EVALUATION OF BANANA VARIETIES FOR QUALITY ATTRIBUTES

By

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THESIS

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DECLARATION

I hereby declare that this thesis entitled ***"Evaluation of banana varieties for quality attributes"*** *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.*

Vellanikkara
16.12.2010

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CERTIFICATE

Certified that this thesis, entitled **"Evaluation of banana varieties for quality attributes"** is a record of research work done independently by **Ms.Sabeena Thajuddeen,** 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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CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

Introduction

INTRODUCTION

Banana is one of the most important fruit crops of Kerala. The demand for this fruit in the international market is increasing and this fetches its export potentialities, food value and status as a fruit of common man. It is one of the most important fruit crops. contributing to 31 per cent of total fruits produced in India with an annual production of 13.2 million tonnes (Negi *et al,* 1998). It is a crop of humid tropics but well acclimatized to a wide range of climate from humid subtropics to semi – arid sub tropics.

Banana is a nourishing fruit but does not contain fat, and can be eaten every hour of the day because of its digestive properties. It contains appreciable amounts of many trace elements, acids, enzymes and physiologically important chemical compounds.

Bananas are a good source of potassium which is a vital mineral for muscle and nerve function. They contain a high level of natural sugar in both fresh and dried form, which release energy quickly into the blood stream. This explains why many atheletes, especially tennis players, often eat bananas before or even during a competition. It has a special value in the human diet as they are rich sources of energy and contain nearly all the nutrients including minerals and vitamins. It helps to relieve both constipation and diarrhoea because of their stabilising effect on digestion (Anon, 1995).

It provides a more balanced diet than any other fruit or vegetables. It is filling, easy to digest, low in sodium and a rich source of carbohydrate (Singh and Uma, 1997).

Large number of banana varieties are grown in Kerala. These varieties are mainly studied in the field of agriculture for their yield characteristics. Hence this study is proposed to evaluate the quality characters like weight of bunch, weight of hands, number of hands, weight of the fruit, colour of the fruit and pulp, firmness of the fruit and pulp and also the nutritive value of the local banana varieties of different genomes in the raw and ripe stages.

Review of Literature

2. REVIEW OF LITERATURE

In Kerala the nutrient evaluation of the different varieties of banana has not been carried out. The literature pertaining to the study are presented under the following heads.

2.1 Nutritional importance of fruits and vegetables

2.2 Importance of banana

2.3 Fruit characters of banana varieties

2.4 Nutritional composition of banana

2.5 Changes during ripening

2.6 Organoleptic evaluation of banana and banana products

2.1 Nutritional importance of fruits and vegetables

Fruits and vegetables play an important role in the balanced diet of human beings by providing not only the energy rich food but also promise supply of vital protective nutrients like vitamins and minerals. The extensive studies carried out by Indian Council of Medical Research, New Delhi and the National Institution of Nutrition, Hyderabad, have revealed that the meagre intakes and low purchasing power of even low cost protective foods such as vegetable and fruits, have been responsible for malnutrition and under nutrition in large segments of the population (Bose and Som, 1986).

The health benefits of a vegetarian diet rich in fruits and vegetables, grains and beans have been well substantiated. Such a diet has been linked to lower high blood pressure and non insulin diabetics (Backer, 1992).

The nutritional contribution of different vegetables is sufficiently varied that it is wise to serve a variety of vegetables to ensure that all the necessary nutrients from the vegetable category are included in the diet. Calcium and iron are

the two minerals found in significant amount in vegetables. Vegetables also help to meet the body's need for sodium, chlorine, cobalt, copper, magnesium, manganese, phosphorus and potassium. Vegetables are useful in the diet for their cellulose content. They provide the roughage necessary to promote mobility of food through the intestines (Mc William, 1974).

Fruits contain a high range of water ranging between 80-90 per cent. They have only a small amount of protein and is also less in fat (Manay and Shadaksharaswamy, 1987).

Fruits are known to provide the vigour and vitality, being a good source of essential nutrients. The chief energy constituent in fruit is carbohydrates mainly as sugars. Fruits like vegetables contain the indigestible material called fiber, which adds bulk to stools. Fruits are thus mild laxatives (Dube, 1988).

Fruit and vegetable intake had been examined in relationship to various types of cancers. Persons with low fruit and vegetable intake have been found to experience twice the risk of cancer compared to high intake (Mathur, 1992).

According to Chadha (1992a) fruits possess advantage over many vegetables because of the acidic media of its juice to nearly neutral vegetable. The fact that many fruits are eaten raw is also an advantage because of some loss of ascorbic acid usually incurred during cooking.

A fruit diet is a best means of disinfecting the stomach and the alimentary canal (Anon, 1997).

India is the home of a wide variety of fruits and vegetables. India is the largest producer of fruits and the second largest producer of vegetables in the world (Attavar, 2000).

Vegetables and fruits constitute an important item of human diet. Recent research findings all over the world have established their beneficial role in the prevention of various chronic non communicable diseases including coronary heart disease and cancers (Rao, 2000).

2.2 Importance of banana

Banana is not a seasonal fruit like many other fruit crops and is available throughout the year (IIHR, 1986). India is the third largest banana producer in the world. Domestic production is concentrated mainly on 'Nendran' in the state of Kerala where the variety of banana is most popularly grown (Norman 1990). According to the author banana provides a more balanced diet than many other fruit crops yielding 37 million calories of energy from one hectare compared to 25 million from wheat. According to Chadha (1990) cultivation of banana in India is poly clonal with an array of varieties under cultivation. The author also reported that among the 300 recorded varieties of banana, 8-10 are grown commercially and the most common varieties in cultivation are the Dwarf Cavendish and Robusta.

Banana is the fourth important food crop in terms of gross value after paddy, wheat and milk products. It also forms an important crop of subsistence farmer an important item for food security and increased income (Singh and Uma, 1997).

Bananas have a special value in the human diet as they are rich sources of energy and contain nearly all the nutrients including minerals and vitamins. About 24 bananas each weighing 100 grams can provide the energy requirement of a sedentary man according to Bose and Mitra (1990). According to Gopalan and Ram, (1990) its energy content makes it a very advantageous and filling staple diet though poorer in protein as compared to cereals. According to Singh and Uma (1997) banana provides a more balanced diet than any other fruit or vegetable. It is

filling, easy to digest, nearly fat free, rich source of carbohydrate, the calorific value being 67-137 Kcal/100g. It is rich in vitamins than any other fruit, free from sodium, making it a sweet and a salt free diet.

Chandler (1995) points out that in some parts of the world, such as East Africa, plantains are a substantial part of the diet. In these situations they supply Vitamin A, C and B_6 as well as energy. For countries where dessert banana is popular they are eaten as – a snack food. In this case they make significant contribution to the diet, especially with respect to minerals and vitamins. The fruit is a fair source of B vitamins and calcium (Gopalan and Ram, (1990).

Bananas are a good source of potassium, which is a vital mineral for muscle and nerve function. Potassium also helps to regulate blood pressure (Anon, 1996).

According to Chadha (1990) all parts of the plant have medicinal applications. Purseglove (1975) had reported that bananas were given to children suffering from coeliac diseases who had an intolerance for carbohydrates. Bananas fit well with the recommendations of the select committee of the united states senate on Nutrition and Human needs for increased consumption of foods low in fats, cholesterol and salt (Anon, 1977). According to the studies conducted by Usha *et al.*, (1984) and Horigome *et al* (1992) it is the soluble and insoluble components of dietary fibre which participate in the hypocholesterolaemic effect of banana pulp. Goel *et al.*, (1986) reported that orally administered powder of plantains showed significant activity against experimentally induced gastric and duodenal ulcers in animals. The powder increased mucosal thickness and incorporation of (3H) thymidine into mucosal DNA. Ancient Chinese and Vedic writing ascribe healing properties to the vegetable as well as fruit. It contains appreciable amounts of many trace elements, acids, enzymes and physiologically important chemical compounds. Ripe plantains have mild laxative property and hence are very useful in the diet of children particularly as a remedy for

constipation. At the same time the fruit is helpful to combact diarrhoea and dysentry (Gopalan and Ram, 1990). Banana can help to relieve both constipation and diarrhoea because it has a stabilizing effect on digestion. Sportsmen go for bananas to keep their energy level high, replace vital electrolytes lost through heavy exertion and prevent cramps (Anon, 1995). According to Rao (1999) the therapeutic effect of banana against coeliac diseases, constipation and peptic ulcer may be due to the presence of active principles like serotonin and norepinephrin. Bananas inhibit the enzyme angiotensin converting enzyme which constricts blood vessels causing high blood pressure.

Oliveria and Cainerieo (1970) suggested that cow's milk banana formula could be given as a well balanced complete food for infants in developing countries and it is locally cheaper than foods supplemented with oilseed proteins. According to Jelliffe (1974) banana is the only food of calorific significance which can be given to the infant uncooked and straight from the tree in a bacteriologically uncontaminated condition. Joseph (1992) reported that banana based food can be used to feed infants as a supplementary food.

Ripe bananas are considered by many to be a nutritious near complete food if taken in combination with protein rich milk. They are favoured as food for young babies and elderly persons because they are easily digested and very nutritious (Rao, 1999).

2.3 Fruit characters of different varieites

Vijayaraghavakumar *et al.* (1984) evaluated 56 dessert banana varieties for twelve morphological characters and indicated that all the characters differed significantly among the varieties.

Eight culinary varieties of banana cultivated in Kerala were evaluated by Rajeevan *et al.* (1988) for growth parameters, finger characteristics and cooking

qualities. According the author the weight of the bunch ranged from 12.83 to 18.92 kg.

Results of an experiment carried out at Kerala Agricultural University (KAU, 1982) revealed that the Nendran clones from Kottayam district recorded the highest mean bunch weight of 12.5 kg.

The pooled analysis for bunch weight conducted at Banana Research Station, Kannara revealed a bunch weight variation of 8.55 to 11.65 kg in Palayankodan (KAU, 1987).

An evaluation of 144 Nendran clones at Banana Research Station, Kannara (KAU, 1989) revealed a bunch weight variation of 9.13 (local variety) to 10.54 kg (clone 123). Prasanna and Arvindakshan (1990) reported that the variation in bunch weight within a clone may probably be contributed to environmental and other factors.

Rajeevan and Mohanakumaran (1983) found significant variation in the bunch weight of 24 accessions in the clones of Palayankodan.

The bunch weight of cultivars Jahaji, Malbhog and Neypoovan were 19.33, 13.87 and 11.08 kg respectively (Uma *et al.*, 1999).

According to Shanmughavelu *et al.* (1992) number of hands differed significantly between clones of Nendran.

Number of hands per bunch for eight varieties varied from 6.00 to 17.83 (Rajeevan, *et al.* 1988). An evaluation of different culinary cultivars of banana (Ram *et al.*, 1994) showed that the number of hand per bunch varied from 4.66 to 8.33.

Rajeevan *et al.* (1988) reported significant difference in the finger characteristics among the eight culinary varieties of banana cultivated in Kerala.

According to Shanmughavelu *et al.* (1992) finger weight differed significantly between the clones of Nendran.

Tripathi *et al.* (1981) studied four banana varieties and reported that physical characters of the fruit varied widely among varieties, weight of the fruits ranged from 81.6-222.5 g.

According to Almazan (1991) average finger pulp weight was higher in plantains than in cooking bananas.

The fruit weight of cultivars Jahaji, Malbhog and Neypoovan were found to be 113.79 g, 97.00 g and 34.05 g respectively (Uma *et al.*, 1999).

According to Tripathi *et al.* (1981) and Asedu (1987) the pulp/peel ratio of the four banana varieties varied from 1.0 to 3.4 while Ngalani *et al.* (1998) reported a pulp/peel ratio of 2.43 to 3.76 in banana cultivars.

Uma *et al.* (1999) reported that the pulp/peel ratio of Jahaji, Malbhog and Neypoovan were 4.81, 4.53 and 4.40 respectively.

The pulp hardness of the banana varieties varied significantly (0.31 to 0.45 kg cm^{-2}) (Ngalani *et al.*, 1998).

According to Ngalani *et al* (1999) the firmness of the varieties evaluated differed significantly (1.10 to 1.90 kg cm^{-2}.

2.4 Nutritional composition of banana

The nutritional composition of the edible portion of banana fruit includes water, carbohydrates, fats, proteins, organic acids, mineral matters and other volatile constituents which vary greatly for different varieties of bananas (Lavollary, 1952).

According to Rao (1999) the major differences between plantain and banana are that the plantain contain lower moisture percentage, lower sugar concentration, more starch and are rich sources of beta carotene when compared to ripe banana.

In both ripe and unripe plantains, the lipids, protein and fibre are present only in minor constituents (Ketiku 1973).

Ketiku (1973) reported that the moisture content of Cavendish banana is 75 per cent while that of plantains is only 60 per cent. According to Marriott (1980) the plantain and banana pulp contain about 60 and 70 per cent of moisture respectively. The moisture content of varieties like Nendran, Kunnan, Monthan, Poovan and Palayankodan was found to be insignificant (KAU, 1983). The moisture content of ripe banana was found to be only 70 per cent (Chadha, 1992 and Gopalan *et al.*, 1989).

Banana powder can be a major source of carbohydrate and calories for large segments of the population (Lavollary, 1952).

In ripe banana less than 5 per cent is starch (Ketiku, 1973).

Starch content of the unripe and ripe pulp was found to be 83.2 and 66.4 per cent respectively on dry weight basis (Ketiku, 1973). The author also reported that plantains even when ripe are much starchier than ripe banana. According to Dube (1988) the pulp of ripe banana contain 1-2 per cent starch.

According to Suntharalingam and Ravindran (1993) the flours of cooking banana contained 70 per cent starch. Ketiku (1973) reported that in plantains 66 per cent of the solids are starch. According to Ketiku (1976) the starch content of the cultivar Omini was 5.2 per cent and 2.9 per cent in Paranta. Chacon *et al.* (1987) observed 17.7 per cent of starch in green banana.

According to Ketiku (1973) ripe and unripe pulp of banana contains 1.3 g, 1.6 g of cellulose and hemicellulose 0.8 g, 1.9 g on dry weight basis. Kayisu *et al.* (1981) observed 1.27 per cent of dietary fibre in banana fruit. According to the author hemicellulose content of ripe banana was found to be higher than that of most fruits and vegetables while cellulose and lignin contents were found to be lower. Dube (1988) reported 0.4 g of dietary fibre in ripe banana.

There is not much variation in the fibre content of varieties like Nendran, Kunnan, Monthan, Poovan and Palayankodan. The availability of fibre was found to be negligible in these varieties (KAU, 1983).

Lavollary (1952) has pointed that although, banana powder is a poor source of protein its nutritional quality is markedly superior to that of other fruits.

Ketiku (1976) observed crude protein content of about one per cent in Omini and Paranta cultivars of banana. Padmaja and Koshy (1977) analysed the protein content of twenty mature banana varieties and found that the values varied from 1.19 to 3.83 per cent. The authors also reported that Robusta and Red banana are superior in their protein content. According to Villalonga (1981) the protein content of the cultivars ranged from 1.1 to 2.7 per cent. Gopalan *et al.* (1989) reported 1.4 g of protein in green plantain.

There is not much variation in the protein content of varieties like Nendran, Kunnan, Monthan, Poovan and Palayankodan (KAU, 1983). Dube (1988) observed that ripe banana has 1.2 g of protein. The crude protein content of two varieties of cooking banana was found to be 3.2 per cent (Suntharalingam and Ravindran, 1993).

According to Ketiku (1976) the pulp is rich in potassium but relatively poor in iron, calcium and phosphorus.

Whole banana is a good source of potassium contributing to 396 mg 100 g^{-1} (Park 1974).

According to Patil and Magen (1976) varieties Bassan, Rajeli, Safed velchi contained several nutritionally important minerals viz. like sodium, potassium, phosphorus and magnesium. High amount of potassium (1139 mg 100 g^{-1}) partly explained the high amount of total ash. Safed velchi banana powder contained largest amount of minerals.

Padmaja and Koshy (1977) analysed 20 varieties of mature banana for different mineral constituents and observed 140 to 560 mg 100 g^{-1} of potassium, 12 - 40 mg 100 g^{-1} of calcium, 24 - 270 mg 100 g^{-1} of magnesium, 0.7 to 2.2 mg 100 g^{-1} of iron, 2.4 mg 100 g^{-1} of manganese. The authors also observed that Robusta and Red banana are superior in their mineral contents.

The mineral contents of the cultivars Pineo Giganl, Pineo Enano, Pineo Martenico, Martenico Cryaco, Manzana and Topocho Cenizo were tabulated by Villalonga (1981) and reported that the varieties contained 156 - 377.77 mg 100 g^{-1} of potassium, 2.67 - 5.07 mg 100 g^{-1} of sodium, 3.36 - 11.04 mg 100 g^{-1} of calcium, 20.63 - 85.10 mg 100 g^{-1} of magnesium and 18.00 - 28.31 mg 100 g^{-1} of phosphorus. Bananas are rich in phosphorus (290 ppm) and calcium (80 ppm) which are essential for bone development (Chadha, 1992).

Suntharalingam and Ravindran (1993) reported that in two varieties of cooking banana the ash content was (3.7 g) Potassium was the main mineral in the banana flour (275 mg) followed by phosphorus (130 mg) and magnesium (95 mg) per 100 gram of dry matter.

According to Sheela (1988) the bland banana porridge is deficient in iron. Gopalan and Ram (1990) reported that ripe banana has 17 mg of calcium, 36 mg of phosphorus, 0.9 mg of iron and 88 mg of potassium. The iron and potassium in banana are wholly available. According to Rao (1999) the mineral

constituents of ripe banana are calcium (17 mg), phosphorus (36 mg), iron (0.36 mg), sodium (36.6 mg), potassium (88 mg) per 100 gram. According to the author the potassium content in banana depends upon the variety and varied from about 90 mg to about 400 mg 100 g^{-1} of the fruit.

Patil and Magen (1976) reported that banana powder contained several important vitamins like thiamine, niacin and ascorbic acid. According to Dube (1988) ripe banana contains 7 mg of vitamin C. Banana contains eleven vitamins, including A, B and C (Chadha, 1992).

According to Akinyele and Keshimo (1980) Paranta variety has a vitamin C content of 9.4 mg 100 g^{-1} of edible portion while Villalonga (1981) observed banana as a poor source of ascorbic acid (1.20-2.66 mg 100 g^{-1}).

Fresh green banana had a vitamin C content of about 90 mg 100 g^{-1} on dry basis (Suntharalingam and Ravindran, 1993).

The ascorbic acid content of the fruits of Nendran banana was 9.37 mg 100 g^{-1} of the fruit (Anil, 1994) while Deepa (1997) reported a vitamin C content of 3.07 mg 100 g^{-1} in Nendran. Rao (1999) derived 32 mg of vitamin C in ripe banana.

According to Ghosh *et al.* (1997) the ascorbic acid content in the fruit of the Champa variety is 4.4 mg 100 g^{-1} of the pulp.

Siddapa and Renganna (1961) reported that the Nendran variety of banana contained carotene.

According to Villalonga (1981) vitamin A content in the cultivars Pineo Gigant, Pineo Enano, Pineo Martenico, Martenico Cryaco, Manzana Topocho, Cenizo ranged from 0.02-0.38 mg 100 g^{-1} except for titiaro with 1.09 mg of vitamin A.

Ripe banana has 78 µg of carotene (Dube, 1988; Rao, 1999).

According to Sheela (1988) the bland banana porridge is deficient in vitamin A.

According to Sheela (1982) the total soluble solids in Palayankodan is 26.76°brix while Anil (1994) reported 22.2 per cent of TSS in Nendran variety.

Significant variation in the total soluble solids (28.7-34.3°brix) was reported in the Nendran clones (KAU, 1987 and KAU, 1989) and Palayankodan accessions (Rajeevan, 1985). Charles *et al.* (1993) observed a total soluble solid content of 19.50 per cent. Rajamony *et al.* (1994) in an experiment with 27 banana clones of AAB noticed that total soluble solid content varied from 22.0 per cent in Mottapoovan to 30 per cent in Kodapanilla Kunnan. Ram *et al.* (1994) reported a TSS content of 14.1 to 14.3 per cent in banana varieties.

In Robusta variety of banana Agrawal (1997) observed a total soluble solid content of 21.20°brix while Ancy (1997) observed 26.75 per cent of TSS in Nendran variety. Deepa (1997) observed 29.13 per cent of total soluble solid in Nendran.

According to Ngalani *et al.* (1998) the total soluble solids in the African banana variety varied from 6.60 to 5.20°brix.

Uma *et al.* (1999) reported that total soluble solids in cultivars like Jahaji, Malbhog, Neypoovan were 23.92, 25.08 and 28.60°brix respectively. According to Shivashankar (1999) most of the accessions had a T.S.S. of 22-26°brix however two accessions showed a higher value of total soluble solid at 29.0 to 29.3°brix.

The titrable acidity of Palayankodan was 0.502 per cent (Sheela, 1982).

In Rajavazhai and Malbhog titrable acidity was found to be 0.18 per cent (Syamal, 1989). Clonal variation studies in Nendran carried out at Banana Research Station, Kannara showed significant variation in acidity (0.21-0.34%) (KAU, 1987).

Charles *et al.* (1993) reported 0.58 per cent acidity in Poovan. Rajeevan and Mohanakumaran (1993) reported 0.30-0.48 per cent of acidity in four plantain cultivars cultivated in Kerala.

The titrable acidity in Nendran is 0.354 per cent (Ancy, 1997; Deepa (1997) and Sindhu, 1999).

According to Agrawal *et al.* (1997) the acid content of Robusta is 0.48 per cent.

The titrable acidity values of the accessions of banana ranged from 0.40-1.10 per cent (Shivashankar, 1999).

The titrable acidity of the cultivars Jahaji, Malbhog and Neypoovan were 0.46, 0.43 and 0.41 per cent respectively (Uma *et al.*, 1999).

According to Ketiku (1973) in ripe bananas some 80 per cent of the solids consists of sugars and in plantain only 17 per cent is sugars.

Syamal and Mishra (1989) reported that total soluble sugar content in Champa and Malbhog varied from 20.7 to 24.5 and total sugar from 19.2 to 21.1.

According to Rajendran (1983) the total sugar content in Palayankodan was 15.82 per cent with reducing sugar 15.07 per cent and 0.77 per cent of non reducing sugar.

Sheela (1982) reported that Palayankodan contained 14.85 per cent of total sugar, 13.82 per cent of reducing sugar and 1.03 per cent of non-reducing sugar.

According to Dube (1988) the pulp of ripe banana contains 15-20 per cent sucrose, fructose and glucose.

Kanagaratnam *et al.* (1990) reported that Kappal had the highest total sugar content of 28.33 per cent while Kathali and Etharai had significantly higher reducing sugar content of 16.38 per cent and 17.33 per cent.

Ketiku (1973) observed 17.3 per cent of total sugar content in ripe banana pulp.

Suntharalingam and Ravindran (1993) reported 2.8 per cent of total sugar in the flour of two varieties of cooking banana.

Charles *et al.* (1993) reported that in Poovan the total sugars, reducing sugars and non-reducing sugars were 13.75, 12.67 and 1.08 per cent respectively.

Anil (1994) reported that the fruits of Nendran banana had 26.13, 8.52 and 17.62 per cent of total sugar, non-reducing and reducing sugar respectively. Deepa (1997) reported a total sugar content of 20.53 per cent in Nendran, reducing sugar content of 15.29 per cent and non-reducing sugar content of 5.15 per cent. According to Ancy (1997) in Nendran the reducing sugar, non-reducing sugar and total sugar content were 12.86, 1.549 and 14.46 per cent respectively. Sindhu (1999) reported that the fruits of Nendran had reducing sugar (11.79%) of reducing sugar, 2.51 per cent non-reducing sugar (2.51%) and 14.30 per cent of total sugar.

According to Agrawal *et al.* (1997) the reducing sugar and total sugar contents of Robusta was 11.60 per cent and 16.40 per cent respectively. According to Ghosh *et al.* (1997) the total sugar content of the Champa variety is 20 per cent.

2.5 Studies on ripening changes

Ripening usually brings about an increase in simple sugars to give sweetness, a decrease in organic acids and phenolic compounds to minimize

astringency and an increase in volatile acids to produce the characteristic flavour (Pantastico, 1975). Manay and Shadaksharaswamy (1987) reported that during ripening of the fruit it is the enzymes which bring about changes such as softening of the edible portion, changes in colour, carbohydrates and flavour.

During ripening many qualitative changes occur within the fruit Jha *et al.* (1990).

Chlorophyll is present in the peel in concentration of 12.13 mg cm^{-2} of the fruit surface in bananas and plantains (Seymour *et al.*, 1987) or 50-90 mg of fresh weight (Desai and Deshpande, 1975). During ripening the chlorophyll in the peel degrades revealing the yellow carotenes and xanthophylls. The pulp of normal preclimateric bananas at the time of harvest is creamy white or pale yellow in colour. As it ripens, the pulp becomes more yellow in colour (Wainwright and Hughes, 1990). Seymour *et al.* (1987) and Semple and Thompson (1988) reported that Cavendish banana cultivars can fail to completely degreen when they are ripened at 25°C and above resulting in fruit which are ripe in every other respect remaining green.

The pulp/peel ratio tended to increase during ripening (Tripathi *et al.*, 1981).

Fresh peel ratio in the green unripe fruit was in the range 1.22-1.68 and increasing to 2.3-2.6 at advanced ripeness. This ratio can be used as a measure of maturity of ripeness (Asedu, 1987).

According the Almazan (1991) pulp peel ratio increased during ripening and was highest in Fougamou. Ngalani and Tchango (1998) reported a significant increase in pulp to peel ratio from stage 1 (1.24-1.64) to stage 7 ripeness (2.43-3.76).

According to John and Marchal (1995) the change in the pulp:peel fresh weight ratio which increases by 40 per cent as the fruit ripens is put forward to support the idea of water movement.

According to Ngalani and Tchango (1998) the pulp hardness or firmness significantly decreased on ripening.

Ngalani *et al.* (1999) on ripening found significant decrease in pulp firmness of the varieties like French Clair, Balaid, Popouku CMR, Lakano and Gramele Maine during ripening.

According to Peacock (1980) an early part of the ripening process is the softening of the fruit. This happens partly because of loss of water from the peel but primarily because of the changes in the chemistry of cell walls. Softening or firmness is often measured with a penetrometer.

On ripening there is a decrease in the viscosity and the elasticity of pulp. The major physical factor associated with pulp softening, was related to the sequential degradation of starch, pectic and hemicelluloses in pulp cell walls (Kojima *et al.*, 1994).

The rate of weight loss of fruits of French Clair and IRFA 904 was highest (22.8-25.0%) compared to other hybrids and cultivars which varied from 12.6 to 16.8 per cent (Ngalani and Tchango, 1998).

The physiological loss of weight (PLW) varied significantly among the accessions (Shivashankar, 1999). Accessions like Alpan, Palayankodan, Jalikal(AAB), Adukkan, Kijnan (AB) and Chenkadali (AAA) recorded significantly higher physiological loss of weight (15.98 - 22.6%) compared with the control variety Karpuravalli (ABB) (7.33%). On the contrary, accessions Gros Michel and Amrit Sagar (AAA), Lalvelchi and Malbhog (AAB), Kodapanilla Kunnan, Chetty (AB), Bankela and Kanthali (ABB) registered very low

physiological loss of weight ranging from 1.81 to 4.80 per cent. According to the author loss of water through transpiration appears to be the most important component accounting for the loss of weight.

Jha *et al* (1990) and Ngalani *et al* (1998) reported significant increase in total soluble solids from stage 1 to 7 of ripeness.

Ripening increases the water concentration in the pulp of Gaint Cavendish bananas from 73 to 82 per cent (Marchal *et al.*, 1998).

According to Aravindakshan (1981) biochemical constituents in banana during the post-harvest period of ripening and storage varied considerably with respect to variety, specific situation, time of harvest, method of ripening and storage conditions.

The acid content of most fruits decrease as the fruit ripens resulting in changes in the pigment of some fruits (Manay and Shadaksharaswamy, 1987). Jha *et al.* (1990) reported that on ripening the titrable acidity decreases to a minimum. Almazan (1991) observed an increase in total acid content during ripening and it was greater in plantains than in cooking bananas.

Starch content is relatively high in unripe fruit but it changes to sugar in ripe fruits (Manay and Shadaksharaswamy, 1987).

According to Lizada *et* al. (1990) the most striking chemical change during ripening is the hydrolysis of starch to simple sugars. The author reported that in dessert banana there is reduction in starch content on ripening from around 15-25 per cent to less than 5 per cent in ripe pulp, coupled with a rise of similar magnitude in total sugar.

According to Goel and Siddique (1999) in ber fruit the total sugars increased during ripening.

Marriot *et al.* (1981) and George (1981) reported that starch hydrolysis with formation of sucrose, glucose and fructose is slower in plantains and less complete than in bananas even when the fruit is fully soft and yellow. Sugar formation from starch was greater in plantains during ripening, and conversion slowed down in cooking banana at the fully yellow peel stage (Almazan, 1991).

The starch content was 17.7 per cent in green bananas and 0.82 per cent in ripe bananas. Total sugar and reducing sugar content were 1.32 and 0.52 per cent respectively, in unripe bananas, and 19.7 and 10.3 per cent in the ripe fruit (Chacon *et al.*, 1987).

The starch content of the pulp significantly decreased from stage 1 to 5, while the reducing sugar content of the pulp significantly increased (Ngalani *et al.*, 1999).

According to (Manay and Shadaskaraswamy, 1987) there is no appreciable changes in the content of fats and minerals during ripening.

According to Almazan (1991) crude fibre content increased with ripening.

According to Izonfuo and Omuarc (1988) potassium was the most abundant mineral with estimated values of 8.4 g kg^{-1} in the green pulp. Small increase in the potassium was found during ripening. Iron, calcium and sodium levels showed similar variation but phosphorus levels decreased during ripening. The concentration of copper and magnesium were fairly constant.

According to Goel and Siddique (1999) in ber fruit the ascorbic acid content decreased with ripening. Firmin (1999) reported a decrease in ascorbic acid in African cherry fruit on ripening.

Tripathi *et al.* (1981) evaluated four banana varieties during ripening and reported a decrease in the vitamin C content. The ascorbic acid content of the

Champa variety decreased from 66 mg/100 g to 4.4 mg/100 g from stage 1 to stage 7 of ripeness (Ghosh *et al.*, 1997).

The ascorbic acid content and ascorbate oxidase activities were monitored during the ripening process of mango at the hard green stage. During ripening ascorbate oxidase activity increased and ascorbic acid content decreased (from 209.3 to 110.0 mg 100 g^{-1} of pulp (Cardello and Cardello, 1999).

2.6 Organoleptic evaluation of banana and banana products

Sensory quality is one of the criteria that determines the acceptability of any food products by the consumer.

According to Stone and Sidel (1993) sensory evaluation helps in ensuring that the consumers gets consistent and enjoyable foods. For consumers the sensory attributes like colour, appearance, feel, aroma, taste and texture are the deciding factors in food acceptance (Pal *et al.*, 1995).

Comparison between analytical and taste panel evaluation of banana quality showed that sugar/acid ratio and T.S.S content were highly correlated with flavour and sweetness (Choon and Choo, 1972).

According to Scow *et al.* (1972) it is the alcohol insoluble solid content of bananas which is highly correlated with sensory assessments of texture, but T.S.S and moisture contents were poorly correlated with texture and juice ness assessments.

Qualglia and Paoletti, (1983) had stated that banana flour is a suitable ingredient in bread making when mixed with soya or wheat flour in the proportion of ten per cent.

Banana flour is prepared from unripe fruit and banana powder from ripe fruit. Banana flour is used as infant food in Kerala and is given in the form of gruel (Rao, 1999).

According to Chadha (1992b) ripe and unripe banana can be readily processed into pulp - liquid fruit, canned slices, deep fried chips, toffees, figs, fruit bar and brandy.

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

Sheela (1988) developed a banana based weaning food and found it to be acceptable.

Joseph (1992) found that banana based supplementary food as a suitable supplementary food.

KAU (1983) analysed the common banana varieties viz. Nendran, Kunnan, Monthan, for the preparation of banana flour. The variety Kunnan scored highest scores in organoleptic test for taste while Nendran accorded highest for texture and appearance.

According to Chadha (1990) the hill banana is preferred for banana chips. Red banana as a aesthetic appeal and a captivating flavour as well.

According to Uma *et al.* (1999) the banana chips from Nendran is a popular processed product. Other products being banana jam, jelly, banana puree, sweet coat bananas, dehydrated banana slices. According to the author, Cavendish banana offer a best status for wine.

Pool (1984) evaluated five dwarf banana for fresh market production in Puerto Rico. All ripe fruits were classed as acceptable or highly acceptable by taste.

According to Ayodele (1987) African fruits are boiled, pounded or fried and eaten alone or mixed with other ingredients. Fruits are processed into flour and chips (Swennen and Vuylsteke, 1988). Firmin (1994) has reported that many African traditional foods are prepared from plantain.

Materials and Methods

3. MATERIALS AND METHODS

The materials and methods used for evaluating the quality attributes of selected banana varieties are given under the following heads.

3.1 Selection of banana varieties

3.2 Collection of sample

3.3 Evaluation of fruit characters

3.4 Nutrient analysis and other constituents of the raw and ripe banana

3.5 Organoleptic evaluation

3.6 Statistical analysis

3.1 Selection of banana varieities

Eleven varieties of banana available at the Banana Research Station, Kannara, Kerala Agricultural University, Thrissur were selected for the study. The varieties selected are.

1. Nendran (*Musa* AAB "Nendran")
2. Palayankodan (*Musa* AAB "Mysore")
3. Karpooravally (*Musa* ABB "Karpooravally")
4. Monthan (*Musa* ABB "Monthan")
5. Robusta (*Musa* AAA "Robusta")
6. Red banana (*Musa* AAA "Red banana")
7. Kunnan (*Musa* AB "Kunnan")
8. Njalipoovan (*Musa* AB "Njalipoovan")
9. Kadali (*Musa* AA "Kadali")
10. Matti (*Musa* AA " Matti")
11. Kanchikela (*Musa* ABB "Kanchikela")

Plates 1 - 4 shows the different banana varieties selected for the study.

Banana varieties selected for the study

Plate 1. Palayankodan, Nendran, Monthan

Plate 2. Robusta, Kunnan, Red banana


Palayankodan
Monthan
Nendran

Plate 3. Njalipoovan, Kadali, Kanchikela

Plate 4. Matti


Kanchikela


Matti

3.2 Collection of samples

The required bunches for the study was tagged and mature banana bunches were harvested. These bunches were kept for ripening in ambient storage condition.

3.3 Evaluation of fruit characters

After harvest following physical characters of the raw fruit were recorded. The physical characters of the ripe fruit were also recorded daily from the day of harvest.

3.3.1 Raw fruit

1. Date of harvest
2. Weight of bunch
3. Weight of hands
4. Number of hands
5. Number of fingers in each hand
6. Pulp / peel ratio

3.3.1.1 Date of harvest

The number of days to reach complete maturity after planting of the selected varieties were recorded

3.3.1.2 Weight of bunch

Bunch were weighed immediately after harvest on a platform balance. The bunch weight was recorded in kilograms (kg)

3.3.1.3 Weight of hands

The weight of the hands was taken on an analytical balance and expressed in grams.

3.3.1.4 Number of hands

The number of hands in each bunch were counted and recorded.

3.3.1.5 Number of fingers in each hand

The number of fingers in each hand were counted and recorded.

3.3.1.6 Pulp/peel ratio

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

3.3.2 Ripe fruit

1. Colour of the fruit
2. Colour of the pulp
3. Weight of fruit
4. Physiological loss of weight
5. Volume of the fruit
6. Physiological loss of volume
7. Firmness of the fruit and pulp

3.3.2.1 Colour of the fruit

Ripening studies were carried out using the colour chart given by Stover and Simmonds (1987) and the time taken to reach 100 per cent ripening colour was noted and expressed in number of days. The colour characteristics of different stages of ripening is given in Appendix I.

3.3.2.2 Colour of the pulp

Colour of the pulp was recorded in accordance with the peel colour changes.

3.3.2.3 Weight of the fruit

Weight of the fruit was taken on an analytical balance and expressed in grams (g).

3.3.2.4 Physiological loss of weight (PLW)

The difference in weight of the fruit immediately after harvest and after reaching 100 per cent ripeness was divided by the initial weight of the fruit and expressed as percentage to get PLW.

3.3.2.5 Volume of the fruit

Volume of the fruit was estimated by water displacement method using measuring cylinder and expressed in ml.

3.3.2.6 Physiological loss of volume (PLV)

The difference in volume of the fruit immediately after harvest and after reaching 100 per cent ripeness was divided by the initial volume of the fruit and expressed as percentage to get PLV.

3.3.2.7 Firmness of the fruit

Firmness of the fruit and pulp was measured by penetrometer method using (Model FT 001 (0-5 kg) and Model FT 001 (5-13 kg). Readings were noted from the pressure gauge as kg per sq cm.

3.4 Nutrient analysis and other constituents of the raw and ripe banana

Banana varieties of different genomes were analysed for the following constituents. All the analysis were carried out in triplicate samples

1. Moisture
2. Total fibre
3. Protein
4. Starch

5. Calcium
6. Phosphorus
7. Iron
8. Potassium
9. Vitamin C
10. Beta-carotene
11. T.S.S
12. Acidity
13. Reducing sugar
14. Total sugar
15. Non-reducing sugar

3.4.1 Moisture

Moisture content of the selected raw and ripe banana varieties was estimated using the method of A.O.A.C (1980)

3.4.2 Total fibre

Total fibre content of the raw and ripe samples were estimated by acid – alkali digestion method suggested by Chopra and Kanwar (1978)

3.4.3 Protein

Protein content of the raw samples was estimated by Nesslers method suggested by Snell and Snell (1967).

3.4.4 Starch

The starch content of the raw and ripe samples were analysed colorimetrically as suggested by Sadasivam and Manikam (1992)

3.4.5 Calcium

Calcium content of the raw and ripe samples were estimated in an Atomic Absorption Spectrophotometer (AAS) after preparing a diacid extract (Perkin – Elmer, 1982)

3.4.6 Phosphorus

The phosphorus content of the raw and ripe samples was estimated colorimetically after preparing a diacid extract by vanadomolybdophosphoric yellow colour method in nitric acid medium (Jackson, 1973)

3.4.7 Iron

Iron content of the raw and ripe samples was estimated in an AAS after preparing a diacid extract (Perkin – Elmer, 1982).

3.4.8 Potassium

Potassium content of the raw and ripe samples was estimated using EEL flamephotometer (Jackson, 1958)

3.4.9 Vitamin C

The Vitamin C content of the raw and ripe banana were estimated on fresh samples by the method of AOAC (1955) using 2,6 dichlorophenol indophenol dye.

3.4.10 Beta-carotene

Beta-carotene of the ripe samples was analysed by the method of AOAC (1970) using saturated n-butanol.

3.4.11 Total soluble solids

Total soluble solids (T.S.S) of the ripe samples was found using a hand refractometer having a range from 0-32°brix (ERMA hand refractometer)

3.4.12 Acidity

Acidity of the ripe samples was analysed as the method suggested by Renganna (1986).

3.4.13 Reducing sugar

Reducing sugar of the ripe samples was estimated by the method suggested by Renganna (1986)

3.4.14 Total sugars

Total sugars of the ripe samples was estimated as per the methods described by Renganna (1986)

3.4.15 Non-reducing sugar

The difference between the total sugars and reducing sugars was calculated and expressed as percent of non-reducing sugars.

3.5 Organoleptic Evaluation

Organoleptic evaluation of the raw and ripe fruit was conducted at the laboratory level

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 18-35 years as suggested by Jellinek (1985).

Preparation of the samples

Sensory evaluation of the raw banana was carried out by preparing thoran and porridge.

Thoran

The raw banana (120g) was washed thoroughly in water and cut into small pieces and cooked in sufficient quantity of water adding salt to taste. Heated 10g of oil and spluttred mustard. Added 30g of scraped coconut, three chopped green chillies, 1/3 teaspoon of turmeric powder. Sautéd for some time and then added the cooked banana into the mixture and cooked on a low flame.

Porridge

The raw fruit was washed, peeled, sliced, dried and powdered and this powder was used for the preparation of porridge.

Porridge was prepared by cooking banana powder (10g) in 200ml of milk which was made by mixing 3 teaspoon full of milk powder. Added 2½ teaspoon of sugar to the porridge and was cooked on a low flame until the required consistency was obtained.

Sensory evaluation

Acceptability trials of the cooked thoran, porridge and ripe banana were conducted using the score card suggested by Swaminathan (1974). Five point Hedonic scale was used to assess the quality attributes like appearance, colour, flavour, texture and taste and a nine point Hedonic scale suggested by Renganna (1968) was used to assess the overall acceptability. The score card used to evaluate the acceptability is given in Appendix II.

Statistical analysis

Analysis of the data was conducted using Duncans Multiple Range test (DMRT) and cluster analysis.

Results

4. RESULTS

The results pertaining to the study entitled "Evaluation of banana varieties for quality attributes" are presented under the following headings.

4.1 Physical characters of the banana varieties

4.2 Nutritional composition and other constituents present in banana varieties

4.3 Acceptability of banana varieties

4.1 Physical characters of the banana varieties

The physical characters like date of harvest, weight of bunch, weight of hands, number of hands, number of fingers in each hand and pulp/peel ratio were recorded.

In accordance with the colour chart for banana the colour of the fruit and colour of the pulp were recorded. Weight and volume of the fruit, firmness of the fruit and pulp from the day of harvest were also recorded.

4.1.1 Duration of maturity

From the date of harvest the duration of different banana varieties to reach maturity was computed and the duration of maturity of different banana varieties are given in Table 1. After planting Nendran took 300 days and Kapooravally 363 days to reach maturity. Monthan, Red banana and Kanchikela took 345 days to reach complete maturity.

Table 1. Duration of maturity of banana varieties

Sl.No.	Variety	Duration to attain maturity (days)
1	Nendran	300
2	Palayankodan	305
3	Karpooravally	363
4	Monthan	345
5	Robusta	310
6	Red banana	345
7	Kunnan	343
8	Njalipoovan	328
9	Kadali	317
10	Matti	330
11	Kanchikela	345

4.1.2 Weight of bunch

The bunch weight of different banana varieties are given in Table 2. The bunch weight ranged from 5.67 to 12.83 kg. The highest value was observed in Robusta and lowest in Kanchikela. The weight of Kanchikela very low representing its varietial character.

Table 2. Bunch weight of banana varieties (kg)

Sl.No.	Variety	Mean
1	Nendran	9.00^{bcd}
2	Palayankodan	11.33^{an}
3	Karpooravally	10.67^{abc}
4	Monthan	10.00^{bcd}
5	Robusta	12.83^{a}
6	Red banana	8.33^{cde}
7	Kunnan	10.00^{bcd}
8	Njalipoovan	8.33^{cde}
9	Kadali	6.00^{ef}
10	Matti	7.83^{def}
11	Kanchikela	5.67^{f}

Values having different superscripts differ significantly at 5% level

On the basis of Duncans Multiple Range Test, the different banana varieties were arranged into eight groups on the basis of bunch weight. All the groups had only one member each except groups bcd and cde which had three and two members respectively.

Analysis of variance test indicated that there was a significant variation between the different banana varieties with respect to the bunch weight at one per cent level (F value = 7.386).

4.1.3 Weight of hands

Weight of the hands of the banana varieties are presented in Table 3. The weight of hands ranged from 693.3 g in Njalipoovan and 2083 g in Monthan.

Table 3. Weight of hands of banana varieties (gram)

Sl.No.	Variety	Mean
1	Nendran	1705.0 ^{abc}
2	Palayankodan	1292.0 ^{bcd}
3	Karpooravally	936.7 ^{d}
4	Monthan	2083.0 ^{a}
5	Robusta	1285.0 ^{bcd}
6	Red banana	1753.0 ^{ab}
7	Kunnan	1280.0 ^{bcd}
8	Njalipoovan	693.3 ^{d}
9	Kadali	953.3 ^{d}
10	Matti	716.7 ^{d}
11	Kanchikela	1067.0 ^{cd}

Values having different superscripts differ significantly at 5% level

According to DMRT, the different banana varieties were classified into 6 groups based on the weight of hands. All the groups had one member each except for groups bcd and d which had three and four members each.

The results of the statistical analysis indicated that there was significant variation in the weight of hands at one per cent level between the varieties (F value = 4.800).

4.1.4 Number of hands

The number of hands of the banana varieties are furnished in Table 4. The mean value ranged from 4.33 in Red banana to 11.67 in Njalipoovan.

Table 4. Number of hands of banana varieties

Sl.No.	Variety	Mean
1	Nendran	5.33^{d}
2	Palayankodan	9.00^{b}
3	Karpooravally	11.33^{a}
4	Monthan	7.00^{c}
5	Robusta	7.00^{c}
6	Red banana	4.33^{d}
7	Kunnan	9.33^{b}
8	Njalipoovan	11.67^{a}
9	Kadali	5.66^{cd}
10	Matti	4.66^{d}
11	Kanchikela	5.00^{d}

Values having different superscripts differ significantly at 5% level

Statistically, the banana varieties were differentiated into five categories. The categories a, b and c had two members each. Nendran, Red banana, Matti and Kanchikela were grouped in the same catagory (d) indicating that there is no significant difference in the number of hands within the varieties included in this group but differ significantly from the varieties included in other groups.

The results of the statistical analysis indicated that there was significant variation in the number of hands at one per cent level between the banana varieties ($F = 36.526$).

4.1.5 Number of fingers in each hand

The number of fingers in each hand of the banana varieties are presented in Table 5. The maximum number of fingers were found in Matti (19.33) and lowest in Kanchikela (8.33).

Table 5. Number of fingers in each hand of banana varieties

Sl.No.	Variety	Mean
1	Nendran	11.33 ^{cd}
2	Palayankodan	13.67 ^{bc}
3	Karpooravally	14.67 ^{abc}
4	Monthan	11.67 ^{cd}
5	Robusta	14.00 ^{bc}
6	Red banana	16.00 ^{abc}
7	Kunnan	16.33 ^{abc}
8	Njalipoovan	18.67 ^{ab}
9	Kadali	18.00 ^{ab}
10	Matti	19.33 ^{a}
11	Kanchikela	8.33 ^{d}

Values having different superscripts differ significantly at 5% level

On the basis of DMRT, the banana varieties were differentiated into 6 categories. The categories ab, bc and cd had two members each. The members of different categories were significantly different from each other.

The analysis of variance test indicated significant variation between the varieties with respect to the number of fingers in each hand (F value 4.650).

4.1.6 Pulp/peel ratio

The pulp/peel ratio of the banana varieties are presented in Table 6. The pulp/peel ratio of the varieties in raw stage varied from 0.60 to 2.40. The highest value was observed in Kadali and the lowest in Palayankodan.

Table 6. Pulp/peel ratio of banana varieties

Sl.No.	Variety	Raw	Ripe
1	Nendran	2.23 ^{ab}	5.60 ^{b}
2	Palayankodan	0.60 ^{f}	4.16 ^{c}
3	Karpooravally	1.43 ^{cde}	2.26 ^{d}
4	Monthan	1.21 ^{de}	1.93 ^{d}
5	Robusta	1.18 ^{def}	1.86 ^{d}
6	Red banana	0.86 ^{ef}	2.33 ^{d}
7	Kunnan	1.63 ^{bcd}	5.00 ^{bd}
8	Njalipoovan	2.03 ^{abc}	5.33 ^{b}
9	Kadali	2.40 ^{a}	8.33 ^{a}
10	Matti	2.03 ^{abc}	4.66 ^{bc}
11	Kanchikela	1.23 ^{de}	2.51 ^{d}

Values having different superscripts differ significantly at 5% level

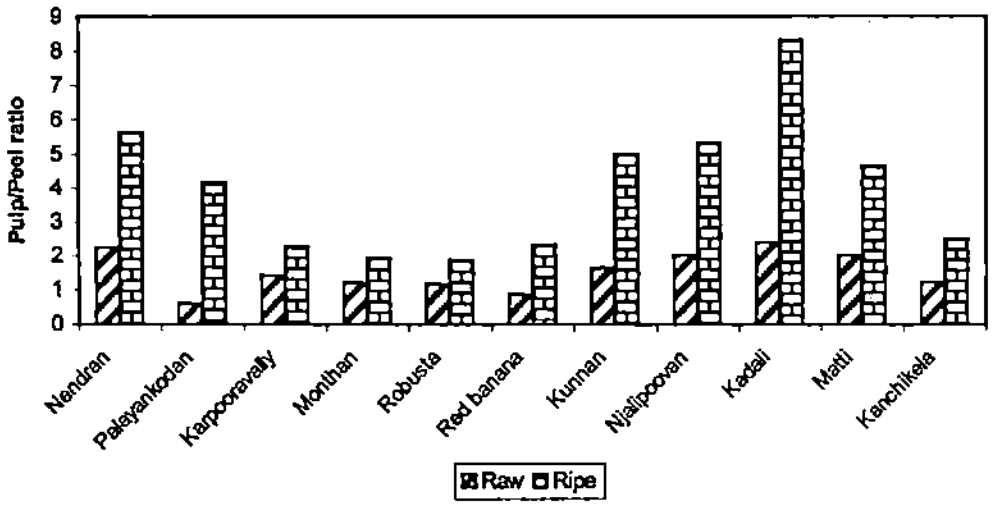


Fig. 1. Pulp/peel ratio of banana varieties

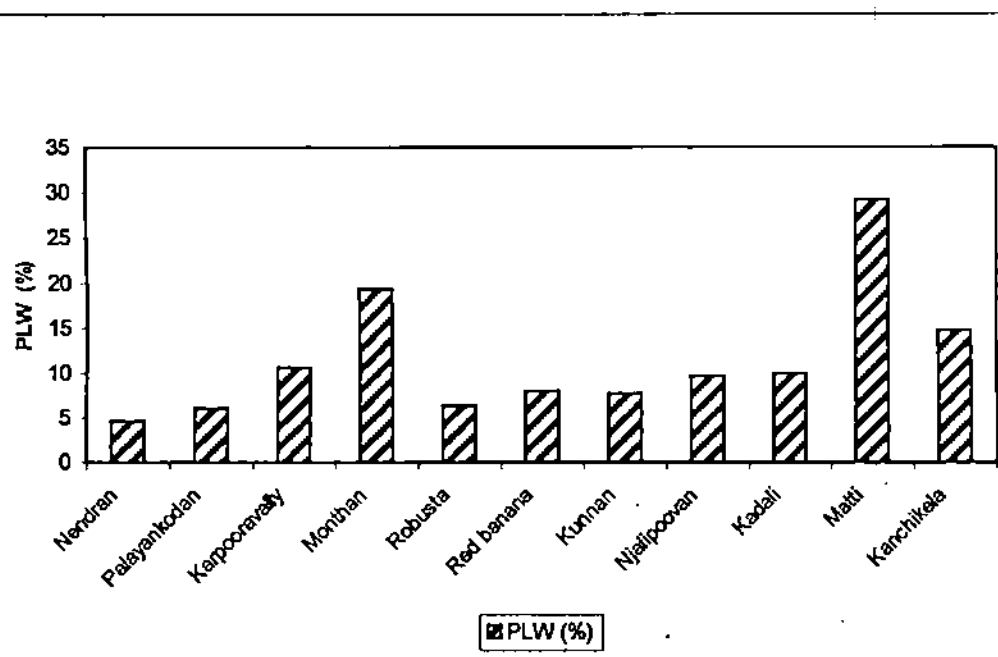


Fig. 2. Physiological loss of weight

The raw banana were grouped into 8 classes based on the pulp/peel ratio. Each group had one member each except group abc (Njalipoovan and Matti) and de (Monthan and Kanchikela) which had two members each.

In the ripe stage the pulp/peel ratio ranged from 1.86 in Robusta to 8.33 in Kadali.

DMRT classified the ripe banana into 5 categories based on the pulp/peel ratio. Each category had two or less members each except in group d which had 5 members. The members of each group had no significant difference within themselves but differed significantly from the banana varieties included in other groups.

The pulp/peel ratio of the raw and ripe banana varieties during raw and ripe stages is illustrated in Figure 1.

Analysis of variance indicated significant difference with respect to pulp/peel ratio between the banana varieties in raw stage (F value = 9.442) as well as in the ripe stage (F value = 33.541). Significant variation existed in the banana varieties between raw and ripe stages (F value = 16.8737) also with respect to the pulp/peel ratio.

4.1.7 Colour of the fruit

The colour of the fruit during the different stages are given in Table 7. Most of the fruits in the raw stage have a green colour except for Red banana which had a maronish colour. Similarly in the ripe stage (stage 7) most of the fruits developed a yellow colour except for Red banana which had a maronish brown colour and Robusta which had a light green colour.

Table 7. Colour of the fruit in different stages

Sl. No.	Variety	I	II	III	IV	V	VI	VII
1	Nendran	Green	Green	Green	Greenish yellow	Greenish tip	Yellow	Yellow
2	Palanyankodan	Green	Green	Green	Greenish yellow	Greenish tip	Yellow	Yellow
3	Karpooravally	Green	Green	Green	Greenish yellow	Greenish tip	Yellow	Yellow
4	Monthan	Green	Green	Green	Greenish yellow	Greenish tip	Yellow	Yellow
5	Robusta	Green	Green	Green	Greenish yellow	Greenish tip	Light green	Light green
6	Red banana	Maronish green	Maronish green	Maronish green	Maronish green	Maronish brown	Maronish brown	Maronish brown
7	Kunnan	Green	Green	Green	Greenish yellow	Greenish tip	Yellow	Yellow
8	Njalipoovan	Green	Green	Green	Greenish yellow	Greenish tip	Yellow	Yellow
9	Kadali	Green	Green	Green	Greenish yellow	Greenish tip	Yellow	Yellow
10	Matti	Green	Green	Green	Greenish yellow	Greenish tip	Yellow	Yellow
11	Kanchikela	Green	Green	Green	Greenish yellow	Greenish tip	Yellow	Yellow

4.1.8 Colour of the pulp

The colour of pulp during the different stages of ripening are presented in Table 8. Most of the fruit pulp had an off-white colour in the first stage except for Red banana which had a pale yellow colour. In the seventh stage most of the fruit pulp had a cream or yellow colour.

Table 8. Colour of the pulp in different stages

Sl. No.	Variety	I	II	III	IV	V	VI	VII
1	Nendran	Off white	Off white	Off white	Light yellow	Dark yellow	Dark yellow	Dark yellow
2	Palanyankodan	Off white	Off white	Off white	Cream	Cream	Light yellow	Light yellow
3	Karpooravally	Off white	Off white	Off white	Cream	Cream	Light yellow	Light yellow
4	Monthan	Off white	Off white	Off white	Off white	Off white	Cream	Cream
5	Robusta	Off white	Off white	Off white	Off white	Off white	Cream	Cream
6	Red banana	Pale yellow	Pale yellow	Pale yellow	Pale yellow	Light yellow	Light yellow	Light yellow
7	Kunnan	Off white	Off white	Off white	Off white	Off white	Cream	Cream
8	Njalipoovan	Off white	Off white	Off white	Off white	Cream	Cream	Cream
9	Kadali	Off white	Off white	Off white	Off white	Light yellow	Light yellow	Light yellow
10	Matti	Off white	Off white	Off white	Off white	Light yellow	Light yellow	Light yellow
11	Kanchikela	Off white	Off white	Off white	Off white	Cream	Cream	Cream

4.1.9 Weight of the fruit

Table 9. Weight of the fruit (g) and physiological loss of weight (PLW %)

Sl.No.	Variety	Raw (g)	Ripe (g)	PLW (%)
1	Nendran	143.30^{ab}	136.70^{a}	4.63^{c}
2	Palayankodan	83.33^{c}	78.33^{c}	6.09^{c}
3	Karpooravally	58.83^{d}	51.67^{d}	10.70^{bc}
4	Monthan	153.30^{a}	123.30^{a}	19.43^{ab}
5	Robusta	80.00^{c}	75.00^{c}	6.37^{c}
6	Red banana	103.30^{b}	95.00^{b}	8.03^{bc}
7	Kunnan	65.00^{d}	70.00^{c}	7.72^{bc}
8	Njalipoovan	35.00^{f}	31.67^{f}	9.70^{bc}
9	Kadali	51.67^{de}	46.67^{de}	10.00^{bc}
10	Matti	40.00^{ef}	28.33^{f}	29.17^{d}
11	Kanchikela	113.30^{b}	96.67^{b}	14.80^{bc}

Values having different superscripts differ significantly at 5% level

Weight of the fruit in raw and ripe stage is furnished in Table 9. The weight of the raw fruit ranged from 35.00 g to 153.3 g in Njalipoovan and Monthan respectively.

On the basis of DMRT, the raw banana varieties were classified into seven groups. Each group had 2 members each except for ab, a, de, ef and f groups which had only one member each. The members of these groups being Nendran (ab), Monthan (a) Kadali (de), Matti (ef) and Njalipoovan (f).

The weight of the ripe fruit ranged from 28.33 g in Matti to 136.7 g in Nendran.

Statistically the ripe fruits were differentiated into seven groups. Members of different groups were found to be significantly different from each other.

The physiological loss of weight of the banana varieties is given in Table 9. The loss of weight was highest in Matti (29.17%) and lowest in Nendran (4.63%).

Statistically the varieties were classified into four groups on the basis of physiological loss of weight. The group bc had six members namely Karpooravally, Red banana, Kunnan, Njalipoovan, Kadali and Kanchikela indicating that there is no significant difference within these varieties with respect to PLW but was significantly different from varieties included in other groups.

The physiological loss of weight of eleven banana varieties is given in Figure 2.

Analysis of variance revealed significant variation (1% level) between the varieties both in the raw (F value = 63.28) and ripe (F value - 47.371) stages. The variation in the weight between the raw and ripe banana was found to be insignificant (F value = 1.53). The physiological loss of weight was found to be statistically significant between varieties (F value = 3.777).

4.1.10 Volume of the fruit

Table 10. Volume of fruit (ml) and physiological loss of volume (%)

Sl.No.	Variety	Raw (g)	Ripe (g)	PLV (%)
1	Nendran	140.00^{c}	135.00^{b}	3.57^{cd}
2	Palayankodan	53.33^{g}	50.00^{f}	9.44^{bcd}
3	Karpooravally	53.33^{g}	46.67^{fg}	12.20^{abc}
4	Monthan	150.00^{b}	123.30^{c}	21.77^{a}
5	Robusta	163.30^{a}	153.30^{a}	6.12^{d}
6	Red banana	96.67^{e}	93.33^{d}	0.00
7	Kunnan	76.67^{f}	70.00^{e}	0.90^{bcd}
8	Njalipoovan	46.67^{g}	40.00^{gh}	13.33^{abc}
9	Kadali	46.67^{g}	36.67^{h}	21.67^{a}
10	Matti	33.33^{h}	31.67^{h}	13.07^{abc}
11	Kanchikela	106.70^{d}	86.67^{d}	18.73^{ab}

Values having different superscripts differ significantly at 5% level

The volume of the fruit in the raw and ripe stage is given in Table 10. The volume of the raw fruit ranged from 33.33 ml in 163.3 ml in Matti and Robusta respectively.

On the basis of DMRT, the raw banana were differentiated into eight groups. Each group had only one member except for group 'g' which had four members indicating that there was no significant variation between the varieties namely Palayankodan, Karpooravally, Njalipoovan and Kadali included in this group with respect to volume of fruit.

The volume of the ripe fruit ranged from 31.67 ml in Matti to 153.3 ml in Robusta.

Statistical analysis differentiated the varieties in the ripe stage into nine groups. Each group had only one member except for group d and h which had 2 members each.

The physiological loss of volume is also given in Table 10. The loss of volume was highest in Monthan (21.77%) and lowest in Red banana with no loss in volume.

Statistically the varieties in the ripe stage were classified into five groups on the basis of physiological loss of volume.

The physiological loss of volume of eleven banana varieties is given in Figure 3.

Analysis of variance revealed significant variation at one per cent level between the varieties both in the raw (F value = 237.422) and ripe (F value = 197.054) stages. There is significant difference in volume at one per cent level between the raw and ripe stages (F value = 3.1753). The physiological loss of volume was significant (at 1% level) between varieties (F value = 4.069).

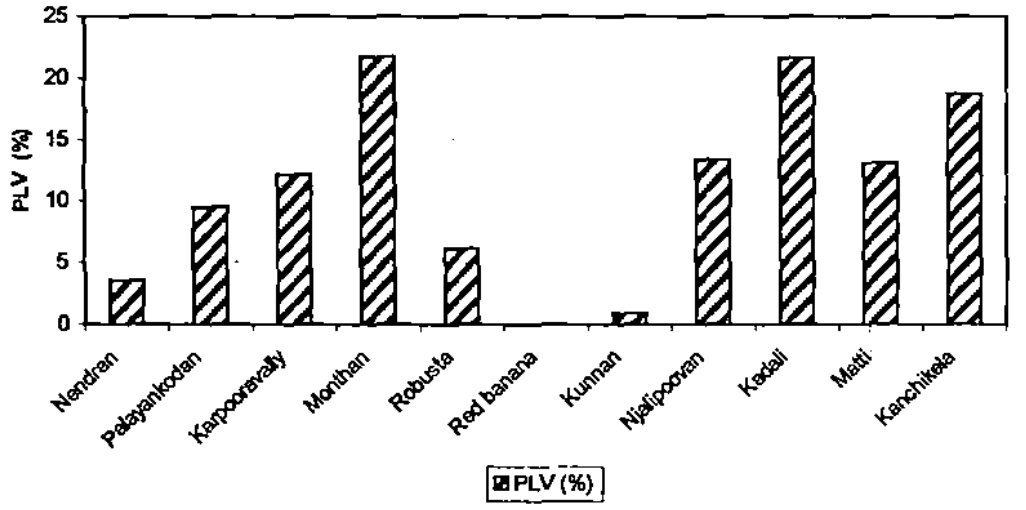


Fig. 3. Physiological loss of volume

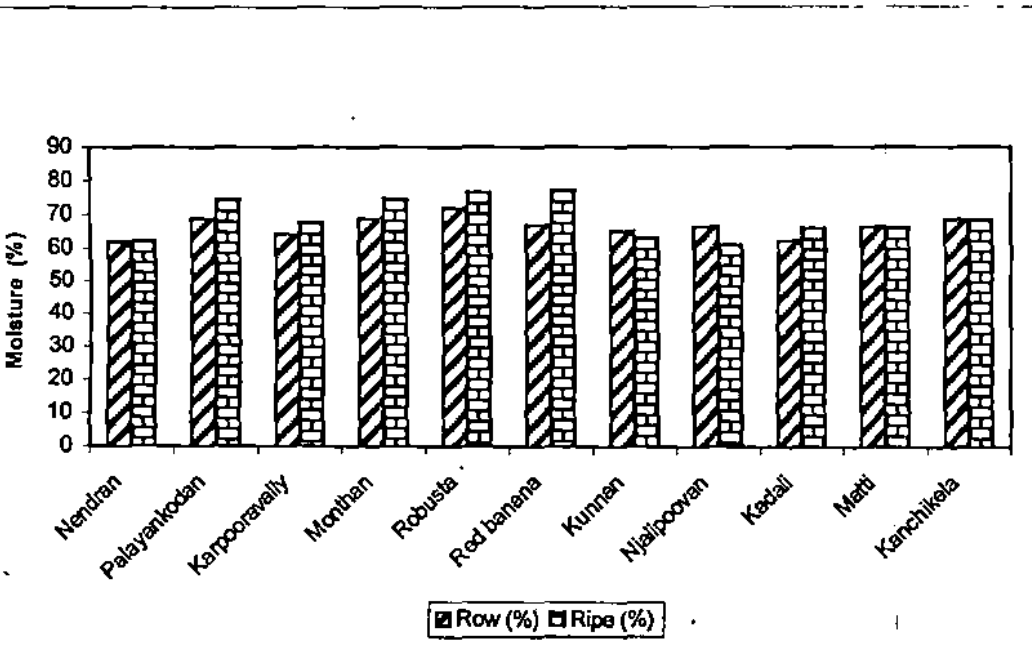


Fig. 4. Percentage of moisture conent

4.1.11 Firmness of fruit and pulp

4.1.11.1 Firmness of fruit

Table 11. Firmness of fruit (kg cm^{-2})

Sl.No.	Variety	Mean
1	Nendran	4.06 [a]
2	Palayankodan	1.43 [d]
3	Karpooravally	1.96 [cd]
4	Monthan	1.86 [cd]
5	Robusta	1.90 [cd]
6	Red banana	3.40 [ab]
7	Kunnan	1.76 [cd]
8	Njalipoovan	2.13 [cd]
9	Kadali	3.53 [ab]
10	Matti	2.26 [cd]
11	Kanchikela	2.73 [bc]

Values having different superscripts differ significantly at 5% level

The firmness of banana varieties is furnished in Table 11. The firmness varied from 1.43 to 4.06 kg cm^{-2}. The highest value was recorded in Nendran and lowest in Palayankodan.

On the basis of DMRT, the fruit varieties were differentiated into five groups. Each group had only two or less members while varieties like Karpooravally, Monthan, Robusta, Kunnan, Njalipoovan and Matti were included in group 'cd' indicating no significant difference between these varieties with respect to firmness of the fruit.

Analysis of variance test indicated significant variation between varieties at one per cent level (F value 7.150) with respect to the firmness of the fruit. There is significant difference with respect to the firmness from the 1st stage to the seventh stage of ripeness (F value = 3.6097) at one per cent level.

4.1.11.2 Firmness of the pulp

The firmness of the pulp is furnished in Table 12 which varied from 0.16 to 0.73 kg cm^{-2}. The lowest value was seen in Robusta, Red banana, Matti and Kanchikela. The highest value was recorded in Nendran.

Table 12. Firmness of pulp (kg cm^{-2})

Sl.No.	Variety	Mean
1	Nendran	0.73 [a]
2	Palayankodan	0.50 [b]
3	Karpooravally	0.23 [c]
4	Monthan	0.30 [bc]
5	Robusta	0.16 [c]
6	Red banana	0.16 [c]
7	Kunnan	0.30 [bc]
8	Njalipoovan	0.30 [bc]
9	Kadali	0.23 [c]
10	Matti	0.16 [c]
11	Kanchikela	0.16 [c]

Values having different superscript differ significantly at 5% level

On the basis of DMRT, the fruit varieties were differentiated into four group. All the groups had one member each except group c which had six members.

Analysis of variance test indicated significant variation between the pulp of different varieties at one per cent level (F value = 5.184) with respect to the firmness. There is significant difference with respect to the firmness from the first stage to the seventh stage of ripeness (F value = 3.4107) at one per cent level.

4.2 Nutritional composition and other constituents present in banana varieties

The banana varieties were analysed for eight nutrients i.e., moisture, total fibre, starch, calcium, phosphorus, iron, potassium and vitamin C both in the raw and ripe stages. Protein was analysed only in the raw stage and betacarotene was estimated in the ripe stage and other chemical constituents like total soluble

solids, acidity, reducing sugar, total sugar and non-reducing sugar were estimated only in the ripe stage.

4.2.1 Moisture

The moisture content of banana varieties are given in Table 13. The moisture content of banana varieties (raw) ranged from 61.93 per cent in Nendran to 71.97 per cent in Robusta.

Table 13. Moisture content of banana varieties (%)

Sl. No.	Variety	Raw	Ripe
1	Nendran	61.93^{c}	62.43^{f}
2	Palayankodan	68.87^{b}	74.43^{b}
3	Karpooravally	64.37^{d}	67.67^{cd}
4	Monthan	68.83^{b}	74.70^{b}
5	Robusta	71.97^{a}	76.60^{a}
6	Red banana	66.83^{c}	77.23^{a}
7	Kunnan	65.10^{d}	63.10^{f}
8	Njalipoovan	66.47^{c}	61.00^{g}
9	Kadali	62.40^{e}	66.03^{e}
10	Matti	66.53^{c}	66.37^{de}
11	Kanchikela	68.57^{b}	68.70^{c}

Values having different superscripts differ significantly at 5% level

According to DMRT, the banana varieties were classified into five groups based on their moisture content in the raw stage. Each group had two or less members except group c and b which had three members each. The banana varieties included in the same class were not significantly different from each other but differed significantly with the varieties included in other classes.

The moisture content of the banana varieties in the ripe stage varied from 61.00 per cent to 77.23 per cent. The highest moisture content was observed in Red banana and lowest in Njalipoovan.

Statistically the different banana varieties were arranged into eight groups on the basis of moisture content in the ripe stage (Table 13). Most of the groups had one member each except for group a, b and f which had two members each.

The moisture content of the eleven banana varieties in the raw and ripe stages is shown in Figure 4.

Analysis of variance indicated that there was significant variation between the banana varieties with respect to moisture in the raw (F value = 120.00) as well as ripe stages (F value = 170.02) at one per cent level. There was significant variation with respect to moisture content of the banana varieties between the raw and ripe stages (F value = 67.7451).

4.2.2 Total fibre

The fibre content of banana varieties in the raw and ripe stages is presented in Table 14.

Table 14. Fibre content of banana varieties (g 100 g^{-1})

Sl. No.	Variety	Raw	Ripe
1	Nendran	0.18 ^{abc}	0.18
2	Palayankodan	0.15 ^{bc}	0.17
3	Karpooravally	0.11 ^{bc}	0.21
4	Monthan	0.36 ^{a}	0.33
5	Robusta	0.18 ^{abc}	0.19
6	Red banana	0.27 ^{ab}	0.15
7	Kunnan	0.21 ^{abc}	0.39
8	Njalipoovan	0.05 ^{c}	0.19
9	Kadali	0.12 ^{bc}	0.28
10	Matti	0.22 ^{abc}	0.27
11	Kanchikela	0.20 ^{abc}	0.20

Values having different superscripts differ significantly at 5% level

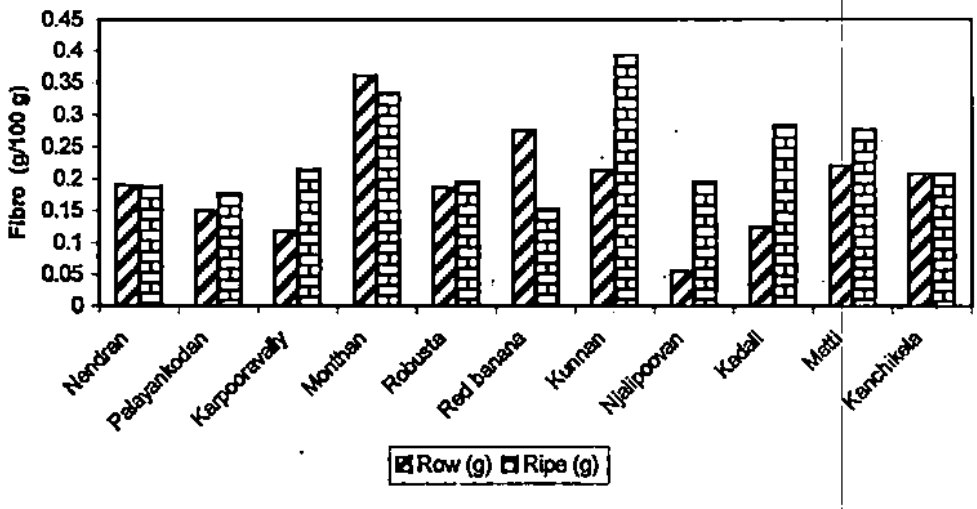


Fig. 5. Total fibre content of banana varieties

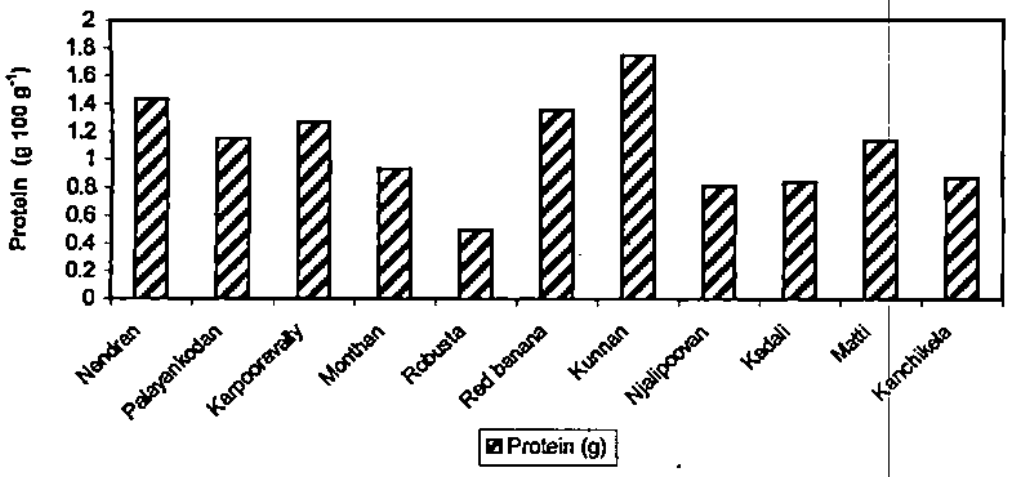


Fig. 6. Protein content of banana varieties

The fibre content of the banana varieties in the raw stage ranged from 0.05 (Njalipoovan) to 0.36 g 100 g^{-1} (Monthan).

Statistically, the different banana varieties were classified into five groups on the basis of fibre content in the raw stages. The group abc had five members in it.

In the ripe stage, the fibre content of the varieties varied from 0.15 to 0.39 g 100 g^{-1} in Red banana and Kunnan respectively.

The fibre content of the eleven banana varieties in the raw and ripe stage is shown in Figure 5.

Analysis of variance test indicated significant variation between the banana varieties in the raw (F value = 2.150) stage while the variation in the banana varieties in the ripe stage was found to be insignificant (F value = 1.765). The variation in the banana varieties between the raw and ripe stages (F value = 0.2589) was also found to be statistically insignificant at one per cent level.

4.2.3 Protein

The crude protein content of raw banana on fresh weight basis are furnished in Table 15.

The protein content of the varieties ranged from 0.5 to 1.74 g 100 g^{-1}. The highest value was observed in Kunnan and the lowest in Robusta.

Statistically the banana varieties were differentiated into eight categories on the basis of protein content. The different categories had two or less members each except for group de which had three members in it.

Table 15. Protein content of banana varieties (g 100 g^{-1})

Sl. No.	Variety	Raw
1	Nendran	1.43 ^{ab}
2	Palayankodan	1.15 ^{bcd}
3	Karpooravally	1.26 ^{bc}
4	Monthan	0.93 ^{cd}
5	Robusta	0.50 ^{e}
6	Red banana	1.35 ^{ab}
7	Kunnan	1.74 ^{a}
8	Njalipoovan	0.81 ^{de}
9	Kadali	0.84 ^{de}
10	Matti	1.13 ^{bcd}
11	Kanchikela	0.86 ^{de}

Values having different superscripts differ significantly at 5% level

The protein content of eleven banana varieties is shown in Figure 6.

The results of the statistical analysis indicated that there was significant variation in the protein content at one per cent level between the banana varieties in the raw stage (F value = 8.149).

4.2.4 Starch

The starch content of eleven banana varieties was estimated and the results are furnished in Table 16.

In the raw stage, the starch content ranged from 8.05 g 100 g^{-1} (Palayankodan) to 13.27 g 100 g^{-1} (Njalipoovan).

Table 16. Starch content of banana varieties (g 100 g^{-1})

Sl. No.	Variety	Raw	Ripe
1	Nendran	12.09^{bc}	1.84^{c}
2	Palayankodan	8.05^{e}	1.77^{de}
3	Karpooravally	12.78^{ab}	1.39^{d}
4	Monthan	10.00^{d}	1.11^{de}
5	Robusta	8.43^{e}	1.25^{de}
6	Red banana	10.08^{d}	0.98^{e}
7	Kunnan	10.33^{d}	2.69^{a}
8	Njalipoovan	13.27^{a}	2.74^{a}
9	Kadali	11.80^{c}	2.77^{a}
10	Matti	10.20^{d}	2.30^{b}
11	Kanchikela	10.55^{d}	1.88^{c}

Values having different superscripts differ significantly at 5% level

DMRT classified the banana varieties into six groups on the basis of their starch content in the raw stage. Each group had two or less members each while group 'd' had five members namely Monthan (10%), Red banana (10.08%), Kunnan (10.33%), Matti (10.20%) and Kanchikela (10.55%) which showed that these varieties did not differ significantly from each other but were significantly different from members of other groups.

In the ripe stage, the starch content ranged between 0.98 g 100 g^{-1} in Red banana to 2.77 g 100 g^{-1} in Kadali.

Statistically the banana varieties were differentiated into six categories. The categories 'a' and 'de' had three members each. The variety Kadali was included in group 'a' along with Njalipoovan and Kunnan indicating that there was no significant difference between these variety based on the starch content.

The starch content of eleven banana varieties in the raw and ripe stages is shown in Figure 7.

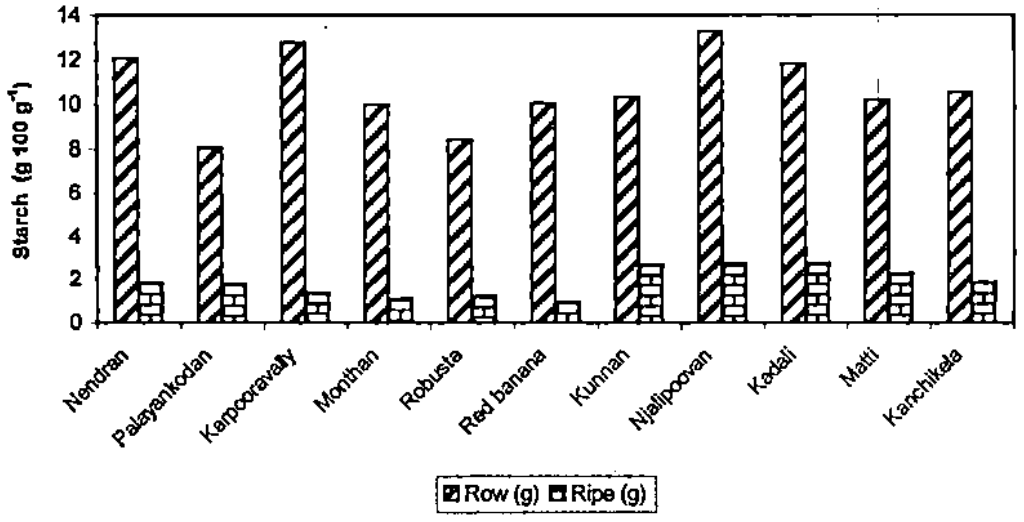


Fig. 7. Starch content of banana varieties

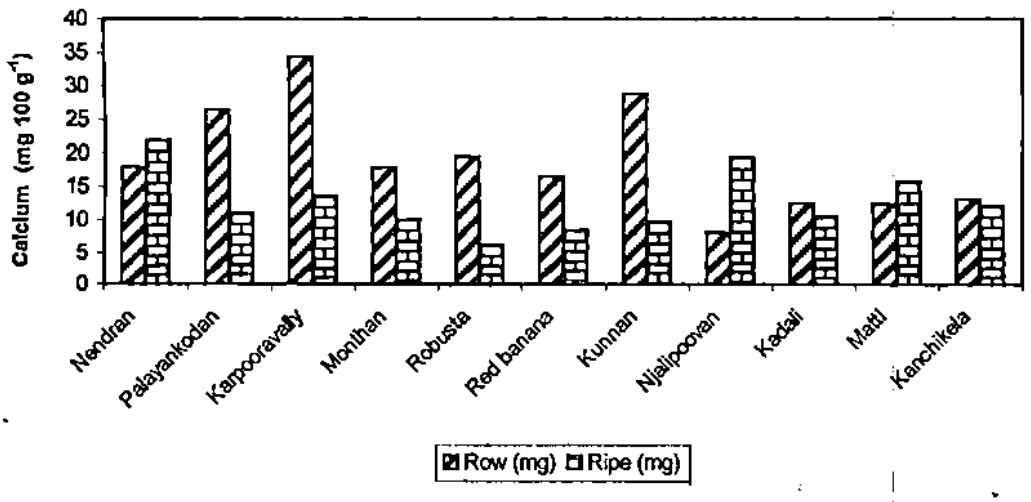


Fig. 8. Calcium content of banana varieties

Analysis of variance revealed significant variation in starch content (1% level) between the banana varieties in the raw (F value = 39.63) and ripe (F value = 55.853) stages. Significant variation was also observed in the starch content of the banana varieties between the raw and ripe stages (F value = 26.032).

4.2.5 Calcium

Calcium content of the eleven banana varieties was analysed on fresh weight basis and the values are furnished in Table 17.

The calcium content of the raw banana ranged from 8.3 mg in Njalipoovan to 34.44 mg 100 g^{-1} in Karpooravally.

Table 17. Calcium content of banana varieties (mg 100 g^{-1})

Sl. No.	Variety	Raw	Ripe
1	Nendran	18.03^{c}	21.93^{a}
2	Palayankodan	26.40^{b}	11.22^{cdef}
3	Karpooravally	34.44^{a}	13.71^{cd}
4	Monthan	17.87^{c}	10.08^{def}
5	Robusta	19.60^{c}	6.42^{f}
6	Red banana	16.58^{cd}	8.53^{ef}
7	Kunnan	28.76^{b}	9.79^{def}
8	Njalipoovan	8.30^{f}	19.50^{ab}
9	Kadali	12.65^{e}	10.62^{def}
10	Matti	12.55^{e}	15.94^{bc}
11	Kanchikela	13.30^{de}	12.29^{cde}

Values having different superscripts differ significantly at 5% level

Statistically the different banana varieties were arranged into seven groups on the basis of calcium content in the raw stage. All the groups had two or less members each except for group c which had three members in it. The members of different groups had significant difference between themselves on the basis of calcium content in the raw stages.

In the ripe stage, the calcium content varied from 6.42 mg in Robusta to 21.93 mg in Nendran per 100 g.

Statistically the different varieties in the ripe stage were classified into nine groups on the basis of the calcium content during the ripe stage. All the groups had only one member each except for group def which had three members in it.

The calcium content of the eleven banana varieties in the raw and ripe stages is shown in Figure 8.

Statistical analysis indicated significant variation in calcium content between the banana varieties in the raw (F value = 46.138) as well as ripe (F value = 9.284) stages at one per cent level. The variation with respect to calcium content of banana between raw and ripe stages at one per cent level (F value = 28.3436) was also found to be significant.

4.2.6 Phosphorus

The phosphorus content of banana varieties in the raw and ripe stages are presented in Table 18.

Table 18. Phosphorus content of banana varieties (mg 100 g^{-1})

Sl. No.	Variety	Raw	Ripe
1	Nendran	26.40 ^{de}	32.97 ^{a}
2	Palayankodan	38.20 ^{a}	29.45 ^{bc}
3	Karpooravally	39.70 ^{a}	26.33 ^{d}
4	Monthan	32.23 ^{b}	30.40 ^{ab}
5	Robusta	20.85 ^{f}	22.67 ^{e}
6	Red banana	24.83 ^{e}	21.23 ^{e}
7	Kunnan	27.57 ^{d}	30.37 ^{ab}
8	Njalipoovan	30.87 ^{bc}	27.27 ^{cd}
9	Kadali	29.93 ^{c}	31.12 ^{ab}
10	Matti	25.57 ^{e}	21.10 ^{e}
11	Kanchikela	22.50 ^{f}	23.47 ^{e}

Values having different superscripts differ significantly at 5% level

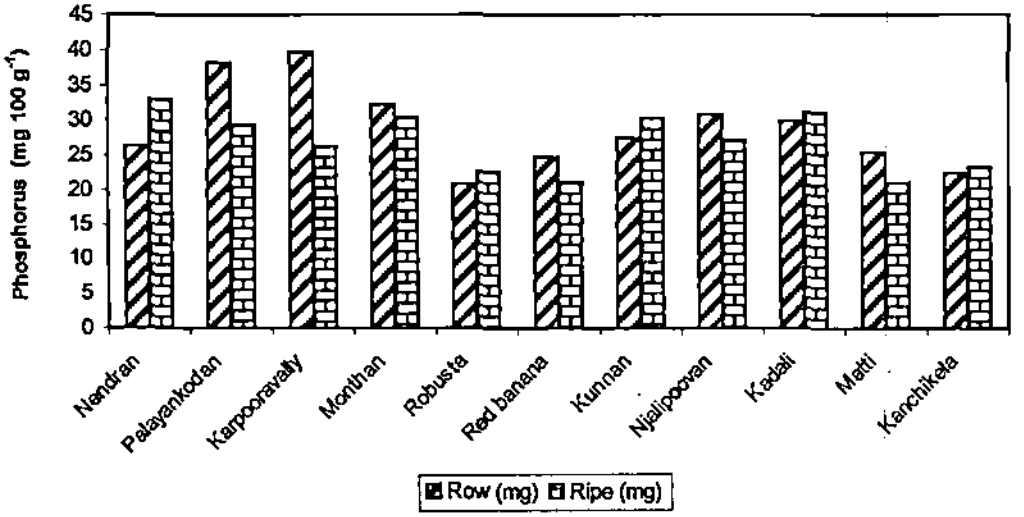


Fig. 9. Phosphorus content of banana varieties

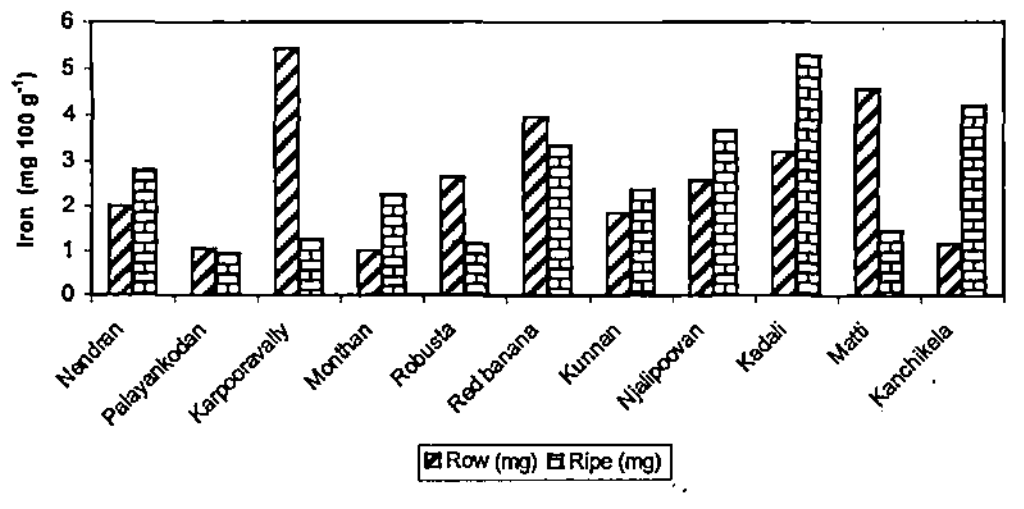


Fig. 10. Iron content of banana varieties

In the raw stage the phosphorus content ranged between 20.85 mg to 39.70 mg 100 g^{-1} with Robusta having the lowest and Karpooravally with the highest value.

On the basis of phosphorus content, the banana varieties were statistically classified into eight categories in the raw stage, each group containing two or less members.

The phosphorus content of the ripe bananas ranged between 21.10 mg in Matti to 32.97 mg in Nendran per 100 gram.

DMRT classified the ripe bananas into six groups on the basis of phosphorus content. Group ab and e has three and four members each.

The phosphorus content of banana in the raw and ripe stages is illustrated in Figure 9.

Analysis of variance indicated significant variation with respect to phosphorus content between banana varieties in the raw (F value = 86.339) well as ripe stages (F value = 22.882) at one per cent level. Significant variation existed in the varieties between the two stages (F value = 26.6974)

4.2.7 Iron

Iron content of banana varieties on fresh weight basis is presented in Table 19.

The iron content of the raw banana ranged between 1.02 to 5.43 mg 100 g^{-1}. The highest value was obtained in Karpooravally and lowest in Monthan.

Table 19. Iron content of banana varieties (mg 100 g^{-1})

Sl. No.	Variety	Raw	Ripe
1	Nendran	2.00^{f}	2.78^{c}
2	Palayankodan	1.05^{g}	0.96^{i}
3	Karpooravally	5.43^{a}	1.28^{h}
4	Monthan	1.02^{g}	2.25^{f}
5	Robusta	2.62^{c}	1.17^{h}
6	Red banana	3.97^{c}	3.34^{d}
7	Kunnan	1.84^{f}	2.35^{f}
8	Njalipoovan	2.56^{e}	3.66^{e}
9	Kadali	3.19^{d}	5.29^{a}
10	Matti	4.57^{b}	1.45^{g}
11	Kanchikela	1.15^{g}	4.22^{b}

Values having different superscripts differ significantly at 5% level

DMRT classified the raw banana into seven categories on the basis of iron content. All the categories had significant variation from each other.

In the ripe banana, the iron content ranged between 0.96 to 5.29 mg $100g^{-1}$ with Palayankodan having the lowest and Kadali having the highest value.

According to DMRT, there were nine categories of banana varieties based on the iron content in the ripe stage. All the groups had one member each except for group f and h which had two members each.

The iron content of the raw and ripe banana is shown in Figure 10.

Significant variation in iron content was observed (at 1% level) between the banana in the raw (F value = 149.347) as well as ripe stages (F value = 1315.626) and between the raw and ripe banana varieties with respect to iron (F value = 288.8964) at one per cent level.

4.2.8 Potassium

Potassium content of banana during raw and ripe stages on fresh weight basis are furnished in Table 20.

The potassium content of the raw banana varied from 391.9 to 563.8 mg 100 g^{-1}. The highest value was obtained in Red banana and the lowest in Karpooravally.

Table 20. Potassium content of banana varieties (mg 100 g^{-1})

Sl. No.	Variety	Raw	Ripe
1	Nendran	514.2^{a}	488.8^{bc}
2	Palayankodan	404.3^{b}	422.4^{d}
3	Karpooravally	391.9^{b}	339.1^{f}
4	Monthan	503.5^{a}	404.8^{de}
5	Robusta	532.0^{a}	446.3^{cd}
6	Red banana	563.8^{a}	399.0^{de}
7	Kunnan	401.3^{b}	442.8^{cd}
8	Njalipoovan	400.1^{b}	409.5^{de}
9	Kadali	526.4^{a}	510.0^{ab}
10	Matti	535.2^{a}	555.0^{a}
11	Kanchikela	491.0^{a}	359.9^{ef}

Values having different superscripts differ significantly at 5% level

On the basis of DMRT, the raw banana was differentiated into two categories a and b. The group 'a' included seven varieties namely Nendran, Monthan, Robusta, Red banana, Kadali, Matti and Kanchikela and group 'b' included four varieties namely Palayankodan, Karpooravaly, Kunnan and Njalipoovan. This indicate that the varieties in group 'a' are significantly different from varieties included in group 'b' with respect to potassium content while they are not significantly different from each other in the same group.

In the ripe stage the potassium content of the banana varieties ranged from 339.1 mg in Karpooravally to 555 mg^{-1} in Matti per 100 gram.

DMRT classified the ripe varieties on the basis of the potassium content into eight groups. The groups had one member in each except for group cd and de which had two and three members in each.

The potassium content of banana in the raw and ripe stages is illustrated in figure 11.

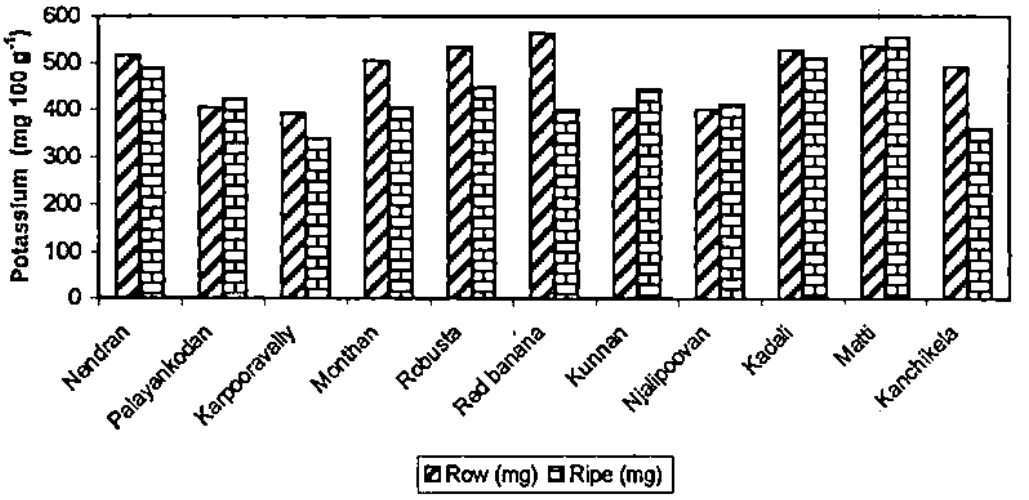


Fig. 11. Potassium content of banana varieties

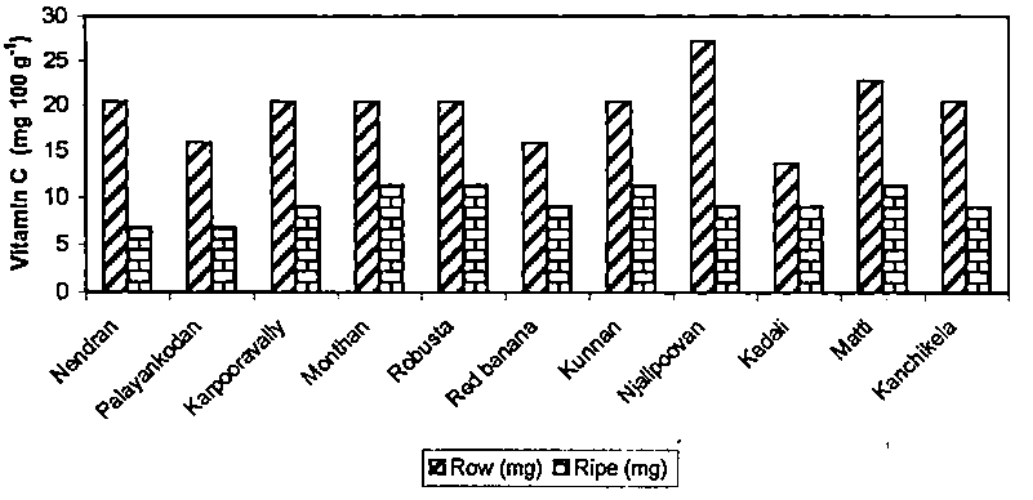


Fig. 12. Vitamin C content of banana varieties

Statistical analysis indicated significant variation in potassium content between the banana varieties in the raw (F value = 8.400) as well as ripe (F value = 11.951) stages at one per cent level. The variation with respect to potassium content of banana between raw and ripe stages at one per cent level (F value = 5.4185) was also found to be significant.

4.2.9 Vitamin C

The vitamin C content of the banana varieties in the raw and ripe stages are presented in Table 21.

Table 21. Vitamin C content of banana varieties (mg 100 g^{-1})

Sl. No.	Variety	Raw	Ripe
1	Nendran	20.40 ^{bc}	6.80
2	Palayankodan	15.87 ^{cd}	6.80
3	Karpooravally	20.40 ^{bc}	9.06
4	Monthan	20.40 ^{bc}	11.33
5	Robusta	20.40 ^{bc}	11.33
6	Red banana	15.87 ^{cd}	9.06
7	Kunnan	20.40 ^{bc}	11.33
8	Njalipoovan	27.20 ^{a}	9.06
9	Kadali	13.60 ^{d}	9.06
10	Matti	22.67 ^{ab}	11.33
11	Kanchikela	20.40 ^{bc}	9.06

Values having different superscripts differ significantly at 5% level

The vitamin C content of the raw banana varied from 13.60 mg $100g^{-1}$ in Kadali to 27.20 mg $100g^{-1}$ in Njalipoovan.

On the basis of vitamin C content in the raw banana the varieties were statistically classified into five categories. The first group (a), second group (ab), and fifth group (d) accommodated one variety each. The varieties included in

group bc are Nendran, Karpooravally, Monthan, Robusta, Kunnan and Kanchikela all having a vitamin C content of 20.40 mg 100 g^{-1}.

The vitamin C content of the ripe banana varied from 6.8 mg in Nendran and Palayankodan to 11.33 mg in Robusta, Monthan, Kunnan and Matti per 100 gram.

The vitamin C content of the banana varieties are shown in Figure 12.

Statistical analysis indicated significant variation in vitamin C content in the varieties during the raw stage (F value = 4.800) while the variation in the varieties during ripe stage was found to be insignificant (F value = 0.689). There existed significant difference between raw and ripe banana in the vitamin C content (F value = 2.8533).

4.2.10 Beta carotene

The beta carotene content of banana in the ripe stage estimated on fresh weight basis is furnished in Table 22.

Table 22. Beta carotene content of banana varieties (µg 100 g^{-1})

Sl. No.	Variety	Ripe
1	Nendran	333.6^{a}
2	Palayankodan	287.0^{b}
3	Karpooravally	42.23^{f}
4	Monthan	17.70^{h}
5	Robusta	87.72^{e}
6	Red banana	37.59^{fg}
7	Kunnan	138.7^{d}
8	Njalipoovan	71.32^{e}
9	Kadali	178.3^{c}
10	Matti	50.34^{f}
11	Kanchikela	20.67^{gh}

Values having different superscripts differ significantly at 5% level

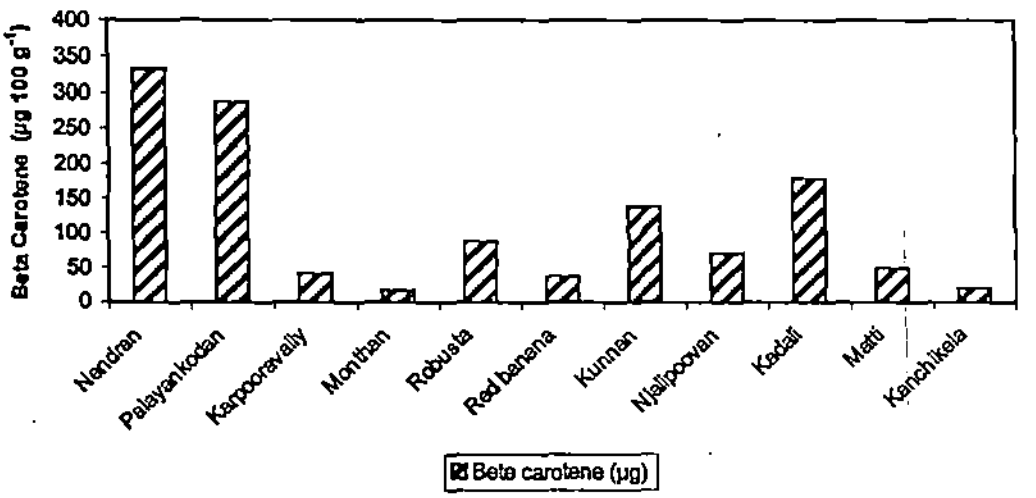


Fig. 13. Beta carotene content of banana varieties

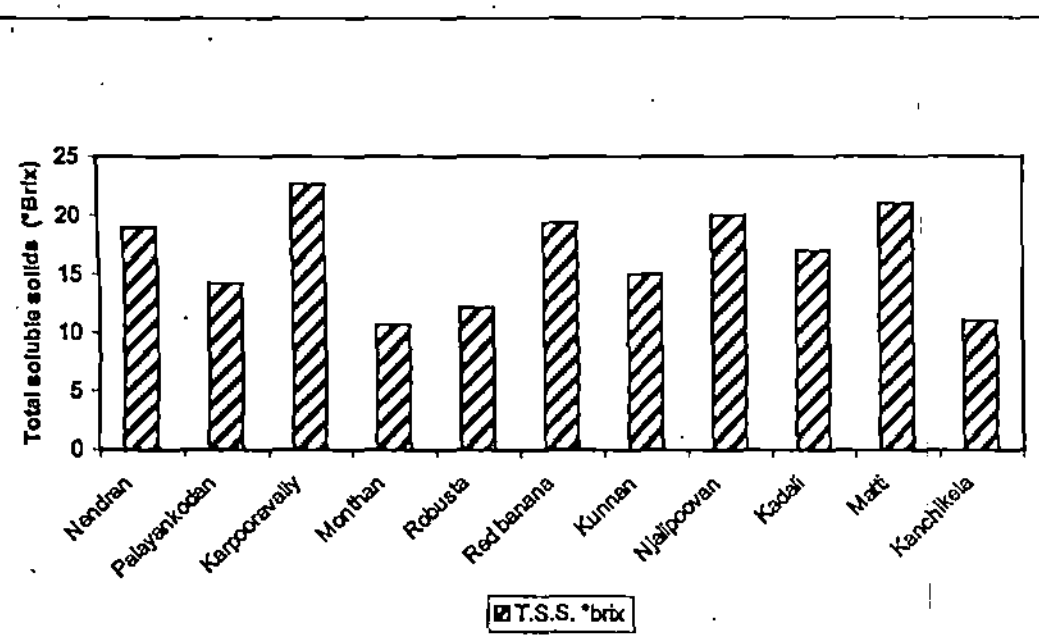


Fig. 14. Total soluble solids of banana varieties

The beta carotene content of the banana varieties ranged from 17.70 µg to 333.6 µg per 100 g. The highest beta carotene content was observed in Nendran and lowest in Monthan.

According to DMRT, the banana varieties were grouped into nine categories on the basis of beta carotene content. The banana varieties belonging to the same group had no significant difference between themselves but they differ from the banana varieties of other categories.

The beta carotene content of banana varieties is shown in Figure 13.

The analysis of variance test revealed that the variation in beta carotene content between banana varieties (F value = 295.741) is statistically significant of one per cent level.

4.2.11 Total soluble solids

The total soluble solids of banana varieties is furnished in Table 23.

The T.S.S of the varieties ranged from 10.67 to 22.67° brix. The highest value was obtained in Karpooravally and lowest in Monthan.

On the basis of DMRT, the banana varieties were classified into seven groups with respect to the total soluble solids. Most of the groups had two or less members in each except for group f which had three members. The varieties Robusta (12.13° brix) and Kanchikela (11.00° brix) were grouped in the same category along with Monthan in group 'f' indicating that there existed no significant variation between these varieties with respect to TSS, but were significantly different from members of other categories.

Table 23. TSS content of banana varieties (° brix)

Sl. No.	Variety	Ripe
1	Nendran	18.93 [e]
2	Palayankodan	14.20 [e]
3	Karpooravally	22.67 [a]
4	Monthan	10.67 [f]
5	Robusta	12.13 [f]
6	Red banana	19.33 [e]
7	Kunnan	15.00 [e]
8	Njalipoovan	20.00 [bc]
9	Kadali	17.00 [d]
10	Matti	21.00 [b]
11	Kanchikela	11.00 [f]

Values having different superscripts differ significantly at 5% level

The T.S.S of the banana varieties are shown in Figure 14.

Statistical analysis indicated significant variation (at 1% level) between the varieties with respect to total soluble solids (F value = 71.924)

4.2.12 Acidity.

The acid content of the banana varieties are furnished in Table 24.

The values ranged from 0.15 to 1.44 per cent. The highest value was observed in Karpooravally and lowest in Nendran.

Statistically the banana varieties were classified into nine groups with respect to acidity. All the groups had two or less members in each.

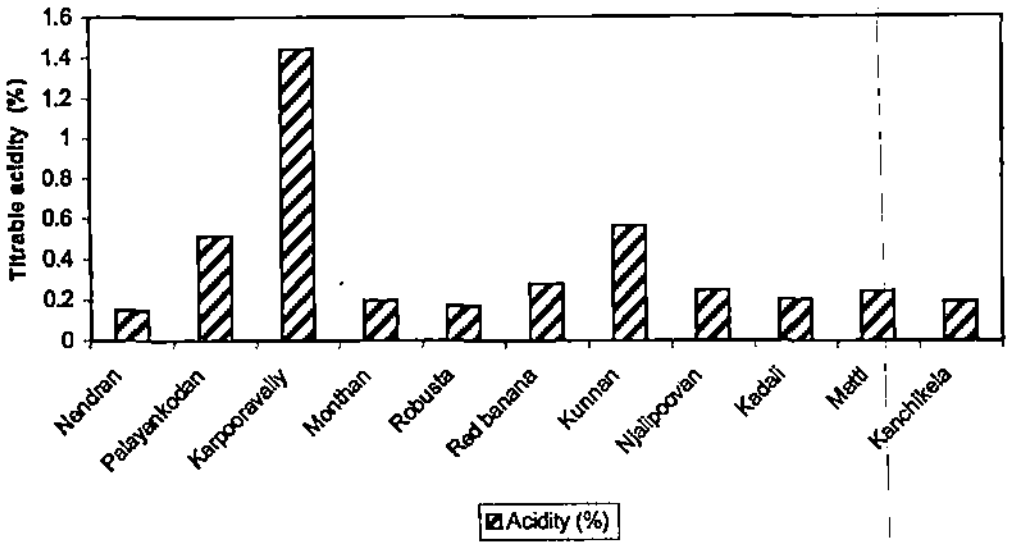


Fig. 15. Titrable acidity of banana varieties

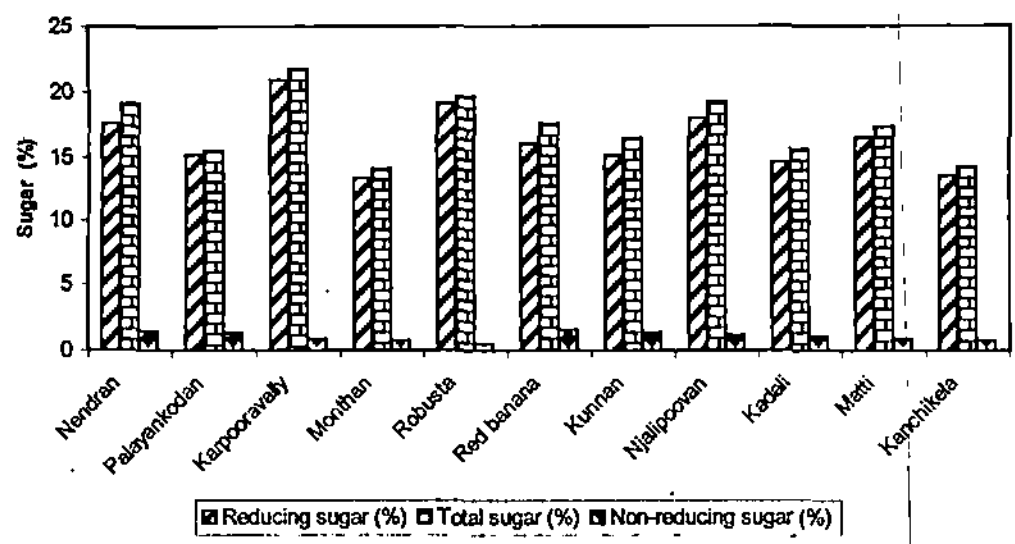


Fig. 16. Sugar content of banana varieties

Table 24. Acid content of banana varieties (%)

Sl. No.	Variety	Ripe
1	Nendran	0.15 [h]
2	Palayankodan	0.51 [b]
3	Karpooravally	1.44 [f]
4	Monthan	0.19 [f]
5	Robusta	0.17 [g]
6	Red banana	0.27 [c]
7	Kunnan	0.56 [a]
8	Njalipoovan	0.24 [d]
9	Kadali	0.20 [e]
10	Matti	0.24 [d]
11	Kanchikela	0.19 [f]

Values having different superscripts differ significantly at 5% level

The acidity of the banana varieties are shown in Figure 15.

Statistical analysis indicated significant variation between varieties at one per cent level with respect to acidity (F value = 222.673).

4.2.13 Reducing sugar

The reducing sugar content of the banana varieties are furnished in Table 25.

The reducing sugar content in the varieties varied from 13.38 to 20.90 per cent. The highest value was obtained in Karpooravally and lowest in Monthan.

On the basis of DMRT, the banana varieties were differentiated into six categories. Members of each category were significantly different from each other.

Table 25. Reducing sugar content of banana varieties (%)

Sl. No.	Variety	Ripe
1	Nendran	17.64 ^{bc}
2	Palayankodan	15.22 ^{de}
3	Karpooravally	20.90 ^{a}
4	Monthan	13.38 ^{e}
5	Robusta	19.12 ^{ab}
6	Red banana	16.08 ^{cd}
7	Kunnan	15.16 ^{de}
8	Njalipoovan	18.03 ^{bc}
9	Kadali	14.58 ^{de}
10	Matti	16.53 ^{cd}
11	Kanchikela	13.50 ^{e}

Values having different superscripts differ significantly at 5% level

The reducing sugar content of banana varieties is illustrated in Figure 16.

Statistical analysis indicated significant difference between varieties at one per cent level with respect to reducing sugar (F value = 13.497).

4.2.14 Total Sugar

The total sugar content of banana varieties is furnished in Table 26.

The values of total sugar varied from 14.13 per cent in Monthan to 21.73 per cent in Karpooravally.

Statistically the banana varieties were grouped into eight categories with respect to the total sugar and most of the categories had two or less members each.

Table 26. Total sugar content of banana varieties (%)

Sl. No.	Variety	Ripe
1	Nendran	19.10 [bc]
2	Palayankodan	15.53 [d]
3	Karpooravally	21.73 [a]
4	Monthan	14.13 [e]
5	Robusta	19.63 [b]
6	Red banana	17.63 [bcd]
7	Kunnan	16.50 [d]
8	Njalipoovan	19.20 [bc]
9	Kadali	15.63 [de]
10	Matti	17.39 [cd]
11	Kanchikela	14.24 [e]

Values having different superscripts differ significantly at 5% level

The total sugar content of the banana varieties is shown in Figure 16.

Statistical analysis indicated significant variation between banana varieties with respect to total sugar at one per cent level (F value = 12.894).

4.2.14 Non – reducing sugar

The non – reducing sugar content of the banana varieties is furnished in Table 27. The non reducing sugar varied from 0.53 per cent in Robusta to 1.55 per cent in Red banana.

On the basis of DMRT, the banana varieties were grouped into six groups with respect to non – reducing sugar. The fifth group (e) had four members.

The non-reducing sugar content of banana varieties is shown in Figure 16.

Table 27. Non reducing sugar content of banana varieties (%)

Sl. No.	Variety	Ripe
1	Nendran	1.45 [a]
2	Palayankodan	1.31 [b]
3	Karpooravally	0.85 [e]
4	Monthan	0.75 [e]
5	Robusta	0.51 [f]
6	Red banana	1.53 [a]
7	Kunnan	1.34 [b]
8	Njalipoovan	1.16 [c]
9	Kadali	1.05 [d]
10	Matti	0.85 [e]
11	Kanchikela	0.75 [e]

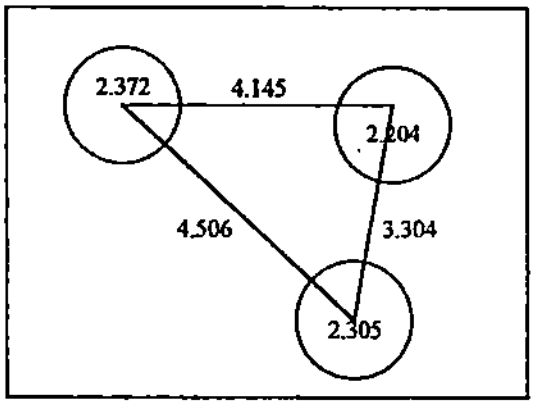
Values having different superscripts differ significantly at 5% level

Analysis of variance test showed a significant variation between the banana varieties at one per cent level with respect to the non reducing sugar (F value = 89.031).

Cluster analysis of banana varieties

Hierarchical Euclidean Cluster Analysis was carried out to find out homogenous groups of the varieties both in the raw and ripe stages based on the nutrient composition. Based on the analysis the banana varieties in the raw stage were grouped into three clusters.

Fig. 17. Cluster analysis of banana varieties in the raw stage.



Cluster I – Njalipoovan

Cluster II – Nendran, Monthan, Robusta, Red banana, Kadali, Matti and Kanchikela

Cluster III – Palayankodan, Karpooravally and Kunnan

The average intra and intercluster matrix for raw banana is shown in Table 28 and represented in Figure 17.

Table 28. Average intra and inter distance matrix (Raw banana).

Cluster No.	I	II	III
I	2.372		
II	4.145	2.204	
III	4.506	3.304	2.305

Note : Values along the principal diagonal indicate the average distance of cluster members from cluster centroids

Cluster I has only one member and it is high in starch and vitamin C. Starch and vitamin C content of Njalipoovan being 13.27 g 100 g^{-1} and 27.20 mg per cent.

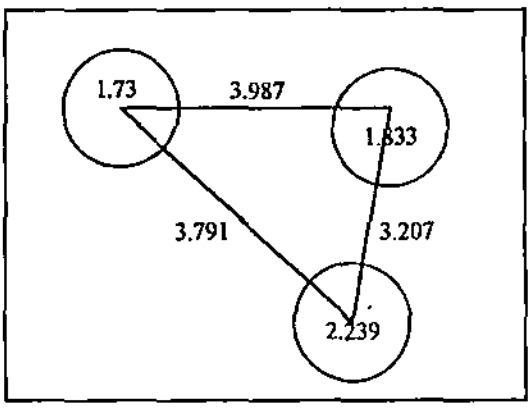
The members of cluster II had high moisture, potassium and fibre. The cluster means for these nutrients were 66.74 per cent, 523.73 mg per cent and 0.23 mg per cent. The moisture content of the cluster members was in between 61.93 and 71.97 per cent, potassium 491.0 and 563.8 mg 100 g^{-1} and fibre 0.12 and 0.28 mg 100 g^{-1}.

Palayankodan, Karpooravally and Kunnan, the members of cluster III were high in calcium, iron, protein and phosphorus. The cluster means for these nutrients were 29.87 mg per cent, 2.78 mg per cent, 1.39 mg per cent and 35.16 mg per cent. The calcium content of cluster members was in between 26.40 and 34.44 mg 100 g^{-1}, iron between 1.05 and 5.44 mg 100 g^{-1}, protein between 1.15 and 1.27 per cent and phosphorus between 27.57 and 39.70 mg per cent.

The members of cluster III namely Palayankodan, Karpooravally, Kunnan were found to be best as they contain high amount of calcium, iron, protein and phosphorus.

On the basis of cluster analysis the banana varieties in the ripe stage were grouped into three clusters as shown in Fig. 18.

Fig. 18. Cluster analysis of banana varieties in ripe stage



Cluster I – Nendran, Palayankodan

Cluster II – Karpooravally, Monthan, Robusta, Red banana, Kanchikela

Cluster III – Kunnan, Njalipoovan, Kadali and Matti

The average intra and inter cluster matrix for ripe banana is shown in Table 29.

Table 29. Average intra and inter distance matrix (Ripe banana)

Cluster No.	I	II	III
I	1.73		
II	3.987	1.833	
III	3.791	3.207	2.239

Note : Values along the principal diagonal indicate the average distance of cluster members from cluster centroids

The members of cluster I were high in phosphorus calcium and beta carotene. The mean phosphorus content for the first cluster was 31.21 mg 100 g^{-1}. Within the cluster, the phosphorus content of the cluster members varied from 29.45 to 32.97 mg 100 g^{-1}. The cluster mean for beta carotene content was 310.32 µg 100 g^{-1}. The mean value varied between 287.0 to 333.6 µg 100 g^{-1}. The cluster mean for calcium was 16.58 mg 100 g^{-1}.

The members of cluster II had high moisture content. The cluster mean being 72.98 per cent and the mean of the cluster members varied from 67.67 to 77.67 per cent.

Kunnan, Njalipoovan, Kadali and Matti, members of cluster III were high in potassium, iron, fibre, starch and vitamin C. The cluster means of these nutrients were 479.34 mg per cent, 3.19 mg per cent, 0.29 per cent, 2.63 per cent and 10.20 mg per cent. Potassium content of cluster was in between 409.5 to 555.0 mg 100 g^{-1}, iron between 1.45 and 5.290 mg 100 g^{-1}, fibre between 0.15 to 0.39 g 100 g^{-1}, starch between 2.3 and 2.7 per cent, vitamin C between 9.06 and 11.33 mg 100 g^{-1}.

The members of cluster I namely Nendran and Palayankodan were considered as the best group as they contain a high amount of calcium, phosphorus and beta carotene.

4.3 Acceptability of banana varieties

The acceptability studies of the raw and ripe banana were assessed by score card method. The raw banana was evaluated by preparing thoran and porridge. Each character was scored using a five point hedonic scale and the overall acceptability was scored using a nine point hedonic scale by a panel of ten judges. The five quality attributes namely appearance, colour, flavour, texture and taste were described as a five point scale and the total score was obtained out of twenty five.

4.3.1 Thoran

The mean scores obtained for thoran prepared from different banana varieties are furnished in Table 30. It can be seen that the mean score for appearance was highest in Kanchikela (4.52) and lowest in Monthan (3.22) among the eleven banana varieties selected for the study.

Table 30. Organoleptic evaluation of thoran

Variety	Appear-ance	Colour	Flavour	Texture	Taste	Total (25)	Overall accepta-bility
Nendran	3.96	4.04	3.90	4.06	4.08	20.06	7.42
Palayankodan	3.60	3.62	3.46	3.50	3.34	17.52	6.48
Karpooravally	4.30	3.96	4.02	2.94	4.00	20.12	7.16
Monthan	3.22	3.48	3.02	3.14	3.00	15.86	5.86
Robusta	4.10	4.00	3.98	3.94	3.84	19.97	7.22
Red banana	3.82	3.80	3.42	3.66	3.68	18.38	6.92
Kunnan	3.50	3.24	3.32	3.40	3.68	17.56	6.84
Njali poovan	3.52	3.44	3.44	3.72	3.04	17.58	6.04
Kadali	3.48	3.92	3.70	3.68	3.74	18.56	6.62
Matti	3.40	3.44	3.66	3.28	3.56	17.10	6.48
Kanchikela	4.52	4.42	4.42	4.08	4.38	21.96	7.62

For the second quality attribute namely colour, the mean scores ranged from 3.48 to 4.42. The lowest score was assigned to Monthan and the highest to Kanchikela.

The scores for flavour, varied from 3.02 (Monthan) to 4.42 (Kanchikela).

In texture, the scores varied from 2.94 to 4.08 with Kanchikela and Karpooravally having the highest and lowest scores respectively.

The mean scores for taste were found to be highest for Kanchikela (4.38) and lowest for Monthan (3.0)

When the total scores for all the quality attributes were considered, the scores ranged from 15.86 to 21.96 with Monthan and Kanchikela having the lowest and highest scores respectively.

When the overall acceptability was considered the scores ranged from 5.86 to 7.62 with Monthan and Kanchikela having the lowest and highest score respectively.

Statistical analysis of data revealed significant difference at one per cent level (F value = 10.532) in the acceptability and also significant difference in the overall acceptability (F value = 7.938) of the thoran prepared from the banana varieties selected for the study.

4.3.2 Porridge

The mean score obtained for porridge prepared from raw banana varieties are furnished in Table 31.

Table 31. Organoleptic evaluation of porridge.

Sl. No.	Variety	Appea-rance	Colour	Flavour	Texture	Taste	Total score	Overall accepta-bility
1	Nendran	4.54	4.48	4.40	4.50	4.56	22.52	7.62
2	Palayankodan	3.94	4.40	3.56	4.06	3.88	19.94	7.04
3	Karpooravally	3.40	2.70	2.90	2.50	1.98	12.62	3.90
4	Monthan	4.28	4.36	3.66	4.42	3.26	20.10	6.70
5	Robusta	4.22	3.92	3.86	3.86	3.78	20.04	7.12
6	Red banana	3.78	3.98	3.72	3.80	3.80	19.84	6.94
7	Kunnan	3.96	3.94	3.76	3.98	3.14	20.04	7.42
8	Njalipoovan	4.18	4.02	3.88	4.06	3.70	19.64	7.26
9	Kadali	3.74	3.66	3.96	3.88	3.52	18.88	6.74
10	Matti	2.48	2.56	2.26	2.22	2.00	11.68	2.94
11.	Kanchikela	2.50	3.46	3.15	3.20	3.05	14.94	5.74

From the table, it can be seen that the mean scores for appearance for porridge was highest in Nendran (4.52) and lowest in Matti (2.48) among the eleven banana varieties selected for the study.

For the second quality attribute namely colour, the mean scores ranged from 2.56 to 4.48. The lowest score was assigned to Matti and the highest to Nendran.

The scores for flavour varied from 2.26 (Matti) to 4.40 (Nendran).

In texture, the scores varied from 2.22 to 4.56 with Matti and Nendran having the lowest and highest values.

The mean scores for taste were found to be highest for Nendran (4.56) and lowest for Karpooravally (1.98).

When the total scores for all the quality attributes were considered, the scores ranged from 11.68 to 22.52 for porridge prepared with Matti and Nendran having the lowest and highest scores respectively.

When the overall acceptability was the considered the scores ranged from 2.94 to 7.62 with Matti and Nendran having the lowest and highest scores respectively.

Statistical analysis of the data revealed significant difference at one per cent level (F value = 28.739) in the acceptability and also a significant difference in the overall acceptability (F value = 18.25) between the banana varieties selected for the study.

4.3.3 Ripe banana

The mean scores obtained for the ripe fruit are furnished in Table 32.

Table 32. Organoleptic evaluation of banana fruit

Sl. No.	Variety	Appear-ance	Colour	Flavour	Texture	Taste	Total score (25)	Overall accepta-bility
1	Nendran	4.70	4.52	4.62	4.54	4.58	22.96	8.24
2	Palayankodan	4.34	4.18	3.96	4.20	4.08	20.76	7.88
3	Karpooravally	4.58	4.60	4.40	4.48	4.64	22.70	8.26
4	Monthan	3.48	3.82	3.20	2.92	2.82	16.24	6.58
5	Robusta	4.36	4.56	4.28	4.42	4.36	21.92	7.34
6	Red banana	3.68	4.44	4.00	3.84	3.64	19.60	6.80
7	Kunnan	3.82	3.74	3.48	4.00	3.74	18.78	6.76
8	Njalipoovan	2.92	3.38	3.24	3.40	3.22	16.18	6.56
9	Kadali	2.72	2.80	2.70	2.50	2.58	13.30	5.42
10	Matti	3.10	3.36	3.60	3.46	3.67	17.20	7.26
11	Kanchikela	3.12	3.28	3.10	2.90	2.81	15.60	5.80

It can be seen that the mean scores for appearance was highest in Nendran (4.7) and lowest in Kadali (2.72).

For the second quality attribute namely colour, the mean score ranged from 2.8 to 4.6. The lowest score was assigned to Kadali and highest to Karpooravally.

The scores for flavour varied from 2.7 for Kadali to 4.62 for Nendran.

The scores for texture varied from 2.5 to 4.54 with Nendran and Kadali having the highest and lowest scores respectively.

The mean scores for taste were found to be highest for Karpooravally (4.64) and lowest for Kadali (2.58).

When the total for all the quality attributes were considered, the scores ranged from 13.3 to 22.96 with Kadali and Nendran having the lowest and highest values.

When the overall acceptability was considered the scores ranged from 5.42 to 8.26 with Kadali and Karpooravally having the lowest and highest scores respectively.

Statistical analysis of data revealed significant difference at one per cent level (F value = 29.725) in the acceptability and also significant difference in the overall acceptability (F value = 10.522) between the different varieties of the fruit.

Discussion

5. DISCUSSION

The study on "Evaluation of banana varieties for quality attributes" was made to evaluate the physical characters, nutritional composition and the acceptability of eleven banana varieties.

The physical characters like date of harvest, weight of bunch, weight of hands, number of hands, number of fingers in each hand, pulp/peel ratio were recorded. In accordance with the colour chart for banana, the colour of the fruit and colour of the pulp was noted. Weight and volume of the fruit, firmness of the fruit and pulp were also recorded from the day of harvest. The varieties were analysed for different nutrients like moisture, total fibre, starch, calcium, phosphorus, iron, potassium and vitamin C both in the raw and ripe samples. Protein was estimated in the raw stage and beta carotene in the ripe stage. Chemical constituents like total soluble solids, acidity, reducing sugar, total sugar and non-reducing sugar were estimated in the ripe stage. The acceptability of the banana varieties was assessed through organoleptic evaluation using score card based on a five point hedonic scale for different parameters like appearance, colour, flavour, texture and taste. Overall acceptability was assessed based on a nine point hedonic scale. The results of the study are discussed under the following headings.

1. Physical characters of banana varieties
2. Nutritional composition and other constituents present in banana varieties
3. Acceptability of banana varieties

5.1 Physical characters of banana varieties

The bunch weight of different banana varieties ranged from 5.67 to 12.83 kg. These results were similar to the values obtained by Rajeevan and Mohanakumaran (1983) in 24 accessions of the Palayankodan clones. The weight of Kanchikela (5.66 kg) was very low representing its varietial character.

The weight of hands of different banana varieties differed significantly from each other. The weight of hands of different varieties ranged from 693.3 g in Njalipoovan to 2083 g in Monthan. The varieties Karpooravally and Matti were grouped along with Njalipoovan due to similarity in the weight of hands of these varieties.

The number of hands per bunch of different varieties differed significantly from 4.33 to 11.67. The results obtained in the present study was similar to the result obtained by Rajeevan *et al.* (1988) and Shanmughavelu *et al.* (1992).

The number of fingers in each hand differed significantly from each variety. The number of fingers ranged from 8.33 to 19.33 with the highest in Matti and the lowest in Kanchikela.

The pulp/peel ratio of banana in the raw stage varied from 0.60 to 2.40. The ratio was almost similar to the values obtained by Ngalani *et al.* (1998) in different African cultivars in the raw stage.

The pulp/peel ratio of the ripe stage ranged from 1.86 to 8.33. Kadali was having the highest pulp/peel ratio. These values were similar to the values obtained by Ngalani *et al.* (1998) in different African cultivars but higher than the values obtained by Asedu (1987).

There was significant increase in the pulp/peel ratio of all banana varieties on ripening. According to John and Marchal (1995) this increase in pulp/peel ratio is due to the water movement.

There was significant difference in the pulp/peel ratio of the raw and ripe bananas. This result was similar to the result obtained by Asedu (1987), Almazan (1991) and Ngalani *et al.* (1998).

The colour of the fruit tabulated has shown that most of the varieties in the raw stage had a green colour except for Red banana which had a maronish green colour. On ripening the colour of the fruit changed to yellow except for Red banana and Robusta which had a maronish red and light green colour respectively on ripening.

The colour of the pulp of most of the varieties is off white in the raw stage except for Red banana which had a pale yellow pulp. In the ripe stage the colour of the pulp differs from cream to light yellow depending upon the variety. The colour change in pulp is similar to the results obtained by Wainwright and Hughes (1990).

The change of colour in fruit and pulp started from the 4^{th} stage of ripening.

Weight of the fruit is significantly different for each variety. The weight of the raw fruit ranged from 35.00 to 153.3 g and that of the ripe fruit varied from 28.33 to 136.7 g. These values were almost similar to the values obtained by Tripathi *et al.* (1981). Though there was a decrease in the weight of the fruit on ripening the change was not found to be significant.

The physiological loss of weight varied from 4.63 to 29.17 per cent. Shivasankar (1999) reported that loss of water through transpiration appears to be the most important component accounting for the loss of weight. In varieties like Nendran, Palayankodan and Robusta the PLW ranged from 4.63 – 6.37 per cent and in varieties like Karpooravally, Red banana, Kunnan, Njalipoovan, Kadali and Kanchikela the PLW varied from 7.72 to 14.80 per cent.

The volume of the raw fruit varied from 33.33 ml in Matti to 163.00 ml in Robusta. Significant variation existed with respect to the physiological loss of volume between the different varieties.

The fruit of Nendran variety had a firmness of 4.06 kg cm^{-2} and this was found to be highest among the varieties. The firmness of the fruit and pulp decreased significantly during ripening as the results obtained by Ngalani and Tchango (1998) and Ngalani *et al.* (1999) in different African cultivars. The physical factor associated with this softening was related to the sequential degradation of starch, pectin and hemicellulose polysaccharides in pulp cell walls suggested by Kojima et al. (1994).

There is significant variation in the firmness of fruits of different varieties as reported by Ngalani *et al.* (1998).

5.2 Nutritional composition of banana

The moisture content of banana in the raw stage varied from 61.93 to 71.97 per cent. The moisture content of the selected banana varieties is slightly lower than the values reported by Ketiku (1973).

The moisture content of the ripe fruit ranged from 61.00 to 77.23 per cent. The moisture content of the varieties was found to be in accordance with the values reported by Ketiku (1973); Marriot (1980); Gopalan *et al.* (1989).

There was a significant difference in the moisture content of banana between the raw and ripe stages. In varieties like Nendran, Palayankodan, Karpooravally, Monthan, Robusta, Red banana and Kadali there was an increase in moisture content on ripening. But varieties like Matti and Kanchikela did not show much change in the moisture content. This clearly indicates that the change in moisture did not follow a specific pattern on ripening.

The fibre content of banana in raw stage ranged from 0.05 per cent in Njalipoovan to 0.36 per cent in Monthan. The fibre content was negligible as reported by KAU (1983).

The fibre content of the ripe varieties varied from 0.15 to 0.39 per cent. This is in accordance with the values reported by Dube (1988) but slightly lower than the values reported by Ketiku (1973) and Kayisu *et al.* (1981).

Though there was an increase in the fibre content of most of the varieties analyzed during ripening, the increase was found to be statistically insignificant. Almazan (1991) reported an increase in crude fibre on ripening.

The protein content of banana in raw stage varied from 0.5 to 1.74 per cent. These values are in accordance with the values reported by Ketiku (1976), Padmaja and Koshy (1977) and Villalonga (1981), but slightly lower than the values obtained by Suntharalingam and Ravindran (1993) in two varieties of cooking banana. These values indicate that bananas are a poor source of protein.

The starch content of banana in raw stage varied from 8.05 per cent to 13.27 per cent. This is in accordance with the values reported by Chacon *et al.* (1987).

The starch content of the ripe varieties ranged from 0.98 per cent to 2.77 per cent. These values are accordance with the values reported by Ketiku (1973); Chacon *et al.* (1987) and Dube (1988).

There was a significant decrease in the starch content on ripening. This decrease in starch content is due to the hydrolysis of starch to sugar as reported by Lizada *et al.* (1990).

The calcium content of banana in the raw stage varied from 8.3 mg in Njalipoovan to 34.44 mg 100 g^{-1} in Karpooravally. The result of the present study is similar to the results obtained by Padmaja and Koshy (1977) but higher than the values suggested by Villalonga (1981) for different cultivars. In the ripe stage the calcium content ranged from 6.42 to 21.93 mg 100 g^{-1}. The highest value was

observed in Nendran. These values are almost similar to the results obtained by Gopalan and Ram (1990).

Though, there existed a significant variation in the banana varieties between the raw and ripe stages with respect to calcium content the change do not follow a specific pattern on ripening. Most of the fruits showed a decrease in the calcium content on ripening, while certain varieties namely Nendran, Njalipoovan and Matti showed an increase in calcium content. This variation can be due to varietal difference. The fruits which showed an increase on ripening supported the results obtained by Izonfuo and Omuarc (1988).

The phosphorus content of banana in the raw stage ranged from 20.85 to 39.70 mg 100 g^{-1}. The highest value was observed in Karpooravally. Phosphorus content in the present study was lower than the values reported by Suntharalingam and Ravindran (1993). In the ripe stage phosphorus content of banana ranged from 21.10 mg to 32.97 mg 100 g^{-1} as Matti and Nendran having the lowest and highest values. These were almost near to the values obtained by Gopalan and Ram (1990).

Varieties like Palayankodan, Karpooravally, Monthan, Red banana, Njalipoovan and Matti showed a decrease in the phosphorus content on ripening as suggested by Izonfuo and Omuarc (1988). But the rest of the varieties showed an increase in the phosphorus content during ripening. This indicates that the change in phosphorus content did not follow a specific pattern on ripening and this may be due to the varietal difference.

Iron content of banana in raw stage varied from 1.02 in Monthan to 5.43 mg 100 g^{-1} in Karpooravally. The results were not similar to the values obtained by Padmaja and Koshy (1977). This may be due to varietal difference.

In the ripe stage Kadali had the highest amount of iron (5.29 mg 100 g^{-1}). Varieties like Nendran, Monthan, Kunnan, Njalipoovan, Kadali and Kanchikela showed an increase in the iron content on ripening but in the rest of the

varieties there was a decrease in the iron content on ripening. This shows that on ripening the change did not follow a specific pattern with respect to iron content.

The highest potassium content in raw stage was observed in Red banana (563.8 mg per cent) and lowest in Karpooravally (391.9 mg per cent) on fresh weight basis. These values were almost similar to the values obtained by Padmaja and Koshy (1977). Varieties like Palayankodan, Kunnan, Njalipoovan, Matti and Kanchikela showed an increase in the potassium content on ripening as reported by Izonfuo and Omuarc (1988). But the rest of the varieties gave a contradictory result.

The vitamin C content of banana in the raw stage varied from 13.60 to 27.20 mg 100 g^{-1}. The highest value was seen in Njalipoovan.

Significant variation was observed in the vitamin C content of banana in the raw stage. There was a decrease in the vitamin C content on ripening. This is in accordance with the findings of Tripathi *et al.* (1981) and Ghosh *et al.* (1997). This decrease may be due to the activity of ascorbate oxidase which increased on ripening as suggested by Cardello and Cardello (1999).

The beta carotene content of the varieties ranged from 17.70 µg to 333.6 µg 100 g^{-1}. The beta carotene content of Nendran and Palayankodan was 333.6 and 287.0 µg respectively. The remaining varieties had lower beta carotene content almost similar to the value given by Dube (1988).

Total soluble solids between varieties varied form 10.67 to 22.67°brix in Monthan and Karpooravally respectively. These values are almost similar to the values obtained by Charles *et al.* (1993); Anil (1994); Agrawal (1997) and Shivashankar (1999). There existed significant variation with respect to TSS between varieties.

The titrable acidity of the banana varieties ranged from 0.15 to 1.44 per cent. These values are in accordance with the values reported by Anil (1994) and Ancy (1997).

Reducing sugar content of the fruit varied from 13.38 to 20.90 per cent. This is similar to the values obtained by Anil (1994) in the Nendran variety. The reducing sugar content of Palayankodan (15.22%) was found to be similar to the values reported by Rajendran (1983).

Total sugar content of the banana varieties ranged from 14.13 to 21.73 per cent. The total sugar content was similar to the values obtained by Sheela (1982), Rajendran (1983) and Ancy (1997).

The non-reducing sugar content of the varieties ranged from 0.51 to 1.53 per cent. These values were similar to the values reported by Rajendran (1983) and Ancy (1997).

5.3 Acceptability of banana varieties

The variety Kanchikela scored the highest in appearance colour, flavour, texture, taste and overall acceptability followed by Nendran when used for the preparation of thoran. Monthan had a mushy appearance and a watery taste when used for thoran and for this reason Monthan variety had a very low score. The highest score for Nendran may be because it is the most commonly used and familiar culinary variety in Kerala when compared to rest of the varieties.

The variety Nendran scored the highest for appearance, colour, flavour, texture, taste and for the overall acceptability followed by Kunnan for porridge. This is similar to the result reported by KAU (1983). The rest of the varieties were having a bland taste when used for the preparation of porridge.

In the case of ripe fruit the overall acceptability of Karpooravally was found to be the highest. The variety Nendran scored highest for appearance, flavour, texture and taste and the variety Karpooravally scored the highest for colour and second for overall acceptability. This high score for Karpooravally may be due to its sweet taste which was acceptable.

Summary

6. SUMMARY

The study on "Evaluation of banana varieties for quality attributes" was made to evaluate the quality characteristics and the nutritive value of the local banana varieties of different genomes. The varieties were selected from the Banana Research Station, Kannara. The eleven banana varieties selected were Nendran, Palayankodan, Karpooravally, Monthan, Robusta, Red banana, Kunnan, Njalipoovan, Kadali, Matti and Kanchikela.

The physical characteristics like date of harvest, weight of bunch, weight of hands, number of hands, number of fingers in each hand, pulp/peel ratio were recorded. In accordance with the colour chart for banana, the colour of the fruit and colour of the pulp was noted. Weight and volume of the fruit, firmness of the fruit and pulp were also recorded from the day of harvest. The banana varieties were analysed for different nutrients like moisture, total fibre, starch, calcium, phosphorus, iron, potassium and vitamin C in the raw and ripe stages. Protein was estimated in the raw stage and beta carotene was estimated in the ripe stage. Chemical attributes like total soluble solids, acidity, reducing sugar, total sugar and non-reducing sugar were estimated in the ripe stage.

The mean bunch weight varied from 5.66 to 12.83 kg. The highest bunch weight was observed in Robusta. The weight of hands of different varieties ranged from 693.3 g to 2083 g. The number of hands per bunch varied from 4.33 in Red banana to 11.67 in Njalipoovan. The number of fingers of different varieties ranged from 8.33 to 19.33.

The pulp/peel ratio of banana in the raw stage ranged from 0.60 to 2.40 in Palayankodan and Kadali respectively and for the ripe from 1.86 in Robusta to 8.33 in Kadali.

Most of the fruits had a green colour in the raw stage except for Red banana which had a maronish colour in the raw state. On ripening almost all fruits had an yellow colour for the peel with exceptions like Red banana and Robusta. In the ripe state the colour of the pulp changed from cream to light yellow depending upon the variety.

The weight of the raw fruit varied between 35.00 g for Njalipoovan and 153.3 g for Monthan and the weight of the ripe fruit varied from 28.33 in Matti to 136.7 g in Nendran. The volume of the fruit ranged from 33.33 ml to 163.3 ml. The highest value was observed in Matti and the lowest in Robusta.

The firmness of the fruit ranged from 1.43 kg cm^{-2} in Palayankodan to 4.06 kg cm^{-2} in Nendran while the firmness of the pulp ranged from 0.16 to 0.73 kg cm^{-2}. The lowest value of 0.16 kg cm^{-2} was observed in four varieties namely Robusta, Red banana, Matti and Kanchikela.

The moisture content of banana in the raw stage varied from 61.93 per cent for Nendran to 71.97 per cent for Robusta and in the ripe stage varied from 61.00 per cent for Njalipoovan to 77.23 per cent for Red banana.

The fibre content of banana in the raw stage varied from 0.05 per cent to 0.36 per cent. The highest fibre content was observed for Monthan and the lowest for Njalipoovan. The fibre content in the ripe stage varied from 0.15 per cent to 0.39 per cent for Red banana and Kunnan respectively. The protein content of the raw varieties varied from 0.5 in Robusta to 1.74 per cent in Kunnan.

In the raw stage the highest starch content was observed in Njalipoovan (13.27%) and lowest in Palayankodan (8.05%). In the ripe stage the highest value was observed for Kadali (2.77%) and lowest for Red banana (0.98%).

The calcium content in the raw stage ranged from 8.3 to 34.44 mg per cent on FWB in the eleven selected varieties. The highest and lowest values were

observed in Karpooravally and Njalipoovan respectively. In the ripe stage the calcium content varied from 6.42 mg in Robusta to 21.93 mg in Nendran on FWB.

The phosphorus content of banana in the raw stage varied from 20.85 mg for Robusta to 39.70 mg for Karpooravally on FWB and in the ripe varied from 21.10 mg per cent in Matti to 32.97 mg per cent in Nendran on FWB.

The iron content of the raw stage varied from 1.02 to 5.43 mg per cent in Monthan and Karpooravally respectively on FWB and in the ripe stage Palayankodan had the lowest value of 0.96 mg per cent and Kadali had the highest value of 5.29 mg per cent of FWB. The highest potassium content in the raw stage was observed in Red banana (563.8 mg %) and lowest in Karpooravally (391.9 mg %) on FWB and in the ripe stage potassium content varied from 339.1 mg to 555 mg per cent for Karpooravally and Matti respectively on FWB.

The vitamin C content of banana in the raw stage varied from 13.60 mg per cent in Kadali to 27.20 mg per cent in Njalipoovan and in the ripe stage the highest vitamin C content was observed in Robusta (11.33 mg %) and lowest in Nendran (6.8 mg %).

The highest beta carotene content was observed in the variety Nendran (333.6 μg 100 g^{-1}) followed by Palayankodan (287 μg 100 g^{-1}).

The total soluble solids of the banana varieties ranged from 10.67 to 22.67°brix in Monthan and Karpooravally respectively.

The highest titrable acidity was observed in Karpooravally (1.44%) and lowest in Nendran (0.15%).

The lowest and highest value of reducing sugar (13.38-20.90%) and total sugar (14.13-21.73%) content was observed in Monthan and Karpooravally

respectively. The non-reducing sugar content varied from 0.51 per cent in Robusta to 1.53 per cent in Red banana.

Statistical analysis indicated significant variation between the varieties during raw and ripe stages for the different nutrients except for total fibre in which it was found to be insignificant.

The acceptability of the selected banana varieties was assessed using a five point hedonic scale and the overall acceptability using a nine point hedonic scale. The total scores for thoran ranged from 15.86 to 21.96 and the overall acceptability from 5.86 to 7.62. With Monthan and Kanchikela having the lowest and highest scores. The total scores for porridge ranged from 11.68 to 22.52 and the overall acceptability from 2.94 to 7.62 for Matti and Nendran respectively. The total scores for ripe banana ranged from 13.3 for Kadali to 22.96 for Nendran and the overall acceptability varied from 5.42 (Kadali) to 8.26 (Karpooravally). Significant variation existed between the banana varieties in acceptability.

From the present study it has been seen that the different banana varieties are not rich in all the nutrients but are rich only in specific nutrients. Among the different varieties selected Nendran was found to be the best for the preparation of porridge and was the most acceptable among the ripe fruits.

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Appendices

APPENDIX-I

Stages of ripening

Stages	Characteristic colour change
I	Hard green
II	Green
III	More green than yellow
IV	More yellow than green
V	Green tipped
VI	Fully yellow
VII	Flecking

APPENDIX-II

Sensory Evaluation of Thoran/Porridge/Ripe banana

Sl.No.	Character	Description	Score	1	2	3	4	5
I	Appearance	Excellent	5					
		Good	4					
		Fair	3					
		Poor	2					
		Very poor	1					
II	Colour	Excellent	5					
		Good	4					
		Fair	3					
		Poor	2					
		Very poor	1					
III	Flavour	Excellent	5					
		Good	4					
		Fair	3					
		Poor	2					
		Very poor	1					
IV	Texture	Excellent	5					
		Good	4					
		Fair	3					
		Poor	2					
		Very poor	1					
V	Taste	Excellent	5					
		Good	4					
		Fair	3					
		Poor	2					
		Very poor	1					
	Overall acceptability	Like extremely	9					
		Like very much	8					
		Like moderately	7					
		Like slightly	6					
		Neither like nor dislike	5					
		Dislike slightly	4					
		Dislike moderately	3					
		Dislike very much	2					
		Dislike extremely	1					
		Comments						

EVALUATION OF BANANA VARIETIES FOR QUALITY ATTRIBUTES

By

SABEENA THAJUDDEEN

ABSTRACT OF THE THESIS

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ABSTRACT

The study entitled "Evaluation of banana varieties for quality attributes" was undertaken to evaluate the quality characters and the nutritive value of the local banana varieties of different genomes.

The banana varieties were evaluated for different quality characters like weight of bunch, weight of hands, number of hands, number of fingers in each hand and pulp/peel ratio. The results revealed that there was significant variation between the varieties in different quality characters.

Physical characters like colour of the fruit, colour of the pulp, weight and volume of the fruit, firmness of the fruit and pulp from the day of harvest were recorded. The weight, volume and firmness of the fruit and pulp decreased significantly on ripening. Most of the fruits had a yellow peel on ripening, the exceptions being Robusta and Red banana which had a light green and maronish brown colour on ripening.

The banana varieties in the raw and ripe stages were analysed for moisture, total fibre, starch, calcium, phosphorus, iron, potassium and vitamin C. All the varieties in the raw stage were found to be high in starch and potassium. The calcium, phosphorus and iron contents were highest in Karpooravally whereas Red banana had the highest value for total fibre and potassium and Njalipoovan was high in starch and vitamin C.

In the ripe stage Nendran was found to have the highest calcium, phosphorus and Beta carotene content. Except total fibre, all the other constituents of different varieties varied significantly in the raw and ripe stages. The starch and vitamin C content decreased significantly on ripening. Though there was a significant variation in the mineral content on ripening this change did not follow a specific pattern and varied depending upon the variety.

Chemical constituents like T.S.S., reducing sugar, non-reducing and total sugar and acidity were assessed in the ripe stage. T.S.S., reducing and total sugar contents were highest in Karpooravally whereas Kunnan had the highest titrable acidity.

Studies on the acceptability levels revealed that thoran prepared from raw fruit of Kanchikela scored highest. Among the varieties Nendran scroed highest for porridge and among ripe fruit Karpooravally scored highest. Significant variation existed between the varieties in acceptability.