultivar, container storage duration and the interaction effect of C x D had significant influence on the total sugar content. Cultivars V_3 and V_1 were on par with the maximum values of 2.42 per cent and 2.40 per cent respectively V_2 had the least value of 2.15 per cent. Murukku stored in container C_3 had the highest value of 2.35 per cent while C_1 and C_2 (2.30 %) were on par with the minimum values showing that storage in polythene covers caused greater increase in total sugar content. In

Table 23. Effect of cultivars, containers, duration of storage and their interactions on the starch content (%) 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	62.15	62.15	60.43	61.57	62.15	62.15	62.15	62.15	60.81	60.81	60.81
V_2	58.15	58.15	56.91	57.74	58.15	54.15	58.15	58.15	57.60	56.98	56.98
V_3	62.15	62.15	60.43	61.57	62.15	62.15	62.15	62.15	60.81	60.81	60.81
V_4	66.75	66.75	65.09	66.20	66.75	66.75	66.75	66.75	65.93	65.22	65.22
Mean	62.30	62.30	60.71		62.30	62.30	62.30	62.30	61.29	60.95	60.95
CD (1 %)	(V) – 1.31 (C) – 1.14 (VC) – ns (D) – ns (VD) – ns (CD) – ns										

	D_1	D_2	D_3	D_4	D_5	D_6	D_7
C_1	62.30	62.30	62.30	62.30	62.30	62.30	62.30
C_2	62.30	62.30	62.30	62.30	62.30	62.30	62.30
C_3	62.30	62.30	62.30	62.30	59.26	58.26	58.26

Interaction effect of V x C x D

V	C_1 D_1	C_1 D_2	C_1 D_3	C_1 D_4	C_1 D_5	C_1 D_6	C_1 D_7	Mean
V_1	62.15	62.15	62.15	62.15	62.15	62.15	62.15	62.15
V_2	58.15	58.15	58.15	58.15	58.15	58.15	58.15	58.15
V_3	62.15	62.15	62.15	62.15	62.15	62.15	62.15	62.15
V_4	66.75	66.75	66.75	66.75	66.75	66.75	66.75	66.75
Mean	62.30	62.30	62.30	62.30	62.30	62.30	62.30	

V	C_2 D_1	C_2 D_2	C_2 D_3	C_2 D_4	C_2 D_5	C_2 D_6	C_2 D_7	Mean
V_1	62.15	62.15	62.15	62.15	62.15	62.15	62.15	62.15
V_2	58.15	58.15	58.15	58.15	58.15	58.15	58.15	58.15
V_3	62.15	62.15	62.15	62.15	62.15	62.15	62.15	62.15
V_4	66.75	66.75	66.75	66.75	66.75	66.75	66.75	66.75
Mean	62.30	62.30	62.30	62.30	62.30	62.30	62.30	

V	C_3 D_1	C_3 D_2	C_3 D_3	C_3 D_4	C_3 D_5	C_3 D_6	C_3 D_7	Mean
V_1	62.15	62.15	62.15	62.15	58.13	58.13	58.13	60.43
V_2	58.15	58.15	58.15	58.15	56.50	54.65	54.65	56.91
V_3	62.15	62.15	62.15	62.15	58.13	58.13	58.13	60.43
V_4	66.75	66.75	66.75	66.75	64.30	62.15	62.15	65.09
Mean	62.30	62.30	62.30	62.30	59.26	58.26	58.26	

CD – ns

Table 24. Effect of cultivars, containers, duration of storage and their interactions on the total sugar content (%) 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		D_1	D_2	D_3	D_4	D_5	D_6	D_7
V_1	2.39	2.39	2.44	2.40	2.27	2.29	2.33	2.38	2.44	2.51	2.61	C_1	2.19	2.21	2.23	2.27	2.33	2.40	2.49
V_2	2.13	2.13	2.18	2.15	2.01	2.04	2.07	2.12	2.19	2.26	2.35	C_2	2.19	2.21	2.24	2.28	2.33	2.40	2.49
V_3	2.40	2.41	2.46	2.42	2.30	2.32	2.35	2.39	2.46	2.53	2.62	C_3	2.19	2.22	2.27	2.32	2.41	2.49	2.59
V_4	2.28	2.29	2.34	2.30	2.17	2.19	2.23	2.27	2.34	2.42	2.50								
Mean	2.30	2.30	2.35		2.19	2.21	2.24	2.29	2.36	2.43	2.52								
CD (1 %)	(V) – 0.02 (C) – 0.01 (VC) – ns (D) – 0.02 (VD) – ns (CD) – 0.03																		

Interaction effect of V x C x D

	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	2.27	2.30	2.32	2.36	2.41	2.48	2.58	2.39	2.27	2.29	2.32	2.36	2.41	2.49	2.59	2.39	2.27	2.30	2.35	2.42	2.50	2.57	2.67	2.44
V_2	2.01	2.03	2.05	2.09	2.17	2.23	2.32	2.13	2.01	2.03	2.06	2.10	2.17	2.23	2.32	2.13	2.01	2.05	2.10	2.16	2.24	2.32	2.42	2.18
V_3	2.30	2.31	2.34	2.37	2.44	2.50	2.53	2.40	2.30	2.32	2.34	2.39	2.44	2.50	2.59	2.41	2.30	2.32	2.37	2.43	2.50	2.60	2.70	2.46
V_4	2.17	2.19	2.21	2.25	2.32	2.38	2.47	2.28	2.17	2.19	2.22	2.26	2.32	2.39	2.47	2.29	2.17	2.20	2.25	2.30	2.39	2.48	2.57	2.34
Mean	2.19	2.21	2.23	2.27	2.33	2.40	2.49		2.19	2.21	2.24	2.28	2.33	2.40	2.49		2.19	2.22	2.27	2.32	2.41	2.49	2.59	

CD – ns

storage period, murukku stored for duration D_7 had the maximum value of 2.52 per cent while D_1 had least value of 2.19 per cent indicating that total sugar content increased as storage duration increased.

C_3D_7 had the maximum value of 2.59 per cent while C_1D_1, C_2D_1 and C_3D_1 all at 2.19 per cent had the least values and on par with C_1D_2 and C_2D_2. The other interaction effects did not have significant influence.

4.5.1.3 Moisture

The data on the influence of cultivar, type of container and storage duration on the moisture content of murukku is presented in Table 25.

The data revealed that the cultivar, container, storage duration and the interaction effect of C x D significantly influenced the moisture content. Murukku of cultivar V_3 (9.57 %) recorded the highest moisture content while V_2 recorded the least (9.43 %) value. Murukku stored in container C_3 recorded the highest value of 9.61 per cent while C_1 (9.44 %) and C_2 (9.45 %) recorded the least values and were on par. Murukku stored for duration D_7 (9.82 %) had the maximum moisture content while D_1 (9.28 %) had the minimum. C_3D_7 had the maximum moisture content of 10.09 per cent while C_1D_1, C_2D_1 and C_3D_1 and all at 9.28 per cent had minimum values. The other interactions effects were not significant.

4.5.1.4 Organoleptic quality

The effects of cultivar, container and storage duration on the organoleptic quality of murukku is presented in Table 26.

Table 25. Effect of cultivars, containers, duration of storage and their interactions on the moisture content (%) 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	9.48	9.49	9.65	9.54	9.32	9.36	9.42	9.50	9.60	9.73	9.87
V_2	9.38	9.38	9.53	9.43	9.23	9.26	9.31	9.39	9.48	9.61	9.74
V_3	9.51	9.51	9.68	9.57	9.35	9.39	9.45	9.52	9.62	9.74	9.89
V_4	9.39	9.39	9.58	9.45	9.24	9.29	9.34	9.41	9.50	9.63	9.77
Mean	9.44	9.45	93.61		9.28	9.32	9.33	9.45	9.55	9.68	9.82
CD (1 %)	(V) – 0.01 (C) – 0.01 (VC) – ns (D) – 0.02 (VD) – ns (CD) – 0.03										

	D_1	D_2	D_3	D_4	D_5	D_6	D_7
C_1	9.28	9.32	9.36	9.41	9.48	9.56	9.68
C_2	9.28	9.32	9.36	9.41	9.48	9.57	9.68
C_3	9.28	9.34	9.42	9.54	9.70	9.90	10.09

Interaction effect of V x C x D

	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	9.32	9.35	9.40	9.45	9.52	9.62	9.71	9.48	9.32	9.36	9.41	9.45	9.53	9.62	9.74	9.49	9.32	9.37	9.47	9.59	9.77	9.95	10.13	9.65
V_2	9.23	9.25	9.30	9.35	9.42	9.50	9.60	9.38	9.23	9.26	9.30	9.37	9.42	9.51	9.60	9.38	9.23	9.27	9.34	9.45	9.60	9.81	10.00	9.53
V_3	9.35	9.38	9.43	9.48	9.55	9.63	9.75	9.51	9.35	9.38	9.43	9.47	9.56	9.64	9.76	9.51	9.35	9.41	9.49	9.60	9.77	9.96	10.17	9.68
V_4	9.24	9.28	9.32	9.36	9.42	9.50	9.61	9.39	9.24	9.29	9.32	9.37	9.41	9.51	9.63	9.39	9.24	9.30	9.38	9.50	9.67	9.88	10.09	9.58
Mean	9.28	9.32	9.36	9.41	9.48	9.56	9.68		9.28	9.32	9.36	9.41	9.48	9.57	9.68		9.28	9.34	9.42	9.54	9.70	9.90	10.09	

CD – ns

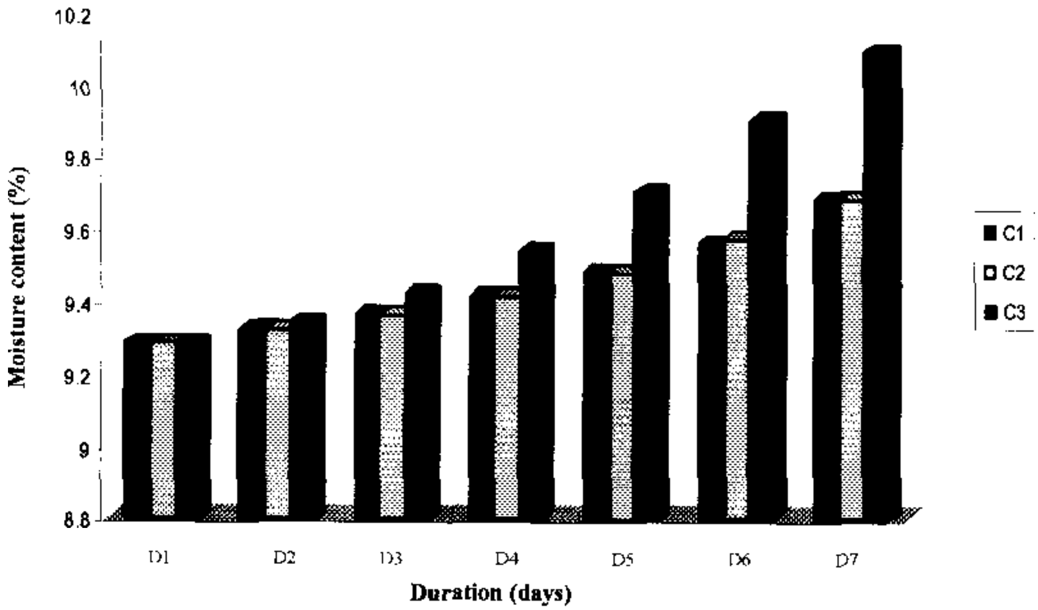

Fig.1. Effect of three types of containers on moisture content of murukkus for a period of 90 days

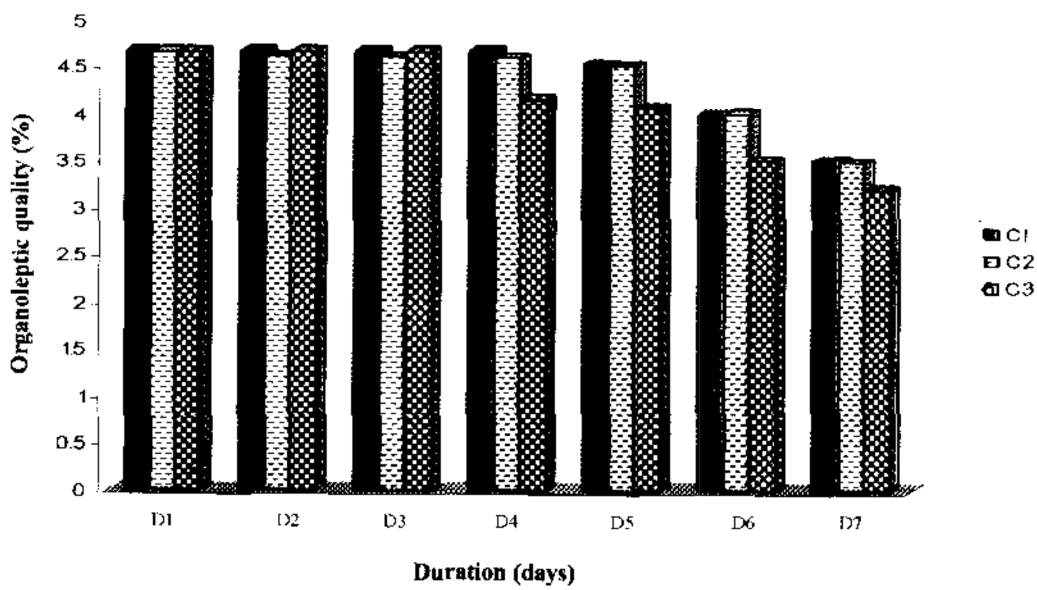

Fig.2. Effect of three types of containers on organoleptic quality of murukkus for a period of 90 days

Table 26. Effect of cultivars, containers, duration of storage and their interactions on the 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		D_1	D_2	D_3	D_4	D_5	D_6	D_7
V_1	4.33	4.29	4.16	4.26	4.50	4.70	4.57	4.40	4.37	3.90	3.37	C_1	4.65	4.65	4.65	4.65	4.52	3.98	3.50
V_2	4.29	4.34	4.11	4.25	4.50	4.57	4.73	4.53	4.33	4.83	3.32	C_2	4.65	4.60	4.60	4.58	4.50	4.00	3.48
V_3	4.46	4.37	4.19	4.34	4.70	4.70	4.77	4.47	4.43	3.87	3.43	C_3	4.65	4.65	4.65	4.15	4.05	3.50	3.18
V_4	4.49	4.44	4.10	4.34	4.90	4.77	4.77	4.47	4.30	3.70	3.50								
Mean	4.39	4.36	4.14		4.65	4.68	4.71	4.47	4.36	3.83	3.38								
CD (1 %)	(V) – 0.07 (C) – 0.06 (VC) – ns (D) –0.09 (VD) – 0.18 (CD) – 0.16																		

Interaction effect of V x C x D

	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	4.50	4.50	4.70	4.50	4.50	4.10	3.50	4.33	4.50	4.70	4.50	4.50	4.50	3.90	3.40	4.29	4.50	4.90	4.50	4.20	4.10	3.70	3.20	4.16
V_2	4.50	4.50	4.70	4.70	4.40	3.90	3.30	4.29	4.50	4.50	4.80	4.70	4.50	4.10	4.30	4.34	4.50	4.70	4.70	4.20	4.10	3.50	3.10	4.11
V_3	4.70	4.70	4.90	4.70	4.70	4.00	3.50	4.46	4.47	4.50	4.70	4.60	4.50	4.10	3.50	4.37	4.70	4.90	4.70	4.10	4.10	3.50	3.30	4.19
V_4	4.90	4.90	4.70	4.80	4.50	3.90	3.70	4.49	4.90	4.70	4.90	4.50	4.50	3.90	3.70	4.44	4.90	4.70	4.70	4.10	3.90	3.30	3.10	4.10
Mean	4.65	4.65	4.75	4.68	4.52	3.98	3.50		4.65	4.60	4.73	4.58	4.50	4.00	3.48		4.65	4.80	4.65	4.15	4.05	3.50	3.18	

CD – ns

Organoleptic quality of murukku was found to be significantly influenced by cultivar, container, storage duration and the interaction effects of V x D and C x D. Murukku of cultivar V_3 (4.34) and V_4 (4.34) scored maximum values and were on par with V_2 *and* V_1. *Murukku stored in* container C_1 (4.39) and C_2 (4.36) had maximum organoleptic quality and were on par while C_3C_4 (4.14) had the least value. Murukku stored for the duration D_7 (3.38) had the least organoleptic quality while those stored for duration D_3 (4.71), D_2 (4.68) and D_1 (4.65) had maximum organoleptic quality and were on par.

V_3D_3 (4.77), V_4D_3 (4.77), V_2D_3 (4.73), V_4D_2 (4.77), V_3D_2 (4.70) and V_3D_1 scored the maximum values for organoleptic quality and were on par while V_2D_7 scored the least value of 3.32 which was on par with V_1D_7 (3.37).

C_1D_1 (4.65) scored the maximum value for organoleptic quality which was on par with C_1D_1, C_2D_1, C_3D_1, C_1D_2, C_2D_2, C_3D_2, C_2D_3, C_3D_3 and C_1D_4 while C_3D_7 (3.18) scored the least value. The remaining interaction effects were not significant.

4.5.2 Papad

4.5.2.1 Starch

The influence of cultivar type of container and storage duration on the starch content of papad is presented in Table 27.

The data revealed that other than cultivar, no other main effect or interaction effect had significant influence on the starch content of papads.

Table 27. Effect of cultivars, containers, duration of storage and their interactions on the starch content (%) of papads on storage

V	C_1	C_2	C_3	Mean	D_1	D_2	D_3		D_1	D_2	D_3
V_1	66.50	66.50	66.50	66.50	66.50	66.50	66.50	C_1	61.20	61.20	61.20
V_2	62.00	62.00	62.00	62.00	62.00	62.00	62.00	C_2	61.20	61.20	61.20
V_3	58.15	58.15	58.15	58.15	58.15	58.15	58.15	C_3	61.20	61.20	61.20
V_4	58.15	58.15	58.15	58.15	58.15	58.15	58.15				
Mean	61.20	61.20	61.20		61.20	61.20	61.20				
CD (1 %)	(V) – 1.98 (C) – ns (VC) – ns (D) –ns (VD) – ns (CD) – ns										

Interaction effect of V x C x D

	C_1			Mean	C_2			Mean	C_3			Mean
	D_1	D_2	D_3		D_1	D_2	D_3		D_1	D_2	D_3	
V_1	66.50	66.50	66.50	66.50	66.50	66.50	66.50	66.50	66.50	66.50	66.50	66.50
V_2	62.00	62.00	62.00	62.00	62.00	62.00	62.00	62.00	62.00	62.00	62.00	62.00
V_3	58.15	58.15	58.15	58.15	58.15	58.15	58.15	58.15	58.15	58.15	58.15	58.15
V_4	58.15	58.15	58.15	58.15	58.15	58.15	58.15	58.15	58.15	58.15	58.15	58.15
Mean	61.20	61.20	61.20		61.20	61.20	61.20		61.20	61.20	61.20	

CD - ns

Among the cultivars, papad made from cultivar V_1 (66.50 %) had the highest value while V_3 and V_4 each at 58.15 % had the minimum value.

4.5.2.2 Total sugar

The influence of cultivar type of container and storage duration on the total sugar content of papad is presented in Table 28.

The data revealed that the total sugar content was influenced by cultivar, container and the storage duration papad of V_3 (1.42 %) had the highest total sugar value while that of V_4 (1.28 %) had the least. Papads stored in container C_3 obtained maximum value of 1.35 per cent while C_1 and C_2 both at 1.33 per cent obtained the least value and were on par with each other. Papads stored at duration D_3 (1.39 %) had the maximum total sugar content while D_1 (1.29 %) had the least. The interaction effects were not found to be statistically significant.

4.5.2.3 Moisture

The influence of cultivar type of container and storage duration on the moisture content of papad is presented in Table 29.

The cultivar, container, storage duration and the interaction effect of C x D were found to significantly influence the moisture content. Papads of V_3 (17.18 %) recorded the highest moisture values which was on par with V_1 (17.15 %) while V_2 (17.01 %) had the least moisture content. Papad stored in container C_3 (17.33 %) had the highest moisture content while C_1 and C_2 at 17.01 per cent and 17.02 per cent respectively had the lowest moisture

Plate 5. Papads prepared using colocasia flour

Table 28. Effect of cultivars, containers, duration of storage and their interactions on the total sugar content (%) of papads on storage

V	C_1	C_2	C_3	Mean	D_1	D_2	D_3
V_1	1.29	1.29	1.32	1.30	1.25	1.30	1.35
V_2	1.36	1.36	1.38	1.37	1.32	1.36	1.42
V_3	1.41	1.41	1.42	1.41	1.37	1.41	1.46
V_4	1.27	1.27	1.28	1.28	1.23	1.27	1.32
Mean	1.33	1.33	1.35		1.29	1.34	1.39
CD (1 %)	(V) – 0.01 (C) – 0.01 (VC) – ns (D) – 0.01 (VD) – ns (CD) – ns						

	D_1	D_2	D_3
C_1	1.29	1.33	1.38
C_2	1.29	1.33	1.38
C_3	1.29	1.35	1.02

Interaction effect of V x C x D

	C_1			Mean	C_2			Mean	C_3			Mean
	D_1	D_2	D_3		D_1	D_2	D_3		D_1	D_2	D_3	
V_1	1.25	1.29	1.33	1.29	1.25	1.30	1.34	1.29	1.25	1.32	1.38	1.32
V_2	1.32	1.36	1.40	1.36	1.32	1.35	1.40	1.36	1.32	1.58	1.45	1.38
V_3	1.37	1.41	1.46	1.41	1.37	1.41	1.46	1.41	1.37	1.42	1.48	1.42
V_4	1.23	1.27	1.32	1.27	1.23	1.28	1.31	1.28	1.23	1.28	1.35	1.28
Mean	1.29	1.33	1.38		1.29	1.33	1.38		1.29	1.35	1.42	

CD – ns

Table 29. Effect of cultivars, containers, duration of storage and their interactions on the moisture content (%) of papads on storage

V	C_1	C_2	C_3	Mean	D_1	D_2	D_3
V_1	17.03	17.05	17.36	17.15	16.39	17.11	17.94
V_2	16.91	16.90	17.23	17.01	16.25	16.91	17.88
V_3	17.06	17.09	17.39	17.18	16.42	17.16	17.97
V_4	17.02	17.04	17.34	17.13	16.37	17.11	17.92
Mean	17.01	17.02	17.33		16.36	17.07	17.93
CD (1 %)	(V) – 0.04 (C) – 0.04 (VC) – ns (D) – 0.04 (VD) – ns (CD) – 0.07						

	D_1	D_2	D_3
C_1	16.36	16.96	17.70
C_2	16.36	16.99	17.71
C_3	16.36	17.26	18.37

Interaction effect of V x C x D

	C_1			Mean	C_2			Mean	C_3			Mean
	D_1	D_2	D_3		D_1	D_2	D_3		D_1	D_2	D_3	
V_1	16.39	17.01	17.70	17.03	16.39	17.04	17.72	17.05	16.39	17.29	18.39	17.36
V_2	16.25	16.78	17.69	16.91	16.25	16.79	17.66	16.90	16.25	17.16	18.29	17.23
V_3	16.42	17.04	17.72	17.06	16.42	17.08	17.77	17.09	16.42	17.33	18.41	17.39
V_4	16.37	17.01	17.69	17.02	16.37	17.04	17.70	17.04	16.37	17.27	18.38	17.34
Mean	16.36	16.96	17.70		16.36	16.99	17.71		16.36	17.26	18.37	

CD – ns

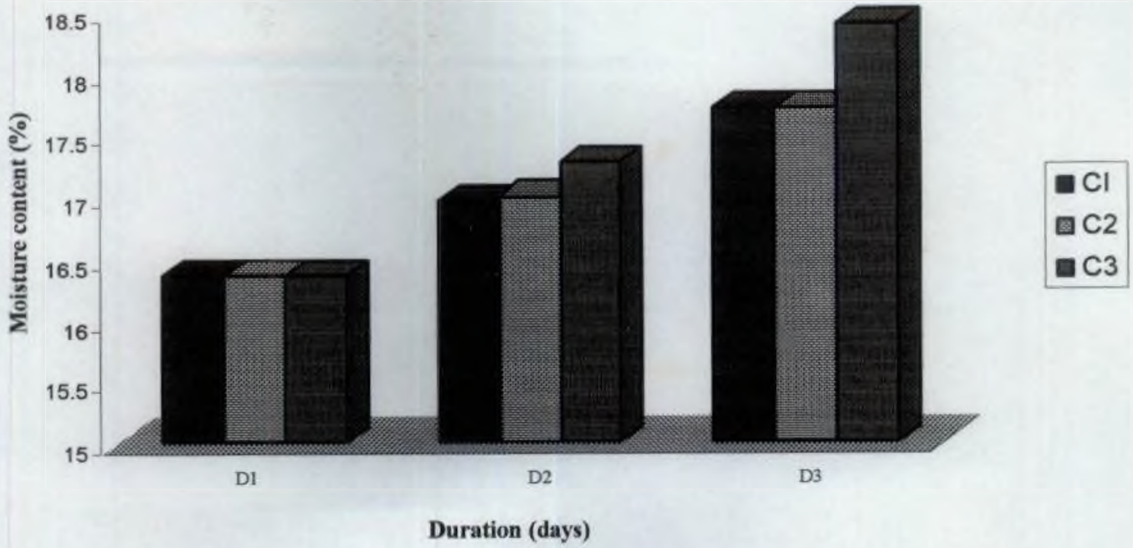

Fig.3. Effect of three types of containers on moisture content of papads for a period of 90 days

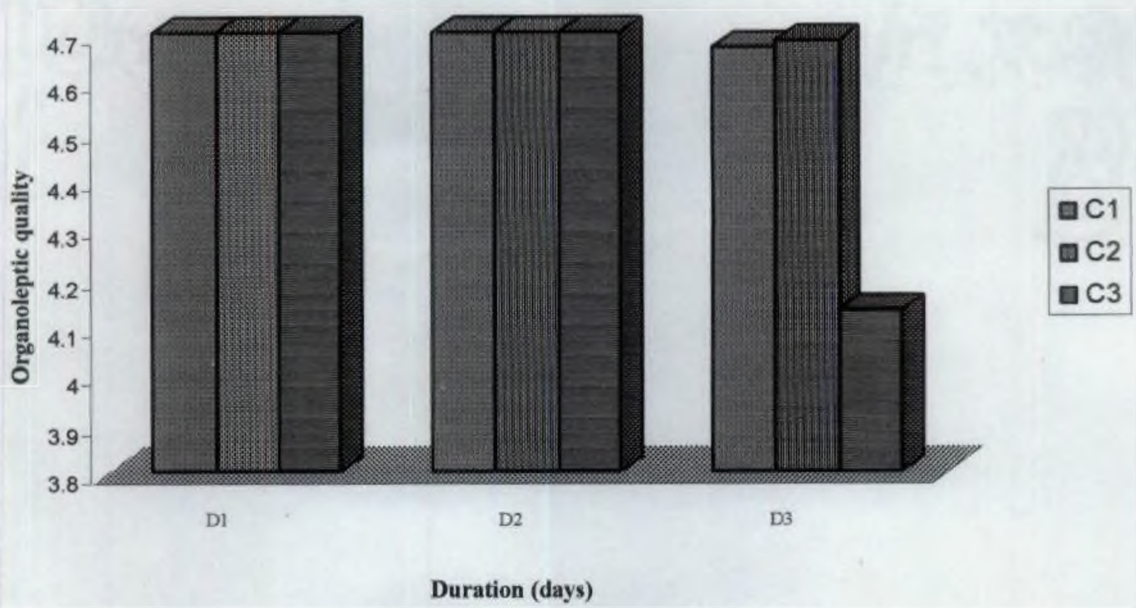

Fig.4. Effect of three types of containers on organoleptic quality of papads for a period of 90 days

Table 30. Effect of cultivars, containers, duration of storage and their interactions on the organoleptic quality of papads on storage

V	C_1	C_2	C_3	Mean	D_1	D_2	D_3
V_1	4.50	4.50	4.40	4.47	4.50	4.53	4.37
V_2	4.47	4.50	4.37	4.44	4.50	4.50	4.33
V_3	4.90	4.93	4.70	4.84	4.90	4.93	4.70
V_4	4.90	4.90	4.57	4.79	4.90	4.90	4.57
Mean	4.69	4.70	4.52		4.70	4.72	4.49
CD (1 %)	(V) – 0.09 (C) – 0.08 (VC) – ns (D) – 0.08 (VD) – ns (CD) – 0.13						

	D_1	D_2	D_3
C_1	4.70	4.70	4.67
C_2	4.70	4.73	4.68
C_3	4.70	4.73	4.13

Interaction effect of V x C x D

	C_1			Mean	C_2			Mean	C_3			Mean
	D_1	D_2	D_3		D_1	D_2	D_3		D_1	D_2	D_3	
V_1	4.50	4.50	4.50	4.50	4.50	4.50	4.50	4.50	4.50	4.60	4.10	4.70
V_2	4.50	4.50	4.40	4.47	4.50	4.50	4.50	4.50	4.50	4.50	4.10	4.37
V_3	4.90	4.90	4.90	4.90	4.90	5.00	4.90	4.93	4.90	4.90	4.30	4.70
V_4	4.90	4.90	4.90	4.90	4.90	4.90	4.80	4.90	4.90	4.90	4.00	4.57
Mean	4.70	4.70	4.67		4.70	4.73	4.68		4.70	4.73	4.13	

CD – *ns*

content and were on par with each other. Papads stored at duration D_3 (17.93 %) had the highest moisture content while D_1 (16.33 %) had the lowest.

C3D3 (18.3 %7) had the highest moisture content while C_1D_1, C_2D_1 and C_3D_1 all at 16.36 per cent had the least moisture content.

4.5.2.4 Organoleptic quality

The influence of cultivar type of container and storage duration on the organoleptic quality of papad is presented in Table 30.

The data revealed that the cultivar, container, storage duration and the interaction effect of C x D had significant influence on the organoleptic quality of the papads. Papads of V_3 (4.84) had the maximum score which was on par with V_4 (4.79), while V_2 (4.44) had the least value and was on par with V_1 (4.47). Papads store in container C_2 had the maximum organoleptic quality at 4.7 which was on par with C_1 (4.69) while C_3 (4.52) had the lowest value. Papads stored for duration D_3 had the least value of 4.49 while that of D_2 (4.72) had the maximum value.

In the interaction effect of C x D, C_3D_3 (4.13) had the least organoleptic quality while C_2D_2 (4.73) has maximum value and is on par with all except C_3D_3.

4.5.3 Wafers

4.5.3.1 Starch

The influence of cultivar type of container and storage duration on the starch content of wafers is presented in Table 31.

Table 31. Effect of cultivars, containers, duration of storage and their interactions on the starch content (%) of wafers 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	57.63	57.63	56.87	57.38	58.15	58.15	58.15	58.15	57.60	56.93	54.50
V_2	61.89	61.56	61.01	61.48	62.15	62.15	62.15	62.15	61.48	61.48	58.82
V_3	54.44	54.44	53.77	54.21	54.65	54.65	54.65	54.65	54.15	54.15	52.60
V_4	57.65	57.65	56.89	57.40	58.15	58.15	58.15	58.15	57.53	56.98	54.65
Mean	57.90	57.82	57.13		58.28	58.28	58.28	58.28	57.69	57.39	55.14
CD (1 %)	(V) – 1.27 (C) – ns (VC) – ns (D) – 1.68 (VD) – ns (CD) – ns										

	D_1	D_2	D_3	D_4	D_5	D_6	D_7
C_1	58.28	58.28	58.28	58.28	58.28	58.22	55.65
C_2	58.28	58.28	58.28	58.28	58.28	58.28	55.07
C_3	58.28	58.28	58.28	58.28	56.53	55.61	54.70

Interaction effect of V x C x D

	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	58.15	58.15	58.15	58.15	58.15	58.15	54.70	57.63	58.15	58.15	58.15	58.15	58.15	58.15	54.50	57.63	58.15	58.15	58.15	58.15	56.50	54.50	54.50	56.87
V_2	62.15	62.15	62.15	62.15	62.15	62.15	60.30	61.89	62.15	62.15	62.15	62.15	62.15	62.15	58.00	61.56	62.15	62.15	62.15	62.15	60.15	60.15	58.15	61.01
V_3	54.65	54.65	54.65	54.65	54.65	54.65	53.15	54.44	54.65	54.65	54.65	54.65	54.65	54.65	53.15	54.44	54.65	54.65	54.65	54.65	53.15	53.15	51.50	53.77
V_4	58.15	58.15	58.15	58.15	58.15	58.15	54.65	57.65	58.15	58.15	58.15	58.15	58.15	58.15	54.65	57.65	58.15	58.15	58.15	58.15	56.30	54.65	54.65	56.89
Mean	58.28	58.28	58.28	58.28	58.28	58.28	55.65		58.28	58.28	58.28	58.28	58.28	58.28	55.07		58.28	58.28	58.28	58.28	56.53	55.61	54.70	

CD – ns

The cultivar and storage duration were found to significantly influence the starch content of wafers. Cultivar V_2 recorded the highest starch content of 61.48 per cent while V_3 (54.21 %) recorded the least value. Wafers stored for duration D_7 (55.14 %) had the least starch content while D_1, D_2, D_3 and D_4 all at 58.28 per cent had maximum starch content and were on par. The interaction effects were not found to be statistically significant.

4.5.3.2 Total sugars

The influence of cultivar type of container and storage duration on the total sugar content of wafer is presented in Table 32.

The cultivar and the storage duration was found to significantly influence the total sugar content of the wafers. The cultivar V_4 (2.18 %) had the highest total sugar content which was on par with V_1 and V_3, while V_2 (2.08 %) recorded the least value. The wafers stored in container C_3 had the highest total sugar content while C_1 and C_2 obtained minimum values of 2.13 and 2.14 per cent respectively and were on par. The interaction effects were not statistically significant.

4.5.3.3 Moisture

The influence of cultivar type of container and storage duration on the moisture content of murukku is presented in Table 33.

The cultivar, container and the storage duration was found to significantly influence the moisture content of wafers of V_2 showed the highest moisture content of 8.89 per cent while V_3 (8.45 %) had the least

Table 32. Effect of cultivars, containers, duration of storage and their interactions on the total sugar content (%) of wafers 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	2.15	2.15	2.20	2.17	2.07	2.10	2.12	2.15	2.19	2.23	2.30
V_2	2.07	2.07	2.11	2.08	1.98	2.00	2.03	2.06	2.11	2.16	2.24
V_3	2.13	2.12	2.17	2.14	2.05	2.06	2.01	2.12	2.16	2.21	2.28
V_4	2.18	2.20	2.17	2.18	2.11	2.12	1.98	2.19	2.24	2.29	2.37
Mean	2.13	2.14	2.16		2.05	2.07	2.05	2.13	2.17	2.22	2.30
CD (1 %)	(V) – 0.04 (C) – ns (VC) – ns (D) – 0.05 (VD) – ns (CD) – ns										

	D_1	D_2	D_3	D_4	D_5	D_6	D_7
C_1	2.05	2.06	2.08	2.11	2.16	2.20	2.26
C_2	2.05	2.07	2.09	2.12	2.15	2.20	2.26
C_3	2.05	2.08	1.99	2.16	2.21	2.27	2.36

Interaction effect of V x C x D

	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	2.07	2.09	2.11	2.14	2.18	2.22	2.28	2.15	2.07	2.09	2.11	2.13	2.16	2.20	2.26	2.15	2.07	2.11	2.14	2.18	2.22	2.28	2.36	2.20
V_2	1.98	2.00	2.01	2.05	2.10	2.14	2.21	2.07	1.98	2.00	2.03	2.05	2.09	2.14	2.21	2.07	1.98	2.01	2.05	2.09	2.14	2.21	2.30	2.11
V_3	2.05	2.05	2.08	2.11	2.15	2.19	2.25	2.13	2.05	2.07	2.08	2.10	2.13	2.18	2.24	2.12	2.05	2.07	2.11	2.15	2.20	2.26	2.34	2.17
V_4	2.11	2.11	2.13	2.16	2.20	2.26	2.32	2.18	2.11	2.12	2.15	2.19	2.23	2.28	2.34	2.20	2.11	2.13	1.66	2.22	2.28	2.34	2.44	2.17
Mean	2.05	2.06	2.08	2.11	2.16	2.20	2.26		2.05	2.07	2.09	2.12	2.15	2.20	2.26		2.05	2.08	1.99	2.16	2.21	2.27	2.36	

CD – ns

Table 33. Effect of cultivars, containers, duration of storage and their interactions on the moisture content (%) of wafers 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	8.56	8.56	8.62	8.58	8.39	8.44	8.49	8.56	8.63	8.74	8.82
V_2	8.87	8.88	8.91	8.89	8.72	8.76	8.80	8.85	8.92	9.02	9.14
V_3	8.44	8.44	8.48	8.45	8.28	8.32	8.37	8.43	8.50	8.59	8.69
V_4	8.49	8.50	8.50	8.50	8.33	8.37	8.42	8.48	8.56	8.66	8.68
Mean	8.59	8.60	8.63		8.43	8.47	8.52	8.53	8.66	8.75	8.83
CD (1 %)	(V) – 0.03 (C) – 0.03 (5 %) (VC) – ns (D) – 0.04 (VD) – ns (CD) – ns										

	D_1	D_2	D_3	D_4	D_5	D_6	D_7
C_1	8.43	8.47	8.51	8.56	8.63	8.72	8.82
C_2	8.43	8.47	8.52	8.57	8.64	8.72	8.83
C_3	8.43	8.48	8.54	8.60	8.70	8.81	8.85

Interaction effect of V x C x D

	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	8.39	8.43	8.47	8.54	8.60	8.69	8.77	8.56	8.39	8.43	8.48	8.55	8.62	8.70	8.79	8.56	8.39	8.46	8.52	8.59	8.68	8.82	8.89	8.62
V_2	8.72	8.76	8.80	8.84	8.90	8.99	9.10	8.87	8.72	8.75	8.81	8.85	8.92	9.00	9.10	8.88	8.72	8.76	8.81	8.87	8.96	9.08	9.22	8.91
V_3	8.28	8.32	8.36	8.42	8.48	8.56	8.66	8.44	8.28	8.33	8.36	8.43	8.48	8.56	8.66	8.44	8.28	8.33	8.38	8.42	8.55	8.64	8.76	8.76
V_4	8.33	8.37	8.41	8.46	8.54	8.63	8.73	8.49	8.33	8.37	8.42	8.47	8.54	8.64	8.75	8.50	8.33	8.37	8.43	8.51	8.62	8.71	8.55	8.55
Mean	8.43	8.47	8.51	8.56	8.63	8.72	8.82		8.43	8.47	8.52	8.57	8.64	8.72	8.83		8.43	8.48	8.54	8.60	8.70	8.81	8.85	

CD – ns

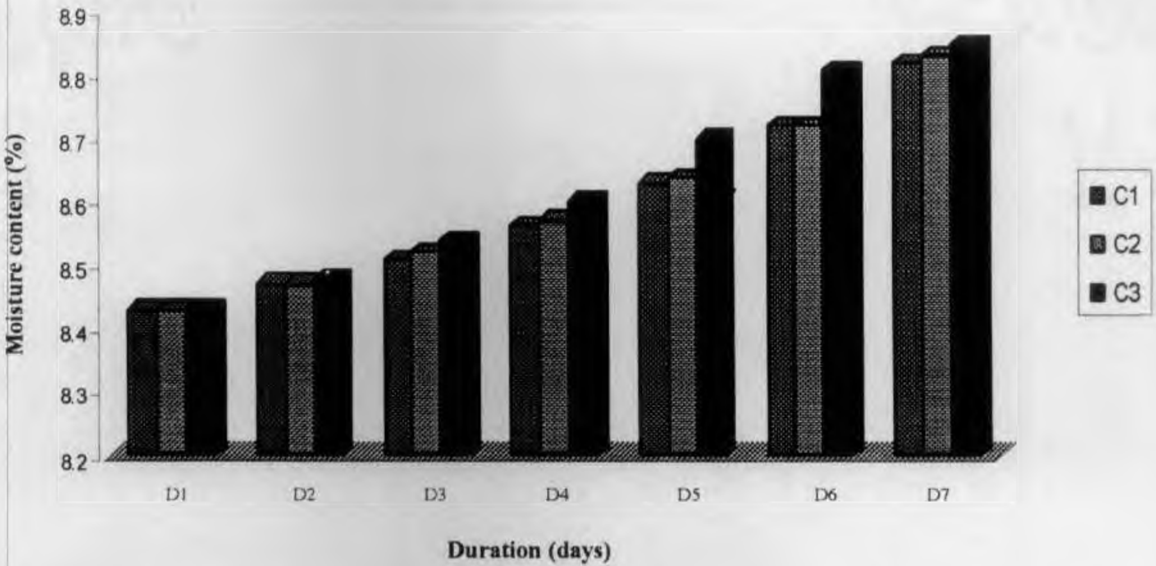

Fig.5. Effect of three types of containers on moisture content of wafers for a period of 90 days

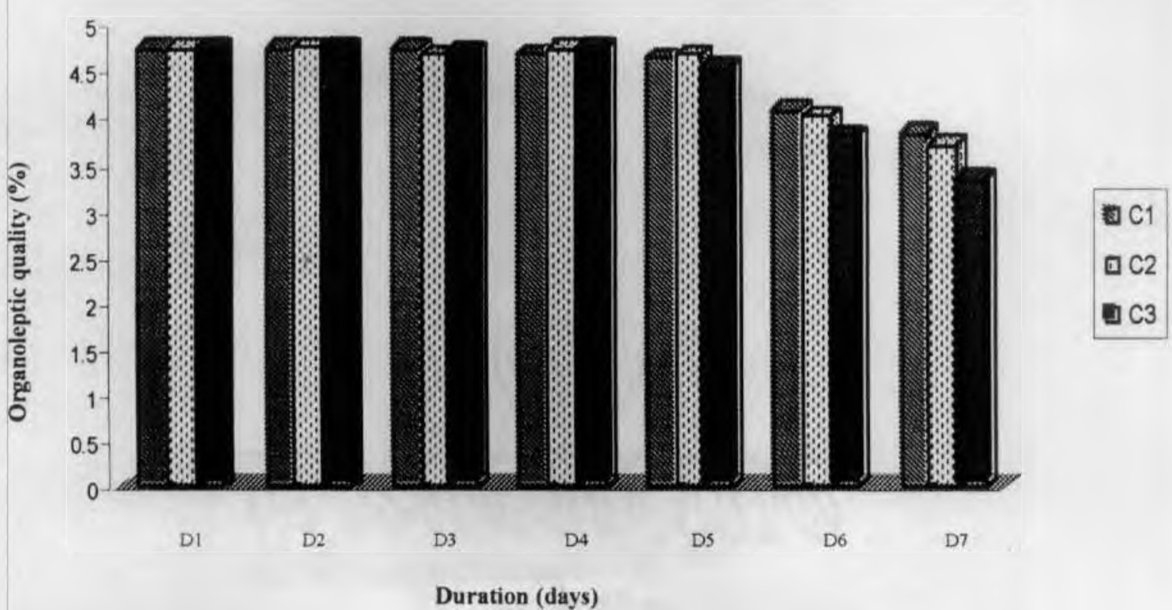

Fig.6. Effect of three types of containers on organoleptic quality of wafers for a period of 90 days

Table 34. Effect of cultivars, containers, duration of storage and their interactions on the organoleptic quality of wafers 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	4.30	4.31	4.17	4.26	4.50	4.33	4.77	4.43	4.37	4.03	3.50
V_2	4.34	4.29	4.20	4.28	4.50	4.50	4.50	4.53	4.37	3.83	3.70
V_3	4.59	4.51	4.51	4.55	4.90	4.93	4.90	4.83	4.77	3.87	3.67
V_4	4.59	4.59	4.47	4.55	4.90	4.90	4.83	4.90	4.80	4.00	3.50
Mean	4.45	4.44	4.34		4.70	4.72	4.67	4.68	4.58	3.93	3.59
CD (1 %)	(V) – 0.06 (C) – 0.05 (VC) – ns (D) – 0.08 (VD) – 0.16 (CD) – 0.14										

	D_1	D_2	D_3	D_4	D_5	D_6	D_7
C_1	4.70	4.70	4.70	4.63	4.60	4.05	3.80
C_2	4.70	4.73	4.65	4.70	4.63	3.98	3.67
C_3	4.70	4.73	4.67	4.70	4.50	3.77	3.30

Interaction effect of V x C x D

	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	4.50	4.50	4.50	4.30	4.50	4.10	3.70	4.30	4.50	4.50	4.50	4.60	4.50	4.10	3.50	4.31	4.50	4.60	4.40	4.40	4.10	3.90	3.30	4.17
V_2	4.50	4.50	4.50	4.40	4.50	4.10	3.90	4.34	4.50	4.50	4.50	4.60	4.50	3.70	3.70	4.29	4.50	4.50	4.50	4.60	4.10	3.70	3.50	4.20
V_3	4.90	4.90	4.90	4.90	4.70	3.90	3.90	4.59	4.90	5.00	4.90	4.70	4.70	3.90	3.80	4.51	4.90	4.90	4.90	4.90	4.90	3.80	3.30	4.51
V_4	4.90	4.90	4.90	4.90	4.70	4.10	3.70	4.59	4.90	4.90	4.90	4.90	4.80	4.20	3.70	4.59	4.90	4.90	4.90	4.90	4.90	3.70	3.10	4.59
Mean	4.70	4.70	4.70	4.63	4.60	4.05	3.80		4.70	4.73	4.65	4.70	4.63	3.98	3.67		4.70	4.23	4.67	4.70	4.50	3.77	3.30	

CD – ns

value. Wafer stored in C_3 (8.63 %) recorded the highest moisture content which was on par with C_2 (8.60 %) while C_1 had the least value of 8.59 per cent which was on par with C_2. Wafers stored for duration D_1 (8.43 %) recorded the least moisture content and was on par with D_2 while D_7 (8.83 %) had the maximum moisture content indicating increase in moisture content with larger storage duration.The interaction effects did not have any significant influence.

4.5.3.4 Organoleptic quality

The influence of cultivar type of container and storage duration on the organoleptic quality content of wafers is presented in Table 34.

Organoleptic quality is significantly influenced by cultivars, container, storage duration and the interaction effects of V x D and C x D. Wafer of cultivars V_3 (4.55) and V_4 (4.55) scored the maximum value and were on par while V_1 (4.26) scored the least. Wafers stored in container C_1 (4.45) had the maximum value and was on par with C_2 (4.44) while C_3 (4.34) had the least value. Wafers stored at duration D_2 (4.72) had the maximum value and was on par with D_1, D_3 and D_4, while D_7 (3.59) had the least organoleptic quality. V_3D_2 (4.93) had the highest value and was on par with V_3D_1, V_4D_1, V_4D_2, V_3D_3, V_4D_3, V_3D_4, V_4D_4, V_3D_5 and V_4D_5. While V_1D_7 (3.50) and V_4D_7 (3.50) had least values and were on par. C_3D_7 (3.30) had the least organoleptic quality. While C_2D_2 (4.73) had the maximum value and was on par with all other except C_3D_5, C_1D_6, C_2D_6, C_3D_6, C_1D_7, C_2D_7 and C_3D_7.

DISCUSSION

5. DISCUSSION

The results of the investigation on "Value addition and evaluation of nutritional quality in taro (*Colocasia esculenta* (L.) Schott)" are discussed below and are presented under the following headings.

5.1 Nutritional quality of corms and leaves of taro

Among the four cultivars evaluated Pathanamthitta local recorded the highest starch content of about 18.50 per cent. This is in conformity with the findings reported by Lila Babu (2000) who stated that starch in the taro corm ranges between 18 to 28 per cent of fresh weight. The starch content in Pathanamthitta local was however lesser than the value reported by Seralathan and Thirumaran (1999) who stated that Colocasia exhibited the second highest starch content after xanthosoma. The starch content in Sree Rashmi was found to be similar to the value reported by CTCRI (1996) stating the starch content in Sree Rashmi to be 14.50 per cent. From the findings it can be concluded that the high starch content in the taro corm can make an important contribution to our daily diets.

Among the four cultivars evaluated, protein content was the highest in corms of Vellayani local and leaves of Sree Rashmi. While corms of Vellayani local expressed a protein content of 2.65 per cent, the leaves of Sree Rashmi had

3.75 per cent. There findings are in accordance with the reports of Lita Babu (2000) who states that taro leaves contain about 3.90 to 7.00 per cent protein and also with the reports of Seralathan and Thirumaran (1999) who observed that the taro corm of contain 3.20 per cent protein. Similar values were also obtained by Gopalan *et al.* (1977) who reported that corms contain three per cent protein while leaves contains 3.90 per cent protein and Tisbe and Cadiz (1967) who stated that the corms contain 2.50 per cent protein while leaves contain 4.40 per cent.

The evaluation of corms and leaves of the four cultivars revealed that corms of Thamarakannan and leaves of Pathanamthitta local produced the highest total sugar content. However Maga (1992) opined 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 Vellayani local and leaves of Thamarakannan recorded the highest vitamin C content. Corms showed a vitamin C content of 17.28 mg per 100 g, while leaves exhibited had a maximum content of 12.16 mg per 100 g. This finding is in agreement with the report of Gopalan *et al.* (1977) who reported that vitamin C content in leaves to be 12 mg per 100 g. Ghosh *et al.* (1988) reported that corms of taro are a poor source of vitamic C. There seems to be some variation in vitamin C contents reported by Tisbe and Cadiz (1967) who stated findings about leaves having a vitamin C content of 143 mg per 100 gm.

The crude fibre contents in corms of all the four cultivars were on par and in the range of 0.75 to 0.85 per cent. Leaves produced a higher crude fibre content than corms with Pathanamthitta local expressing crude fibre content of 2.80 per cent.

These findings are in agreement with the Gopalan *et al.* (1977) who found that crude fibre content in corms was one per cent and that in leaves was 2.90 per cent. However Lila Babu *et al.* (1990) observed much lower crude fibre content in corms (0.35 %) presumably due to varietal variation or due to variation in maturity of tubers.

Among the four cultivars evaluated, calcium oxalate content was found to be highest in corms of Pathanamthitta local and leaves of Thamarakannan. Sree Rashmi expressed the lowest calcium oxalate percent.

Lila Babu (2000) opined that the presence of calcium oxalate crystals has been attributed to be the major cause for acridity. The popular cultivars of C-9 and Sree Rashmi are relatively acrid free after processing, however a number of cultivars retain acridity to a considerable degree even after normal processing. She also showed that by cooking the tuber either by cutting into small pieces or by cooking with tamarind or citric acid helped in reducing calcium oxalate levels thus reducing acridity.

Corms and leaves of Sree Rashmi scored highest for organoleptic quality. This was probably due to the low calcium oxalate levels which resulted in lesser acridity. Pathanamthitta local which exhibited the least score for organoleptic quality, also recorded the highest calcium oxalate content.

The evaluation of nutritional quality revealed that the corms of taro are good source of starch. The corms and leaves contain some amounts of protein and vitamin C. They have good organoleptic quality can be utilized for culinary purpose if not for the acridity 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 the highest in Vellayani Local and least in Sree Rashmi. It was also found that oil uptake increased with increasing thickness as one mm chips showed the least oil uptake and three mm chips exhibited the greatest oil uptake. Parboiling helped to reduce the oil uptake significantly almost by half. Parboiling, drying and frying of chips was an effective method to reduce oil uptake and one mm thickness was good for reduced oil uptake. Compared to potato chips where oil uptake would be as high as 30 - 40 per cent, Colocasia chips have a relatively low oil uptake of about 24.00 per cent. This is in corroboration with the earlier findings of Maga (1992) who reported that taro chips contain about 25.50 per cent oil which is absorbed from the frying medium.

Mottur (1989) on the contrary demonstrated that the quality of potato chips was 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 of chips was found to be influenced only by the technique. Freshly fried chips expressed a higher moisture content than parboiled fried chips. This can be explained by the fact that parboiled chips are dried first and then fried so at the time of frying they might have a lower moisture content, whereas freshly fried chips are not dried before frying thereby having more initial moisture content.

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

The starch content of the chips were found to be more or less in the same proportion of that in fresh corms. It was seen that parboiling of taro chips did not produce any reduction in starch content.

Total sugar content of the chips of the various cultivars were more or less in the same proportion as that found in fresh corm. Freshly fried chips showed higher sugar content than parboiled fried chips. It seems that some sugars were leached out during parboiling. This statement is supported by Raja and

Ramakrishna (1990) who reported that the percentage of reducing sugars was lowered from 0.99 to 0.23 per cent during parboiling of cassava chips for five minutes.

Sree Rashmi recorded the highest score for organoleptic quality presumably due to its low acridity. It was seen that thinner chips scored more as one mm thick chips expressed the highest score. It seems that thinner chip could facilitate easy leaching or destruction of calcium oxalate than thicker chips. Parboiled chips scored more for organoleptic quality than freshly fried chips. This could be due to the reduction in acridity during parboiling. This is also supported by previous findings of Lila Babu (2000) who observed stated that leaching of calcium oxalate into water seem to render the tuber less acrid and the small pieces of tuber facilitates leaching action.

Taro chips contain high amounts of starch and have low oil uptake. Thus can occupy an important place as a snack item in our normal diets. Parboiled fried chips were more desirable than freshly fried chips since they had lower oil uptake and high organoleptic quality.

The chips used for making flour was dried at different temperature for different drying periods. The variation in the starch contents 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 each cultivars were more or less in the same proportion as seen in the fresh corm. It seems that the various heat treatments do not affect the starch and total sugar content of the flour. The evaluation of moisture content in the flour revealed that with increasing temperatures and drying periods, moisture content decreased. Though the 95^0C temperature and 24 hr drying period recorded the least moisture content in flour, it also brought about browning of the flour which could be due to charring. Drying at 55^0C moisture content was higher than that of flour dried at 75^0C. Thus flour dried at 75^0C for 18 hrs could be judged as the best because it exhibited fairly low moisture content and good colour indicating that no charring had occurred.

5.3 Value addition through secondary products

Secondary products *viz*, murukku, wafers, pappads were prepared from taro flour for evaluating the organoleptic quality. The organoleptic evaluation indicated that products made from flour of Sree Rashmi and Thamarakannan expressed higher organoleptic quality. This could possibly be due to the lower acridity in these two varieties. All the products received fairly good scores, indicating a good possibility for the usage of these two cultivars for taro flour in preparing snack items. Similar findings are reported by Ghosh *et al.* (1988) wherein they have stated that taro flour has been used to produce noodles, flakes, cookies, biscuits, infant foods and pudding.

Taro flour has already been used in Hawaii by mixing with 15 per cent winged bean flour or 15 per cent soya protein and extruding into rice noodle and macaroni (Moy *et al.* 1980).

5.4 Storage studies of primary products

The starch content of the chips over the period of storage was not affected by the type of container or duration. The starch content of chips of the various cultivars were more or less in the same proportion as that found in the fresh corm.

The total sugar content was found to increase during the storage period. This could be 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 the stored products. Moisture content was lowest in chips of Vellayani local. The chips stored in glass and PET bottles had lost moisture content. Moisture content slightly increased in chips stored in all containers however, 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. This could have occurred due to spoilage of the oil in the chips. For organoleptic quality chips stored in glass bottles scored highest and were on par with PET jars. The organoleptic quality remained high for initial 30 days and declined afterwards. Among the cultivars Sree Rashmi and Thamarakannan again scored highest for organoleptic quality due to their low acridity.

The starch and total sugar content of the parboiled chips of the various cultivars differed from each other more or less in the same proportion as that in the fresh corm. The starch content declined towards the end of the storage period in chips stored in LDPE bags, however the change was not significant. Moisture content was found to be the highest in parboiled chips of Vellayani local. The moisture content of the chips increased over the duration of storage. Among the containers though chips stored in LDPE bags showed higher moisture content this was not significant. It does appear that glass and PET bottle exposed the products less to the outer environment. This has been supported by Seth and Rathore (1993) who stated that regarding storage of snack foods stored in different containers, glass containers exhibited a lower increase in moisture content when compared to tin and polythene bags. Organoleptic quality of chips stored in glass bottles and PET jars was better than LDPE bags. This was because the scores of organoleptic quality for chips stored in glass and PET bottles were high upto 60 days whereas those in LDPE bags were high only upto 45 days. In regard to moisture absorption by chips Kumar and Anandaswamy (1984) reported that to retard the effect of pickup of moisture from tapioca chips during storage polyethylene lined gunny sacks or laminated bitumen and polyethylene lined gunny sacks or high density polyethylene or polypropylene wooden sacks could be used.

The starch and total sugar contents of flour of various cultivars differed from each other more or less in the same proportion as that in the fresh corms. The starch content was found to decline in flour stored in LDPE bags towards the end of storage however, 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, through the sugar content of flour among various containers was not 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 in polythene bag was higher than the other containers during the storage period. It seems that glass bottles and PET jars can provide longer shelf life for taro flour than LDPE bags, as they did not allow the moisture content in flour to increase much.

5.5 Storage studies on secondary products.

Murukku stored in LDPE bags showed a decrease in starch content, towards the end of storage period, indicating some deteriorative changes. The total sugar and moisture content of murukku increased over the period of storage in all containers though those stored in LDPE bags exhibited the greatest increase. The mean organoleptic quality too was the lowest in murukku stored in LDPE bags. This indicated that LDPE bags by allowing absorption of moisture caused some deteriorative changes. This is in corroboration with the findings of Beerah *et al.* (1990) who reported the highest moisture content in murukku stored in polythene bags from a study on the preparation, packing and storage of potato snacks. The murukku in glass bottles recorded high scores for organoleptic quality upto 45 days of storage while murukku in LDPE bags found good scores upto 30 days of storage then declined.

The observation for papads were taken only upto 30 days of storage as after this they were subject to mould attack when stored beyond this time. 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 through 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.

The starch content in wafers stored in glass and pet bottles declined towards the last 30 days of storage while starch content of those stored in LDPE bags started to decline after 45 days of storage. Total sugar content of wafers increased slightly once the duration of storage, however the effect of containers was not significant in this regard. The difference in moisture content among wafers stored in different containers was very slight but those stored in LDPE bags showed significantly higher moisture content. Regarding the organoleptic quality wafers stored in glass bottles and PET jars were significantly higher than of LDPE bags at the end of the storage period. The organoleptic quality of wafers in all the three containers was high upto 60 days of storage and then declined. Here also it seems that glass and PET bottles are better for storage of wafers.

SUMMARY

SUMMARY

The present investigation entitled "Value addition and evaluation of nutritional quality in taro (*Colocasia esculenta* (L.) Schott)" was carried out to evaluate the nutritional quality of four different cultivars of colocasia and also to explore the possibility of value addition in taro through development of various food products. The experiment was carried out in the department of Processing technology, College of Agriculture, Vellayani, Thiruvananthapuram during the period 1999-2001.Major findings of the study are summarized below.

Among the nutritional qualities attributed to the corms, Pathanamthitta local had the highest starch content and Vellayani local had the highest protein content. Total sugar content was greater in Thamarakannan while vitamin C content was the highest in Vellayani local. The crude fibre contents of all the four cultivars were on par. The calcium oxalate content was the higher in corms of Pathanamthitta local, while Sree Rashmi had the higher organoleptic quality.

In case of leaves, protein content and organoleptic quality were high in Sree Rashmi while total sugar was high in leaves of Pathanamthitta local. Vitamin C content was high in leaves of Thamarakannan while Vellayani local recorded the highest calcium oxalate content.

The chips prepared from colocasia 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, drying and frying. Oil uptake was high in chips of Vellayani local and least in Sree Rashmi. It was also seen that oil uptake increased with increasing thickness as one mm chips expressed least oil uptake and three mm chips showed highest. Parboiling helped to reduce the oil uptake significantly almost by half. Moisture content of chips was influenced only by the technique. Freshly fried chips exhibited a higher moisture content than parboiled fried chips probably because parboiled chips are dried before frying. The starch and total sugar content of the chips varied more or less in the same proportion as that in the fresh corm.

Chips of Sree Rashmi recorded the highest scores for organoleptic quality presumably due to its low acridity. It was also seen that thinner chips scored higher for organoleptic quality than thicker chips while parboiled chips scored higher than freshly fried chips.

Flour prepared from colocasia was analyzed for starch, total sugars, moisture and colour. The starch and total sugar contents among the various cultivars was 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. The flour dried at high temperatures and long periods also turned slightly brown. The flour dried at 75°C for 18 hours was judged the best by the panel of judges because it had low moisture content and good colour.

Secondary products *viz.*, murukku, wafers, pappads were prepared from colocasia flour. The organoleptic evaluation revealed that products made from flour of Sree Rashmi and Thamarakannan showed higher organoleptic quality.

Storage studies of the primary and secondary products evaluated the changes in starch, total sugars, moisture content and organoleptic quality. In case of chips while starch content did not change significantly, the total sugar and moisture content increased slightly on storage. The organoleptic quality declined on prolonged storage. Glass and PET bottles gave better storage results than LDPE bags.

The moisture and total sugar content in stored flour increased more rapidly in LDPE bags than in glass and PET jars while changes in starch content were not significant.

Murukku and wafers stored in LDPE bags showed a decrease in starch content. The total sugars and moisture content of murukku increased over the period of storage in all containers, though those in LDPE bags expressed the greatest increase. The murukku and wafers stored in glass and PET jars had higher organoleptic quality than those stored in LDPE bags. Pappads exhibited a shelf life of only 30 days after which they were subject to mould attack.

From the above study it can be concluded that the corms and leaves of colocasia can be used for culinary purposes as it is a good source of starch and some nutrients. Chips prepared from colocasia received fairly good scores for organoleptic quality indicating the possibility of developing them as snack items. Colocasia flour can also be used in preparation of some traditional snack items like murukku and wafers. These products along with good scores for organoleptic quality also found a satisfactory storage life.

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*Original not seen

APPENDIX - I
KERALA AGRICULTURAL UNIVERSITY
Department of Processing Technology, College of Agriculture, Vellayani

Score card for evaluation of cooked colocasia corm

			V_1	V_2	V_3	V_4
Appearance						
	Excellent	5				
	Good	4				
	Fair	3				
	Poor	2				
	Very poor	1				
Colour						
	Light cream	5				
	Cream	4				
	Creamy brown	3				
	Dull brown	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 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 colocasia 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 colocasia chips

				V_1	V_2	V_3	V_4
Appearance							
	Excellent	5					
	Good	4	FFC				
	Fair	3	PFC				
	Poor	2					
	Very poor	1					
Colour							
	Light cream	5					
	Cream	4	FFC				
	Creamy brown	3	PFC				
	Dull brown	2					
	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 colocasia flour 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				
	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 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 colocasia flour wafers

			V_1	V_2	V_3	V_4
Appearance						
	Excellent	5				
	Good	4				
	Fair	3				
	Poor	2				
	Very poor	1				
Colour						
	Light cream	5				
	Cream	4				
	Creamy brown	3				
	Dull brown	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 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 colocasia flour pappads

			V_1	V_2	V_3	V_4
Appearance						
	Excellent	5				
	Good	4				
	Fair	3				
	Poor	2				
	Very poor	1				
Colour						
	Light cream	5				
	Cream	4				
	Creamy brown	3				
	Dull brown	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 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 colocasia flour

Colour

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

VALUE ADDITION AND EVALUATION OF NUTRITIONAL QUALITY IN TARO (*Colocasia esculenta* (L.) Schott)

BY

SHAMSUDEEN LIYA

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

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2002

ABSTRACT

A study on "Value addition and evaluation of nutritional quality in taro (*Colocasia esculenta* (L.) Schott)" was carried out in the Department of Processing technology, College of Agriculture, Vellayani, Thiruvananthapuram during the period 1999- 2001. The objectives of the study were to evaluate four cultivars of colocasia for nutritional quality, to examine the potentiality of developing value added products using colocasia and to assess the storage and shelf life of the colocasia products.

The nutritional quality of four cultivars *ie.*, Pathanamthitta local, Vellayani local, Thamarakannan and Sree Rashmi were evaluated. Corms of Pathanamthitta local had the highest starch and calcium oxalate content. Vellayani local exhibited the highest protein and vitamin C content while Thamarakannan had the highest total sugar content. The crude fibre contents of all the four cultivars were on par. Sree Rashmi recorded the maximum organoleptic quality. In case of leaves protein content and organoleptic quality were high in Sree Rashmi while total sugars was maximum in Pathanamthitta local. Vitamin C content was high in leaves of Thamarakannan while Vellayani local recorded the highest calcium oxalate content.

Value addition was done through preparation of chips and traditional snack items *viz.*, Murukku, Wafers and Papads.

Chips were prepared by two techniques *ie.* by freshly frying and by parboiling and frying. Oil uptake was the highest in chips of Vellayani local and it was seen that oil uptake increased with increasing thickness. Parboiling helped to reduce the oil uptake significantly almost by half. Freshly fried chips had a higher moisture content than parboiled fried chips. Chips of Sree Rashmi recorded the greatest score for organoleptic quality presumably due to its low acridity. Thinner chips score higher for organoleptic quality than thicker chips while parboiled chips scored higher than freshly fried chips.

Evaluation of flour prepared from colocasia revealed that with increasing temperatures and drying periods moisture content decreased. The flour dried at 75^0C for 18 hours was judged the best because it had low moisture content and good colour.

The evaluation of secondary products prepared *viz.*, Murukku, Wafers and Papads revealed that products made from flour of Sree Rashmi and Thamarakannan had higher organoleptic quality.

Storage studies of the primary and secondary products evaluated the changes in starch, total sugars, moisture content and organoleptic quality. In case of chips while starch content did not change significantly, the total sugar and moisture content increased slightly on storage. The organoleptic quality declined on prolonged storage. Glass and PET bottles gave better storage results than LDPE bags. The moisture and total sugar content in stored flour increased more rapidly in LDPE bags than in glass and PET jars while changes in starch content were not significant. Murukku and Wafers stored in LDPE bags showed a decrease in starch content. The total sugars and moisture content of murukku increased over the period of storage in all containers, though those in LDPE bags showed the maximum increase. The murukku and wafers stored in glass and PET jars had higher organoleptic quality than those stored in LDPE bags. Pappads had a shelf life of only 30 days after which they were subject to mould attack.