EVALUATION OF FRUIT QUALITY IN BANANA 'NENDRAN' (*MUSA* AAB)

By

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THESIS

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DECLARATION

I hereby declare that the thesis entitled **"Evaluation of fruit quality in banana 'Nendran' (*Musa* AAB)"** 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 to me of any degree, diploma, fellowship or other similar title, of any other University or Society.

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CERTIFICATE

Certified that the thesis, entitled " **Evaluation of fruit quality in banana 'Nendran' (*Musa* AAB)**" is a record of research work done independently by **Miss.Lakshmy, P.S.,** under my guidance and supervision and that it has not previously formed the basis for the award of any degree, diploma, fellowship or associateship to her.

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ABBREVIATIONS

A.O.A.C.	-	Association of Official Analytical Chemists
cfu	-	Colony forming units
cm	-	Centimeters
DMRT	-	Duncan's Multiple Range Test
EDTA	-	Ethelene diamine tetra acetic acid
g	-	Gram
kg	-	Kilogram
mg	-	Milligram
ml	-	Milliliters
ppm	-	Parts per million
RBC	-	Red blood corpuscles
%	-	Per cent

Introduction

1. INTRODUCTION

Banana is one of the earliest crops cultivated by man. It is delicious and seedless and is available in all seasons at a price that is within everybody's reach. Original home of banana is believed to be India and Malaya. The fruit as well as its plant is considered to be very auspicious in all the religious and social ceremonies in India. In the mythological ages, in Europe, it was called the "apple of paradise". The Greek and Arabian writers referred to it as a wonderful fruit of India. It is one of the most important global food commodities, and India is largest banana and plantain producing country in the world.

In India, banana ranks third in area covering about 13 per cent of total area. It ranks first in fruit production contributing nearly one third of the total fruit production (India Budget, 2002), India produces 16,450,000 metric tonnes of banana per year (FAOSTAT, 2002).

Banana is the most important fruit in Kerala, both in terms of acreage and production and it occupies an area of 80.64 thousand hectares with an annual production over 793.33 thousand tonnes (Farm Guide, 2001). Banana occupies a unique place among the people of all walks of life in the state. It's ability to yield high returns from a unit area within a short time has resulted in its cultivation being taken up by small as well as big farmers. Large number of varieties grown under diverse systems of cultivation is a unique feature of Kerala.

The banana is of great nutritional value. It has a rare combination of energy and tissue building elements like protein, vitamins and minerals. It can make a useful contribution to the vitamin A, C and B_6 content of the diet, and is an important and immediate source of energy (Robinson, 2000). It is a very good source of potassium and it also contains other minerals such as calcium, magnesium and phosphorus.

Banana fruit may be eaten raw or as a cooked vegetable. The fruit can also be processed for a number of food products. Ripe fruits can be pulped for puree for use in variety of products including ice cream, yoghurt, cake, bread, nectar and baby

food. Banana flour, prepared from raw fruit is a highly nutritive baby food. Ripe bananas can be dried and eaten, or sliced, canned with syrup, and used in bakery products, fruit salads and toppings. Green bananas can be sliced and fried as chips. Vinegar and alcoholic beverages can be made from fermented ripe bananas.

The state of Kerala is blessed with a wide array of banana varieties with specific regional preferences and commercial importance. Among the different culinary varieties of banana used by Keralites, nendran is one of the most popular varieties and is cultivated on a commercial scale in Kerala. It is a dual purpose variety used as a table fruit and for production of chips.

Large numbers of nendran varieties are cultivated in Kerala. These varieties are usually evaluated in the field of agriculture mainly for yield characteristics. In order to meet the growing demand for banana in both domestic and export markets, diverse varieties with high yield and good quality attributes have to be cultivated on a commercial basis depending upon local needs, preferences and agroclimatic conditions. For this, identification of varieties with good nutritional and organoleptic qualities along with yield which are suitable for product development is essential.

Hence, the study entitled "Evaluation of fruit quality in banana 'Nendran' (*Musa* AAB)" was undertaken with following objectives.

(1) To evaluate the fruit quality of nendran types with respect to its nutrient composition and physical characters and organoleptic qualities.

(2) To study the suitability of nendran types for product development.

Review of Literature

2. REVIEW OF LITERATURE

The literature connected to the study entitled "Evaluation of fruit quality in banana 'Nendran' (*Musa* AAB)" is presented under the following heads.

2.1 NUTRITIONAL IMPORTANCE OF VEGETABLES

Vegetables are an important food group that is mainly classified as protective foods. Though, Indian population is mostly vegetarian, the intake of vegetables has been too low in the diet. Vegetables supply protective nutrients like vitamins and minerals, besides providing variety to the diet (Srilakshmi, 1999).

Vegetables contain enzymes, vitamins, minerals, antioxidants and most importantly phytonutrients that prevent cancer, heart disease, strokes, osteoporosis and most other degenerative diseases (Noonan and Savage, 1999). According to Decoteau (2000) vitamin C, β carotene and vitamin E present in vegetables offer protection against cancer, immune response, wound healing, vision and allergic reactions. Rock and Wahenfried (2002a) indicated that a diet high in vegetables increased the plasma carotenoid level and can reduce the progression of breast cancer. Mursu *et al.* (2003) also reported that diet rich in fruits and vegetables have potential health benefits against chronic diseases such as cardiovascular diseases and cancer and high intake of fruits and vegetables is associated with reduced risk of mortality in middle aged men.

Raghavan and Mohan (1999) reported that vegetables, which are rich in fibre, can reduce blood sugar and serum cholesterol and relieve constipation. According to Haney (2003) vegetarian diet can cut cholesterol levels up to one third.

Herber (2000) observed that intake of 400-600 g of fruits and vegetables daily is associated with reduced incidence of many common forms of cancer by the action of phytochemicals found in them. According to Dutt (2000) men who eat three or more servings of vegetables per day have 48 per cent lower risk of prostrate cancer, compared to those who take lesser than one serving a day.

According to Racchi (2001) vegetables have antioxidant action *in vitro* against lipid peroxidation in the micellar model system. Naturally occurring flavanoids in vegetables have shown to 'spare' vitamin E and protect cell membranes from deterioration (Rock and Wahenfried, 2002b).

Two important minerals namely calcium and iron found in vegetables are essential for strong bones and teeth and also for blood formation (Colbert, 1998).

According to Corliss (2000) vegetables are valuable in maintaining alkaline reserves in the body. They also supply trace elements which are necessary to the body.

Koebnick *et al.* (2001) observed that the long term high vegetable intake favourably affects plasma folate as well as R.B.C. folate concentrations throughout pregnancy and reduces the risk of folate deficiency.

2.2 VERSATILE USES OF BANANA IN HUMAN DIET

Cultivation of banana in India is polyclonal with an array of varieties under cultivation. Among 300 recorded varieties of banana, 8-10 are grown commercially (Chadha, 1990). According to Thajudeen *et al.* (1996) banana is one of the earliest crops cultivated by man and it is the most important global commodity in terms of gross value of the produce after rice, wheat and milk products.

Banana is a vegetable as well as a fruit apart from being used for the preparation of various products. It provides more balanced diet than any other fruit or vegetable (Bhaskar, 2000).

Bananas have a special value in the human diet, as they are rich in energy and contain nearly all nutrients including minerals and vitamins (Bose and Mitra, 1990). According to the authors, 24 bananas weighing 100 g can provide the energy requirement of a sedentary man. Aravindakshan *et al.* (1992) opined that though banana is considered as 'Poor man's apple', it is liked and consumed both by poor and rich. According to Singh and Uma (1997) banana is filling, easy to digest, nearly fat free and rich in carbohydrates. The authors also reported that banana is rich in vitamins than any other fruit. Plantain, yam and other minor species of vegetables are main source of energy in human diet (Treche, 1997).

Though, banana is cultivated for its fruits, in South India, the leaves, flower, pseudo stem and rhizomes are also used for different purposes (Singh and Uma, 1994). The authors also reported that it is used as a medicine to cure many ailments and banana powder is the first baby food.

Horigome *et al.* (1992) reported that the soluble and insoluble components of dietary fibre present in banana are hypocholesterolaemic.

Animal studies conducted by Goel *et al.* (1986) indicated that oral administration of plantain powder is effective in reducing duodenal ulcer. According to Rao (1999) the therapeutic effect of banana against colic diseases, constipation and peptic ulcer is due to the presence of active principles like serotonin and norepinephrin present in them.

Singh and Uma (1997) reported that banana is effective in dissolving kidney stones.

Bananas inhibit the angiotensin converting enzyme which constricts blood vessel causing high blood pressure (Rao, 1999). Diller (2000) indicated that two bananas daily keep the blood pressure at bay. Rangarajan (2000) observed a 10 per cent fall in blood pressure in patients suffering from hypertension when they consumed two bananas daily for a week. According to Josh (2001) due to the presence of potassium in banana, it can be used for treating hypokalemia.

In a clinical trial conducted by Arias *et al.* (1997) plantain flour based solution was proved to be effective for the treatment of dehydration due to acute diarrhoeal diseases and can be considered as an alternative for Oral Rehydration Salt (ORS). Emery *et al.* (1997) reported that banana flakes are safe and cost effective to treat diarrhoea in critically tube fed patients.

According to Gopalan and Ram (1990) and Rai (2000) ripe plantains have mild laxative property and hence are very useful in the diet of children, particularly as a remedy for constipation.

Banana flower is widely used in the treatment of diabetes mellitus (Pari and Umamaheswary, 2000). The authors indicated that oral administration of the chloroform extract of the flower decreased the blood glucose glycosylated haemoglobin and free radical formation in the tissues. According to Rai (2000) banana has red blood cell generating potency as it stimulates the production of haemoglobin. The author also reported that banana is emollunt, demulcent and it increases alkalinity of the blood and thus corrects acidosis.

Langkilde *et al.* (2002) indicated that the addition of raw banana flour containing resistant starch to the diet of ileostomy subjects did not interfere with small bowel absorption of nutrients on total sterols except for small increase in iron absorption.

2.3 QUALITY ATTRIBUTES OF BANANA

Nendran banana occupies a place of pride in Kerala as a dual purpose variety cultivated under irrigated conditions (Anil and Nair, 1994). According to Radhadevi and Nayar (1996) Nendran has the lowest frequency of seed set while crossing and is without much clonal variation.

2.3.1 Physical characters of banana

The banana varieties differ in respect of duration, plant height, plant colour, shape and size of leaves, bunch weight, number of hands and fruits, fruit quality and incidence of pests and diseases (Thajudeen *et al.*, 1996).

Eight culinary varieties of banana were evaluated by Rajeevan *et al.* (1988) and reported significant difference in the finger characteristics among the varieties. Thajudeen (2000) evaluated eleven varieties of banana available at Banana Research Station, Kannara, Kerala Agricultural University, for different physical qualities like weight of bunch, weight of hands, number of hands, number of fingers in each hand and pulp/peel ratio in the raw stage and indicated significant variation between the varieties.

Higher doses of fertilizers significantly influenced the weight of hand and weight of fingers of bananas while the length of the bunch, number of hands per bunch and length and girth of fingers remained unaffected (Natesh and Aravindakshan, 1993).

Significant improvement in finger length, bunch weight and curvature was observed by Sindhu (1999) due to the effect of post bunching sprays.

Differences in growth and yield of nendran ecotypes collected from different parts of Kerala were also reported (KAU, 1990, 1991).

Nendran clones from Kottayam district recorded the highest mean bunch weight of 12.5 kg (KAU, 1982). Rajeevan and Mohanakumaran (1993) found significant variation in the bunch weight of 24 accessions of Palayankodan. Uma *et al.* (1999) reported bunch weight of 19.33, 13.87 and 11.08 kg in Jahaji, Malbhog and Neypoovan cultivars. The bunch weight of thirteen banana cultivars varied from 6.80 kg to 22.19 kg with the highest in the cultivar China and and lowest in Monthan (Kishan *et al.*, 2000). The authors also reported a highest bunch weight of 12.30 kg in Chandrabale among the table varieties. Thajudeen (2000) evaluated eleven banana varieties and reported a bunch weight of 5.67 kg to 12.83 kg. Josh (2001) reported an average bunch weight of 11 kg in banana, but in some varieties, bunch weight exceeded 18 kg.

In a study on the effect of season of planting on growth and yield of Nendran, Robusta, Rasthali and Poovan, maximum bunch weight was recorded when planted during the month of February-April (Narayanan and Mustaffa, 2001). The authors also reported highest bunch weight in conventional planting over raised raw planting under 100 per cent E° and 125 per cent N° fertigation.

Shanmughavelu *et al.* (1992) observed significant variation in the finger weight, number of hands and fingers per bunch between the clones of nendran.

An evaluation of different culinary cultivars of banana showed that number of hands per bunch varied from 4.66-8.33 (Ram *et al.*, 1994). Thajudeen (2000) observed variation of 4.33 to 11.67 in the number of hands of eleven banana varieties of Kerala.

A variation of 33.3 g to 203 g in fruit weight was reported by Singh and Uma (1995) in the 74 accessions of banana. The authors also reported that the finger length of these accessions varied from 10.8 cm to 24.7 cm. Uma *et al.* (1999) indicated a fruit weight of 113.79 g, 97.00 g and 34.05 g in the banana cultivars Jahaji, Malbhog and Neypoovan respectively. A study conducted by Thajudeen (2000) indicated a variation of 35.00 g to 153.30 g in the fruit weight of eleven banana varieties. Among the table varieties of banana Chandrabale recorded the highest finger weight (120 g) and finger length (18.0 cm) (Kishan *et al.*, 2000).

Kumar (2001) evaluated ten accessions of banana cv. Nendran and indicated that bunch length, number of hands and number of fingers had highly significant connection with yield.

According to Josh (2001) banana fruits vary in length from about 10 cm to 30 cm.

In the eleven varieties of banana evaluated by Thajudeen (2000) the author observed a variation of 8.33 to 19.33 in the number of fingers of banana varieties.

Almazan (1991) observed higher finger pulp in plantains than in cooking bananas.

Singh and Uma (1995) reported a variation of pulp to peel ratio from 1.15-5.70 among the 74 accessions of banana.

Uma *et al.* (1999) reported a pulp/peel ratio of 4.81, 4.53 and 4.40 in Jahaji, Malbhog and Neypoovan respectively. Among the eleven banana varieties analysed by Thajudeen (2000), the pulp/peel ratio varied in between 0.60-2.23.

2.3.2 Chemical composition

Bananas and plantains are high yielding sources of dietary carbohydrates, rich in vitamins, particularly vitamin B, vitamin C and several minerals such as calcium, potassium, phosphorus and magnesium (Singh and Uma, 1994). Ripe plantain contains lower moisture percentage and sugar and is rich in β carotene when compared to ripe banana (Rao, 1999). Bose *et al.* (1999) opined that banana is the cheapest, plentiful and most nourishing of all fruits. It contains nearly all essential nutrients, including minerals and vitamins.

Lipids, protein and fibre are the constituents in ripe and unripe plantain (Ketiku, 1973).

Marriott (1981) reported that the plantain and banana pulp contain about 60 and 70 per cent of moisture respectively. Chadha (1992) indicated that banana contain mainly water which is about 70 per cent. Chia and Huggins (1998) reported that Asian tropics banana contains about 74 per cent water. According to the authors, the moisture content of Cavendish banana is 75 per cent while that of plantains is only 60 per cent. Thajudeen (2000) observed a variation of 61.93 to 71.97 per cent in the moisture content of eleven banana varieties. Josh (2001) observed an average of 75 per cent moisture in the edible part of banana.

Izonfuo and Omuarc (1998) reported that the moisture content is higher in banana peel than in the unripe plantain pulps.

According to Mota *et al.* (2000) moisture content of the banana flour obtained from eight different banana cultivars varied from 4 to 6 per cent.

According to Chadha (1992) banana contains 27 per cent carbohydrates and provides energy.

Starch content of the unripe banana pulp was found to be 83.2 per cent on dry weight basis (Ketiku, 1973). Studies on the developing and ripening bananas showed that there occurs a linear increase in starch content from immature to mature stage (Singh *et al.*, 1980). According to Chadha (1992) unripe fruit contains more starch and less sugar than ripe banana. Patel and Shurpalekar (1994) reported that plantain containing high amount of resistant starch. The average yield of starch isolated from unripe plantain was found to be 10 to 12 per cent (Sira, 1997). Castillo *et al.* (1997) found 31 g of starch in 100 g of fresh plantain. Thajudeen (2000) reported a starch content of 12.09 g 100 g^{-1} in nendran variety of banana. The author also observed significant variation in the starch content of eleven banana varieties and the content varied from 8.05 to 12.09 g 100 g^{-1}. Josh (2001) reported 25 per cent starch in unripe banana.

In banana flour Suntharalingam and Ravindran (1993) found 70 per cent of starch while Mota *et al.* (2000) reported a starch content of 61 to 76.5 per cent.

Keitku (1973) reported that ripe and unripe pulp of banana contains 1.3 g and 1.6 g of cellulose and 0.8 g and 1.9 g of hemicellulose respectively per 100 g on dry weight basis. Varietal differences in the soluble and insoluble fibre content of plantains were reported by Tanya *et al.* (1997). Gopalan *et al.* (1999) reported a fibre content of 0.7 g 100 g^{-1} in nendran variety of banana while Thajudeen (2000) observed

of 0.18 g 100 g^{-1} of fibre in nendran variety of banana. Josh (2001) indicated that banana contains about 1 per cent of fiber.

Suntharalingam and Ravindran (1993) reported that green banana flour contains 8.9 per cent neutral detergent fiber, 3.8 per cent acid detergent fiber, 3.8 per cent cellulose, 3.1 per cent lignin and 1 per cent hemicellulose on dry weight basis. According to Ranzani *et al.* (1996) the flour prepared from banana peel contain about 32 per cent dietary fiber, while the total fiber content of banana flour varied from 6 to 15.5 per cent.

Fat content of banana is very low (Chadha, 1992). Chia and Huggins (1998) indicated that bananas contain about 0.5 per cent fat while Gopalan *et al.* (1999) indicated a fat content of 0.2 g per 100 gm in green plantain.

Suntharalingam and Ravindran (1993) reported a fat content of 1.3 per cent in banana flour. Mota *et al.* (2000) observed 0.3 to 0.8 per cent of lipid in banana flour.

Gopalan *et al.* (1999) reported a protein content of 1.4 g 100 g^{-1} in green plantain. Thajudeen (2000) evaluated eleven varieties of banana and reported that protein content varied between 0.5 g to 1.74 g 100 g^{-1}. The author observed a protein content of 1.43 g 100 g^{-1} in nendran variety of banana.

The protein content of green banana flour was found to be 3.2 per cent (Suntharalingam and Ravindran, 1993). Mota *et al.* (2000) studied the chemical composition of flour obtained from 8 different banana cultivars and reported a variation of 2.2 to 3.3 per cent in the protein content.

Bananas are good sources of several minerals such as calcium, potassium, phosphorus and magnesium (Singh and Uma, 1994).

The mineral content of cultivars Pineo Gianl, Pineo Enano, Pineo Martenico Cryaco, Manzana and Topocho Cenizo were tabulated by Villalonga (1981) and reported that the varieties contained 156 to 377.77 mg 100 g^{-1} of potassium, 2.67 to 5.07 mg 100 g^{-1} of sodium, 3.36 to 11.04 mg 100 g^{-1} of calcium, 20.63 to 85.10 mg 100 g^{-1} of magnesium and 18.00 to 28.31 mg 100 g^{-1} of phosphorus.

Whole banana is a good source of potassium contributing to 396 mg 100 g^{-1} (Park, 1974 and Chia and Huggins, 1998). Isonfuo and Omuarc (1998) indicated that potassium is the most abundant mineral present in green peel (37 g kg^{-1}) and green pulp (8.4 g kg^{-1}). Higher amount of potassium was found in green plantain than in ripe banana (Rao, 1999). Thajudeen (2000) reported a potassium content of 391.9 mg 100 g^{-1} to 563.8 mg 100 g^{-1} in eleven banana varieties and the nendran variety had a potassium content of 514.2 mg 100 g^{-1}.

About 290 ppm of phosphorus and 80 ppm of calcium were found in banana (Chadha, 1992). According to Gopalan *et al.* (1999) green plantain had 10 mg of calcium and 29 mg of phosphorus per 100 g. Thajudeen (2000) evaluated eleven banana varieties and reported a variation of 8.30 mg to 34.44 mg 100 g^{-1} in the calcium and 20.85 mg to 39.70 mg 100 g^{-1} in the phosphorus contents.

Josh (2001) observed calcium content of 5 mg per 100 g in banana.

Izonfuo and Omuarc (1998) estimated the mineral composition of peel and pulp of green bananas and reported that they contain 1.3 mg and 10 mg of copper and 41 and 350 mg of magnesium and 350 mg of sodium per kilogram.

Iron content of banana varied from 7.59 mg to 15.20 mg kg^{-1} (Elpo *et al.*, 1998). However Gopalan *et al.* (1999) reported an iron content of 6.27 mg per 100 g in green plantain. The iron content of eleven banana varieties varied from 1.02 mg to 5.43 mg 100 g^{-1} (Thajudeen, 2000).

Suntharalingam and Ravindran (1993) observed an ash content of 3.7 per cent in green banana flour. Mota *et al.* (2000) observed that the ash content in banana flour ranged between 2.6 to 3.5 per cent.

According to Chadha (1992) banana contains vitamins A, B and C. Singh and Uma (1994) reported that plantains are rich in vitamins, particularly vitamin C.

Prasad (1998) stated that banana is a rich source of vitamin C. Emerald and Sreenarayanan (1999) reported an ascorbic acid content of 8.2mg in 100g of banana with an increase in vitamin C content during storage. According to the author the vitamin C content increased with storage time. Bhaskar (2000) reported a vitamin C content of 16.01 mg 100 g^{-1} in raw nendran variety. Thajudeen (2000) evaluated eleven varieties of banana and reported that vitamin C content varied from 13.60 mg 100 g^{-1} to 27.20 mg 100 g^{-1} in raw fruit.

Suntharalingam and Ravindran (1993) observed that fresh green banana is a good source of vitamin C, but almost 65 per cent is lost during the preparation of flour.

Subagio *et al.* (1996) indicated that the carotenoid content of the banana peel varied in between 3-4 micrograms per gram of leutein equivalent.

2.4 PRODUCT DEVELOPMENT FROM BANANA

As a cooked vegetable, the banana is eaten virtually throughout the tropics (Simmonds, 1970). Most of the world's bananas are either eaten raw, in the ripe stage or as cooked vegetable (Thomson, 1998).

Banana chips is one of the processed products of banana, which can be easily produced (Hameed, 1981). According to Uma *et al.* (1999) banana chips made from Nendran is best. Thirteen cultivar of banana were evaluated for the preparation of chips by Kishan *et al.* (2000) and indicated that Dakhnisagar is the best cultivar to prepare chips and the other suitable varieties are Bersain and Gauria.

In a study conducted on the physiochemical and sensory characteristics of deep fat fried banana chips, fresh bananas with higher firmness and carbohydrate

content gave banana chips with higher crispness and oil absorption (Ammawath *et al.*, 2001).

Narayanan and Mustaffa (2001) indicated a shelf life of 30 days for the chips and antioxidants like citric acid and propylene glycol were found to be effective in checking the rise of acid value and peroxide value in nendran banana chips.

Common banana varieties viz., nendran, kunnan and monthan were evaluated for the preparation of banana flour and the variety kunnan scored highest scores in organoleptic test for taste while nendran accorded highest for texture and appearance (KAU, 1983). According to Rao (1999) banana flour can be prepared from both ripe and unripe fruits.

Prasad (1988) conducted a study to develop a nutritious, low cost and acceptable weaning food with banana flour. Weaning food containing banana flour, horse gram, sesame and skim milk powder in the ratio 3:2:3:2 gave the most satisfactory product with respect to acceptability.

Thajudeen *et al.* (1996) suggested that banana flour prepared from raw fruit is a highly nutritive baby food. Kunnan and Nendran varieties of banana are suitable to prepare weaning food (Singh and Uma, 1997). Giraldo (2000) developed a weaning food with banana flour enriched with degreased soyabean flour, vitamins and minerals.

Singh (1983) used banana, mango and jack fruit powder for the preparation of 'payasam' and the storage study of the powder showed that minimum change from zero storage conditions can be obtained if the materials are stored in polyethylene or polypropylene bags.

Low fat snacks can be prepared from banana flour (Arroyave, 2000). The final products have similar organoleptic characteristics of fresh bananas.

According to Muyonga (2001) banana flour produced by predehydration and steaming gives pastes of low paste bulk density, which is desirable for weaning and supplementary foods.

Highly nutritious weaning food was prepared using banana pumpkin slurry, cowpea flour, rice and skim milk powder (Jirapa *et al.*, 2001).

Banana biscuits prepared from banana powder was found to have good consumer acceptance (Narayanan and Mustaffa, 2001).

Banana figs are another product prepared by cutting the peeled fruits longitudinally and drying after exposing to burning sulphur (Bose *et al.*, 1999). Banana figs or fingers according to Banks (2000) are usually whole peeled fruit carefully dried so as to retain their shape although sometimes the fruit is sliced or halved to facilitate drying.

Banana varieties Robusta, Harichal, Red banana, Kunnan, Nakitechi, Pachakadale and Thenkunnan varieties were found to be suitable to prepare banana figs (Jacob, 1967).

Banana puree is obtained by pulping peeled ripe bananas and then preserving the pulp by acidification, aseptic method or by quick freezing (Dauthy, 1995). According to Bose *et al.* (1999) banana puree is one of the most important processed products prepared from the pulp of the ripe fruit. The puree is canned and used as an ingredient in dairy dessert, baking items and beverages.

Ralda and Wei (1980) developed an infant weaning food namely soyabean banana food bars which is pressed from soyabean banana flakes.

According to Dauthy (1995) best quality canned slices are obtained from fruit at an early stage of ripeness. Thomson (1998) reported that canned banana slices are used in tropical fruit salads.

In East Africa, ripe banana is used to make a beer with low alcohol content (Acland, 1971).

Adams (1978) described a procedure for making vinegar from ripe banana.

According to Singh and Uma (1997) Cavendish bananas are found to be best for the wine while 'Pisang Awak' is best for beer production.

Over ripe banana and acid whey are combined to form a nutritious beverage called whey banana shake and whey banana (Shekilango *et al.*, 1997).

According to Dauthy (1995) banana jam is made by boiling equal quantities of fruit and sugar together with water and lemon juice or citric acid. According to Bose *et al.* (1999) ripe banana is used as an important component of mixed fruit jam.

2.5 MICROBIAL QUALITY OF FLOURS

In recent years, the increasing consumer awareness has emphasized the need for microbiologically safe food. Serious health hazards due to presence of pathogenic microbes in food can lead to food poisoning outbreak (Frazier and Westhoff, 1997).

Dwivedi *et al.* (1982) reported that natural occurrence of several microflora in various flours may arise due to contamination during harvesting, drying, grinding and storage. According to Brown (1996) the microbial load of powdered food stuffs depends mainly on processing technique used and their keeping quality depend on the type of packaging and temperature of storage.

According to Jay (1998) the microflora of flour is relatively low, since some of the bleaching agents used reduce the microbial load.

Frazier and Westhoff (1997) reported that slight moistening of flour brings about spoilage by moulds.

Storage studies on potato flour by Vaidehi and Sunanda (1982) revealed that potato flour could be safely stored in polyethylene pouches for six months without any fungal or insect infestation. Sagar and Roy (1997) also reported that potato flours can be stored safely in polyethylene bags for six months at room temperature and for nine months at low temperature. Misra and Kulshrestha (2002) reported a microbial count of 1.85×10^3 to 1.91×10^3 and 1.81×10^3 to 1.86×10^3 cfu/g in potato flour stored for six months under room and refrigerated temperature respectively. The authors also reported an increasing trend in total bacterial count with increase in storage time.

Materials and Methods

3. MATERIALS AND METHODS

The materials and methods used to evaluate the quality attributes of nendran types are given under the following heads.

3.1 Selection of nendran types

3.2 Collection of samples

3.3 Quality evaluation of nendran types

3.4 Preparation of products and evaluation of chemical constituents

3.5 Organoleptic evaluation of nendran types and products

3.6 Microbial evaluation of banana flour

3.7 Statistical analysis

3.1 SELECTION OF NENDRAN TYPES

Seven nendran types available at Banana Research Station, Kannara, Kerala Agricultural University, Thrissur were selected for the study. The nendran types selected are:

1. Attunendran
2. Changanassery nendran
3. Chengalikodan
4. Kaliethan
5. Manjeri nendran I
6. Myndoli
7. Nedunendran

Plates 1-7 shows the different nendran types selected for the study.

3.2 COLLECTION OF SAMPLES

From each of the seven nendran types selected, fully mature bunches were collected from three plants.

Plate 1. Attunendran

Plate 2. Changanassery nendran

Plate 3. Chengalikodan

Plate 4. Kaliethan

Plate 5. Manjeri nendran 1

Plate 6. Myndoli

Plate 7. Nedunendran

3.3 QUALITY EVALUATION OF NENDRAN TYPES

3.3.1 Evaluation of physical characters

After the harvest, physical characters like finger weight, finger length, weight of pulp and peel, pulp/peel ratio, curvature and angularity of the raw fruit were recorded in triplicate samples.

3.3.1.1 Weight of fingers

The weight of fingers was taken in an analytical balance and expressed in grams.

3.3.1.2 Length of fingers

Length of fingers was measured using a twine and then the length was measured by a measuring scale and expressed in centimeters.

3.3.1.3 Weight of pulp and peel

The weight of pulp and peel was taken on an analytical balance and expressed in grams.

3.3.1.4 Pulp/peel ratio

After peeling the fruit, the weight of pulp and peel were separately taken on an analytical balance and the weight was recorded in grams. The pulp/peel ratio was calculated by dividing the weight of pulp by weight of the peel.

3.3.1.5 Curvature

Curvature was assessed according to the fruit shape as slightly curved, straight in the distal part, curved and curved in 'S' shape.

3.3.1.6 Angularity

The raw fruit was cut horizontally and angularity was assessed according to the ridges seen as having pronounced ridges, slight ridges and rounded.

3.3.2 Analysis of nutrients and other constituents

Raw nendran types were analysed for the following constituents.

3.3.2.1 Moisture

Moisture content was estimated using the method of A.O.A.C. (1980).

3.3.2.2 Protein

To estimate the protein content, nitrogen content was estimated by Micro-kjedhal digestion and distillation method as described by Jackson (1958), which was then multiplied with a factor of 6.25 to get the protein content.

3.3.2.3 Crude fibre

Crude fibre content was estimated by acid-alkali digestion method as suggested by Chopra and Kanwar (1978).

3.3.2.4 Starch

The starch content was estimated colorimetrically using anthrone reagent, as suggested by Sadasivam and Manikam (1992).

3.3.2.5 Calcium

The calcium content was estimated using titration method with EDTA as suggested by Page (1982).

3.3.2.6 Phosphorus

The phosphorus content was estimated colorimetrically after preparing a diacid extract by Vandomolybdophosphoric yellow colour method in nitric acid medium (Jackson, 1973).

3.3.2.7 Iron

Iron content was estimated by the Atomic Absorption Sectrophotometric method using the diacid extract prepared from the sample (Perkin-Elmer, 1982).

3.3.2.8 Potassium

Potassium content was estimated using flame photometer as suggested by Page (1982).

3.3.2.9 Vitamin C

The vitamin C content of the raw fruit was estimated by the method of A.O.A.C. (1980) using 2, 6 dichlorophenol indophenol dye.

All the analysis were carried out in triplicate samples.

3.4 PREPARATION OF PRODUCTS AND EVALUATION OF CHEMICAL CONSTITUENTS

3.4.1 Preparation of products

3.4.1.1 Banana flour

Banana flour with the selected nendran types was prepared after peeling the fruits and cutting into thin slices. The slices were dried in the sun and powdered. The prepared banana flour was packed in pet jars (100 g) and stored for three months at ambient storage conditions.

3.4.1.2 Chips

Chips from the nendran types were prepared after peeling and cutting the fruit into thin uniform slices. The slices were fried in coconut oil and packed (100 g) in polyethylene packets of 250 gauge thickness for a period of three months at ambient storage conditions.

3.4.2 Evaluation of chemical constituents

Banana flour was evaluated for moisture, protein, crude fibre, starch, calcium, phosphorus, iron and potassium at monthly intervals for a period of three months by the methods given in 3.3.2.1, 3.3.2.2, 3.3.2.3, 3.3.2.4, 3.3.2.5, 3.3.2.6, 3.3.2.7 and 3.3.2.8 respectively.

The moisture content of the chips was also estimated using the method given in 3.3.2.1.

3.5 ORGANOLEPTIC EVALUATION OF NENDRAN TYPES AND PRODUCTS

3.5.1 Nendran types

Organoleptic evaluation of the selected nendran types in the raw stage was carried out after cooking (boiling). Hundred gram of raw banana was washed thoroughly in water and cut into small pieces and cooked in sufficient quantity of water, adding salt to taste.

3.5.2 Banana flour and chips

Organoleptic evaluation of the two products namely banana flour and chips was also carried out at monthly intervals for a period of three months. The chips were evaluated as such and banana flour was evaluated after preparing porridge by using the method suggested by Thajudeen (2000). Ten gram of banana flour was cooked in 200 ml of milk, made by mixing three teaspoon full of milk powder. 2½ teaspoon of sugar was added and was cooked on a low flame until the required consistency was obtained.

3.5.3 Selection of Judges

A series of acceptability trials were carried out using simple triangle test at the laboratory level to select a panel of ten judges between the age group of 18 to 35 years as suggested by Jellinek (1985).

3.5.4 Sensory evaluation

Acceptability trials of the cooked banana, chips and porridge were conducted using score card (Appendix I, II and III) as suggested by Swaminathan (1974). Quality attributes like appearance, colour, flavour, texture and taste were included for evaluation. The overall acceptability of cooked banana and products were also evaluated. Each of the above quality attributes was assessed by five point Hedonic scale by the selected judges.

3.6 MICROBIAL EVALUATION OF BANANA FLOUR

The microbial evaluation of the stored banana flour was conducted at monthly intervals for a period of three months. The method used for the evaluation was serial dilution and plate count method as described by Agarwal and Hasija (1986). One gm of sample was added to 10 ml sterile Ringer solution and shaken. One ml of this dilution was transferred to test tube containing 9 ml sterile Ringer solution to get 10^{-2} dilution. Like wise 10^{-3}, 10^{-4}, 10^{-5} and 10^{-6} dilution were also prepared.

Enumeration of total microflora was carried out using nutrient agar media for bacteria, potato dextrose agar media for fungi and malt dextrose agar media for yeast (Agarwal and Hasija, 1986). The dilution used was 10^{-6} for bacteria and 10^{-4} for fungi and yeast.

3.7 STATISTICAL ANALYSIS

Statistical analysis was done using Duncan's Multiple Range Test (Das and Giri, 1986).

Results

4. RESULTS

The results pertaining to the study entitled 'Evaluation of fruit quality in banana 'Nendran' (*Musa* AAB)' is presented under the following headings.

4.1 Physical characters of nendran types

4.2 Chemical constituents of nendran types, banana flour and chips

4.3 Organoleptic evaluation of banana products

4.4 Enumeration of total microflora of banana flour

4.1 PHYSICAL CHARACTERS OF NENDRAN TYPES

The physical characters like finger weight, finger length, weight of pulp and peel, pulp/peel ratio, curvature and angularity of the selected nendran types are given in Table 1 to Table 6.

4.1.1 Finger weight

The finger weight of the nendran types varied from 125.5 g in Changanassery nendran to 183.20 g in Manjeri nendran I (Table 1) with a mean weight of 161.73 g.

Table 1. Finger weight of nendran types

Sl.No.	Nendran Type	Mean finger weight (g)
1	Attunendran	174.20[a]
2	Changanassery nendran	125.50[b]
3	Chengalikodan	130.80[b]
4	Kaliethan	179.40[a]
5	Manjeri nendran I	183.20[a]
6	Myndoli	168.90[a]
7	Nedunendran	171.11[a]
	Mean	161.73

Values having different superscripts differ significantly at 5% level
DMRT column wise comparison

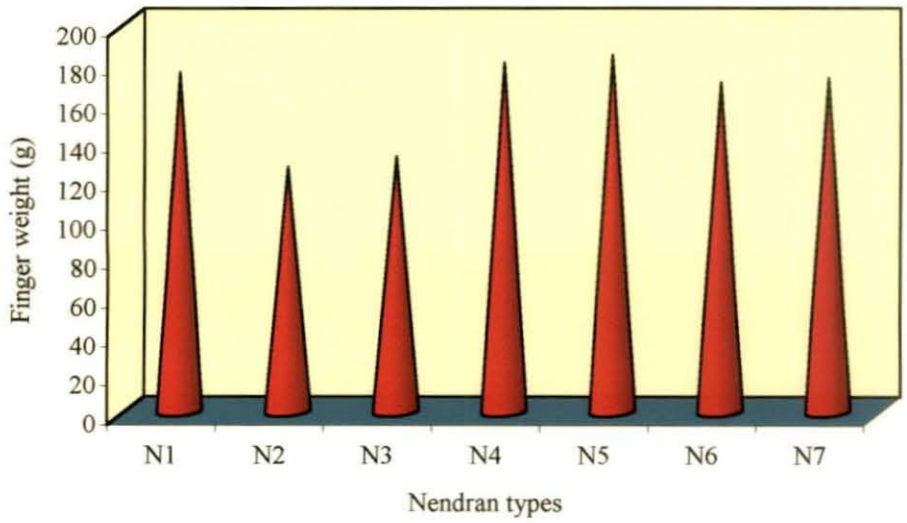

Fig. 1. Finger weight of nendran types

N1 - Attunendran
N2 - Changanassery nendran
N3 - Chengalikodan
N4 - Kaliethan
N5 - Manjeri nendran I
N6 - Myndoli
N7 - Nedunendran

On the basis of DMRT, the nendran types were categorised into two groups ('a' and 'b') in which the five nendran types namely Attunendran, Kaliethan, Manjeri nendran I, Myndoli, and Nedunendran, included in group 'a' were found to be significantly different from the two nendran types namely Changanassery nendran and Chengalikodan included in group 'b'. The finger weight of nendran types is illustrated in Fig.1.

4.1.2 Length of fingers

The length of fingers of nendran types is presented in Table 2 and Fig.2.

Nedunendran had the highest finger length of 26.84 cm while Chengalikodan recorded the lowest length of 20.06 cm with a mean finger length of 21.92 cm.

Table 2. Finger length of nendran types

Sl.No.	Nendran Type	Finger length (cm)
1	Attunendran	21.41^{bc}
2	Changanassery nendran	20.48^{bc}
3	Chengalikodan	20.06^{c}
4	Kaliethan	20.92^{bc}
5	Manjeri nendran I	21.32^{bc}
6	Myndoli	22.44^{b}
7	Nedunendran	26.84^{a}
	Mean	21.92

Values having different superscripts differ significantly at 5% level
DMRT column wise comparison

Statistically the nendran types were categorised into 4 groups on the basis of finger length. Group 'a', 'b' and 'c' included one nendran type each and were found to be significantly different from each other. Group 'bc' had four numbers namely Attunendran, Changanassery nendran, Kaliethan and Manjeri nendran I and indicated that finger length of these nendran types had no significant difference between themselves and between nendran types included in group 'b' and 'c'.

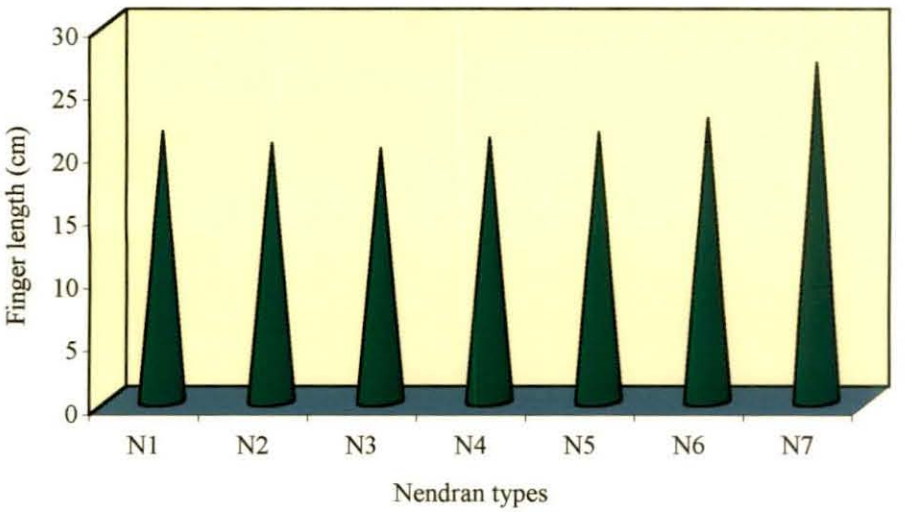

Fig. 2. Finger length of nendran types

N1 - Attunendran
N2 - Changanassery nendran
N3 - Chengalikodan
N4 - Kaliethan
N5 - Manjeri nendran I
N6 - Myndoli
N7 - Nedunendran

4.1.3 Weight of pulp and peel

The pulp and peel weight of nendran types is indicated in Table 3 and Fig. 3. A highest pulp weight of 107.20 g for Attunendran and lowest for Changanassery nendran (82.30 g) were observed. The peel weight ranged in between 45.88 g to 67.22 g. The highest peel weight was observed in Attunendran and lowest in Changanassery nendran. The mean weight of the pulp and peel were 96.28 g and 55.52 g respectively.

Table 3. Pulp and peel weight of nendran types

Sl.No.	Nendran type	Weight of pulp (g)	Weight of peel (g)
1	Attunendran	107.20^{a}	67.22^{a}
2	Changanassery nendran	82.33^{c}	45.88^{e}
3	Chengalikodan	96.67^{b}	48.33^{de}
4	Kaliethan	100.90^{ab}	56.11^{bcd}
5	Manjeri nendran I	96.11^{b}	51.44^{cde}
6	Myndoli	93.30^{b}	59.44^{abc}
7	Nedunendran	97.44^{ab}	60.22^{ab}
	Mean	96.28	55.52

Values having different superscripts differ significantly at 5% level
DMRT column wise comparison

On the basis of DMRT, the seven nendran types were categorised into four separate groups with respect to pulp weight. Group 'b' had three members namely Chengalikodan, Manjeri nendran I and Myndoli. These three nendran types had no significant difference between themselves, but were significantly different from the nendran types of other two groups namely 'a' and 'c'.

Significant difference in the peel weight was observed between the nendran types. Seven nendran types were categorised into seven separate groups which shows that significant difference existed between the nendran types with respect to peel weight.

4.1.4 Pulp/peel ratio

The pulp/peel ratio of the nendran types are presented in Table 4. The pulp/peel ratio of the nendran types varied from 1.57 to 2.01 with a mean ratio of 1.75. The highest value was observed in Chengalikodan and lowest in Attunendran.

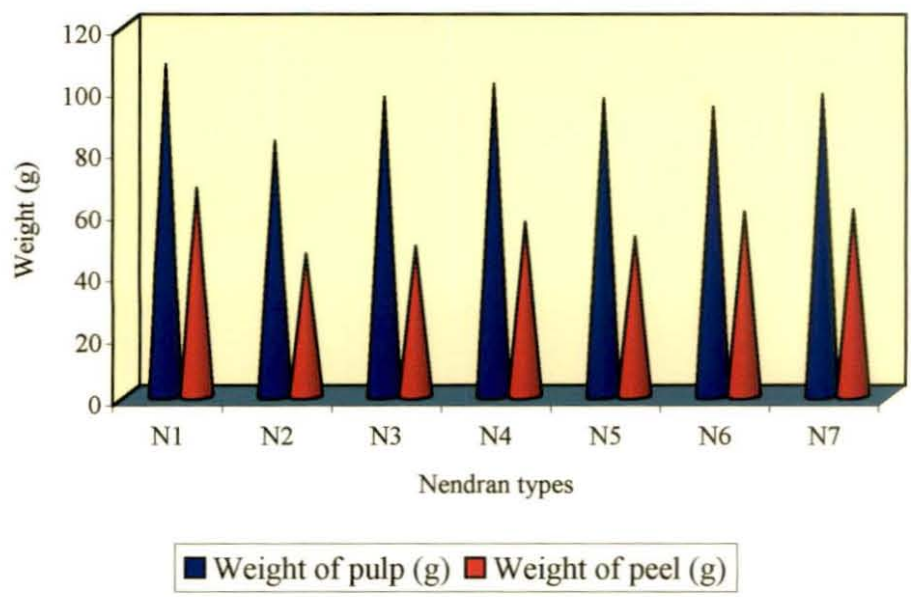

Fig. 3. Pulp and Peel weight of nendran types

N1 - Attunendran
N2 - Changanassery nendran
N3 - Chengalikodan
N4 - Kaliethan
N5 - Manjeri nendran I
N6 - Myndoli
N7 - Nedunendran

Table 4. Pulp/peel ratio of nendran types

Sl.No.	Nendran Type	Pulp/peel ratio
1	Attunendran	1.57[c]
2	Changanassery nendran	1.79[b]
3	Chengalikodan	2.01[a]
4	Kaliethan	1.79[b]
5	Manjeri nendran I	1.87[b]
6	Myndoli	1.60[c]
7	Nedunendran	1.63[c]
	Mean	1.75

Values having different superscripts differ significantly at 5% level
DMRT column wise comparison

On the basis of pulp/peel ratio, the nendran types were categorised into three groups. The nendran types, which were included in the same category, had no significant difference between themselves, but were significantly different from the nendran types of other classes.

4.1.5 Curvature

The curvature of Attunendran, Myndoli and Nedunendran was found to be straight in the distal part, while Chengalikodan, Kaliethan and Manjeri nendran I had a slightly curved appearance in the distal part and the distal part of Changanassery nendran was found to be having curved appearance. The details are presented in Table 5.

Table 5. Curvature of nendran types

Sl.No.	Nendran Type	Curvature
1	Attunendran	Straight in the distal part
2	Changanassery nendran	Curved
3	Chengalikodan	Slightly curved
4	Kaliethan	Slightly curved
5	Manjeri nendran I	Slightly curved
6	Myndoli	Straight in distal part
7	Nedunendran	Straight in distal part

Values having different superscripts differ significantly at 5% level
DMRT column wise comparison

4.1.6 Angularity

The angularity of nendran types is given in Table 6.

Table 6. Angularity of nendran types

Sl.No.	Nendran Type	Angularity
1	Attunendran	Slightly ridged
2	Changanassery nendran	Pronounced ridges
3	Chengalikodan	Slightly ridged
4	Kaliethan	Slightly ridged
5	Manjeri nendran I	Rounded
6	Myndoli	Slightly ridged
7	Nedunendran	Pronounced ridges

The angularity of Manjeri nendran I was found to be round where as Attunendran, Chengalikodan, Kaliethan and Myndoli had slightly ridged angularity and Changanassery nendran and Nedunendran had pronounced ridges.

4.2 CHEMICAL CONSTITUENTS OF NENDRAN TYPES, BANANA FLOUR AND CHIPS

4.2.1 Chemical constituents of nendran types

The selected nendran types were analysed for nine chemical constituents i.e., moisture, protein, crude fibre, starch, calcium, phosphorus, iron, potassium and vitamin C.

The chemical constituents of different nendran types are given from Table 7 to 15.

4.2.1.1 Moisture

The moisture content of the nendran types is given in Table 7 and in Fig.4.

The moisture content of nendran types ranged from 60.91 to 71.48 g 100 g^{-1} with a mean moisture content of 65.68 g 100 g^{-1}. The highest value was observed in Attunendran and the lowest in Manjeri nendran I.

Table 7. Moisture content of nendran types

Sl.No.	Nendran Type	Moisture (g 100 g^{-1})
1	Attunendran	71.48 [a]
2	Changanassery nendran	68.14 [ab]
3	Chengalikodan	62.63 [bc]
4	Kaliethan	61.61 [bc]
5	Manjeri nendran I	60.91 [c]
6	Myndoli	68.21 [ab]
7	Nedunendran	66.78 [abc]
	Mean	65.68

Values having different superscripts differ significantly at 5% level
DMRT column wise comparison

Statistically the nendran types were differentiated into five categories on the basis of moisture content. The group 'ab' and 'bc' had two members each and the other groups namely 'a', 'c' and 'abc' had one member in them. Significant difference existed between nendran types included in group 'a' and 'c', 'a' and 'bc' and 'c' and 'ab' with respect to moisture content.

4.2.1.2 Protein

The protein content of the seven nendran types is present in Table 8 and Fig. 5.

The protein content of nendran types, varied from 1.20 to 1.60 g 100 g^{-1} with the highest protein content in Chengalikodan and Manjeri nendran I and lowest in Attunendran. The mean protein content of nendran types was found to be 1.50 g 100 g^{-1}.

Table 8. Protein content of nendran types

Sl.No.	Nendran Type	Protein (g 100 g^{-1})
1	Attunendran	1.20 [ab]
2	Changanassery nendran	1.50 [a]
3	Chengalikodan	1.60 [a]
4	Kaliethan	1.40 [a]
5	Manjeri nendran I	1.60 [a]
6	Myndoli	1.40 [a]
7	Nedunendran	1.49 [a]
	Mean	1.50

Values having different superscripts differ significantly at 5% level
DMRT column wise comparison

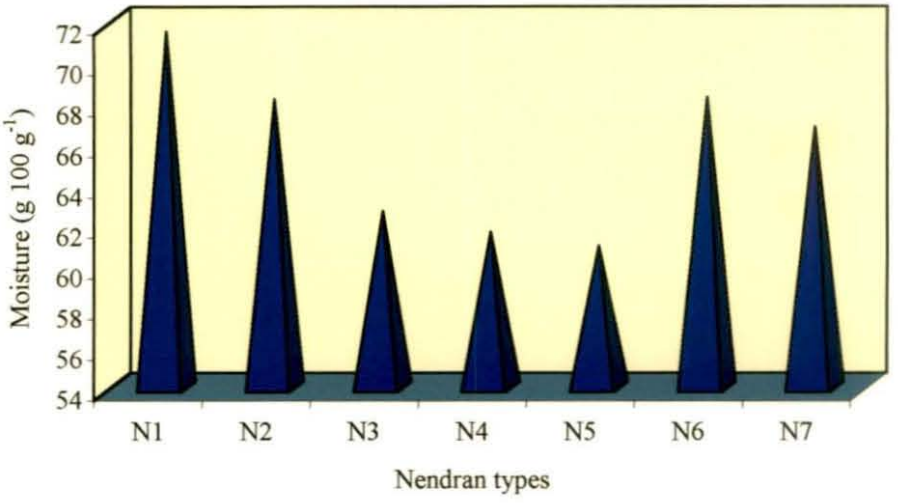

Fig. 4. Moisture content of nendran types

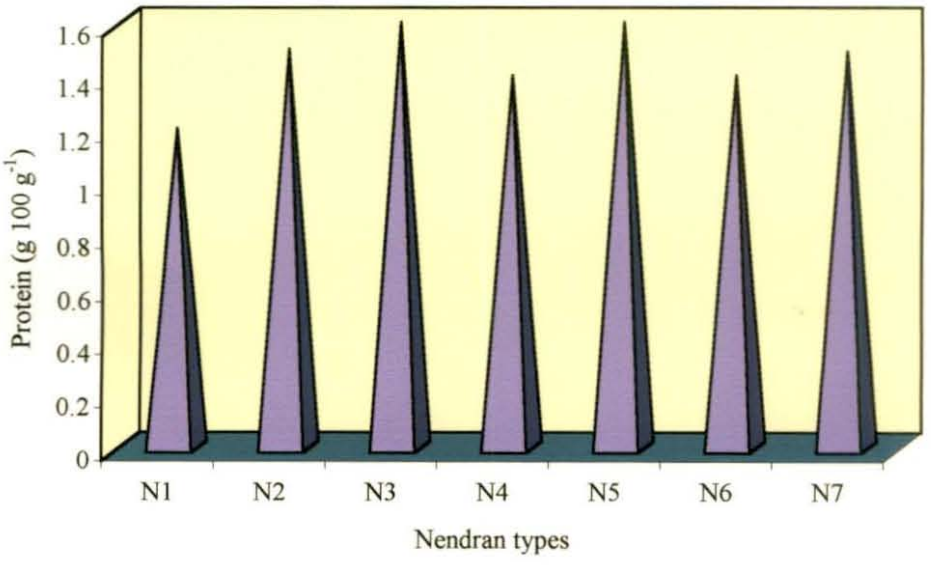

Fig. 5. Protein content of nendran types

N1 - Attunendran
N2 - Changanassery nendran
N3 - Chengalikodan
N4 - Kaliethan
N5 - Manjeri nendran I
N6 - Myndoli
N7 - Nedunendran

Statistically the different nendran types were arranged into two groups namely 'a' and 'ab'. Attunendran with the lowest protein content was included as the sole member of group 'ab' and the other six types were included in group 'a'. The protein content of nendran types showed no significant difference between themselves.

4.2.1.3 Crude fibre

The crude fibre content of nendran types on fresh weight basis is presented in Table 9 and Fig.6.

Table 9. Crude fibre content of nendran types

Sl.No.	Nendran Type	Crude fibre (g 100 g^{-1})
1	Attunendran	0.71 ^{ab}
2	Changanassery nendran	0.55 ^{b}
3	Chengalikodan	0.60 ^{b}
4	Kaliethan	0.62 ^{b}
5	Manjeri nendran I	0.71 ^{ab}
6	Myndoli	0.65 ^{b}
7	Nedunendran	0.86^{a}
	Mean	0.57

Values having different superscripts differ significantly at 5% level
DMRT column wise comparison

The crude fibre content of the nendran types varied from 0.55 g 100 g^{-1} in Changanassery nendran to 0.86 g 100 g^{-1} in Nedunendran with a mean crude fibre content of 0.57 g 100 g^{-1}.

Statistically, the different nendran types were classified into three groups on the basis of fibre content. Group 'b' with a fibre content in the range of 0.55 g to 0.65 g 100 g^{-1} had four members namely Changanassery nendran, Chengalikodan, Kaliethan, and Myndoli. The members in group 'ab' had two members in them (Attunendran and Manjeri nendran I). Nedunendran with the highest fibre content was grouped as the sole member in group 'a'. Significant difference was observed between the nendran types included in group 'b' and Nedunendran in group 'a'.

4.2.1.4 Starch

The starch content of nendran types are furnished in Table 10.

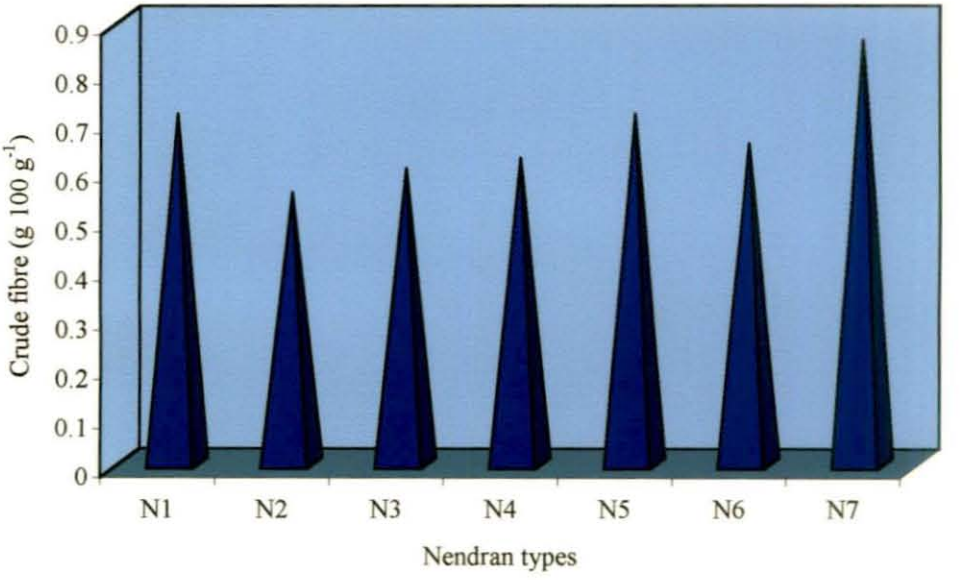

Fig. 6. Crude fibre content of nendran types

N1 - Attunendran
N2 - Changanassery nendran
N3 - Chengalikodan
N4 - Kaliethan
N5 - Manjeri nendran I
N6 - Myndoli
N7 - Nedunendran

Table 10. Starch content of nendran types

Sl.No.	Nendran Type	Starch (g 100 g^{-1})
1	Attunendran	18.44 ^{d}
2	Changanassery nendran	18.92 ^{d}
3	Chengalikodan	25.75 ^{a}
4	Kaliethan	22.84 ^{c}
5	Manjeri nendran I	23.91 ^{b}
6	Myndoli	18.10 ^{e}
7	Nedunendran	23.94 ^{b}
	Mean	21.70

Values having different superscripts differ significantly at 5% level
DMRT column wise comparison

The starch content of the different nendran types varied from 18.1 to 25.75 g 100 g^{-1}. The lowest and highest content were observed in Myndoli and Chengalikodan respectively. The mean starch content was found to be 21.7 g 100 g^{-1}. The starch content of nendran types is illustrated in Fig.7.

Statistically, the nendran types were differentiated into five categories on the basis of starch content. Each nendran type was categorised into separate groups except group 'b' and 'd' which had two nendran types each.

4.2.1.5 Calcium

The calcium content of the seven nendran types is furnished in Table 11 and Fig. 8.

Table 11. Calcium content of nendran types

Sl.No.	Nendran Type	Calcium (mg 100 g^{-1})
1	Attunendran	17.73 ^{c}
2	Changanassery nendran	18.08 ^{bc}
3	Chengalikodan	24.31 ^{a}
4	Kaliethan	20.27 ^{b}
5	Manjeri nendran I	23.68 ^{a}
6	Myndoli	12.75 ^{d}
7	Nedunendran	23.26 ^{a}
	Mean	20.01

Values having different superscript differ significantly at 5% level
DMRT column wise comparison

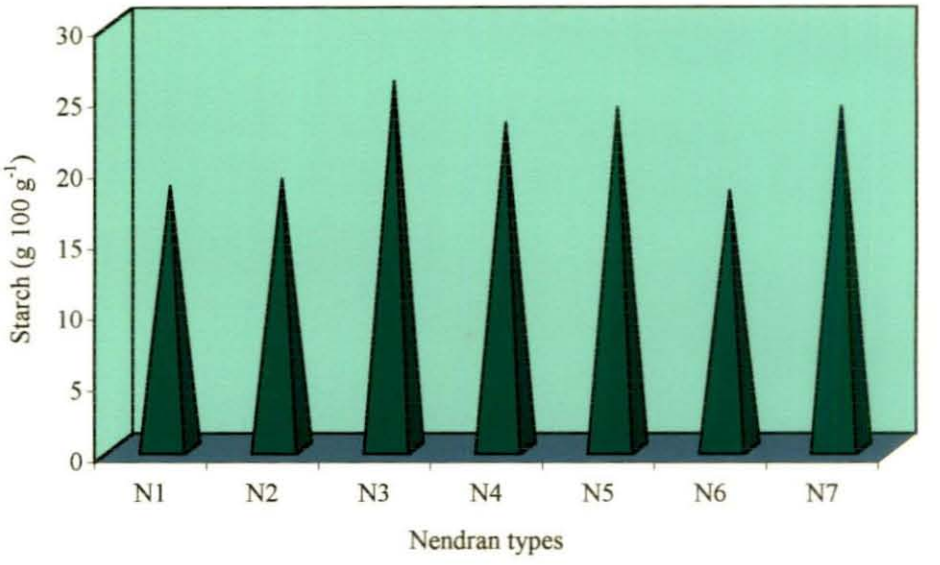

Fig. 7. Starch content of nendran types

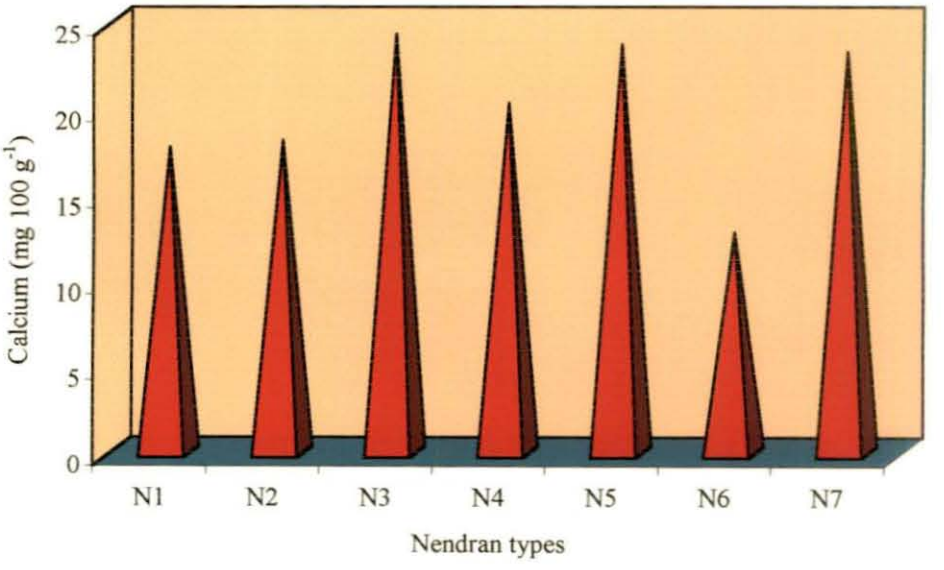

Fig. 8. Calcium content of nendran types

N1 - Attunendran
N2 - Changanassery nendran
N3 - Chengalikodan
N4 - Kaliethan
N5 - Manjeri nendran 1
N6 - Myndoli
N7 - Nedunendran

Calcium content of the different nendran types varied from 12.75 mg in Myndoli to 24.31 mg in Chengalikodan per 100 g. The mean calcium content obtained for the seven nendran types was 20.01 mg 100 g^{-1}.

Statistically, the different nendran types were arranged into five groups on the basis of calcium content. All the groups had only one member each except for group 'a' which had three members in it. The calcium content of the nendran types included in group 'c' and 'bc' and 'b' and 'bc' showed no significant difference between themselves, but the members of other groups had significant difference between themselves on the basis of calcium content.

4.2.1.6 Phosphorus

The phosphorus content of seven nendran types is presented in Table 12.

Table 12. Phosphorus content of nendran types

Sl.No.	Nendran Type	Phosphorus (mg 100 g^{-1})
1	Attunendran	26.40 ^{d}
2	Changanassery nendran	28.73 ^{c}
3	Chengalikodan	38.69 ^{a}
4	Kaliethan	28.78 ^{c}
5	Manjeri nendran I	28.57 ^{c}
6	Myndoli	27.84 ^{c}
7	Nedunendran	33.19 ^{b}
	Mean	30.31

Values having different superscript differ significantly at 5% level
DMRT column wise comparison

The phosphorus content of seven nendran types ranged between 26.40 mg to 38.69 mg 100 g^{-1} with a mean phosphorus content of 30.31 mg 100 g^{-1}. The highest phosphorus content was found to be in Chengalikodan and the lowest was in Attunendran. The phosphorus content of nendran types is presented in Fig.9.

On the basis of DMRT, the nendran types were differentiated into four categories 'a', 'b', 'c' and 'd'. Group 'c' included four nendran types namely Changanassery nendran, Kaliethan, Manjeri nendran I and Myndoli. The other three groups had only one type in each indicating that these three nendran types are significantly different from each other and from the nendran types included in group

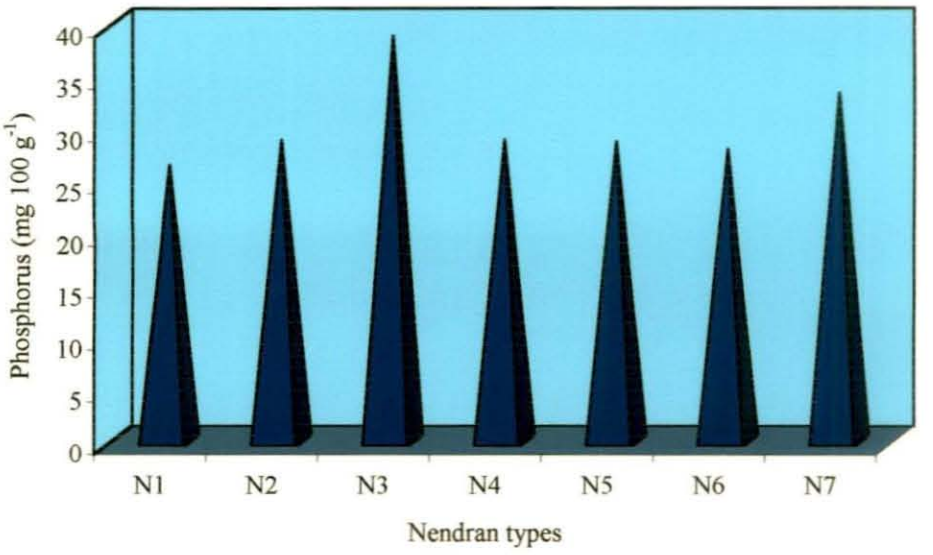

Fig. 9. Phosphorus content of nendran types

N1 - Attunendran
N2 - Changanassery nendran
N3 - Chengalikodan
N4 - Kaliethan
N5 - Manjeri nendran I
N6 - Myndoli
N7 - Nedunendran

'c'. There is no significant difference in the phosphorous content of nendran types included in group 'c'.

4.2.1.7 Iron

The iron content of the nendran types is given in Table 13 and Fig.10.

The mean iron content of seven nendran types was found to be 5.69 mg 100 g^{-1}. The highest iron content was seen in Chengalikodan (7.44 mg 100 g^{-1}) and the lowest in Myndoli (3.16 mg 100 g^{-1}).

Table 13. Iron content of nendran types

Sl.No.	Nendran Type	Iron (mg 100 g^{-1})
1	Attunendran	4.58 ^{d}
2	Changanassery nendran	5.59 ^{c}
3	Chengalikodan	7.44 ^{a}
4	Kaliethan	5.21 ^{cd}
5	Manjeri nendran I	7.21 ^{ab}
6	Myndoli	3.16 ^{e}
7	Nedunendran	6.67 ^{b}
	Mean	5.69

Values having different superscripts differ significantly at 5% level
DMRT column wise comparison

Statistical analysis indicated that on the basis of DMRT, each nendran type was included in separate categories, indicating significant difference in the iron content between the nendran types included in most of the groups except between the nendran types included in group 'cd' and 'c', 'cd' and 'd', 'ab' and 'a' and 'ab' and 'b'.

4.2.1.8 Potassium

The potassium content of nendran types is furnished in Table 14.

The potassium content of nendran types varied from 316.70 mg to 455.01 mg 100 g^{-1}. The lowest potassium content was observed in Attunendran and highest in Chengalikodan respectively. The mean potassium content was 387.02 mg 100 g^{-1}. The potassium content in nendran types is illustrated in Fig.11.

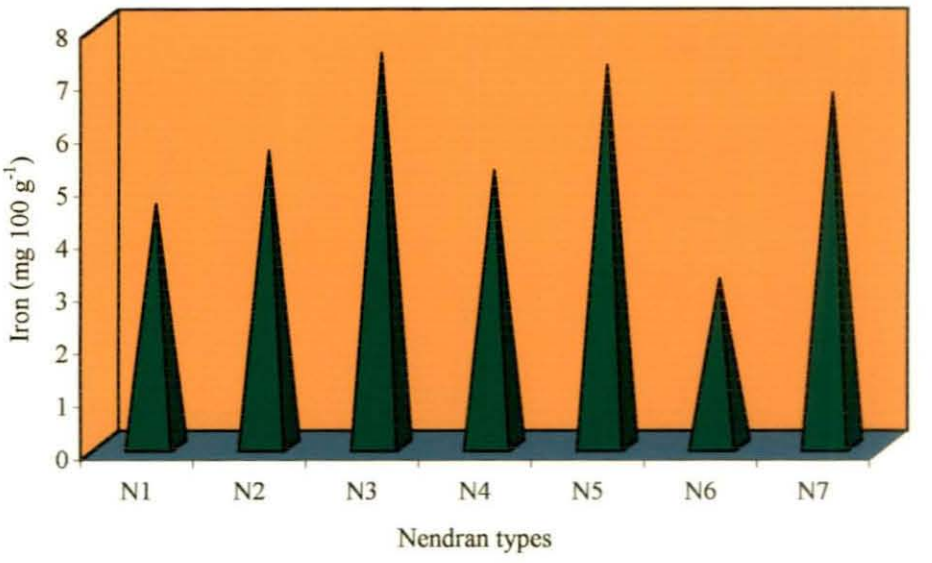

Fig. 10. Iron content of nendran types

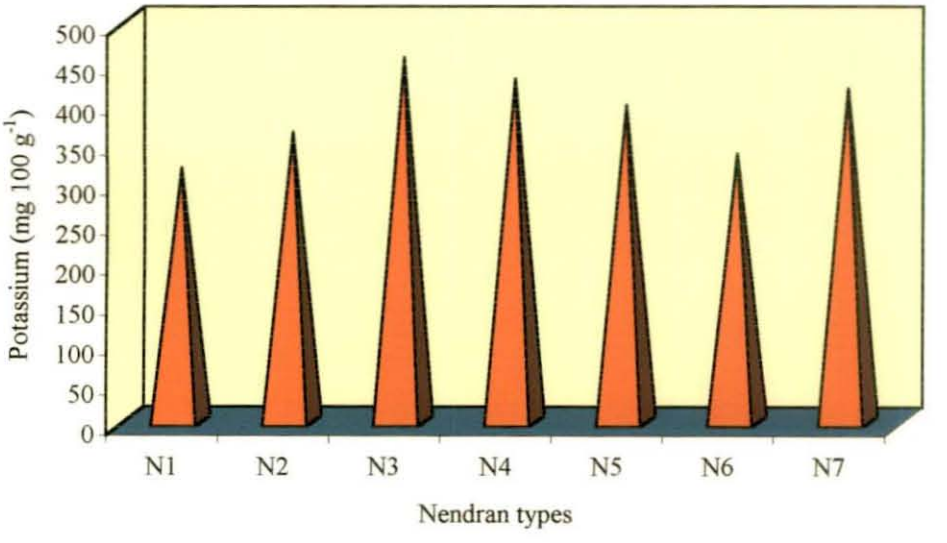

Fig. 11. Potassium content of nendran types

N1 - Attunendran
N2 - Changanassery nendran
N3 - Chengalikodan
N4 - Kaliethan
N5 - Manjeri nendran I
N6 - Myndoli
N7 - Nedunendran

Table 14. Potassium content of nendran types

Sl.No.	Nendran Type	Potassium (mg 100 g^{-1})
1	Attunendran	316.70 ^{d}
2	Changanassery nendran	361.44^{c}
3	Chengalikodan	455.01 ^{a}
4	Kaliethan	428.80^{ab}
5	Manjeri nendran I	395.30 ^{b}
6	Myndoli	334.70^{cd}
7	Nedunendran	417.20 ^{b}
	Mean	387.02

Values having different superscripts differ significantly at 5% level
DMRT column wise comparison

On the basis of potassium content of the nendran types, they were statistically classified into six categories. Each category included only one nendran type except category 'b' which had two nendran types namely Manjeri nendran and Nedunendran.

4.2.1.9 Vitamin C

The vitamin C content in different nendran types is presented in Table 15 and Fig.12.

Table 15. Vitamin C content of nendran types

Sl.No.	Nendran Type	Vitamin C (mg 100 g^{-1})
1	Attunendran	24.79 ^{a}
2	Changanassery nendran	21.05 ^{b}
3	Chengalikodan	19.48 ^{bc}
4	Kaliethan	19.73 ^{bc}
5	Manjeri nendran I	18.19 ^{c}
6	Myndoli	13.67 ^{d}
7	Nedunendran	24.78 ^{a}
	Mean	20.24

Values having different superscripts differ significantly at 5% level
DMRT column wise comparison

The vitamin C content of the seven nendran types varied from 13.67 mg 100 g^{-1} to 24.79 mg 100 g^{-1} with a mean vitamin C content of 20.24 mg 100 g^{-1}. Highest vitamin C content was seen in Attunendran and lowest in Myndoli.

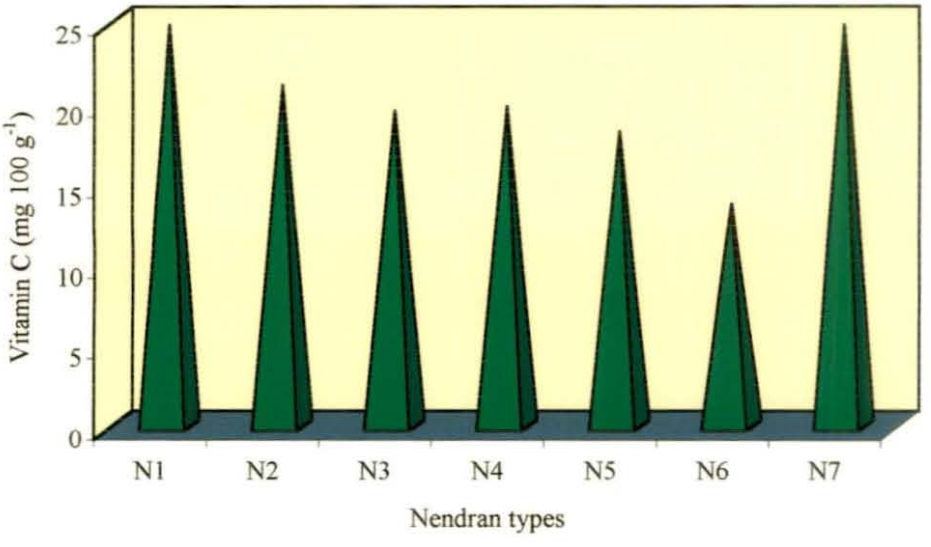

Fig. 12. Vitamin C content of nendran types

N1 - Attunendran
N2 - Changanassery nendran
N3 - Chengalikodan
N4 - Kaliethan
N5 - Manjeri nendran I
N6 - Myndoli
N7 - Nedunendran

On the basis of DMRT the nendran types were differentiated into 5 categories 'a', 'b', 'c', 'd' and 'bc'. Category 'a' and 'bc' included two types each namely Attunendran and Nedunendran in group 'a' with the highest vitamin C content and 'bc' included Chengalikodan and Kaliethan. Significant difference was seen in the vitamin C content of nendran types included in different categories except the members included in groups 'b' and 'bc' and 'c' and 'bc'. The vitamin C content of the nendran types included in the same category was found to be statistically insignificant.

4.2.2 Chemical constituents of banana flour

The chemical constituents of banana flour like moisture, protein, crude fibre, starch, calcium, phosphorus, iron and potassium were analysed at monthly intervals for a period of three months. The findings of the chemical analysis of banana flour are given below.

4.2.2.1 Moisture

The moisture content of the banana flours stored for a period of three months is furnished in Table 16.

Table 16. Effect of storage period on moisture content of banana flour of different nendran types

Sl. No.	Nendran types	Moisture (g 100 g^{-1})			
		Initial	1st month	2nd month	3rd month
1	Attunendran	5.00 ^{c}	5.70 ^{c}	6.60 ^{c}	7.43 ^{d}
2	Changanassery nendran	5.01 ^{c}	6.06 ^{b}	6.67 ^{c}	7.08 ^{f}
3	Chengalikodan	6.43 ^{a}	6.98 ^{a}	7.57 ^{a}	8.28 ^{b}
4	Kaliethan	5.20 ^{bc}	6.03 ^{b}	7.53 ^{a}	8.70 ^{a}
5	Manjeri nendran I	4.50 ^{d}	5.27 ^{d}	6.43 ^{d}	7.06 ^{f}
6	Myndoli	5.35 ^{b}	5.93 ^{b}	6.35 ^{d}	7.22 ^{e}
7	Nedunendran	6.34 ^{a}	7.00 ^{a}	7.28 ^{b}	7.95 ^{c}
	Mean	5.40	6.14	6.19	7.70

Values having different superscripts differ significantly at 5% level
DMRT column wise classification

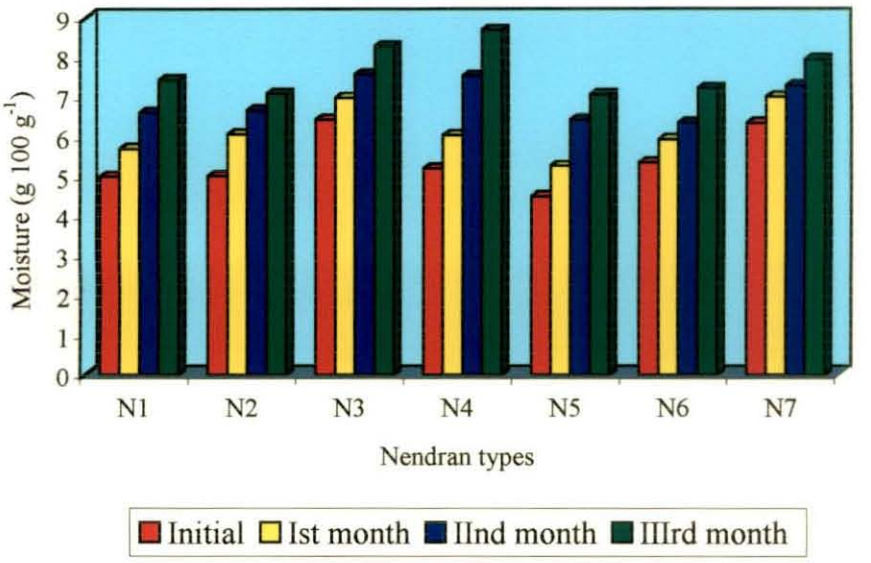

Fig. 13. Effect of storage period on moisture content of banana flour

N1 - Attunendran
N2 - Changanassery nendran
N3 - Chengalikodan
N4 - Kaliethan
N5 - Manjeri nendran I
N6 - Myndoli
N7 - Nedunendran

Significant variation in the moisture content in the banana flour prepared from the nendran types was observed during the three months of storage. During the initial period, the moisture content of the flour varied from 4.5 g 100 g^{-1} in Manjeri nendran I to 6.43 g 100 g^{-1} in Chengalikodan with a mean moisture content of 5.40 g 100 g^{-1}. On the basis of DMRT, the banana flour was categorized into five groups during the initial storage period. Groups 'a' and 'c' had two nendran types each and 'b' 'bc'and 'd' had only one nendran type each. The moisture content of the banana flour of Kaliethen included in group 'bc' had no significant difference from Myndoli ('b'), Attunendran and Changanassery nendran ('c').

The mean moisture content of the banana flour was found to be 6.14, 6.19 and 7.70 g 100 g^{-1} during the first, second and third months of storage. The highest and lowest moisture content were found to be in banana flour prepared from Nedunendran (7 g 100 g^{-1}) and Manjeri nendran I (5.27 g 100 g^{-1}) during the first month of storage. During the second month of storage, the moisture content of the banana flour varied from 6.35 g 100 g^{-1} in Myndoli to 7.57 g 100 g^{-1} in Chengalikodan and during the third month, the moisture content varied from 7.06 to 8.7 g 100 g^{-1} in Manjeri nendran I and Kaliethan respectively.

DMRT classified the banana flour of different nendran types into four groups during the first and second months of storage while, in the third month, the banana flour were categorised into six different groups. During the third month of storage, each nendran type was categorised into separate groups except group 'f' which had two types namely Changanassery nendran and Manjeri nendran I showing significant variation in the moisture content of the banana flour prepared from other nendran types.

The effect of storage period on the moisture content of the banana flour of different nendran types is illustrated in Fig.13.

4.2.2.2 Protein

The protein content of the banana flours and the effect of storage on the protein content are furnished in Table 17.

Table 17. Effect of storage period on protein content of banana flour of different nendran types

Sl. No.	Nendran types	Protein (g 100 g^{-1})			
		Initial	1st month	2nd month	3rd month
1	Attunendran	3.50^{f}	3.46^{c}	3.50^{d}	3.43^{c}
2	Changanassery nendran	4.86^{ab}	4.80^{a}	4.86^{ab}	4.70^{ab}
3	Chengalikodan	5.06^{a}	4.96^{a}	4.96^{a}	4.90^{a}
4	Kaliethan	3.73^{e}	3.50^{c}	3.53^{d}	3.56^{a}
5	Manjeri nendran I	4.83^{c}	4.90^{a}	4.80^{b}	4.76^{a}
6	Myndoli	4.00^{d}	3.83^{b}	3.76^{c}	3.56^{c}
7	Nedunendran	4.83^{b}	4.83^{a}	4.76^{b}	4.50^{b}
	Mean	4.40	4.30	4.30	4.20

Values having different superscripts differ significantly at 5% level
DMRT column wise classification

The mean protein content of the banana flour was found to be 4.4 g (initial period), 4.3 g (first and second months of storage) and 4.2 g (third month of storage) per 100 g.

During the initial period of storage, the protein content of banana flour varied from 3.50 to 5.06 g per 100 g. The highest protein content was found to be in Chengalikodan and the lowest in Attunendran. During the first, second and third months of storage also the highest protein content was observed in Chengalikodan with a protein of 4.96 g 100 g^{-1} during the first and second months of storage and 4.90 g during the third month. The lowest protein content was found in Attunendran with a protein content of 3.46, 3.5 and 3.43 g 100 g^{-1} during first, second and third months of storage respectively.

Significant variation in the protein content of banana flour between the nendran types was observed during the different months of storage. In the initial stage, the banana flour of different nendran types were categorised into seven different groups showing significant variation in the protein content of banana flour of different nendran types except in group 'a' and 'ab' and 'b' and 'ab'. During the first month of storage, the banana flour of nendran types were categorised into three groups showing significant variation in the protein content of banana flour between the three groups. Group 'a' had four and groups 'b' and 'c' had one and two members each. During the second and third months of storage, the banana flours of different nedran types were

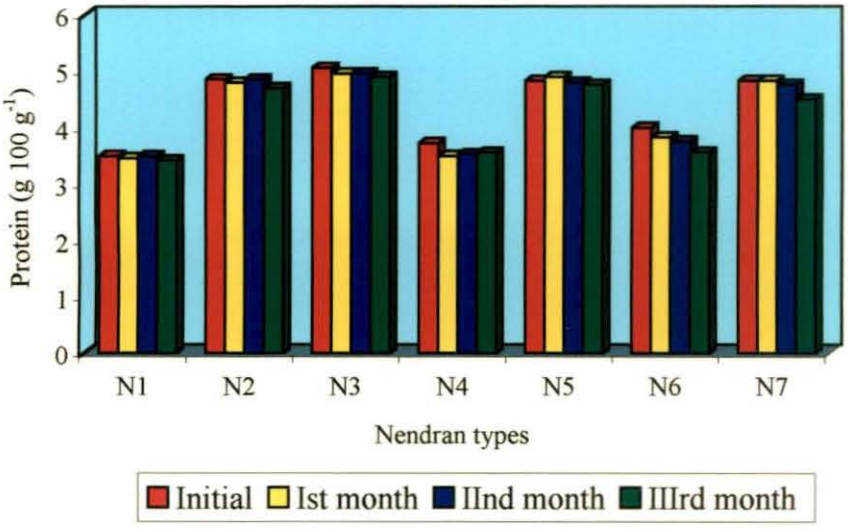

Fig. 14. Effect of storage period on protein content of banana flour

N1 - Attunendran
N2 - Changanassery nendran
N3 - Chengalikodan
N4 - Kaliethan
N5 - Manjeri nendran I
N6 - Myndoli
N7 - Nedunendran

categorised into five and four groups respectively indicating significant variation in protein content between the groups except the nendran types included in group 'a' and 'ab' and 'b' and 'ab'.

The effect of storage period on the protein content of the banana flour of different nendran types are furnished in Fig.14.

4.2.2.3 Crude fibre

The crude fibre content of banana flours is given in Table 18.

Table 18. Effect of storage period on crude fibre content of banana flour of different nendran types

Sl. No.	Nendran types	Crude fibre (g 100 g^{-1})			
		Initial	1st month	2nd month	3rd month
1	Attunendran	0.13 ^{c}	0.12 ^{bc}	0.10 ^{ab}	0.10 ^{a}
2	Changanassery nendran	0.00 ^{d}	0.00 ^{d}	0.00 ^{c}	0.00 ^{b}
3	Chengalikodan	0.00 ^{d}	0.00 ^{d}	0.00 ^{c}	0.00 ^{b}
4	Kaliethan	0.13 ^{c}	0.06 ^{c}	0.05 ^{bc}	0.07 ^{ab}
5	Manjeri nendran I	0.22 ^{ab}	0.15 ^{ab}	0.13 ^{ab}	0.12 ^{a}
6	Myndoli	0.20 ^{ab}	0.15 ^{ab}	0.15 ^{a}	0.13 ^{a}
7	Nedunendran	0.27 ^{a}	0.18 ^{a}	0.15 ^{a}	0.13 ^{a}
	Mean	0.14	0.09	0.08	0.08

Values having different superscripts differ significantly at 5% level
DMRT column wise classification

The mean crude fibre content of the banana flour of different nendran types varied from 0.08 g to 0.14 g 100 g^{-1}. The highest mean fibre content was found during the initial period of storage and the lowest during the second and third months of storage. A gradual decrease in the fibre content was noticed in the banana flour during the storage.

Significant vriation in the fibre content of the banana flour was observed during the storage period between the nendran types. During the initial period, the crude fibre content varied from 0 to 0.27 g 100 g^{-1} with highest fibre content in Nedunendran. The banana flour prepared from Chengalikodan and Changanassery nendran did not contain any crude fibre. The highest fibre content was observed in Nedunendran during the first (0.18%), second (0.15%) and third months (0.15%) of

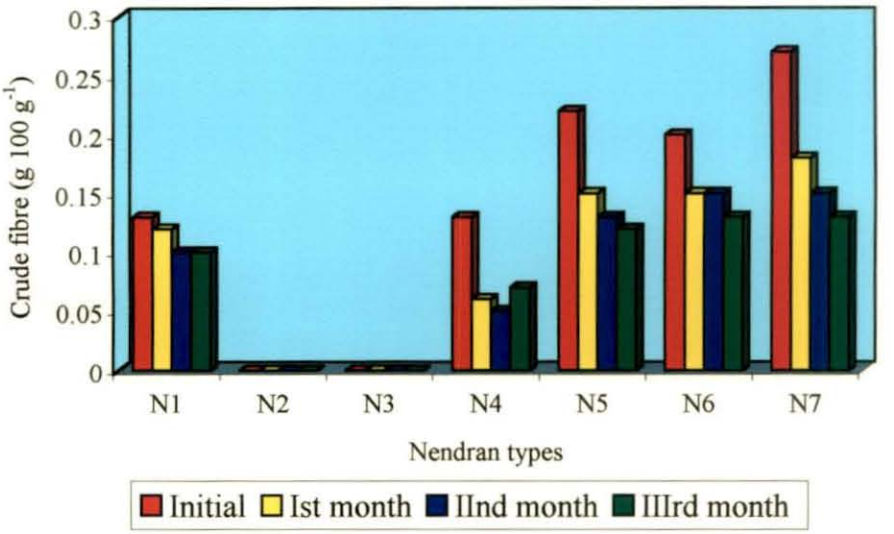

Fig. 15. Effect of storage period on crude fibre content of banana flour

N1 - Attunendran
N2 - Changanassery nendran
N3 - Chengalikodan
N4 - Kaliethan
N5 - Manjeri nendran I
N6 - Myndoli
N7 - Nedunendran

storage. The banana flour prepared from Myndoli also contains 0.15 and 0.13 per cent of crude fibre during the second and third months of storage.

The effect of storage period on the fibre content of banana flours of seven nendran types is furnished in Fig.15.

On the basis of DMRT, the banana flour of different nendran types were categorised into five groups during the initial and first month of storage based on the crude fibre content. Group 'a' with the highest crude fibre was categorised into a separate entity during the initial and first month of storage showing significant variation in the fiber content of banana flours of different nendran types except the members included in group 'ab' and 'a', 'bc' and 'c' and 'bc' and 'ab'. During the second and third months of storage, the banana flour of different nendran types were categorised into four and three groups respectively. During the second month of storage, Nedunendran and Myndoli with the highest crude fibre content were grouped together in group 'a'. Group 'ab' and 'c' also had two members each. During the third month of storage, group 'a' had four members namely, Attunendran, Manjeri nendran I, Myndoli, and Nedunendran which shows that the crude fibre content in the banana flour of these four nendran types had no significant difference between themselves.

4.2.2.4 Starch

The starch content of banana flour of different nendran types is given in the Table 19.

Table 19. Effect of storage period on starch content of banana flour of different nendran types

Sl. No.	Nendran types	Starch (g 100 g^{-1})			
		Initial	1st month	2nd month	3rd month
1	Attunendran	63.50 ^{d}	62.97 ^{d}	61.55 ^{d}	60.60 ^{d}
2	Changanassery nendran	66.40 ^{c}	65.80 ^{c}	64.30 ^{c}	63.40 ^{c}
3	Chengalikodan	71.10 ^{b}	70.60 ^{b}	69.80 ^{b}	69.02 ^{b}
4	Kaliethan	60.60 ^{e}	59.60 ^{f}	57.96 ^{f}	57.20 ^{f}
5	Manjeri nendran I	62.70 ^{d}	61.70 ^{e}	60.87 ^{e}	59.60 ^{e}
6	Myndoli	55.90 ^{f}	55.03 ^{g}	54.60 ^{g}	53.70 ^{g}
7	Nedunendran	72.34 ^{a}	71.50 ^{a}	70.50 ^{a}	70.16 ^{a}
	Mean	64.60	63.90	62.80	61.90

Values having different superscripts differ significantly at 5% level
DMRT column wise classification

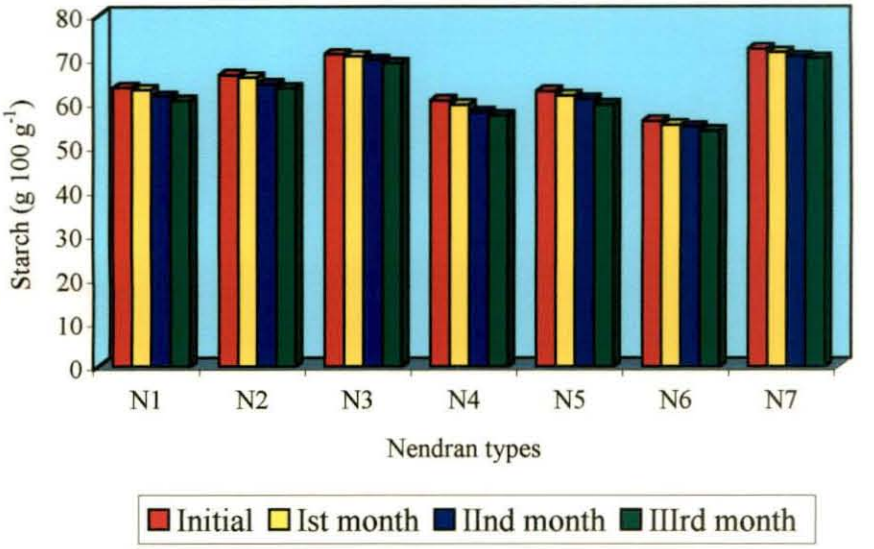

Fig. 16. Effect of storage period on starch content of banana flour

N1 - Attunendran
N2 - Changanassery nendran
N3 - Chengalikodan
N4 - Kaliethan
N5 - Manjeri nendran I
N6 - Myndoli
N7 - Nedunendran

The mean starch content of the banana flour varied from 61.90 to 64.60 g 100 g^{-1}. The highest starch content was seen during the initial storage period and the lowest during the third month of storage.

The starch content of banana flour during the initial storage period varied from 55.90 to 72.34 g 100 g^{-1}. The highest and lowest starch content was observed in Nedunendran and Myndoli respectively. During the first, second and third months of storage the starch content varied from 55.03 to 71.50 per cent, 54.60 to 70.5 per cent and 53.70 to 70.16 per cent respectively. The highest and lowest starch content were in Nedunendran and Myndoli during most of the storage periods. A gradual decrease in the starch content of banana flour of all nendran types was also noticed during storage. Significant variation in the starch content of banana flour between the nendran types was observed except for Attunendran and Manjeri nendran I during the initial period of storage.

On the basis of DMRT, the banana flour of different nendran types were categorised into seven separate groups during the first month of storage showing significant variation in the starch content between the nendran types. The starch content of banana flours of all nendran types had significant difference between themselves during first, second and third months of storage.

The effect of storage period on the starch content of banana flour of different nendran types is illustrated in Fig.16.

4.2.2.5 Calcium

The calcium content of the banana flour of seven nendran types is presented in Table 20.

The calcium content of banana flour initially varied from 33.90 to 78.98 mg 100 g^{-1} with a mean calcium content of 57.3 mg 100 g^{-1}. The highest calcium content was in banana flour of nendran type Nedunendran and the lowest in Myndoli. During the three months of storage also the highest and lowest calcium contents were seen in Nedunendran and Myndoli. The mean calcium content of banana flour was found to be 55, 53.21 and 51.9 mg 100 g^{-1} during the first, second and third months of storage. Significant variation in the calcium content of banana flour of the nendran type was also observed.

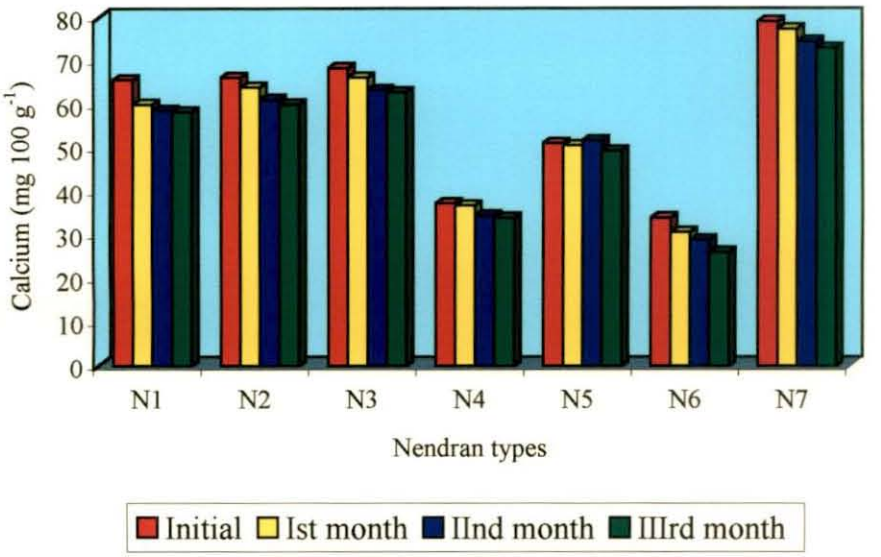

Fig. 17. Effect of storage period on calcium content of banana flour

N1 - Attunendran
N2 - Changanassery nendran
N3 - Chengalikodan
N4 - Kaliethan
N5 - Manjeri nendran I
N6 - Myndoli
N7 - Nedunendran

Table 20. Effect of storage period on calcium content of banana flour of different nendran types

Sl. No.	Nendran types	Calcium (mg 100 g^{-1})			
		Initial	1st month	2nd month	3rd month
1	Attunendran	65.60 ^{b}	60.00 ^{c}	58.70 ^{c}	58.30 ^{c}
2	Changanassery nendran	66.10 ^{b}	63.90 ^{b}	61.10 ^{bc}	60.00 ^{b}
3	Chengalikodan	68.30 ^{b}	66.11 ^{b}	63.30 ^{b}	62.80 ^{b}
4	Kaliethan	37.20 ^{d}	36.70 ^{e}	34.40 ^{e}	33.90 ^{e}
5	Manjeri nendran I	51.10 ^{c}	50.60 ^{d}	51.70 ^{d}	49.40 ^{d}
6	Myndoli	33.90 ^{d}	30.60 ^{f}	28.90 ^{f}	26.10 ^{f}
7	Nedunendran	78.98 ^{a}	77.22 ^{a}	74.40 ^{a}	72.80 ^{a}
	Mean	57.30	55.00	53.21	51.90

Values having different superscripts differ significantly at 5% level
DMRT column wise classification

On the basis of calcium content, the banana flour of different nendran types were categorised into four groups during the initial storage period. Banana flour of each nendran type was categorised into a separate entity except 'b' and 'd' during the initial storage period.

During the first month of storage, the nendran types were categorised into six groups with Chengalikodan and Changanassery nendran in group 'b' and the five nendran types into five separate groups. During the second month of storage, the banana flour of different nendran types were categorised into seven different groups which revealed signification variation in the calcium content in the banana flour of different nendran types except in groups 'c' and 'bc' and 'b' and 'bc'. During the third month of storage Changanassery nendran and Chengalikodan were grouped into the same group 'b' showing similarity in the calcium content of the banana flour of these two nendran types.

The effect of storage period on the calcium content of banana flour of different nendran types is given in Fig.17.

4.2.2.6 Phosphorus

The phosphorus content of the banana flour is given in Table 21.

Table 21. Effect of storage period on phosphorus content of banana flour of different nendran types

Sl. No.	Nendran types	Phosphorus (mg 100 g^{-1})			
		Initial	1st month	2nd month	3rd month
1	Attunendran	56.50 ^{g}	53.10 ^{g}	52.10 ^{e}	51.50 ^{f}
2	Changanassery nendran	69.30 ^{d}	68.50 ^{d}	66.60 ^{b}	66.20 ^{c}
3	Chengalikodan	81.80 ^{a}	79.40 ^{a}	76.10 ^{a}	74.40 ^{a}
4	Kaliethan	60.00 ^{f}	58.60 ^{f}	57.20 ^{d}	55.90 ^{e}
5	Manjeri nendran I	74.40 ^{c}	70.60 ^{c}	67.80 ^{b}	65.70 ^{c}
6	Myndoli	65.20 ^{e}	63.80 ^{e}	63.00 ^{c}	62.90 ^{d}
7	Nedunendran	78.60 ^{b}	76.90 ^{b}	74.80 ^{a}	72.50 ^{b}
	Mean	69.40	67.30	65.40	63.90

Values having different superscripts differ significantly at 5% level
DMRT column wise classification

The initial phosphorus content of the banana flour varied from 56.5 to 81.8 mg 100 g^{-1} with a mean phosphorous content of 69.4 mg 100 g^{-1}. The highest phosphorus content was in Chengalikodan and lowest in Attunendran. During the three months of storage, the banana flour of Attunendran had the lowest phosphorus content which varied from 51.5 mg (third month) to 53.1 mg (first month). The nendran type Chengalikodan showed the highest phosphorus content during the first (79.40 mg 100 g^{-1}), second month (76.10 mg 100 g^{-1}) and third month (74.40 mg 100 g^{-1}) of storage.

Significant variation in the phosphorus content of banana flour between the nendran types was noticed at all stages of storage. During the initial and first month of storage, all the nendran types showed significant difference from each other and was categorised into seven different groups. During the second and third months of storage, the nendran types Changanassery nendran and Manjeri nendran I and Nedunendran and Chengalikodan respectively were categorised in same group showing statistically insignificant variation in the phosphorus content of the flour of these nendran types.

The effect of storage period on the phosphorus content of the banana flour of seven nendran types is given in Fig.18.

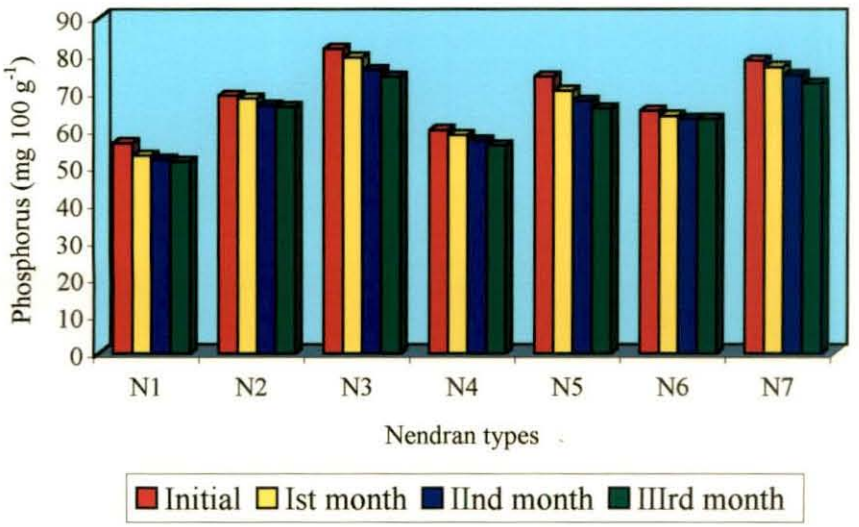

Fig. 18. Effect of storage period on phosphorus content of banana flour

N1 - Attunendran
N2 - Changanassery nendran
N3 - Chengalikodan
N4 - Kaliethan
N5 - Manjeri nendran I
N6 - Myndoli
N7 - Nedunendran

4.2.2.7 Iron

The iron content of banana flour is given in Table 22.

Table 22. Effect of storage period on iron content of banana flour of different nendran types

Sl. No.	Nendran types	Iron (mg 100 g^{-1})			
		Initial	1st month	2nd month	3rd month
1	Attunendran	6.40 ^{b}	6.30 ^{ab}	6.20 ^{ab}	4.20 ^{c}
2	Changanassery nendran	4.60 ^{c}	4.00 ^{d}	2.90 ^{e}	2.90 ^{d}
3	Chengalikodan	6.60 ^{b}	6.20 ^{ab}	6.00 ^{b}	5.20 ^{b}
4	Kaliethan	5.20 ^{c}	4.80 ^{cd}	4.40 ^{cd}	3.90 ^{c}
5	Manjeri nendran I	7.70 ^{a}	7.20 ^{a}	7.00 ^{a}	6.70 ^{a}
6	Myndoli	5.70 ^{bc}	5.40 ^{bc}	4.20 ^{d}	4.20 ^{c}
7	Nedunendran	6.40 ^{b}	5.80 ^{bc}	5.30 ^{bc}	5.30 ^{b}
	Mean	6.10	5.70	5.10	4.90

Values having different superscripts differ significantly at 5% level
DMRT column wise classification

The mean iron content of the banana flour was 6.10, 5.70, 5.10 and 4.90 mg 100 g^{-1} at the initial, first, second and third months of storage.

The highest iron content was observed in Manjeri nendran I (7.70, 7.20, 7.00 and 6.70 mg 100 g^{-1}) and the lowest was observed in Changanassery nendran (4.60, 4.00, 2.90 and 2.90 mg 100 g^{-1}) during the initial, first, second and third months of storage respectively.

On the basis of DMRT, the banana flour of different nendran types were categorised into four groups during the initial period. Significant difference was not observed in the iron content of the banana flour between the nendran types Attunendran, Chengalikodan, Myndoli and Nedunendran and also between Changanassery nendran, Myndoli and Kaliethan.

During the first and third months of storage, the nendran types were classified into five groups showing significant variation in the iron content of the flour between the nendran types included in the different groups. During the second month of storage, the banana flour of each nendran types was categorised in a separate group

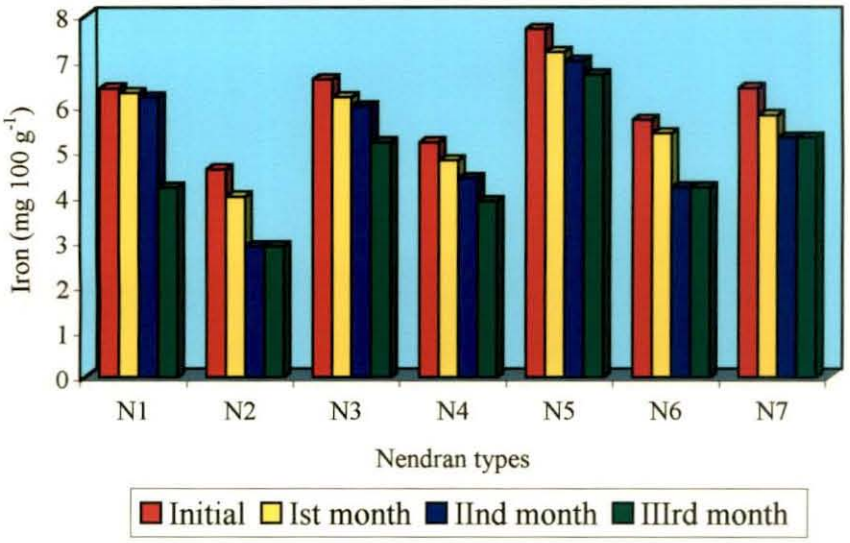

Fig. 19. Effect of storage period on iron content of banana flour

N1 - Attunendran
N2 - Changanassery nendran
N3 - Chengalikodan
N4 - Kaliethan
N5 - Manjeri nendran I
N6 - Myndoli
N7 - Nedunendran

showing variation in the iron content of the banana flour of the nendran types except the members of groups 'a' and 'ab', 'b' and 'ab' and 'b' and 'bc'.

Effect of storage period on iron content of banana flour is given in Fig.19.

4.2.2.8 Potassium

The potassium content in banana flour is furnished in Table 23.

Table 23. Effect of storage period on potassium content of banana flour of different nendran types

Sl. No.	Nendran types	Potassium (mg 100 g^{-1})			
		Initial	1st month	2nd month	3rd month
1	Attunendran	505.60 ^{ab}	483.30 ^{d}	466.70 ^{a}	450.00 ^{d}
2	Changanassery nendran	594.40 ^{a}	561.10 ^{bc}	600.00 ^{a}	572.20 ^{ab}
3	Chengalikodan	633.30 ^{a}	638.90 ^{a}	622.20 ^{a}	616.70 ^{a}
4	Kaliethan	616.70 ^{a}	616.70 ^{ab}	611.10 ^{a}	588.90 ^{ab}
5	Manjeri nendran I	633.30 ^{a}	616.70 ^{ab}	611.10 ^{a}	605.60 ^{ab}
6	Myndoli	600.00 ^{a}	583.30 ^{abc}	544.40 ^{a}	538.80 ^{bc}
7	Nedunendran	555.60 ^{ab}	544.40 ^{cd}	544.40 ^{a}	500.00 ^{cd}
	Mean	591.30	577.80	571.40	553.20

Values having different superscripts differ significantly at 5% level
DMRT column wise classification

The mean potassium content varied from 553.20 mg 100 g^{-1} to 591.30 mg 100 g^{-1}. The highest and lowest potassium contents were observed during the initial storage period and third month of storage respectively. During the initial storage period, the potassium content of banana flour varied from 505.60 mg (Attunendran) to 633.30 mg 100 g^{-1} (Chengalikodan and Manjeri nendran I). On the basis of potassium content of the banana flour, the nendran types were categorised into two groups with group 'a' having five nendran types in it. During the first, second and third months of storage, the highest potassium content was observed in Chengalikodan and the lowest in Attunendran.

On the basis of DMRT, the nendran types were classified into six categories, during the first month of storage. The banana flours of Kaliethan and Manjeri nendran I were grouped in the same group 'ab' which showed no significant difference in the potassium content. All the nendran types were included in the same category except Attunendran during the second month of storage, which indicated that

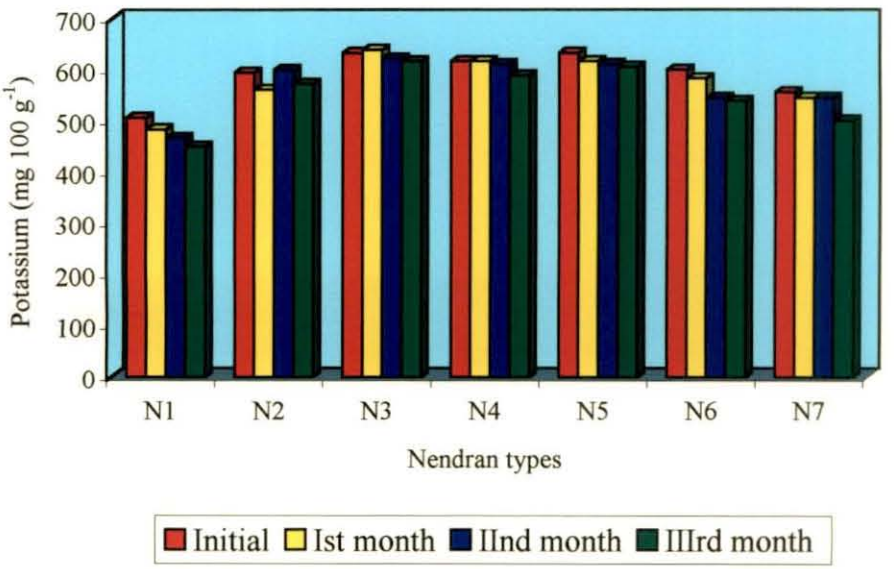

Fig. 20. Effect of storage period on potassium content of banana flour

N1 - Attunendran
N2 - Changanassery nendran
N3 - Chengalikodan
N4 - Kaliethan
N5 - Manjeri nendran I
N6 - Myndoli
N7 - Nedunendran

the variation in the potassium content of the banana flour was statistically insignificant between the members of group 'a'. During the third month of storage, the nendran types were classified into five categories with group 'ab' having three members namely Changanassery nendran, Kaliethan and Manjeri nendran I and the other nendran types in separate groups. Attunendran with the lowest potassium content showed significant difference from the potassium content of the banana flours of all other nendran types except Nedunendran included in group 'cd'.

The effect of storage period on the potassium content of banana flour of different nendran types is given in Fig.20.

4.2.3 Moisture content of banana chips

Moisture content of banana chips prepared from nendran types which were packed in polyethylene bags were evaluated at monthly intervals for a period of three months. The results are furnished in Table 24.

Table 24. Effect of storage period on moisture content of chips of different nendran types

Sl. No.	Nendran types	Moisture (g 100 g^{-1})			
		Initial	1st month	2nd month	3rd month
1	Attunendran	2.60 ^{b}	3.60 ^{abc}	5.40 ^{a}	6.03 ^{b}
2	Changanassery nendran	3.04 ^{a}	4.10 ^{ab}	4.10 ^{b}	6.10 ^{b}
3	Chengalikodan	1.50 ^{c}	2.80 ^{c}	3.50 ^{c}	4.30 ^{d}
4	Kaliethan	2.60 ^{b}	3.40 ^{bc}	5.33 ^{a}	6.70 ^{a}
5	Manjeri nendran I	2.30 ^{b}	4.20 ^{a}	4.90 ^{a}	5.80 ^{b}
6	Myndoli	1.30 ^{c}	3.20 ^{c}	4.20 ^{b}	5.80 ^{b}
7	Nedunendran	2.70 ^{ab}	3.60 ^{abc}	4.20 ^{b}	5.10 ^{c}
	Mean	2.29	3.56	4.52	5.69

Values having different superscripts differ significantly at 5% level
DMRT column wise classification

It was found that the moisture content of banana chips of different nendran types increased during storage. The mean moisture content of the chips varied from 2.29 g 100 g^{-1} during the initial period of storage to 5.69 g 100 g^{-1} at the third month of storage. The lowest, moisture content during the initial (1.3 g 100 g^{-1}) and first month of storage (2.80 g 100 g^{-1}) was found in banana chips prepared from Myndoli and Chengalikodan while the highest moisture content was in Changanassery nendran

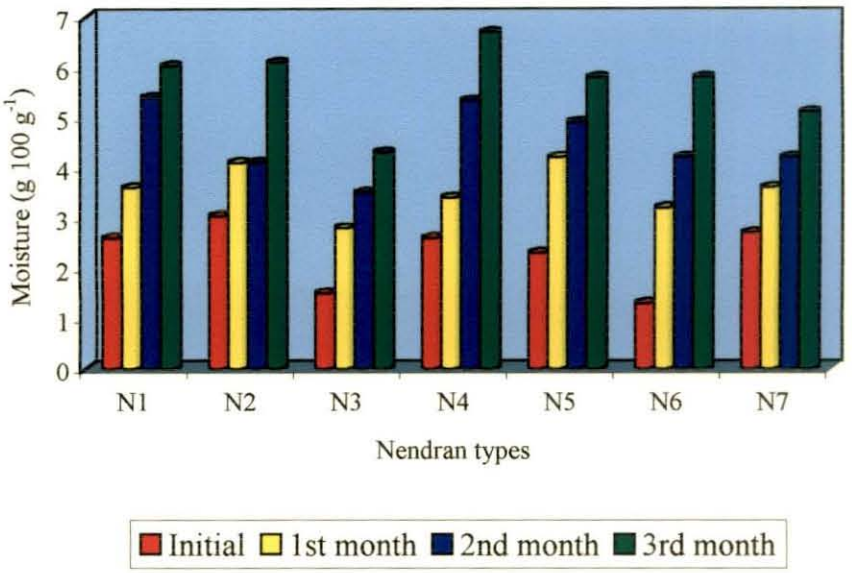

Fig. 21. Effect of storage on moisture content of chips

N1 - Attunendran
N2 - Changanassery nendran
N3 - Chengalikodan
N4 - Kaliethan
N5 - Manjeri nendran I
N6 - Myndoli
N7 - Nedunendran

(3.04 g 100 g^{-1}) and Manjeri nendran I (4.20 g 100 g^{-1}) respectively during these storage period. The highest moisture content was present in the chips prepared from Attunendran (5.40 g 100 g^{-1}) and Kaliethan (6.70 g 100 g^{-1}) during the second and third month of storage while the lowest was in Chengalikodan during both these storage periods (3.50 and 4.30 g 100 g^{-1}).

Significant variation in the moisture content was noticed in the banana chips of different nendran types during all the storage periods. On the basis of DMRT, the banana chips prepared from different nendran types were categorised into four, five, three and four groups during the initial, first, second and third months of storage.

The effect of storage period on the moisture content of banana chips is illustrated in Fig.21.

4.3 ORGANOLEPTIC EVALUATION OF BANANA PRODUCTS

Acceptability of the cooked banana, chips and porridge was evaluated by score card method for different quality attributes like appearance, colour, flavour, texture and taste. Each character was scored using a five point hedonic scale by a panel of 10 judges. Banana chips and porridge were evaluated at monthly intervals for a period of three months. The results are furnished from Table25 to Table27.

4.3.1 Cooked banana

The mean scores obtained for cooked banana prepared from different nendran types are given in Table 25.

Table 25. Organoleptic evaluation of cooked banana

Character / Variety	Appearance	Colour	Flavour	Texture	Taste	Overall acceptability
Attunendran	3.46^{ab}	2.31^{bc}	3.37^{a}	4.16^{a}	3.39^{a}	3.80^{a}
Changanassery Nendran	3.14^{ab}	3.06^{ab}	2.29^{b}	3.88^{a}	3.15^{ab}	2.99^{b}
Chengalikodan	2.74^{abc}	2.15^{bc}	3.13^{ab}	3.32^{a}	2.63^{ab}	2.91^{b}
Kaliethan	2.50^{bc}	1.70^{c}	2.72^{ab}	3.41^{a}	3.03^{ab}	2.96^{b}
Manjeri Nendran I	2.83^{abc}	2.80^{ab}	2.63^{ab}	3.78^{a}	2.86^{ab}	3.15^{b}
Myndoli	2.00^{c}	2.30^{bc}	3.36^{b}	3.62^{a}	2.10^{b}	3.15^{b}
Nedunendran	3.67^{a}	3.58^{a}	2.31^{b}	3.29^{a}	2.52^{ab}	2.90^{b}

Values having different superscripts differ significantly at 5% level
DMRT column wise comparison

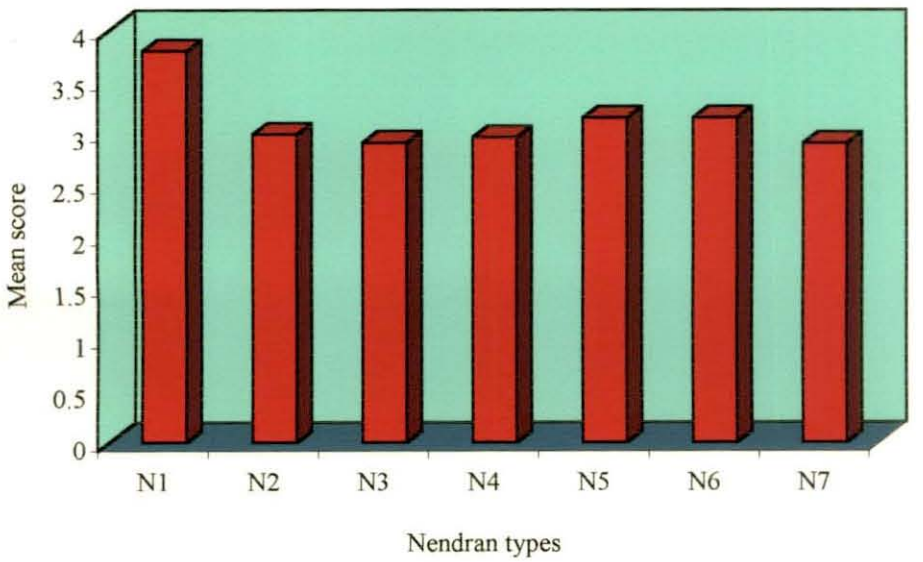

Fig. 22. Overall acceptability of cooked banana

N1 - Attunendran
N2 - Changanassery nendran
N3 - Chengalikodan
N4 - Kaliethan
N5 - Manjeri nendran I
N6 - Myndoli
N7 - Nedunendran

It can be seen that the mean scores for appearance was highest in Nedunendran (3.67) and lowest in Myndoli (2.00) among the seven nendran types. The mean score for colour varied from 1.70 to 3.58 with Nedunendran and Kaliethan having the highest and lowest score respectively.

Changanassery nendran had the lowest score (2.29) for flavour and Attunendran had the highest score (3.37). Myndoli also got an almost similar score (3.36) as that of Attunendran.

For texture, Attunendran (4.16) and Nedunendran (3.29) obtained the highest and lowest scores respectively. The mean scores for taste ranged in between 2.10 to 3.39 with highest score for Attunendran and the lowest for Myndoli.

The overall acceptability of the cooked banana prepared from the different nendran types ranged from 2.90 to 3.80 with Attunendran and Nedunendran having the highest and lowest scores respectively.

The overall acceptability of cooked banana is illustrated in Fig.22.

Statistically, the seven nendran types were categorised into different categories based on appearance (5), colour (4), flavour (3) and taste (3). The results also indicated that there is no significant difference between the nendran types for the quality attributes namely texture. On the basis of the overall acceptability of the cooked banana, the nendran types were categorised into two groups with six nendran types namely Changanassery nendran, Chengalikodan, Kaliethan, Manjeri nendran I, Myndoli and Nedunendran in group 'b' and Attunendran in group 'a'. The nendran types included in the same category were significantly different from the types included in the other categories.

4.3.2 Chips

The mean scores obtained for stored chips prepared from raw nendran types stored at monthly intervals for a period of three months are furnished in Table 26.

Table 26. Organoleptic evaluation of chips of different nendran chips

Character / Variety	Appearance				Colour				Flavour			
	Initial	Ist month	IInd month	IIIrd month	Initial	Ist month	IInd month	IIIrd month	Initial	Ist month	IInd month	IIIrd month
Attunendran	4.78^{a}	4.71^{a}	4.69^{a}	3.80^{ab}	4.50^{ab}	4.10^{a}	4.03^{a}	4.00^{a}	5.00^{a}	4.15^{a}	3.44^{ab}	2.56^{a}
Changanassery nendran	4.42^{a}	4.41^{a}	4.06^{b}	3.60^{ab}	4.40^{ab}	4.09^{a}	3.80^{a}	3.73^{a}	4.29^{ab}	4.00^{ab}	3.36^{ab}	2.29^{a}
Chengalikodan	4.85^{a}	4.76^{a}	4.46^{ab}	4.09^{a}	5.00^{a}	4.30^{a}	4.09^{a}	4.06^{a}	4.40^{ab}	4.25^{a}	3.21^{ab}	2.80^{a}
Kaliethan	4.63^{a}	4.47^{a}	4.12^{b}	3.35^{b}	4.00^{bc}	3.96^{a}	3.88^{a}	3.80^{a}	4.33^{ab}	3.84^{ab}	3.05^{ab}	2.29^{a}
Manjeri nendran I	4.48^{a}	4.38^{a}	4.31^{ab}	3.39^{b}	4.33^{b}	4.06^{a}	3.92^{a}	3.88^{a}	4.47^{ab}	3.88^{ab}	3.21^{ab}	2.36^{a}
Myndoli	4.49^{a}	4.46^{a}	4.24^{ab}	3.88^{ab}	4.12^{bc}	4.00^{a}	3.92^{a}	3.89^{a}	4.53^{ab}	4.30^{a}	3.73^{a}	2.70^{a}
Nedunendran	3.11^{b}	2.81^{b}	2.58^{c}	2.42^{c}	3.51^{c}	3.41^{b}	2.98^{b}	2.78^{b}	4.00^{b}	3.52^{b}	2.81^{ab}	2.40^{a}

Contd.

Table 26. Continued

Character / Variety	Texture				Taste				Overall acceptance			
	Initial	Ist month	IInd month	IIIrd month	Initial	Ist month	IInd month	IIIrd month	Initial	Ist month	IInd month	IIIrd month
Attunendran	4.62^{a}	3.37^{a}	3.01^{a}	2.96^{a}	4.50^{ab}	3.96^{a}	3.32^{a}	2.66^{a}	4.30^{a}	3.96^{a}	2.79^{a}	2.50^{a}
Changanassery nendran	4.61^{a}	3.27^{a}	3.08^{a}	2.89^{a}	4.59^{ab}	3.92^{a}	3.31^{a}	3.05^{a}	4.50^{a}	3.92^{a}	2.70^{a}	2.40^{a}
Chengalikodan	4.70^{a}	3.60^{a}	3.20^{a}	3.01^{a}	4.90^{a}	4.12^{a}	3.47^{a}	2.89^{a}	4.80^{a}	4.10^{a}	3.06^{a}	2.76^{a}
Kaliethan	4.59^{a}	3.39^{a}	2.88^{a}	2.50^{a}	4.77^{a}	3.99^{a}	3.55^{a}	2.49^{a}	4.66^{a}	3.88^{a}	2.76^{a}	2.40^{a}
Manjeri nendran I	4.74^{a}	3.40^{a}	3.06^{a}	2.90^{a}	4.56^{ab}	4.12^{a}	3.22^{a}	2.79^{a}	4.80^{a}	3.96^{a}	2.73^{a}	2.10^{a}
Myndoli	4.60^{a}	3.68^{a}	3.15^{a}	2.99^{a}	4.39^{ab}	4.30^{a}	3.28^{a}	2.81^{a}	4.50^{a}	4.03^{a}	2.88^{a}	2.63^{a}
Nedunendran	4.50^{a}	3.38^{a}	3.09^{a}	2.81^{a}	3.96^{b}	3.87^{a}	3.63^{a}	2.95^{a}	4.23^{a}	4.02^{a}	3.02^{a}	2.56^{a}

Values having different superscript differ significantly at 5% level
DMRT column wise comparison

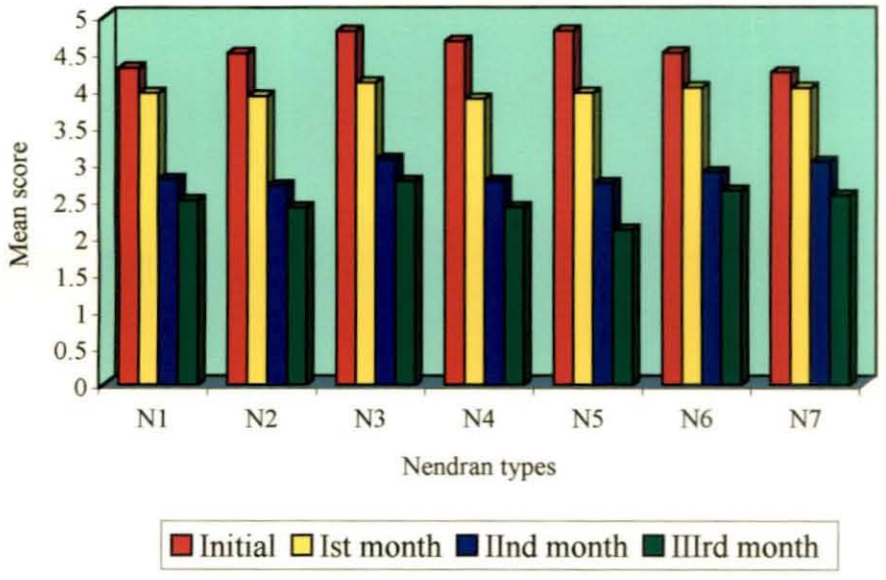

Fig. 23. Effect of storage period on overall acceptability of nendran chips

N1 - Attunendran
N2 - Changanassery nendran
N3 - Chengalikodan
N4 - Kaliethan
N5 - Manjeri nendran I
N6 - Myndoli
N7 - Nedunendran

The mean scores for appearance varied from 3.11 to 4.85 during the starting of the experiment and 2.42 to 4.09 at the end of the storage period. The scores for appearance during both stages were found to be lowest in Nedunendran and highest in Chengalikodan.

The mean score for colour was found to be highest in Chengalikodan and lowest in Nedunendran during initial and at the end of the storage period.

The initial mean scores for flavour was found to be highest in Attunendran (5.00) and lowest in Nedunendran (4.00), while at the end of the storage, highest score for flavour was observed in Chengalikodan (2.80) and lowest in Changanassery nendran and Kaliethan (2.29).

The initial scores for texture of chips prepared from seven nendran types varied from 4.50 to 4.74 with Nedunendran and Manjeri nendran I having the lowest and highest scores respectively. At the end of three months of storage, the scores ranged between 2.50 to 3.01. Chengalikodan and Kaliethan obtained the highest and lowest scores for texture respectively.

The mean score for taste varied from 3.96 to 4.90 with the chips of Nedunendran and Chengalikodan having the lowest and highest scores respectively. The taste of the chips decreased gradually during the storage period and Changanassery nendran had the highest mean score and Attunendran the lowest score for taste at the end of the storage period.

The overall acceptability of chips was found to be highest (4.80) for Chengalikodan and Manjeri nendran I and lowest for Nedunendran (4.23) at the starting of the storage period. At the end of the storage period Chengalikodan got the highest mean score (2.76) for overall acceptability and lowest was for Manjeri nendran I (2.10).

Effect of storage period on the overall acceptability of chips prepared from different nendran types is shown in Fig.23.

Statistical analysis revealed that in the initial stage and in the first month of storage, chips of Nedunendran differed significantly from other nendran types with respect to appearance and colour. At the second months of storage Chengalikodan, Manjeri nendran I and Myndoli were categorised in the same group ('ab') and Changanassery nendran and Kaliethan into group 'b' and Attunendran in group 'a' with respect to appearance. The third month of storage showed a DMRT classification of four categories. Three of the members were grouped in 'ab', two in group 'b' and one each in 'a' and 'c' categories.

DMRT classified the initial colour of chips of different nendran types into five categories. The categories 'ab' and 'bc' had two members each and the categories 'a', 'b' and 'c' had one member each. The classification of first, second and third months were done in two groups. Group 'a' had six members and group 'b' had only one member. The members of group 'ab' were comparable with 'a' and 'b' and 'bc' with 'b' and 'c'.

With respect to the flavour characteristics during the initial, and first months of storage, the chips were categorised into three groups. Initially group 'a' and 'b' had one member each and group 'ab' had five members. In the first month of storage, group 'a' and 'ab' had three members each and during the second month of storage group 'ab' had five members and group 'a' had only one member. DMRT classified the flavour characteristic of the different nendran types stored up to third month into a single category 'a', showing that variation in flavour of chips was insignificant.

Statistical classification with respect to texture of chips of different nendran types stored for a period of three months showed that there was no significant variation statistically between the nendran types at each stages of storage and hence they were classified into a single group 'a'.

On the basis of taste of chips made from different nendran types, they were classified into three categories. Group 'ab' had four members, group 'a' had two and

group 'b' had one member. During the first, second and third months of storage, statistically significant variation was not observed between the nendran types at each phases of storage and was classified in a single group 'a'.

The overall acceptability of the chips during different months of storage showed that the chips did not differ significantly between the nendran types at each stages of storage and was categorised into a single group 'a'.

4.3.3 Porridge

The mean scores obtained for porridge prepared from raw banana flour is furnished in Table 27 and the effect of storage of banana flour on the overall acceptability of porridge is illustrated in Fig. 24.

From the table, it can be seen that the initial mean scores for the appearance of porridge prepared from different nendran types ranged from 3.96 (Chengalikodan) to 4.09 (Changanassery nendran). At the end of storage period, Myndoli had the highest score of 3.92 and Kaliethan had the lowest score of 3.68.

The highest mean score for colour during the initial period and at the end of the third month of storage was obtained for Chengalikodan (3.96) and Myndoli (3.69) while the lowest score initially was for Kaliethan (3.75) and for Changanassery nendran (3.38) at the end of the storage period.

The initial mean scores for flavour was found to be highest in Myndoli (4.7) and lowest in Manjeri nendran I (4.03). Final phase of the storage period revealed highest mean score of 4.1 for Chengalikodan and Myndoli and lowest for Changanassery nendran (3.46).

The initial scores for texture varied from 3.56 to 4.63 with Kaliethan and Chengalikodan having the lowest and highest scores respectively. At the end of three months, the scores ranged between 2.98 (Kaliethan) to 3.86 (Nedunendran).

Table 27. Organoleptic evaluation of porridge of different nendran types

Character / Variety	Appearance				Colour				Flavour			
	Initial	Ist month	IInd month	IIIrd month	Initial	Ist month	IInd month	IIIrd month	Initial	Ist month	IInd month	IIIrd month
Attunendran	4.06^{a}	3.96^{a}	3.89^{a}	3.88^{a}	3.76^{a}	3.62^{a}	3.59^{a}	3.43^{a}	4.33^{ab}	4.22^{ab}	4.00^{a}	3.96^{a}
Changanassery nendran	4.09^{a}	3.99^{a}	3.82^{a}	3.71^{a}	3.95^{a}	3.76^{a}	3.68^{a}	3.38^{a}	3.77^{b}	3.66^{b}	3.52^{a}	3.46^{a}
Chengalikodan	3.96^{a}	3.88^{a}	3.79^{a}	3.70^{a}	3.96^{a}	3.89^{a}	3.68^{a}	3.58^{a}	4.36^{ab}	4.20^{ab}	4.16^{a}	4.10^{a}
Kaliethan	3.99^{a}	3.96^{a}	3.92^{a}	3.68^{a}	3.75^{a}	3.65^{a}	3.55^{a}	3.39^{a}	4.30^{ab}	4.15^{ab}	3.69^{a}	3.81^{a}
Manjeri nendran I	4.03^{a}	4.00^{a}	3.96^{a}	3.85^{a}	3.92^{a}	3.85^{a}	3.60^{a}	3.64^{a}	4.03^{ab}	4.00^{ab}	3.72^{a}	3.69^{a}
Myndoli	4.06^{a}	3.93^{a}	3.93^{a}	3.92^{a}	3.79^{a}	3.75^{a}	3.69^{a}	3.69^{a}	4.70^{a}	4.40^{a}	4.20^{a}	4.10^{a}
Nedunendran	4.03^{a}	3.95^{a}	3.89^{a}	3.87^{a}	3.92^{a}	3.75^{a}	3.65^{a}	3.59^{a}	4.30^{ab}	4.30^{ab}	4.10^{a}	4.02^{a}

Contd.

Table 27. Continued

Character / Variety	Texture				Taste				Overall acceptance			
	Initial	Ist month	IInd month	IIIrd month	Initial	Ist month	IInd month	IIIrd month	Initial	Ist month	IInd month	IIIrd month
Attunendran	4.13^{ab}	4.00^{a}	3.88^{a}	3.81^{a}	3.69^{a}	3.50^{a}	3.49^{a}	3.64^{a}	3.95^{a}	3.78^{a}	3.55^{a}	3.42^{a}
Changanassery nendran	4.02^{ab}	3.88^{a}	3.71^{a}	3.71^{a}	3.73^{a}	3.46^{a}	3.10^{a}	3.26^{a}	3.92^{a}	3.89^{a}	3.67^{a}	3.47^{a}
Chengalikodan	4.63^{a}	4.06^{a}	3.95^{a}	3.78^{a}	3.70^{a}	3.65^{a}	3.62^{a}	3.52^{a}	4.20^{a}	4.13^{a}	4.00^{a}	3.78^{a}
Kaliethan	3.56^{b}	3.33^{b}	3.27^{a}	2.98^{a}	3.92^{a}	3.92^{a}	3.92^{a}	3.76^{a}	3.96^{a}	3.96^{a}	3.81^{a}	3.59^{a}
Manjeri nendran I	4.20^{ab}	4.10^{a}	4.06^{a}	3.80^{a}	3.70^{a}	3.36^{a}	3.20^{a}	3.41^{a}	3.96^{a}	3.90^{a}	3.80^{a}	3.38^{a}
Myndoli	4.13^{ab}	4.03^{a}	3.94^{a}	3.78^{a}	3.60^{a}	3.72^{a}	3.58^{a}	3.92^{a}	4.00^{a}	4.00^{a}	3.58^{a}	3.53^{a}
Nedunendran	4.30^{a}	4.00^{a}	3.92^{a}	3.86^{a}	3.90^{a}	3.86^{a}	3.62^{a}	3.35^{a}	4.00^{a}	4.00^{a}	3.78^{a}	3.54^{a}

Values having different superscript differ significantly at 5% level
DMRT column wise comparison

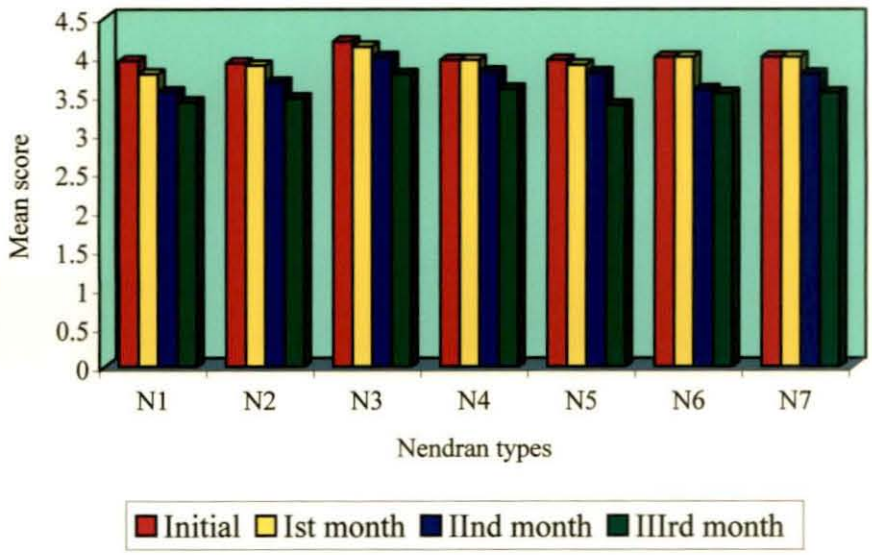

Fig. 24. Effect of storage period on overall acceptability of porridge

N1 - Attunendran
N2 - Changanassery nendran
N3 - Chengalikodan
N4 - Kaliethan
N5 - Manjeri nendran I
N6 - Myndoli
N7 - Nedunendran

The mean scores for taste ranged from 3.60 (Myndoli) to 3.92 (Kaliethan) during the initial period while at the end of the storage period it varied in between 3.26 to 3.92 with Myndoli having the highest mean score and Changanassery nendran having the lowest.

Overall acceptability of the porridge prepared from all the seven nendran types also showed a decrease during the storage period. Overall acceptability of the porridge was found to be highest for Chengalikodan during the initial storage period and at the end of the storage period. The lowest score was observed for the porridge prepared from Changanassery nendran during the initial period (3.92) and Manjeri nendran I at the end of the storage period (3.38).

Effect of storage period on the overall acceptability of banana porridge is given in Fig. 24.

When the mean scores were analysed statistically it was seen that there was no significant difference between the nendran types for the porridge with respect to appearance, colour, taste and overall acceptability at any stage of storage. Significant variation in the porridge flavour was noticed only during initial and first month of storage between the members included in group 'a' and 'b'. Statistically significant variation in textural characteristics of porridge was noticed between the nendran types included in group 'a' and 'b' during the initial and first month of storage. During the second and third months of storage, no significant variation was observed among the nendran types with respect to texture of porridge.

4.4 ENUMERATION OF TOTAL MICROFLORA OF BANANA FLOUR

The enumeration of total bacteria, fungi and yeast was done in banana flour stored in pet jars at monthly intervals and the results are furnished in Table 28.

4.4.1 Total bacterial count

Under control conditions, the total bacterial count ranged from 2.33×10^6 to 11.33×10^6 cfu g^{-1} with Nedunendran variety having the highest count and Attunendran having the lowest count.

Table 28. Total microbial count of banana flour (cfu g^{-1} of the sample) at monthly intervals

Treat-ments	Nendran types	Storage period (months)											
		Control			1st			2nd			3rd		
		Bacteria (x 10^6)	Fungi (x 10^4)	Yeast (x 10^4)	Bacteria (x 10^6)	Fungi (x 10^4)	Yeast (x 10^4)	Bacteria (x 10^6)	Fungi (x 10^4)	Yeast (x10^4)	Bacteria (x 10^6)	Fungi (x 10^4)	Yeast (x 10^4)
T_1	Attunendran	2.33 (6.36)^b	3.66 (4.56)^b	0	3.33 (6.52)^b	5.0 (4.69)^{abc}	0	4.33 (6.63)^b	6.66 (4.82)^{ab}	0	4.33 (6.63)^b	7.33 (4.86)^{abc}	0
T_2	Changanassery nendran	3.66 (6.56)^b	3.66 (4.58)^b	0	4.0 (6.59)^{ab}	3.66 (4.56)^c	0	4.66 (6.67)^{ab}	5.66 (4.75)^b	0	5.0 (6.69)^{ab}	6.33 (4.8)^c	0
T_3	Chengalikodan	2.66 (6.56)^b	5.66 (4.75)^{ab}	0	4.66 (6.65)^{ab}	6.66 (4.82)^a	0	6.33 (6.8)^a	7.3 (4.88)^b	0	6.66 (6.82)^a	9.0 (4.94)^{ab}	0
T_4	Kaliethan	4.0 (6.59)^b	3.66 (4.56)^b	0	6.0 (6.77)^a	5.66 (4.75)^{ab}	0	6.33 (6.78)^{ab}	8.66 (4.93)^a	0	8.0 (6.79)^a	9.33 (4.97)^a	0
T_5	Manjeri nendran I	2.66 (6.42)^b	3.33 (4.52)^b	0	4.0 (6.59)^{ab}	4.66 (4.67)^{bc}	0.33 (4.00014)	4.33 (6.63)^b	6.66 (4.82)^{ab}	0	5.33 (6.73)^{ab}	7.0 (4.84)^{bc}	0
T_6	Myndoli	3.33 (6.50)^b	3.66 (4.56)^b	0	4.0 (6.59)^{ab}	6.33 (4.79)^{ab}	0.33 (4.000014)	4.33 (6.63)^b	6.0 (4.77)^b	0	4.0 (6.59)^b	7.0 (4.84)^{bc}	0
T_7	Nedunendran	11.3 (6.95)^a	3.3 (4.52)^b	0.66 (4.00028)	5.55 (6.52)^a	5.0 (4.69)^{abc}	0	6.0 (6.78)^{ab}	5.0 (4.8)^b	0	6.0 (6.78)^a	7.33 (4.86)^{abc}	0.33 (4.000014)

Values having different superscript differ significantly at 5% level
DMRT column wise comparison
(Values in parenthesis indicates log transformed value)

The maximum total bacterial count of banana flour after one month of storage was found in Kaliethan (6.0 x 10^6 cfu g^{-1}) and the lowest count being in Attunendran (3.33 x 10^6 cfu g^{-1}).

During the second month of storage, the bacterial count was maximum in the banana flour of nendran types Chengalikodan and Kaliethan (6.33 x 10^6 cfu g^{-1}) and the minimum count in Attunendran, Manjeri nendran I and Myndoli (4.33 x 10^6 cfu g^{-1}).

During the third month of storage the bacterial count varied from 4 x 10^6 cfu g^{-1} (Myndoli) to 8 x 10^6 cfu g^{-1} (Kaliethan).

The effect of storage period on the total bacterial count of banana flour is given in Fig. 25.

4.4.2 Total fungal count

The fungal count in control ranged from 3.33 x 10^4 cfu g^{-1} in the banana flour of nendran types Manjeri nendran I and Nedunendran to 5.66 x 10^4 cfu g^{-1} in Chengalikodan.

After one month of storage, the fungal count was found to be maximum in the banana flour of Chengalikodan (6.66 x 10^4 cfu g^{-1}) and minimum in Changanassery nendran (3.66 x 10^4 cfu g^{-1}).

The banana flour of nendran type Kaliethan showed the maximum fungal count (8.66 x 10^4 cfu g^{-1}) and Myndoli and Nedunendran showed the least count (6.0 x 10^4 cfu g^{-1}) after two months of storage.

The fungal count ranged from 6.33 x 10^4 to 9.33 x 10^4 cfu g^{-1} after three months of storage of banana flour with Kaliethan and Changanassery nendran having the maximum (9.33 x 10^4 cfu g^{-1}) and minimum (6.33 x 10^4 cfu g^{-1}) count respectively.

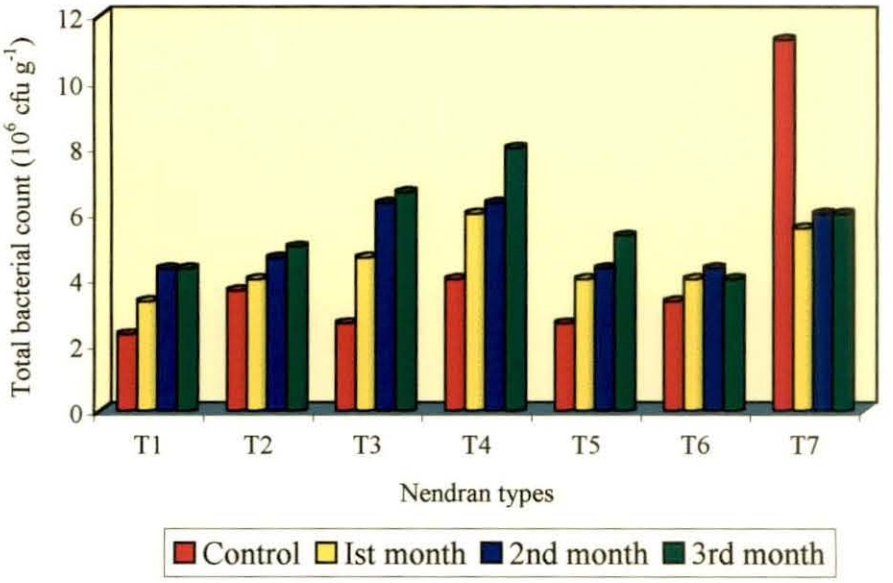

Fig. 25. Effect of storage period on total bacterial count of banana flour

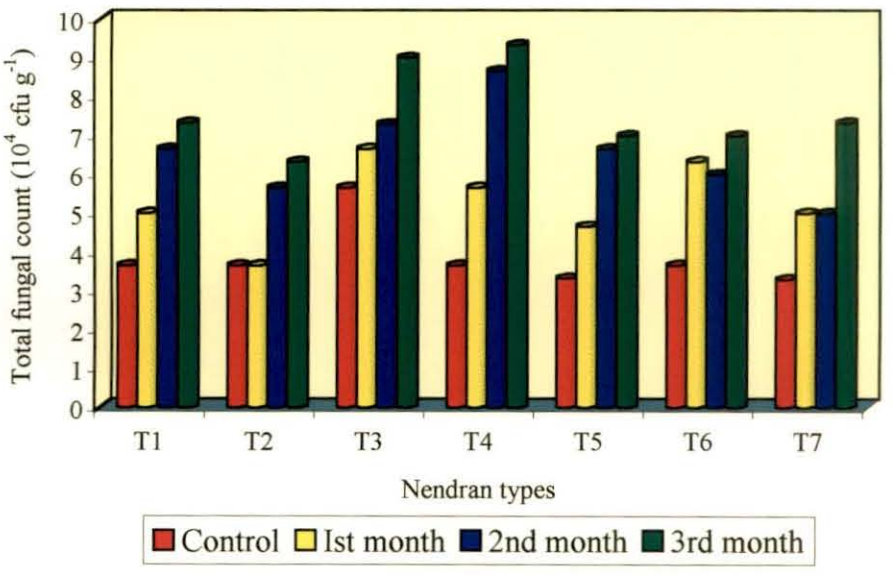

Fig. 26. Effect of storage period on total fungal count of banana flour

T1 - Attunendran
T2 - Changanassery nendran
T3 - Chengalikodan
T4 - Kaliethan
T5 - Manjeri nendran I
T6 - Myndoli
T7 - Nedunendran

The effect of storage period on the total fungal count of banana flour is given in Fig. 26.

4.4.3 Total yeast count

The presence of yeast was found to be meager in all stages of storage. In control only Nedunendran showed the presence of yeast in them (0.66×10^4 cfu g^{-1}.

After one month of storage, yeast was found in nendran types Manjeri nendran I and in Myndoli (0.33×10^4 cfu g^{-1}).

There was absence of yeast in the second month of storage in all the nendran types.

After three months of storage, Nedunendran showed an yeast count of 0.33×10^4 cfu g^{-1}.

The effect of storage period in the total yeast count of banana flour is given in Fig. 27.

In effect, the banana flour made from the nendran types Attunendran, Manjeri nendran I and Myndoli was found to have the minimum total micro flora in comparison with other nendran types and thus showed good shelf life with respect to total micro flora.

Logarithmic transformation of the mean count was done and DMRT was applied to it. Statistically significant difference was observed in the banana flour among the nendran types on the basis of total bacterial count and total fungal count at all stages of storage. DMRT classified the nendran types into separate groups. The members of each group had no significant difference within themselves but differed significantly from the nendran types included in other groups.

Statistical analysis with regard to total yeast count was not done since it was present sparingly.

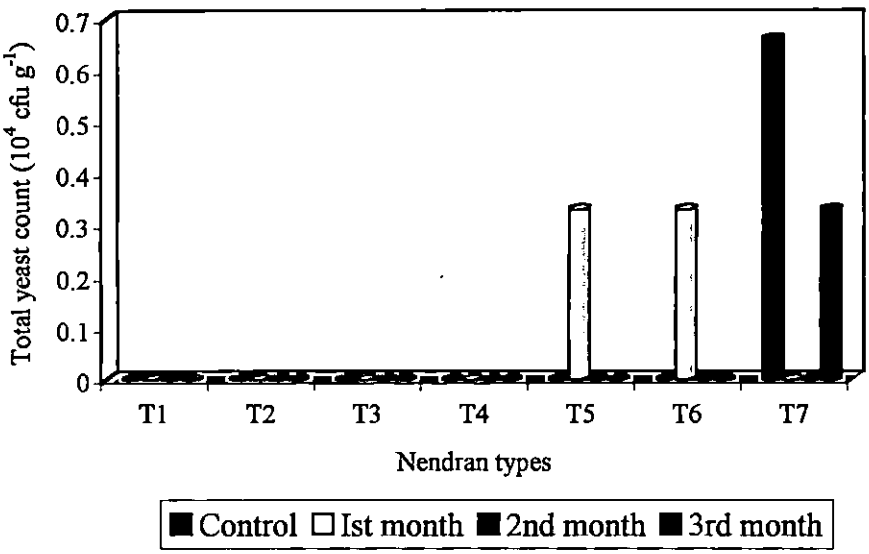

Fig. 27. Effect of storage period on total yeast count of banana flour

T1 - Attunendran
T2 - Changanassery nendran
T3 - Chengalikodan
T4 - Kaliethan
T5 - Manjeri nendran I
T6 - Myndoli
T7 - Nedunendran

Discussion

5. DISCUSSION

The results of the study entitled "Evaluation of fruit quality in banana 'Nendran' (*Musa* AAB)" are discussed under the following headings.

5.1 Physical characters of nendran types

5.2 Chemical constituents of nendran types and products

5.3 Quality evaluation of banana products

5.1 PHYSICAL CHARACTERS OF NENDRAN TYPES

Significant variation in the different physical characters namely finger weight and finger length was observed in the seven nendran types. The mean finger weight and finger length of the nendran types was found to be 161.73 g and 21.92 cm respectively. The highest finger weight was observed in Manjeri nendran I (183.20 g), while Nedunendran had the highest finger length (26.84 cm). Thajudeen (2000) in a study conducted on quality evaluation of eleven banana varieties reported a mean finger weight of 143.30 g in nendran variety and the author observed significant variation in the finger weight of nendran fruit in the raw stage with the other ten banana varieties. Shanmughavelu *et al.* (1992) also reported significant variation in the finger weight of nendran clones. Tripathi *et al.* (1981) also reported almost similar finger weight for nendran banana.

With respect to the finger length, significant difference was observed among the nendran types. The finger length ranged from 20.06 cm (Chengalikodan) to 26.84 cm (Nedunendran). Josh (2001) reported a variation in finger length of banana varieties from 10 cm to 30 cm which was also found to be almost similar to the finger length observed in the nendran clones of the study. Variation observed in the finger weight and length of nendran clones may be due to varietal differences and seasonal influences.

The pulp and peel weight of nendran types showed significant variation. The pulp weight of the nendran clones was found to be above 82 g with a highest pulp

weight in Attunendran and a mean pulp weight of 96.28 g. All the nendran types had high pulp weight as reported by Almazan (1991). The highest peel weight was also observed in Attunendran and lowest in Changanassery nendran with a mean peel weight of 55.52 g. Varietal differences were observed clearly with respect to the peel weight.

The pulp/peel ratio of the nendran types varied from 1.57 to 2.01. The highest pulp peel ratio of 2.01 was observed in Chengalikodan. Thajudeen (2000) reported a high pulp/peel ratio of 2.23 in nendran variety. The results obtained in this study are in the range observed by Tripathi *et al.* (1981), Asedu (1987) and Singh and Uma (1995), but lower than those reported by Ngalani *et al.* (1998).

The curvature of nendran type Attunendran, Myndoli and Nedunendran was found to be straight in distal part and the nendran types Chengalikodan, Kaliethan and Manjeri nendran I showed a slightly curved curvature. The nendran type Changanassery nendran had curved curvature, showing its varietal character.

Pronounced ridged angularity was observed in the nendran types Changanassery nendran and Nedunendran and the nendran types Attunendran, Chengalikodan, Kaliethan and Myndoli showed a slightly ridged angularity. The angularity of nendran type Manjeri nendran I was round showing the varietal character of this nendran type.

5.2 CHEMICAL CONSTITUENTS OF NENDRAN TYPES AND PRODUCTS

5.2.1 Chemical constituents of nendran types

The mean moisture content of seven nendran types was found to be 65.68 g 100 g^{-1} with significant variation in the moisture content within the nendran types was observed. The moisture content in nendran types varied from 60.91 to 71.48 g 100 g^{-1} with Manjeri nendran I having the lowest and Attunendran the highest. Thajudeen (2000) also observed 61.93 per cent moisture in nendran variety of banana. The findings of present study was found to be in accordance with the moisture content in

different banana varieties reported by Marriot *et al.* (1981), Chadha (1992), and Thajudeen (2000). However, the moisture content observed in the present study are slightly lower than the moisture content in banana varieties reported by Chia and Huggins (1998), Josh (2001) and Swaminathan (1999) who reported a mean moisture content of 74 to 83.2 per cent in banana varieties.

Significant variation was observed in the protein content of different nendran types. The protein content varied from 1.2 to 1.6 per cent with a mean protein content of 1.5 per cent. Thajudeen (2000) also observed a protein content of 1.43 per cent in nendran variety of banana and the author reported significant variation in the protein content of different banana varieties with a range in between 0.50 g in Kanchikela to 1.74 in Kunnan variety of banana. Padmaja and Koshy (1977) reported a protein content of 1.19 to 3.83 per cent in banana varieties. The values obtained in the present study were found to be in accordance with these findings. Gopalan *et al.* (1999) also reported similar protein content in banana. However, Swaminathan (1999) reported a protein content of 0.58 per cent in banana which was found to be slightly lower than the protein content observed in the nendran types evaluated in the present study. This variation may be due to the varietal difference and also due to the difference in the location.

Crude fibre content of the nendran types varied from 0.50 to 0.86 per cent. Significant variation in the fibre content was observed in the nendran types with mean crude fibre content of 0.57 per cent. Gopalan *et al.* (1999) and Swaminathan (1999) also reported almost similar crude fibre content in banana. However, Josh (2001) found slightly lower crude fibre than the values obtained in the present study. Thajudeen (2000) reported that the nendran variety of banana had a 0.19 per cent of crude fiber. The author also reported a variation of 0.05 to 0.36 per cent of crude fibre in different banana varieties. The fibre content of nendran types observed in the present study was higher than the values reported earlier by Thajudeen (2000). The variation may be due to the varietal differences.

The starch content of nendran types varied from 18.1 to 25.75 per cent with the highest and lowest values in Chengalikodan and Myndoli respectively. Significant

variation in the starch content of nendran types was observed in the present study with a mean starch content of 21.7 per cent. Josh (2001) also reported a starch content of 25 per cent in banana which was in tune with the results obtained in the present study. However, the starch content observed in the present study was higher than the values reported by Chacon *et al.* (1987) and Sira (1997) who reported a starch content ranging from 10 to 17.7 per cent. Thajudeen (2000) reported a starch content of 12.0 g 100 g^{-1} in nendran variety of banana. Castillo *et al.* (1997) reported a starch content of 31 g 100 g^{-1} in banana which was higher than the values observed in the present study.

The calcium content of nendran types varied from 17.73 to 24.31 mg 100 g^{-1} with a mean calcium content of 20.01 mg 100 g^{-1}. Thajudeen (2000) also observed almost similar calcium content of 18.03 mg 100 g^{-1} in nendran variety of banana. However, the calcium content of different banana varieties studied by Thajudeen (2000) were in between 8.3 to 34.44 mg 100 g^{-1}. But Villalonga (1981), Gopalan *et al.* (1999), Swaminathan (1999) and Josh (2001) reported a very low calcium content in banana which varied from 5 mg to 11.04 mg 100 g^{-1}.

The phosphorus content of nendran types ranged from 26.40 mg to 38.69 mg 100 g^{-1} with the highest and lowest phosphorus contents in Chengalikodan and Attunendran respectively and a mean phosphorus content of 30.31 mg 100 g^{-1}. The phosphorus content observed in the present study was in close range with the values reported by Villalonga (1981), Chadha (1992), Gopalan *et al.* (1999) and Swaminathan (1999). Thajudeen (2000) reported a phosphorus content of 26.40 mg 100 g^{-1} in nendran variety of banana and in other varieties, the phosphorus content varied from 20.85 to 39.70 mg 100 g^{-1}.

Significant variation in the iron content of nendran types was observed with a variation of 3.16 to 7.44 mg 100 g^{-1} and a mean iron content of 5.69 mg 100 g^{-1}. Chengalikodan had the highest and Myndoli had the lowest iron content. Thajudeen (2000) reported a slightly lower iron content of 2 mg 100 g^{-1} in nendran variety of banana and the iron content varied from 1.02 to 5.43 mg 100 g^{-1} in other banana varieties. Elpo *et al.* (1998) and Gopalan *et al.* (1999) reported almost similar iron

content of 7.59 mg to 15.20 mg and 6.27 mg 100 g^{-1} respectively. The variation in the iron content may be due to the differences in the varieties selected for the study.

The potassium content of nendran types varied from 316.7 mg 100 g^{-1} to 455.01 mg 100 g^{-1} with Attunendran having the lowest and Chengalikodan having the highest value and a mean potassium content of 387.02 mg 100 g^{-1}. The potassium content of nendran types evaluated in the present study was found to be almost similar to the values reported by Thajudeen (2000) who observed a potassium content of 391.9 to 563.8 mg 100 g^{-1} in banana varieties. However, the author a observed potassium content of 514.2 mg 100 g^{-1} in nendran variety of banana which was found to be higher than the potassium content of all the seven nendran types in the present study. Park (1974) and Chia and Huggins (1998) reported almost similar potassium content in nendran types as in the present study.

The vitamin C content of nendran types were found to be very low. Significant variation in the vitamin C content of nendran types was observed with a mean content of 20.24 mg 100 g^{-1}. The vitamin C content of nendran types varied from 13.67 to 24.79 mg 100 g^{-1}. Anil (1994) reported an ascorbic acid content of 9.37 mg 100 g^{-1}, while Deepa (1997) reported a vitamin C content of 3.07 mg 100 g^{-1} in nendran variety of banana. The vitamin C content observed in nendran types was in tune with the values reported by Swaminathan (1999). Thajudeen (2000) also observed a vitamin C content of 20.40 mg 100 g^{-1} in nendran variety of banana which was similar to the mean vitamin C content observed in the present study.

5.2.2 Chemical constituents of banana flour

The mean moisture content of the banana flour varied from 5.40 per cent at the beginning of the experiment to 7.7 per cent during the third month of storage. The mean moisture content of banana flour was found to be in accordance with the moisture content of the banana flour reported by Mota *et al.* (2000). The nendran types Chengalikodan and Nedunendran reported higher initial moisture content than the other nendran types.

A gradual increase in the moisture content of the banana flour of all nendran types was noticed during storage which resulted in lumpiness in banana flour during the end of storage. The gradual increase in the moisture content might be due to the absorption of moisture from the atmosphere. The banana flour prepared from the nendran type Kaliethan had a higher moisture content of 8.78 per cent towards the end of the storage period. The storage study of this banana flour was conducted during the peak of monsoon season when the relative humidity of the atmosphere was high. This might have resulted in the highest moisture content in the banana flour of this particular nendran type. Variation in moisture content of banana flour was observed between the nendran types. Manjeri nendran I had the lowest moisture content during the initial, first and third months of storage.

The mean protein content of the banana flour varied from 4.20 to 4.48 per cent. Suntharalingam and Ravindran (1993) and Mota *et al.* (2000) reported a slightly lower protein content of 3.2 per cent and 3.3 per cent respectively in banana flour. Though, a decrease in the mean protein content of the banana flour was observed during storage, the decrease was found to be very negligible. The mean protein content of banana flour was found to be same during the second and third months of storage. The protein content of Attunendran and Kaliethan was found to be low when compared with other nendran types, showing their varietal character from other nendran types.

The protein content of raw nendran types and banana flour showed similarity. In both the cases, high protein content was found in Chengalikodan and Manjeri nendran I and lowest in Attunendran.

The crude fibre content of the banana flour was found to be very low. A decrease in the mean fibre content of banana flour and the flour of different nendran types was observed during storage with a mean crude fibre content of 0.08 per cent at the end of the storage and 0.14 per cent during the initial period of storage.

The values observed were lower than the values observed by Suntharalingam and Ravindran (1993). The gradual decrease in the mean fibre content

might be due to the degradation of polysaccharides during storage. Two nendran types namely Changanassery nendran and Chengalikodan did not contain any fibre.

The low level of crude fibre content in banana flour in comparison with the fibre content of nendran types might be due to the removal of the peel while preparing banana flour. Banana peel had been found to be a good source of fibre and Ranzani *et al.* (1996) reported a fibre content of 32 per cent in banana peel.

The mean starch content of banana flour varied from 61.9 g 100 g^{-1} to 64.6 g 100 g^{-1}. The highest and lowest starch content was observed during the initial stage and the end of the experiment. The mean starch content of banana flour is in accordance with the values reported by Suntharalingam and Ravindran (1993) and Mota *et al.* (2000).

Gradual decrease in the starch content was observed in all nendran types during storage. This might be due to the conversion of starch to sugars.

Singh and Uma (1994) observed that banana flour is a good source of minerals. The mean calcium content in the present study was 57.3 mg 100 g^{-1} at the initial stage and 51.9 mg 100 g^{-1} at the end of the storage period. A slight decrease in the mean calcium content and the calcium content of the banana flour of different nendran types was observed during storage. The nendran types Kaliethan and Myndoli had exceptionally low calcium content when compared with other nendran types. The calcium content in banana flour was higher than those obtained in raw nendran types, which indicates that most of the calcium in banana is present in the pulp of banana and not in peel which was discarded during the preparation of flour.

The mean phosphorus content ranged from 63.9 mg 100 g^{-1} to 69.4 mg 100 g^{-1}. Highest phosphorus content was seen during the initial stage of storage. A gradual decrease in the phosphorus content was seen during storage. High phosphorus content was observed in nendran types Chengalikodan and Nedunendran and lowest in Attunendran. The phosphorus content in the raw nendran types had the maximum and minimum in the same nendran types.

The mean iron content of the banana flour was 6.1, 5.7, 5.1, 5.1 and 4.9 mg 100 g^{-1} at the initial, first, second and third months of storage. A gradual decrease in the iron content of banana flour was observed during storage. The highest iron content was observed in Chengalikodan and Manjeri nendran I and low in Kaliethan and Myndoli as in the case of raw nendran types. The variation in the iron content may be due to the varietal difference.

The mean potassium content was 591.3 mg 100 g^{-1} at the initial stage and 553.2 at the end of three months. The results obtained showed that banana is a good source of potassium. Park (1974) and Chia and Huggins (1998) also reported a high potassium in banana. A gradual decrease in the mean potassium content of banana flour was observed during storage. Highest potassium content was observed in nendran type Chengalikodan and lowest in Attunendran as in the case of raw nendran types.

The gradual decrease in nutrients in banana flour on storage might have also been due to the utilization of nutrients by the microbes growing in the banana flour. This view has been suggested by Rangaswami and Bagyaraj (2000) who reported that microbes in foodstuffs utilize the nutrients from the food for their needs.

5.2.3 Moisture content of chips

Moisture content affects the texture of chips and their overall acceptability. An increase in moisture content of chips was observed during storage in all nendran types. Hence, the chips became soggy in texture. This will have a very good say in the organoleptic evaluation. The mean moisture content increased from 2.29 per cent at the initial stage to 5.69 per cent after three months of storage. The effect of moisture content on the texture of chips can be clearly explained by the fact that the chips from the nendran type Kaliethan which had the highest moisture content towards the end of the storage period obtained very low score for the quality character texture in the acceptability studies.

The gradual increase in the moisture content of the chips over the period of storage may be due to the fact that polyethylene bags allows the absorption of

moisture as reported by Beerah *et al.* (1990) in potato chips. Liya (2001) also reported that taro chips when stored in low density polyethylene (LDPE) bags lost their crisp texture due to the absorption of moisture. High moisture content observed in the chips prepared from the nendran type Kaliethan may be due to the fact that the storage study of this particular chips was done during the peak of monsoon season when relative humidity was high. Thus, the moisture absorption of the chips depends on moisture barrierness of the packaging media and relative humidity of the atmosphere.

5.3 QUALITY EVALUATION OF BANANA PRODUCTS

5.3.1 Organoleptic evaluation

5.3.1.1 Cooked banana

The nendran type Attunendran had the highest mean score for overall acceptability (3.8) and Nedunendran the lowest (2.90) for cooked banana. The highest score for the quality characters namely flavour, texture and taste were also found to be maximum for Attunendran when compared with the other nendran types. The appearance and colour of cooked banana was found to be best for Nedunendran. Attunendran was categorised as a single member in group 'a' showing significant variation in the overall acceptability of cooked banana of this nendran type from other nendran types.

The overall acceptability of chips prepared from different nendran types did not show significant difference at any stage of storage. This might be due to the fact that the nendran chips which are very popular in Kerala would not have shown any difference between the nendran types. The chips prepared from Nedunendran had the lowest score for all the quality characters at the starting of the experiment and also during the end of the storage period, thus making it the least suitable nendran type for preparing chips. Chengalikodan had the highest score for most of the quality characters. Chips prepared from Chengalikodan was found to be the best, since the overall acceptability of the banana chips of Chengalikodan was found to have a high score during different storage periods. The chips of this nendran type scored the highest score also for different quality characters during most of the storage periods.

The lowest score for overall acceptability was found to be for Nedunendran at the initial stage and for Manjeri nendran I at the end of the storage period. These nendran types had low score for the quality characters namely appearance, texture and taste and hence this might be the reason for their low score for overall acceptability.

There was a gradual decrease in the scores for different quality characters and overall acceptability during storage. The chips made from all the nendran types lost their crisp texture gradually due to the absorption of moisture. Deterioration in the flavour of chips was also noticed with the increase in storage periods. This might be due to the rancidity of fats during storage. This is in corroboration with the findings of Liya (2001) who reported similar changes when taro chips were stored.

In effect, the acceptability of chips decreased gradually towards the end of the storage period. This is in accordance with the findings of Hameed (1981), Sathyarathi *et al.* (1981) and Bhaskar (2000) who had similar observations for the chips packed in polyethylene bags. Narayanan and Mustaffa (2001) reported a shelf life of thirty days for banana chips.

The banana porridge did not show significant variation between the nendran types with respect to different quality characters and overall acceptability. The scores for appearance and colour of the porridge prepared from the flours of nendran types Chengalikodan and Kaliethan respectively were low. This might be due to the slight ash colour of the porridge prepared from these varieties and the porridge of other nendran types had more of creamy tinge. Overall acceptability was found to be highest in Chengalikodan and lowest in Attunendran and Changanassery nendran during most of the storage periods.

All the quality characters remained more or less the same during storage. The decrease in scores was negligible. Decrease in textural characteristics might be due to the degradation of starch to sugars that occur in the flour during storage. The low scores obtained for taste might be due to the preference and acceptability of commercial weaning foods available in the market.

5.3.2 Enumeration of total microflora of banana flour

The quality of banana flour depends on the total microflora present in them. Many organisms causing food-borne illness may grow in foods under favorable conditions.

In the present study, a gradual increase in the bacterial count and fungal count was observed. There was a gradual increase in the moisture content of the banana flour on storage. According to Bera *et al.* (2001), the growth of fungi and bacteria in the food samples are influenced by moisture content, high or low relative humidity, temperature of storage and type of samples. The increase in the bacterial count and fungal count in the banana flour can thus be correlated with the increase in moisture content on storage. Banana flour made from the nendran type Kaliethan showed maximum total microflora. This might have been due to the fact that storage study of this particular nendran type was done during the peak of monsoon season, when relative humidity in the atmosphere was high.According to Bryan (1974) and Nanu *et al.* (1992), several factors such as quality of raw materials, storage temperature, processing temperature, storage containers, processing technique, the environment in which it is processed, etc. will have an effect on microbial quality of processed foods. In the present study, the banana flour made from the nendran types Attunendran, Changanassery nendran, Manjeri nendran I and Myndoli was found to have the minimum total microflora in comparison with other nendran types. The low amount of microflora in these banana flours might have been due to low moisture content observed in these banana flours (5.00 to 7.43) and also due to the other factors mentioned by Bryan (1974) and Nanu *et al.* (1992) that affect the total microflora.

Summary

6. SUMMARY

The study on the "Evaluation of fruit quality in banana 'Nendran' (*Musa* AAB)" was made to evaluate seven nendran types namely Attunendran, Changanassery nendran, Chengalikodan, Kaliethan, Manjeri nendran I, Myndoli and Nedunendran. The selected nendran types were evaluated for different physical characteristics and nutrient composition. Two products namely banana flour and chips were prepared from the selected nendran types to find out the suitability of the nendran types for product development and to evaluate the quality attributes.

The finger weight varied from 125.50 g in Changanassery nendran to 183.20 g in Manjeri nendran I with a mean finger weight of 161.73 g.

The finger length was highest in Nedunendran (26.84 cm) and lowest in Chengalikodan (20.06 cm) with a mean finger length of 21.92 cm.

The pulp weight of nendran types ranged in between 82.33 g (Changanassery nendran) to 107.2 g (Attunendran) and the peel weight ranged in between 45.88 to 67.22 g.

The highest pulp peel ratio was observed in Chengalikodan (2.01) and lowest in Attunendran (1.57).

Variation in the curvature of the nendran types was observed. The distal part of Chengalikodan, Kaliethan and Manjeri nendran I was found to be slightly curved, while Changanassery nendran had a sharp curve. The distal part of Attunendran, Myndoli and Nedunendran were found to be straight.

The angularity of Manjeri nendran I was found to be round whereas Attunendran, Chengalikodan, Kaliethan and Myndoli had slightly ridged angularity and Nedunendran had pronounced ridges.

The moisture content of raw nendran types varied from 60.91 g 100 g^{-1} (Manjeri nendran I) 71.48 g 100 g^{-1} (Attunendran). The mean protein of nendran types

was found to be 1.50 g 100 g^{-1} with the highest protein content in Chengalikodan and Manjeri nendran I (1.60 g 100 g^{-1}) and lowest in Kaliethan and Myndoli (1.40 g 100 g^{-1}). The highest (0.86 g 100 g^{-1}) and lowest (0.55 g 100 g^{-1}) crude fibre content was found to be in Nedunendran and Changanassery nendran respectively.

The starch content of raw nendran types varied from 18.10 g 100 g^{-1} (Myndoli) to 25.75 g 100 g^{-1} (Chengalikodan) with a mean starch content of 21.70 g 100 g^{-1}.

Highest calcium (24.31 mg 100 g^{-1}), phosphorus (38.69 mg 100 g^{-1}), iron (7.44 mg 100 g^{-1}) and potassium (455.01 mg 100 g^{-1}) was found to be in Chengalikodan and lowest calcium (12.75 mg 100 g^{-1}) and iron (3.16 mg 100 g^{-1}) contents were found to be in Myndoli and Phosphorus (26.40 mg 100 g^{-1}) and Potassium (316.70 mg 100 g^{-1}) in Attunendran. The mean calcium, phosphorus, iron and potassium content were found to be 20.01, 30.31, 5.69 and 387.02 mg 100 g^{-1} respectively.

The vitamin C content of nendran types was found to be low which varied from 13.67 mg 100 g^{-1} in Myndoli to 24.79 mg 100 g^{-1} in Attunendran with a mean vitamin C content of 20.24 mg 100 g^{-1}.

The banana flour was also analysed for different chemical constituents at monthly intervals for a period of three months.

The mean moisture content of banana flour increased from 5.40 g 100 g^{-1} at the beginning of the experiment to 7.70 g 100 g^{-1} at the end of storage. Banana flour of nendran type Chengalikodan had higher initial moisture content than banana flour prepared from other nendran types, while at the end of the storage period, Kaliethan had the highest moisture content.

A gradual decrease in the mean protein, crude fibre, starch, calcium, phosphorus, iron and potassium contents was noticed in the banana flour during storage. The mean protein, crude fibre and starch content of banana flour

from the nendran type Chengalikodan was found to be the best for preparing chips and had the highest overall acceptability score at all stages of storage. A gradual decrease in the scores of all quality attributes and overall acceptability of chips prepared from all nendran types was also noticed.

The banana porridge prepared from different nendran types did not show much variation with respect to different quality characters and overall acceptability at any stage of storage. The overall acceptability was found to be highest in the nendran type Chengalikodan and lowest in Attunendran and Changanassery nendran.

The enumeration of total microflora of banana flour was done at monthly intervals for a period of three months by serial-dilution and plate count method. A gradual increase in the bacterial and fungal count was observed during storage. The presence of yeast was found to be negligible. The banana flour prepared from the nendran types Attunendran, Manjeri nendran I and Myndoli showed minimum total microflora when compared with the banana flours prepared from other nendran types.

From the present study, it was found that raw nendran types and the banana flour made from different nendran types was rich in most of the nutrients, but was particularly poor in nutrients like protein and crude fibre. A gradual decrease in all the chemical constituents of banana flour except moisture content was noticed during storage. The acceptability studies showed Attunendran as the best nendran type for cooking. The nendran type Chengalikodan was found to be the best for preparation of chips and porridge. A gradual decrease in the quality attributes and overall acceptability of chips and banana porridge was observed during storage. Microbial quality of banana flour also degraded on storage.

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Appendices

APPENDIX-I

SCORE CARD FOR ORGANOLEPTIC EVALUATION OF COOKED BANANA

Sl. No.	Criteria	Description	Score	1	2	3	4	5
1	Appearance	Excellent	5					
		Very good	4					
		Good	3					
		Fair	2					
		Poor	1					
2	Colour	Excellent	5					
		Very good	4					
		Good	3					
		Fair	2					
		Poor	1					
3	Taste	Excellent	5					
		Very good	4					
		Good	3					
		Fair	2					
		Poor	1					
4	Flavour	Excellent	5					
		Very good	4					
		Good	3					
		Fair	2					
		Poor	1					
5	Texture	Soft	5					
		Very soft	4					
		Hard	3					
		Very hard	2					
		Mushy	1					
6	Overall acceptability	Like extremely	5					
		Like moderately	4					
		Neither like nor dislike	3					
		Dislike moderately	2					
		Dislike extremely	1					

Name:
Date :

APPENDIX-II

SCORE CARD FOR ORGANOLEPTIC EVALUATION OF NENDRAN CHIPS

Sl. No.	Criteria	Description	Score	1	2	3	4	5
1	Appearance	Excellent	5					
		Good	4					
		Fair	3					
		Poor	2					
		Very poor	1					
2	Colour	Bright yellow	5					
		Light yellow	4					
		Light brown	3					
		Brown	2					
		Dark brown	1					
3	Flavour	Excellent	5					
		Good	4					
		Fair	3					
		Poor	2					
		Very poor	1					
4	Texture	Very crisp	5					
		Crisp	4					
		Mildy soggy	3					
		Soggy	2					
		Hard	1					
5	Taste	Excellent	5					
		Good	4					
		Fair	3					
		Poor	2					
		Very poor	1					
6	Overall acceptability	Like extremely	5					
		Like moderately	4					
		Neither like nor dislike	3					
		Dislike moderately	2					
		Dislike extremely	1					

Name:
Date :

APPENDIX-III

SCORE CARD FOR ORGANOLEPTIC EVALUATION OF BANANA PORRIDGE

Sl. No.	Character	Description	Score	1	2	3	4	5
1	Appearance	Excellent	5					
		Good	4					
		Fair	3					
		Poor	2					
		Very poor	1					
2	Colour	Excellent	5					
		Good	4					
		Fair	3					
		Poor	2					
		Very poor	1					
3	Flavour	Excellent	5					
		Good	4					
		Fair	3					
		Poor	2					
		Very poor	1					
4	Texture	Very smooth	5					
		Smooth	4					
		Watery	3					
		Slightly Lumpy	2					
		Lumpy	1					
5	Taste	Excellent	5					
		Good	4					
		Fair	3					
		Poor	2					
		Very poor	1					
6	Overall acceptability	Like extremely	5					
		Like moderately	4					
		Neither like nor dislike	3					
		Dislike moderately	2					
		Dislike extremely	1					

Name:
Date :

EVALUATION OF FRUIT QUALITY IN BANANA 'NENDRAN' (*MUSA* AAB)

By

LAKSHMY. P. S.

ABSTRACT OF THE THESIS

Submitted in partial fulfilment of the requirement for the degree of

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Department of Home Science

COLLEGE OF HORTICULTURE

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ABSTRACT

The study entitled "Evaluation of fruit quality in banana 'Nendran' (*Musa* AAB)" was undertaken to evaluate the chemical constituents of seven nendran types and their products and also to assess the quality characters of banana products during storage.

The nendran types were evaluated for different physical characters like finger weight, finger length, pulp and peel weight, pulp/peel ratio, curvature and angularity. Significant variation in all the physical characters was noted between the nendran types.

The chemical composition of raw nendran types also showed significant variation. The nendran types were found to be rich in starch, potassium and phosphorus, but were lower in protein and crude fibre. The nendran type Chengalikodan had the highest mineral, protein and starch content whereas Attunendran had the highest value for moisture and vitamin C and Nedunendran had the highest crude fibre content.

Banana flour were analysed for different nutrients at monthly intervals for a period of three months. The banana flour of all nendran types was poor in crude fibre. A gradual decrease in all the chemical constituents except moisture content was observed during storage. The banana flour prepared from the nendran types Chengalikodan and Nedunendran showed good starch and mineral contents.

A gradual increase in the moisture content of chips was observed during storage. The chips prepared from the nendran type Chengalikodan had the lowest and Kaliethan had the highest moisture content at the end of the storage period.

The acceptability studies of cooked banana revealed that Attunendran is the best nendran type for table purpose while Chengalikodan was organoleptically the best to prepare chips and porridge. Storage studies revealed a gradual decrease in quality attributes and overall acceptability of chips and porridge.

There was a steady increase in the total bacterial and fungal count on storage. The presence of yeast was negligible. The banana flour prepared from the nendran types Attunendran, Changanassery nendran, Manjeri nendran I and Myndoli showed minimum count of total microflora when compared to flours made from other nendran types.