POST-HARVEST HANDLING IN *MUSA* (AAB GROUP) 'Nendran'

BY

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THIRUVANANTHAPURAM

2001

DECLARATION

I hereby declare that this thesis entitled **"Post harvest handling in *Musa* (AAB Group) 'Nendran' "** is a bonafide record of research work done by me during the course of research and that the thesis has not previously formed the basis for the award of any degree, diploma, associateship, fellowship or other similar title, of any other university or society.

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Rani Suseel

Dedicated
to
My Pappa & Amma

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INTRODUCTION

1. INTRODUCTION

Banana is one of the most important remunerative tropical fruit crops. It is also one of the major fruit crops of India, which is cultivated extensively in Kerala. In India, the crop is grown in an area of 3,25,700 hectare, with an annual production of 60,56,400 tonnes. This corresponds to 9.75 per cent of total area and 21.45 per cent of total production of fruit crops in India (Anonymous, 1990).

In Kerala, banana is cultivated in an area of 23,850 hectares, with a production of 339,994 tonnes which corresponds to 7.32 per cent of area and 5.61 per cent of its production in India (Anonymous, 1996). It is a popular crop and stands next only to mango in terms of area and production of fresh fruits. Kerala grows multitude of varieties of banana suitable for dessert and culinary purpose and it occupies an important place in the agricultural economy of the state.

Among these varieties of banana, "Nendran" is well known for the multifarious use and it is the most popular commercial variety of Kerala. It occupies an important place covering about 32 per cent of the total area under all plantains, and about 45 per cent of the total production. The crop gives and attractive net income and the production is largely market oriented. The yield potential of banana is very high and there is a lot of export potential which in yet to be exploited due to the lack of sufficient knowledge of post harvest technology.

The post harvest losses are high in a tropical country like India. The losses due to improper handling, transportation, storage marketing and processing these come to about 20-40 percent net post harvest losses (Anonymous, 1986). Since, fruits are constantly subjected to spoilage caused by senescence, microbial decay and improper market channels, it is highly desirable to standardise the post harvest technology for banana especially Nendran.

Since fruits remain biologically active even after harvest and do continue their metabolic activities such a respiration, transpiration, ripening and senescence, it is absolutely essential to understand the effect of pre and post harvest treatments on the shelf life and quality of the fruits. Without proper post- harvest practices during storage and transportation, the magnitude of post harvest loss will be high and the quantity of marketable fruits will be considerably reduced. In view of the above, 'Nendran' one of the most popular commercial varieties having export potential was selected for the present study.

With the existing common storage facilities, the fruit lose their fresh appearance and the market value due to various reasons such as ageing, physiological moisture-loss, bruising during handling and transportation, pre-packaging of fresh fruit before transportation is known to help in extending shelf-life and reducing transportational injuries. A study was therefore undertaken at the Department of processing technology, College of Agriculture, Vellayani during the period 1998- 2000 on "Post harvest handling in *Musa* (AAB group) Nendran" with the following objectives.

- To assess the condition of fruits soon after transportation.
- To assess the ripening behaviour of fruits in different packages

REVIEW OF LITERATURE

2. REVIEW OF LITERATURE

Despite the fact that India is the second target producers of both fruits and vegetables, the per capita consumption of the same in India is far less than that in other horticulturally rich countries. A considerable amount of fruit and vegetables produced in India is lost due to improper post harvest operation and poor infrastructural facilities. Consequently there is a considerable gap between the gross production and net availability.

Banana is a very important crop grown throughout the tropical and subtropical areas of the world. In India it is cultivated in 400 thousand hectares and the production is 13,200 thousand tonnes, whereas in Kerala the area under banana cultivation is 31 thousand hectares and the production is 437 thousand tonnes (Anonymous, 2001).

There is a great scope of improving this system by adopting modern methods of post harvest handling operation. Literature on the use of various packaging material and their effect on transportation and shelf life of fruits and vegetables in general and banana in particular in India and abroad are briefly reviewed in this chapter.

2.1 Introduction to banana

Banana is not a seasonal fruit like many other fruit crops and is available throughout the year (Anonymous, 1986). Banana has a special value in the human diet as they are a rich source of energy and contain nearly all the nutrients including minerals and vitamins. About 24 bananas, each weighing 100 g can provide the energy requirement (2400 cal/day) of a sedentary man (Bose and Mitra, 1990).

Aravindakshan *et al.* (1992) stated that banana cultivation in India is as old as Indian civilization and though banana is considered as "poor man's apple", it is liked and consumed by both poor and rich alike and hence appropriate measures need to be taken to check post harvest losses. This can successfully be carried out by post-harvest processing and preservation of the fruits.

2.2 Post-Harvest Losses

Salunke and Desai (1984) reported that banana, being a highly perishable fruit, suffers from high post harvest losses to the extent of 30-40 per cent. The post harvest losses are high in a tropical country like India due to various reasons such as adequate processing climatic conditions and improper storage facilities (Anonymous, 1986).

A joint working group sponsored by the Indian National Science Academy and the National Academy of Science, U.S.A. estimated that post harvest losses in fruits and vegetables in India were 30 percent or more (Subrahmanyam, 1986).

Losses during handling and marketing of tropical produce were often high with post harvest losses sometimes exceeding 50 per cent (Campbell, 1994). This was due to inadequate equipment and technology and long marketing chain.

2.2.1 Causes of Post –Harvest Losses

Bourne (1988) grouped the causes of post harvest crop losses in developing countries into primary losses (insects, rodents, birds, microbial contamination, sprouting and mechanical damage) and secondary losses (inadequate drying, storage, cooking and transportational facilities). Sethi and Maini (1989) reported that the principal cause of post harvest losses in fruits and vegetables were ripening, sprouting, wilting, water loss, bruising, over ripening, sprouting, high respiration rate, chilling injury and decay.

2.2.2 Effective measures to reduce Post Harvest Losses

Hardenburge (1971) in U.S.A has reported that improvement in packaging has contributed greatly to more efficient marketing of fresh fruits and vegetables. Harvey (1978) observed that proper packaging of a product can reduce not only bruising and crushing damage but also moisture loss, contaminations of the product with spoilage organisms and pilferage. Wills *et al.* (1989) stated that packaging provide convenient units for marketing and distribution, besides protecting the fruits and vegetables from under damages, thereby reducing the post harvest losses.

An adequate packaging protects the produce from physical, physiological deterioration during transport and marketing thus retaining its attractiveness (Shanthakrishnamurthy, 1990). Maini *et al.* (1993) stated that packaging is a vital component of post harvest management to assemble the produce in convenient units and in marketing channels.

2.3 Transportation

Considerable losses occur during transport of fresh fruits and vegetables to various destination.

Neelgreevam *et al.* (1985) and Subrahmanyam (1986) found that the losses during transport might increase the cost upto 24.2 per cent.

Ramana *et al.* (1988) reported that in India for transporting fruits and vegetables from the production centres to the urban markets, even if two per cent wastage is reduced, there will be a saving of Rupees hundred to two hundred crores per annum.

The deterioration of bananas in connection to the problems of transport from plantations were studied by Subijanto *et al.* (1990). The bananas were transported in all kinds of vehicles and small boats.

2.4 Packaging Materials

A comparison of the advantages and disadvantages of various type of packaging materials have been made in a study by FAO (1989).

2.4.1 Corrugated fibre board boxes

Packaging and transportation trials on apples from Kashmir to Bangalore by rail and road in corrugated fibre board boxes (CFB) and improved wooden packaging cases were carried out in CFTRI, Mysore (Anandaswamy, 1982). Bruising of apples were found to be much less in CFB boxes as compared to conventional wooden cases in both the systems of transport.

Joshi and Roy (1986) found that fruits packed in CFB boxes with partition showed slow rate of ripening, spoilage, bruises and shriveling during storage. It also recorded less physiological loss in weight.

Parmer and Chundawat (1989) stated that wrapping of individual fruits in tissue paper and packing in ventilated cardboard boxes delayed ripening and reduced shrinkage in mango.

In an experiment conducted to study the post harvest losses in sapota fruits in different packages after road transportation (630 km) to the distant market with subsequent storage, the fruits packed in polyethylene lined CFB cartons had better shelf life and marketability with higher organoleptic values. The total post harvest losses after transportation and storage were 10-16 per cent, irrespective of package. The major post harvest loss was found to be physiological weight loss (Jagtap and Katrodia, 1998).

2.4.2 Crates

Sethi and Maini (1989) reported that the existing practices of packaging of fruits and vegetables in gunny bags, woven baskets and traditional wooden crates resulted in excessive mechanical damage resulting in heavy economic losses. Plastic crates showed less bruising losses as compared to conventional field baskets for collecting fruits from the field. This has been substantiated by Subijanto (1990) in a study using reusable plastic crates, wooden crates and bamboo baskets in which paper or banana leaves were used as a cushioning material. He found that reusable plastic crates caused less injury to the banana fruits during transportation as compared to wooden crates and banana baskets.

2.4.3 Polyethylene packages

Polyethylene covers delay the softening of fruits by reducing the respiration rate, but the accumulation of CO_2 and water vapour inside the film packs during storage exerts unfavourable effects which could be overcome by providing suitable vents.

Efficacy of polythene films packs has been reported to be of material importance in increasing the shelf life of fruits like and mandarine (Subba Rao *et al.*, 1967).

Mc Carron (1972) reported that the most satisfactory package material is cellophane and cellophane based laminates with respect to aroma. Sadashivam *et al* (1973) also reported that polythene packages ensure better storage of sathgudi fruits. Kumar *et al.* (1976) reported the range of packaging films and laminates for water vapour transmission rate, tensile strength and grease resistance.

Mahadeviah *et al.* (1977) reported that for long term storage of about 8-10 months and to withstand physical and environmental hazards, low density polyethylene (LDPE) film 400 guage thickness are quite suitable in offering a desired protection for pusher of unit packs of 500 g. However for short-term storage of about three to four months, 200 guage of LDPE is quite adequate under all conditions of storage.

Aravindakshan (1981) compared different storage methods of Nendran banana on the shelf life and quality. In the study conducted it was found that the fruits stored in polyethylene bag with Potassium permanganate took 17 days to reach full ripening stage. While fruits stored in polyethylene bags with out $KMnO_4$ and that in the open took nine to eleven days, and five to seven days respectively to reach full ripening of stage.

Pre-packaging of the fresh fruit in plastic bags in known to help in extending the shelf life, both at room temperature and cold storage (Hasan and Kushma, 1971; Khedkar *et al.*, 1982; Adsule and Tandon, 1983).

Khan *et al.* (1990) reported that polyethylene bags could be advantageously used for consumer packaging of fruits as they are fully transparent, convenient to handle during storage and marketing and retain the produce in good condition for a considerable long period. It was observed that packaging of fruits in polyethylene bags reduced the weight loss and delayed the ripening process.

Adak (1990) reported the usefulness of low density polyethylene (LDPE) as an effective packaging materials for fresh producers. Satyan *et al.* (1992) stated that the use of sealed polyethylene tubes with ethylene absorbent allowed a storage life up to Six weeks at 20-28^{0}C in banana cv. Williams.

Shanmughavelu *et al.* (1992) reported that banana packed in 100 guage polythene bags with 0.2 per cent ventilation gave 58 per cent greenish, yellow fruits with hard pulp at the end of 20 days against 50 per cent full ripe fruits in control. After 90 days of storage there were 100 per cent yellow hard fruits in

100 guage bags with 0.4 per cent vents and 85 per cent in 100 guage bags with 0.6 per cent vents. Fruits in control and in other treatment were soft after 30 days.

Roy and Pal (1993) reported that the use of plastics in packaging of horticultural produce helps in minimizing the cost of packaging materials and makes the whole process less dependent on scarce materials like wood thereby resulting in conservations of environment.

Elzayat (1996) studied the effects of packaging, pre treatment and storage temperature (13 or 15^0C) as the storage quality of banana cv. Magrabi (green fruits harvested at three quarter stage). Sarkar *et al.* (1997) conducted studies to determine the suitable thickness and colour of polyethylene films used to extend the shelf life of banana cv. Giant Governor and found that the fruits remained in marketable condition up to 28 days after harvest in 300 or 400 guage polyethylene packs. Advantages of moulded plastic containers as packaging materials was described by Pruthi (1993).

2.5 Cushioning Material

Plantains stored with dry coir dust as packaging material has less loss of weight and those in moist coir dust retained weight with no shriveling and less skin blackening. The fruits in coir dust remained green for long periods before ripening rapidly (Thompson *et al.*, 1974).

Subijanto *et al.* (1990) reported that packing banana in wooden crates with paper or banana leaves as protection is efficient in reducing injury during transportation. Banana leaves were the only protection for the bottom and sides of the loads. The paddy straw as cushioning, punctures the skin of the soft fruit resulting in bruising and uncleaned appearance which resulted in heavy wastage and poor prices (Kim, 1988). Similar results have been reported by Ingale (1980) Joshi and Paralkar (1991) in Sapota.

Agbo *et al.* (1996) studied new storage techniques of plantain with local plant materials (cocoa leaf powder, cocoa pod powder or coffee husk power). The results showed that these materials could help to increase the green life of plantain to more than two weeks at 30^0C and more than four weeks at 20^0C with no loss of culinary qualities.

2.6 Harvest

Singh (1969) reported that like mango, banana is also harvested raw and ripened artificially. The fruit was harvested after the finger begin to turn light green and the ridges on the surface change from angular to rounded in case of local types.

Ayub *et al.* (1996) conducted studies to determine acidity, pH, soluble solids concentration, chlorophyll, and colour of banana (cv. Prata) harvested at 15 days interval from plants growing at the Universidade Federal de Vicosa, Brazil. The results indicated that fruits harvested 105 days after anthesis ripen normally in storage. Harvesting between 105 and 135 days after anthesis resulted in higher yields but a shorter storage life.

Waskar and Roy (1996) reported several methods for extending the shelf life of banana fruits. The methods adopted for extending shelf life of bananas harvested a few days before they reach full maturity (i.e., three fourth maturity) include storage at reduced temperature, modified atmosphere storage, packaging in film bags, pre-treatment with fungicides etc.

Madhavarao (1984) states that bunches selected for harvesting should be green, three fourth ripe whole and free from rubbing, scratching, bruises, sunburn or blemishes. Three quarter full stage is recognized by sharp angularities of the fingers.

2.7 Maturity indices

The study of maturation of banana with a view to improving transport conditions revealed that maturation after harvesting consists of a pre climacteric phase of low respiration activity during which composition remain practically unchanged, followed by a climacteric phase of higher respiratory activity and rapid physiological change which begins when the fruit is dark green and ends before it is completely yellow (Anonymous, 1952). Hence it is suggested to cut the fruit at highest weight permitting a pre-climacteric phase coinciding with the transportation period.

As the length of pre climacteric phase depends principally on the stage of maturation of fruits at the time of harvest, various workers have suggested different criteria to assess the maturity index at harvest to suit different purpose.

Decillin and Monnet (1960) reported that the fullness in bananas can be determined based on the surface median transverse section of the fruit. Wally *et al.* (1969) suggested to make use of the number of days from flowering to maturity as an index for harvesting. He reported that the fruits of 'Hindi' bananas takes 128 days after flowering to reach full maturity and the climacteric occurred at 145 days when fruits were over ripe.

Singh *et al.* (1976) on the basis of biochemical studies reported that good quality Basari dwarf bananas can be obtained if the harvesting of the bunches was done 80 days after spike emergence. Desai and Deshpande (1978) reported that on the basis of their studies on cultivars Pachabale, Rasabale and Rajabole that bananas packed at 90 and 105 days, stores better and showed better quality than bananas picked at 120 days. They further pointed out that the firmness, total chlorophyll and the ratio of total sugars to acidity were the most promising maturity indices.

Ryall and Pentzer (1982) stated that selection for longer green life is desirable as it would facilitate transportation of the fruit to the distinct market and also reduce the post harvest losses. Therefore green life potential of varieties is a very important characteristic that could be used for selection of desirable varieties.

The TSS, total and reducing sugar content, acidity pH and tannins which showed distinct trends during fruit growth and development could be considered as chemical indices of maturity (Paralkar *et al.* , 1987).

Observations on ripening of fruits were recorded by Dadzie and Orchard (1997) by routine visual examinations of fruits. The green life and yellow life of fruits were reckoned as the time elapsed from harvesting to ripening (change of peel colour from green to yellow) and from ripening to the end of yellow life respectively.

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Shivashankar (1999) stated that the 67 banana accessions tested revealed large variations in green life, shelf life, TSS and acidity. The study shows that it is possible to select for longer green life which helps in avoiding post harvest losses in transportation and storage.

2.8 Ripening

Zica and Brune (1973) in a study conducted on storage of bananas cv. Prata in perforated and non perforated polythene bags, with and without absorbent, reported that the most suitable commercial treatment was with perforated polythene bags without absorbent which delayed ripening by about five days while the fruits stored in non perforated bags with absorbent were commercially unacceptable though the ripening was markedly delayed.

Seo and Hosokawa (1982) found that sugar content of banana pulp can be used to estimate degree of ripening. Relationships were established between pulp sugar content and skin colour and pulp hardness and CO_2 evolution rates.

Shanthakrishnamurthy (1989) reported that the fruits remained green, firm and unripe for 2-3 weeks at all temperatures (control, 15 and 20^{0}C). The delay in ripening was related to reduced rates of softening and peel colour development to increased pulp to peel ratios, levels of tannin, total sugars and alcohol, insoluble residue in the fruit pulp. Sometimes changes in skin colour do not reflect the edible quality of the pulp. Total dry matter and total soluble solids were reported to be important parameters in judging the ripeness of fruits (Skorikova *et al.*, 1992).

2.9 Physiological loss of weight

Wilkinson (1965) reported that the loss in weight of apples during storage is due to evaporation and transpiration. The loss in weight under different conditions of storage has been reported to be 6.14 percent in a storage period of 135-210 days as reported by Maini *et al.* (1985), and Mahajan and Chopra (1994).

Siddiqui *et al.* (1991) reported that physiological loss of weight is due to evapo-transpiration and respiration in his studies on guava. In a study on sapota fruits Joshua and Sathiamoorthy (1993) stated that fruits stored in poly bags of 200 guage with 0 per cent vent recorded the least PLW during a storage of 6 days (10.65 per cent) as compared to control (27.4 per cent). However, spoilage was the highest (98 per cent) in all the unventilated treatments irrespective of the thickness of polybags. And this was attributed to reduced rate of moisture loss and decreased rate of respiration. Similar results have been reported by Shivarama Reddy and Thimma Raju (1988).

Venkatesha and Reddy (1994) reported that packaging of fruits in polyethylene bags had remarkable effect on reducing the PLW and increasing the storage life of fruits. The check to PLW may be attributed to the retardation of the process of transpiration and respiration. Similar results were obtained by Hardenburg (1971); Ramana *et al.* (1989).

Sarkar *et al.* (1997) reported that PLW, was least for fruits packed in 300 or 400 guage non perforated poyethylene packs, and fruits remained in marketable condition upto 28 days after harvest.

Jagtap and Katrodia (1998) found that the fruits packed in CFB cartons showed least PLW and ripening percentage with higher organoleptic values than that of wooden crates. This might be due to the fact that plastic lined CFB packed fruits were least exposed to the atmosphere directly as to that of wooden crates.

Physiological loss in weight during storage is due to the loss of water through transpiration, evaporation and respiration. A higher PLW is therefore an undesirable feature commercially as it leads to large reduction in bunch weight during ripening (Shivashankar, 1999).

2.10 Total Soluble Solids

The increase in TSS may be due to the break down of starch into sugars and the subsequent decrease may be related to the higher respiratory activity (Hulme *et al.*, 1963 ; Maini *et al.*, 1985 ; Mahajan and Chopra, 1994).

Clonal variation studies in Nendran at Banana Research Station, Kannara showed significant variations in the quality aspects such as TSS (28.7-34.3 per cent), acidity (0.27-0.34 per cent) total sugar and sugar / acid ratio (Anonymous, 1984).

The quality analysis by Rajeevan (1985) showed significant difference in TSS, total sugar and reducing sugar among the accessions of Palayankodan.

Rajeevan and MohanaKumaran (1993) observed the following quality variations in the 24 accessions of the clone Palayankodan. TSS 22 to 26.17 per cent acidity 0.30 to 0.48 per cent, total sugars 16.41 to 17.40 per cent, reducing sugars 15.5 to 17.18 per cent and non-reducing sugar 0.14 to 0.27 per cent.

During ripening of the fruits, increase in acidity and hydrolysis of starch to simple sugars takes place. Increase in sugars in turn increases the TSS content. The increase in TSS was high compared to increase in acidity (Firmin, 1991).

Rajamony *et al.* (1994) in an experiment with 27 banana clones of AAB group noticed a TSS variation of 22.0 percent in Mottapoovan to 30.0 percent in kodapanillakannan. The quality variation of the table varieties of banana were reported by Ram *et al.* (1994) to be 15.1-16.15 per cent TSS, 0.22-0.37 per cent acidity and 14.1-14.3 per cent total sugars.

Shivashankar (1999) reported that the TSS content of screened varieties showed significant differences. Most of the accessions had a TSS 22 to 26^0 Brix with higher values of TSS up to 29.0 to 29.3^0 Brix.

2.11 Acidity

Barnell (1940) reported that there was not much increase in acidity of fruits during the early stages of development. His studies revealed that simultaneous with the synthesis of starch, continuous fall in acidity occurred through out the development until starch hydrolysis began when rising values for acid content was observed.

Simmonds (1966) stated that the acidity of the pulp of banana, whether measured as pH or as titrable acidity raised to a maximum at or soon after the climactric and showed a slight fall as ripening progressed. Papost and Phillip (1960) reported that the decrease in TA (titrable acidity) during storage varied with variety, location, growing condition and storage temperature.

Lakshminarayana *et al.* (1970) found that in Alphonso mangoes acidity reached a peak around the 7th week but had decreased at ripening . Elobi and Khan (1974) also reported similar changes in ripening of mango fruits. But Singh *et al.* (1976) reported that in banana acidity did not indicate any relationship with maturity or quality of ripe fruits. Rao and Roy (1980) reported that acidity increased with the increase in temperature of storage in case of mango pulp.

Venkatesha and Venkatesha Reddy (1994) observed a decrease in TA more in control fruits, where as it was reduced to 50 per cent on 9th day of storage, while retention of acid content was more in polyethylene packed fruits. These findings are in general agreement with the findings of researchers in guava (Khedkar *et al.*, 1982; Tandon *et al.*,1984).

Magdaline and Sreenarayanan (1999) reported that ascorbic acid content of banana decreased significantly from 1st day to 30th day in all packages, and it is minimum in control as compared to that in packages.

2.12 Firmness

Kidd *et al.* (1951) reported that the decrease in firmness was attributed to the breakdown of starch and pectin, mainly responsible for the firmness of fruits. The strength of fruit tissue is mainly due to the physical properties of the individual cell walls and the middle lamella which contain the cementing pectic materials and as the fruit approaches ripening, the tissue become soft due to degradation of cell wall and intercellular adhesive substances (Dilley, 1970).

Wills *et al.* (1980) related the decrease in firmness in apple during ripening and storage to cell size and protoplasm in older cells, whereas Bartley and Knee (1982) observed that the decrease might be due to increase in soluble pectin and decrease in insoluble pectin.

Firmness was directly related to thickness of the polyethylene bags and inversely proportional to levels of ventilation tried. The highest firmness registered on 9th day in control fruits might be due to excessive moisture loss, more shriveling and over-ripening which makes the fruit surface hard and dry (Adsule and Tandon,1983).

Ramana *et al.* (1989) showed that by continuously flushing the storage atmosphere with air saturated with moisture it is possible to ensure slower changes in firmness. He also attributed the decrease in firmness due to breakdown of starch and pectin during storage. Vacuum packed fruits softened much less at all times compared to air packed fruits (Ben-Arie *et al.*, 1991).

2.13 Sugars

Simmonds (1966) reported that sugars were present in the green fruits only in very small amounts, averaging about 1-2 per cent of the fresh pulp, which increased to 15-20 per cent at ripening, the beginning of the increase coinciding with the respiratory climacteric.

Lodh *et al.* (1971) reported that the total sugar were low until 100 days and increased markedly after harvest in Dwarf Cavendish banana. The concentration of sugar is higher in the hybrids than acuminata clones (Nambisan, 1972). He also observed that among the acuminata clones Namarai recorded higher per cent of sugars than Dwarf Carendish. The mean sugar content of predominantly balbisiana hybrids was 1.086 per cent and this was significantly higher than that of predominantly acuminata hybrids which recorded 0.817 per cent of sugars.

Increase in sugars during storage took place due to the degradation of poly saacharides into simple sugars by metabolic activities as reported by Naik *et al.*(1993) in tomatoes.

Rangavalli *et al.* (1993) reported a gradual increase in the non-reducing and reducing sugar contents of mango cv. Baneshan which reached their maximum at ripening stage (6th day). This was attributed to the starch hydrolysis in the ripening process. However, the proportion of reducing sugar content was less compared to non- reducing sugar both at ripe stage and at the end of shelf life.

Magdaline and Sreenarayanan. (1999) observed maximum total soluble sugar content in banana fruits kept in control and minimum sugar content in those kept under vacuum with ethylene absorbent. He reported that the lower sugar levels were due to low availability of oxygen under vacuum packed conditions which reduced the respiration rate.

2.14 Sensory Evaluation

Organoleptic evaluation done by Sadasivam *et al* . (1973) showed that 100 guage film packs with 0.2 per cent vents to be the best rather than 150 and 200 guage film packs on the storage of sweet-oranges.

Loss in sensory quality (appearance, taste and texture) was noticed with the advancement in storage period in apple (Mukherjee and Srivastava, 1980). This was in conformity with results of workers such as Sharma *et al*. (1999) and Singh (1969).

Significant differences were noticed between packed and control fruits for their organoleptic qualities. The control fruits recorded low scores, indicating the early onset of senescence to tissue resulting in decrease of firmness and dull appearance. The polyethylene bagged fruits retained better quality by securing high scores. (Adsule and Tandon, 1983; Singh, 1988; Venkatesha and Ventaersh Reddy 1994).

The fruits held in 300 guage PE bag with no ventilation can be stored upto 10 days without much loss in weight and quality, if held in PE bags beyond 10 days of storage an off flavour develops. This might be due to excessive accumulation of carbon di oxide and non availability of oxygen in the pack. (Venkatesh and Venkatesha Reddy 1994 in guava , Chaplin *et al* ., 1982 in mango and Hruschka and Kaufmann, 1954 in citrus).

According to Stone and Sidel (1993) sensory evaluation involves the measurement and evaluation of the sensory properties of foods and other materials. Sensory evaluation is the most suitable criterion for judging the quality of papaya in respect of colour , flavour, appearance, texture and taste. Jack *et al.* (1995) reported that texture is a percept resulting from interaction between food and consumer.

2.15 Degree of disease incidence

Fungal infection was very high (40-60 per cent) in the non ventillated polythene film packs, but only 0.1 percent in the ventialled (Rygg, 1951; Hruschka and Kaufman, 1954; Kaufman *et al.*, 1956 and Subbarao *et al.*, 1967).

When the harvested fruit is cut into hands and washed, the newly exposed tissue is vulnerable to infection, spores which has accumulated in the washing water can be drawn several millimeter into the wound (Greene and Goos, 1963).

Crown rot is characteristically a disease complex caused by several fungi, sometimes associated with bacteria (Lukezie *et al.*,1967). He also reported that if the site of infection remains beyond the reach of fungicides, decay ensues and the combined effects of the various organisms can lead to rapid rotting. Crown rot is caused by different organism and predominate according to locality, time of year and other factors (Meredith, 1971).

Paul Thomas *et al.* (1968) reported that the fungicidal paste is applied to give a uniform smear and complete coverage of cut ends to prevent stem end rot of banana during storage and transport . It also seals off the pores thus reducing moisture loss and entry of fungal organism through the cut end.

Ogawa (1970) reported that many of the causal fungi survive on leaf debris in the plantation. The fungal spores are dispersed either by wind or rain splash and impinge on all parts of the developing bunch. (Meredith,1971).

Shillingford and Sinclair (1978) reported that post harvest fungicide application is essential and systemic fungicides application are invaluable because of their ability to be carried into the internal peel tissues.

Sethi and Maini (1989) reported that ripening process could be controlled by the proper use of fungicides for controlling spoilage.

Higher losses due to post harvest diseases were observed in the perishable with long route and hours of transit period during transportation. The fruits spoiled due to rotting after transportation were affected by *Penicillium* sp. (Dasgupta and Mandal, 1989).

Storage conditions also affected post harvest losses. Fornaris-Rullan *et al.* (1990) reported that higher storage temperature caused some increase in anthracnose and stem end rot in mango.

MATERIALS AND METHODS

3. MATERIALS AND METHODS

The present investigation entitled "Post - harvest handling in *Musa* (AAB Group) Nendran" was conducted in the Department of Processing Technology, College of Agriculture, Vellayani during 1999-2000. The investigation comprised of Nendran banana in two different forms at two stages of maturities in three different types of packages and two cushioning materials. Fruits were obtained directly from the local farmers. The details of the methodology followed in the investigation are described below.

3.1 Layout of the experiment.

Design : 2x3x2x2 factorial experiment in CRD

Treatments : (2x3x2+2) x 2 = 28

Replication : 3

Variety : Nendran *(Musa* AAB group)

Factors	**Notation**
Full Matured hands (Stage I)	s_1
Hands turning yellow (Stage II)	s_2
Corrugated fibre box	p_1
Plastic crates	p_2
Tray Packing	p_3
Paper Shreds	c_1
Dried banana leaves	c_2
Banana hands	f_1
Banana fingers	f_2

Plate 1. Different packing materials used

Treatments	**Notation**
Stage I + CFB + Paper shreds + Hands	$s_1 p_1 c_1 f_1$
Stage I +CFB + Paper shreds + Fingers	$s_1 p_1 c_1 f_2$
Stage I +CFB + Dried banana leaves + Hands	$s_1 p_1 c_2 f_1$
Stage I+ CFB + Dried banana leaves + Fingers	$s_1 p_1 c_2 f_2$
Stage I +Plastic crates+ Paper shreds + Hands	$s_1p_2 c_1 f_1$
Stage I + Plastic crates +Paper shreds + Fingers	$s_1 p_2 c_1 f_2$
Stage I + Plastic crates + Dried banana leaves _+ Hands	$s_1 p_2 c_2 f_1$
Stage I + Plastic crates + Dried banana leaves + Fingers	$s_1 p_2 c_2 f_2$
Stage I + Trays + Paper shreds + Hands	$s_1 p_3 c_1 f_1$
Stage I + Trays + Paper shreds +Fingers	$s_1 p_3 c_1 f_2$
Stage I +Trays +Dried banana leaves + Hands	$s_1 p_3 c_2 f_1$
Stage I + Trays + Dried banana leaves + Fingers	$s_1 p_3 c_2 f_2$
Stage I + Hands in Control	$s_1 p_0 c_0 f_1$
Stage I + Fingers in Control	$s_1 p_0 c_0 f_2$
Stage II + CFB + Paper shreds + Hands	$s_2 p_1 c_1 f_1$
Stage II + CFB + Paper shreds + Fingers	$s_2 p_1 c_1 f_2$
Stage II +CFB + Dried banana leaves + Hands	$s_2 p_1 c_2 f_1$
Stage II + CFB + Dried banana leaves + Fingers	$s_2 p_1 c_2 f_2$
Stage II +Plastic crates + Paper shreds + Hands	$s_2 p_2 c_1 f_1$
Stage II +Plastic crates + Paper shreds + Fingers	$s_2 p_2 c_1 f_2$
Stage II +Plastic crates + Dried banana leaves + Hands	$s_2 p_2 c_2 f_1$
Stage II +Plastic crates + Dried banana leaves + Fingers	$s_2 p_2 c_2 f_2$
Stage II + Trays + Paper shreds + Hands	$s_2 p_3 c_1 f_1$
Stage II + Trays + Paper shreds + Fingers	$s_2 p_3 c_1 f_2$
Stage II + Trays + Dried banana leaves + Hands	$s_2 p_3 c_2 f_1$
Stage II + Trays + Dried banana leaves + Fingers	$s_2 p_3 c_2 f_2$
Stage II + Hands in Control	$s_2 p_0 c_0 f_1$
Stage II + Fingers in Control	$s_2 p_0 c_0 f_2$

Plate 2.Packing of banana hands and fingers in corrugated fibre board boxes (Hands)

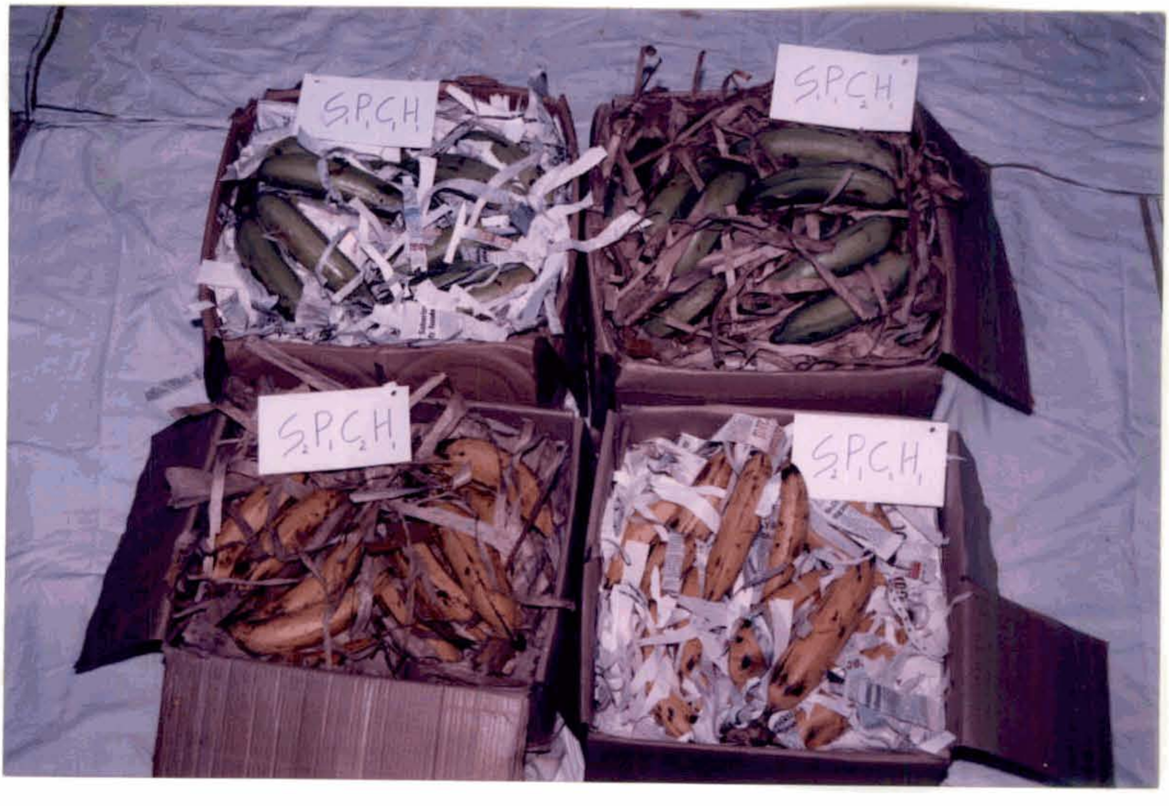
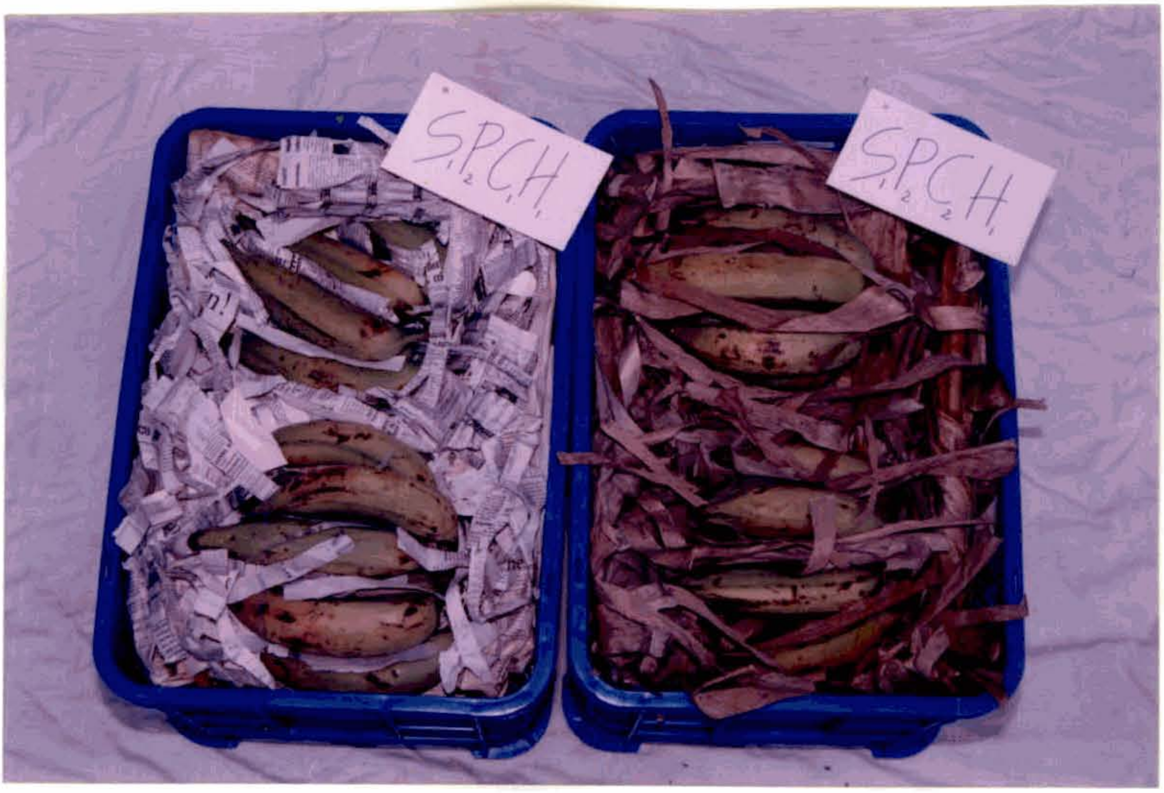
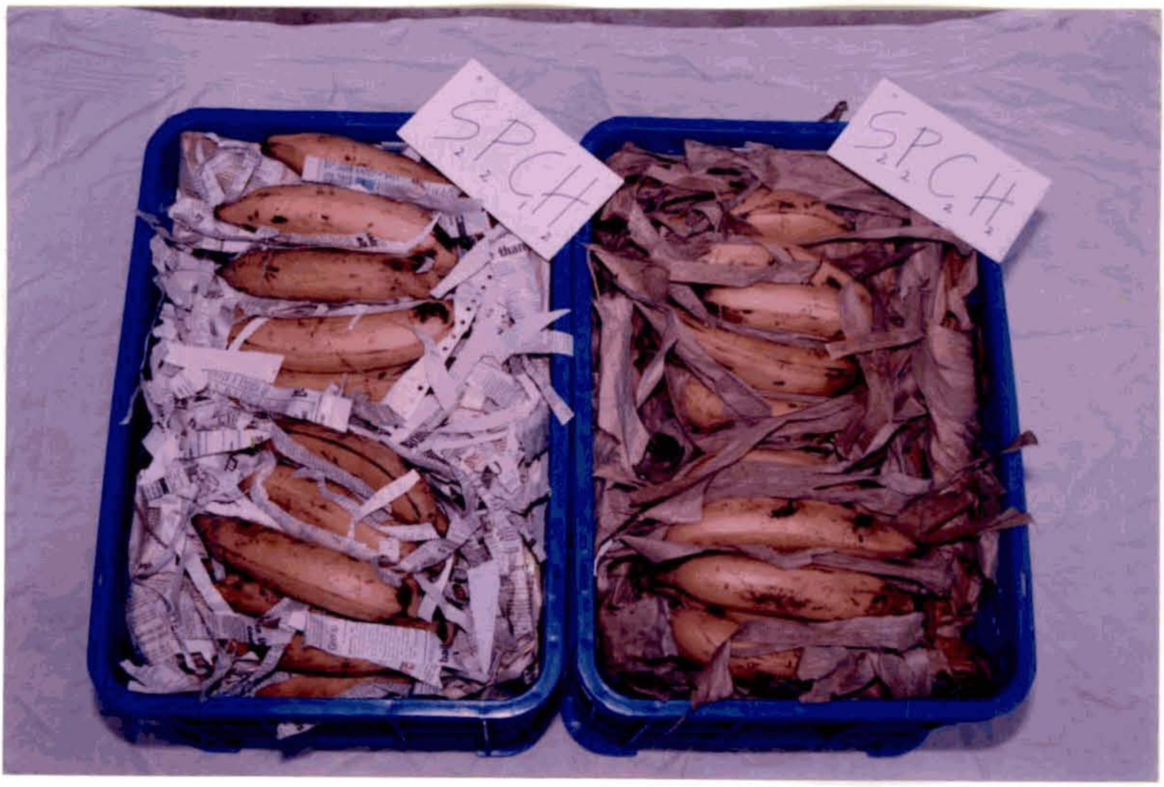

$S_1P_1C_1H_1$
$S_1P_1C_2H_1$
$S_2P_1C_2H_1$
$S_2P_1C_1H_1$

Plate 3. Packing of banana hands and fingers in corrugated fibre board boxes (Fingers)

$S_1P_1C_1F_1$
$S_1P_1C_2F_1$
$S_2P_1C_2F_1$
$S_2P_1C_1F_1$

Plate 4.Packing of banana hands in plastic crates (Hands)


$S_1P_2C_1H_1$
$S_1P_2C_2H_1$


$S_2P_2C_1H_2$
$S_2P_2C_2H_2$

3.2 Selection of bunches

Bunches are selected from the same plot and from those plants planted at same time and given same treatments of fertilizers and manure. They should have no marks of phytosanitary treatments or of fungal or insect attack. Bunches having malformed fingers (twin fingers) torn/ split fingers etc are rejected. Bunches with uniform size and cylindrical shape are selected. Two stages of maturity are observed fully matured green hands and hands turning yellow (3 days after harvest are taken).

3.3 Harvest

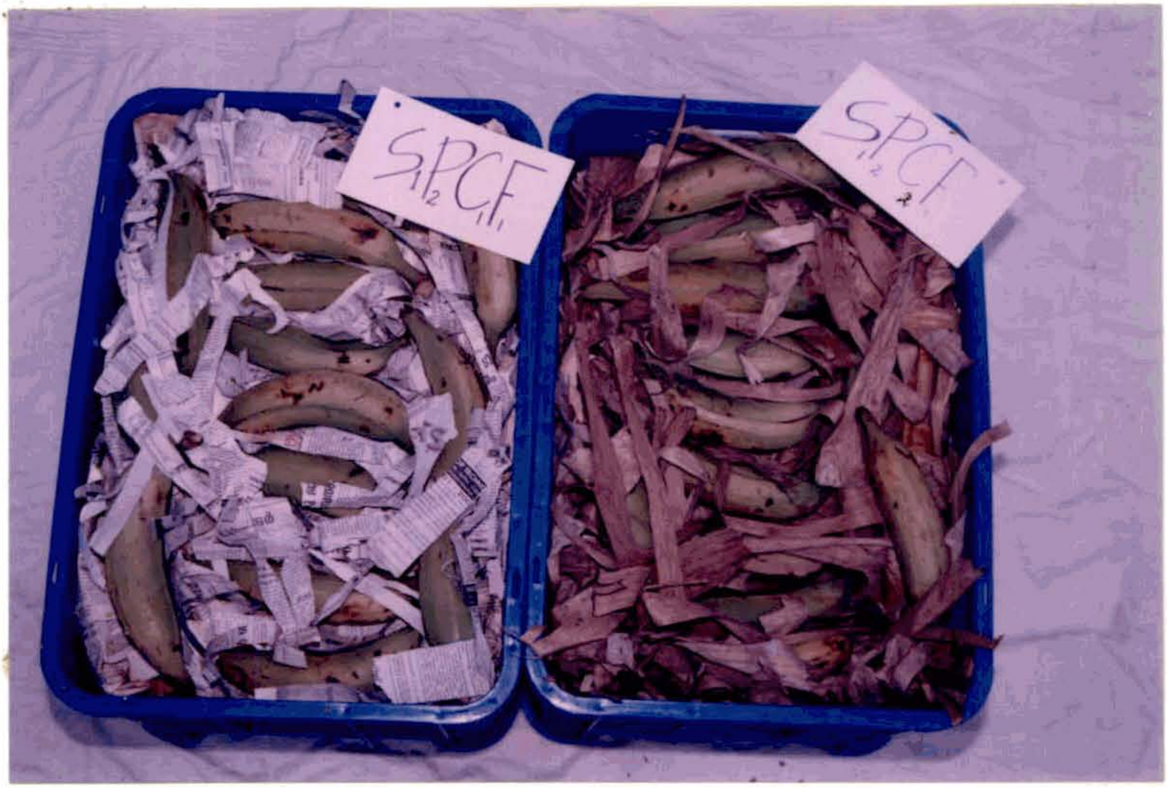
In the field the cutter cuts the bunches in one single stroke 8" to 10" above the first hand. The bunches are placed carefully on freshly cut leaves. Sufficient time is given for the latex flow to cease. Care is given to protect staining of fingers with latex.

3.4 Packaging of the hands:

The bunches are weighed and then hung in an upright (vertical) position for cutting into hands. The bunches are cut with a sharp knife leaving 1-1 1/2 inches of stem portion attached to the hands without inflicting knife wound on fingers of lower hands. The cut hands are then carefully placed on wilted banana leaves. Care is given to prevent the oozing latex from staining the fingers.

The hands are washed to clear the dirt and inert materials. Then, application of fungicide i.e., Bavistin 0.01 per cent is given when the latex

Plate 5. Packing of banana hands in plastic crates (Fingers)


$S_1P_2C_1F_1$
$S_1P_2C_2F$

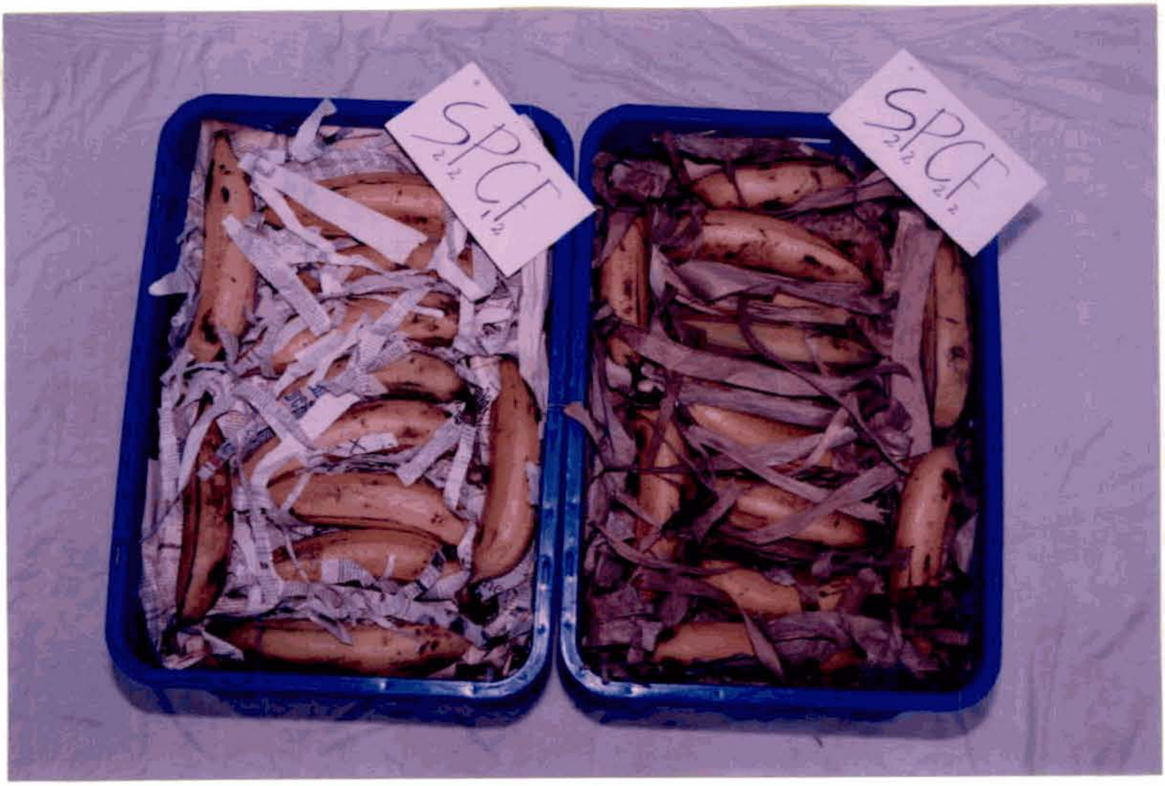

$S_2P_2C_1F_2$
$S_2P_2C_2F_2$

Plate 6. Packing of banana hands in trays covered with 0.4 per cent ventilation (hands)

$S_1P_3C_2H_2$
$S_1P_3C_2H_1$

$S_1P_3C_1H_2$
$S_1P_3C_2H_2$

Plate 7. Packing of banana hands in trays covered with 0.4 per cent ventilation (Fingers)

$S_1P_3C_2F_1$
$S_1P_3C_1F_1$

flow ceases. The fungicide is applied to prevent stem end rot during storage and transportation. It also seals off the pores thus reducing moisture loss and entry of fungus through the cut ends. Later the hands are spread under shade on ground for drying.

Hands with an average length of 20 cm and an average number of 8-10 fingers are packed in each unit. Hands are placed with tips of the fingers and stem end portions of the hand resting on the tray. Sufficient cushioning is provided with paper shreds and dried banana leaves. The banana leaves were also given fungicidal dip and dried thoroughly. This is to reduce the infestation of fungus which survive on the leaves.

The surface sterilised hands in the trays were covered with polythene bags of 0.4 per cent vents, and it is heat sealed. The hands were also packed in corrugated fibre board boxes and perforated plastic crates with all the above said pre- treatments.

3.5 Transportation

To stimulate actual conditions of transportation the fruits packed in different containers were transported over a distance of 20 Km in a tractor trolly through the Public road.

After reaching the collecting centre (College of Agriculture, Vellayani) the fruits were subjected to ripening behaviour studies. The fruits from each package were taken out for assessing the effect of transportation and there-after stored for ripening. The fruits were examined from 2nd day onwards till 10 per cent of the fruits are spoiled. The ripe fruits were distinguished from the unripe by virtue of their colour, softness, aroma and were sorted out for recording the following observation.

3.6.1 Type and extend of surface injuries

Fruits showing cuts, deformation, scratches caused due to aberrations or effect of transportation were recorded and expressed as percentage of bruising .

3.6.2 Marketable fruits:

The number of fruits that ripened normally and found suitable for marketing was observed in each case and the total weight and numbers of such fruits were expressed as percentage of marketable fruits.

3.7.1 Duration of ripening:

Observations on ripening of fruits were recorded by routine visual examination of fruits. The "green-life" and "yellow life" of fruits was reckoned as the time elapsed from harvesting to ripening.

The "green life" was recorded as the number of days from harvest to ripening at room temperature as indicated by change in peel colour from green to yellow. The "yellow life" from ripening to the end of yellow life (beginning of peel darkening).

3.7.2 Physiological loss of weight

The loss of weight of the fruits were recorded at 2 days interval until two fruits of the lot become unmarketable due to spoilage. The mean value was expressed as mean PLW per day. PLW was calculated on the initial weight basis as suggested by Srivastava and Tandon (1962) and expressed as percentage.

$$\text{PLW \%} = \frac{\text{Initial weight - Final weight}}{\text{Initial weight}} \times 100$$

3.7.4 Percentage of marketable fruits

Marketability was calculated based on cumulative spoilage and PLW (Onwuzulu *et al.*, 1995).

3.7.5 Shelf life of fruits

Number of days required from the date of harvest to the development of black colour on the peel was taken as the storage life of fruits at room temperature.

3.7.6 TSS of ripe fruits

TSS was measured using a pocket type refractometer (Model : Erma) and was expressed in terms of percentage on fresh weight basis.

3.7.7 Degree of disease incidence

Fruits showing symptoms of decay due to microbial infection were grouped and expressed as percentage of disease incidence. The causal organisms were identified and scoring was done.

Score	Description
0	Nil to 10 % of the area of the fruit
1	10% to 25% of the area of the fruit
2	25% to 50% of the area of the fruit
3	50% to 75% of the area of the fruit
4	75% to 100% of the area of the fruit

3.7.8 Total sugars

The total sugars were determined as per the method described by Ranganna (1977). The results were expressed as percentage on fresh weight basis.

3.7.9 Reducing sugar

The reducing sugars of the samples were determined as per the method described by Ranganna (1977) as percentage on fresh weight basis.

3.7.10 Non- reducing sugars

Observations under total sugar and reducing sugars were used for calculating non reducing sugar based on the procedure suggested by Ranganna (1977).

Non - reducing sugar = Total sugar - reducing sugar

3.7.12 Acidity

Titrable acidity was determined by the procedure proposed by Ranganna (1977). Results were expressed as percentage anhydrous citric acid.

3.7.13 Sugar-acid ratio

Observations under acidity and total sugars were used for calculating sugar - acid ratio.

3.7.14 Sensory quality

Score cards were prepared for scoring the sensory qualities such as colour, aroma, taste, texture, firmness and appearances (as whole fruit and cut fruit). Gradings were given as

Quality	Score
Excellent (4.5-5.0)	5
Good (3.5 - 4.4)	4
Satisfactory (2.5 -3.4)	3
Fair (1.5 - 2.4)	2
Poor (1 - 1.4)	1

3.8 Statistical analysis

The data collected on different characters were analysed by applying the techniques of analysis of variance for CRD (Completely Randomised Design).

RESULTS

4. RESULTS

Any technology which give high emphasis to post-harvest management of highly perishable crops should be an area of research which has to be given top priority. It was with this objective that an investigation on the post-harvest handling in *Musa* AAB group var. Nendran was taken up to study the effect of different packing materials on transportation and shelf-life of banana at different stages of maturity. The salient results of this study are presented in this chapter.

4.1 Transportational studies

4.1.1 Type and extent of surface injuries

4.1.1.1 Resistance to bruise scratch injury

The results on the extent of resistance to bruising / scratch injury that occurred during the transportation of banana packed at two stages of maturity of fruits in different packing materials to their destination is presented in Table 1 and their four factor interaction is depicted in the Appendix V.

The individual effect of stages of maturity and packing materials were highly significant whereas the effect of cushioning materials and the form of banana packed were non-significant on the resistance to scratch injury. Among the stages s_1 (47.86) gave high resistance to scratch injury than s_2 (45.97). In the case of packing materials greatest resistance to scratch injury was obtained in p_3 (48.25) followed by p_1 (47.04) and comparatively less resistance was offered by p_2 (45.46) as depicted in Table 1.

The two factor interactions S x F, S x C, C x F, P x F and P x C showed no effects on the resistance to scratch injury, while S x P exhibited significant interaction. The highest score was recorded in s_1p_3 (49.08) which was on par with s_1p_1 (48.67). The lowest score was obtained in the interaction s_2p_2 (45.08) which was on par with s_2p_1 (45.42) and s_1p_2 (45.83) as shown in Table 2 and 3. In the package p_1 and p_3 higher resistance was offered by fruits packed at s_1 stage. In p_2 both s_1 and s_2 showed similar effect.

The three factor interactions and the SPCF interactions were absent on the effect of resistance to bruise / scratch injury.

4.1.1.2 Resistance To Pressure injury

The main effect of stages of maturity and form of banana packed did not show any significant effect on the resistance to pressure injury whereas the packing materials and cushioning materials were found to have significant influence. Among the packing materials, p_3 (47.58) gave the best result followed by p_1 (40.13) and then p_2 (39.38). Here p_2 and p_1 were found to be on par. The resistance offered by cushioning material c_2 (42.89) was greater than that of c_1 (41.83) as depicted in Table 1.

All the two factor interactions, three factor interactions and the SPCF interactions were absent on the effect of resistance to pressure injury as shown in the Tables 2 and 3 and Appendix V.

Table 1. Type and extent of surface injuries

Factors	Scratch injury	Pressure injury	Cut injury
Stages			
s_1	47.86	42.72	49.47
s_2	45.97	42.00	49.39
F	38.26**	2.40	<1
SE	0.216	-	-
CD	0.612	-	-
Packing Materials			
p_1	47.04	40.13	49.25
p_2	45.46	39.38	49.21
p_3	48.25	47.58	49.83
F	28.02**	126.58**	7.03**
SE	0.26	0.40	0.13
CD	0.75	1.14	0.37
Cushioning Materials			
c_1	46.86	41.83	49.50
c_2	46.97	42.89	49.36
F	<1	5.14*	<1
SE	-	0.329	-
CD	-	0.933	-
Hands / Fingers			
f_1	46.78	42.72	49.42
f_2	47.06	42.00	49.44
F	<1	2.40	<1

Table 2. Type and extent of surface injuries (Two factor interaction)

Interaction	Scratch injury	Pressure injury	Cut injury
s_1f_1	47.83	43.11	49.39
s_1f_2	47.89	42.33	49.56
s_2f_1	45.72	42.33	49.44
s_2f_2	46.22	41.67	49.33
F 1,56	<1	<1	<1
s_1c_1	47.67	42.39	49.50
s_1c_2	48.06	43.06	49.44
s_2c_1	46.06	41.28	49.50
s_2c_2	45.89	42.72	49.28
F 1,56	<1	<1	<1
c_1f_1	46.61	42.33	49.50
c_1f_2	47.11	41.33	49.50
c_2f_1	46.94	43.11	49.33
c_2f_2	47.00	42.67	49.39
F (1,56)	<1	<1	<1

Table 3. Type and extent of surface injuries (Two factor interaction)

Interaction	Scratch Injury	Pressure Injury	Cut Injury
s_1p_1	48.67	41.08	49.42
s_1p_2	45.83	39.92	49.33
s_1p_3	49.08	47.17	49.67
s_2p_1	45.42	39.17	49.08
s_2p_2	45.08	38.83	49.08
s_2p_3	47.42	48.00	50.00
F (2, 56)	5.72**	3.06	1.91
SE	0.374	-	-
CD	1.060	-	-
p_1f_1	46.58	40.92	49.25
p_1f_2	47.50	39.33	49.25
p_2f_1	45.42	39.67	49.25
p_2f_2	45.50	39.08	49.17
p_3f_1	48.33	47.58	49.75
p_3f_2	48.17	47.58	49.92
F (2, 56)	1.15	<1	<1
p_1c_1	47.00	39.58	49.42
p_1c_2	47.08	40.67	49.08
p_2c_1	45.25	38.50	49.17
p_2c_2	45.67	40.25	49.25
p_3c_1	48.33	47.42	49.92
p_3c_2	48.17	47.75	49.75
F (2, 56)	<1	<1	<1

4.1.1.3 Resistance to cut injury

The effect of various packing materials, stages of maturity and the form of banana packed on the resistance to cut injury are depicted in the Tables 1, 2 and 3 and Appendix V.

Among the individual effects, packing materials were highly significant apart from the stages of maturity, cushioning materials and the form of banana packed. The greatest resistance to cut injury was obtained from p_3 (49.83) as compared to p_1 (49.25) and p_2 (49.21). The package p_1 was on par with p_2 as shown in Table 1.

All the two factor interactions, three factor interactions and the SPCF interactions did not show any significant effect on the resistance to cut injury.

4.1.2 Marketability of fruits soon after transportation

As far as the marketability of banana is concerned, it was found that the treated fruits were fully marketable after being transported to the destination. However some of the fruits in the control samples were discarded as not marketable. The mean score of the controls were $s_1p_0c_0f_1$ (99.33), $s_1p_0c_0f_2$ (99.67), $s_2p_0c_0f_1$ (98.00) and $s_2p_0c_0f_2$ (98.34).

As all the treated samples elicited the same value for marketability (100 per cent) the data on the marketability of fruits were left unanalysed statistically.

4.2 Storage studies

4.2.1 Duration of ripening

The main effects of stages of maturity and packing materials and form of banana packed were not significant on the duration of ripening as depicted in the Table 4. Duration of ripening in green life at the stages of maturity s_1 (7.31) was greater than that at s_2 (6.44). In the case of yellow life also s_1 (4.94) was greater than s_2 (4.33). Among the packing materials p_3 (9.29) gave greatest green life followed by p_2 (6.13) and the lowest green life was recorded by p_1 (5.21). In the case of yellow life the greatest duration of ripening was found in p_2 (5.13) followed by p_1 (4.54) and the least in p_3 (4.25). The two factor interactions S x P, P x F, P x C and C x F were found to have significant effects whereas S x F and S x C were absent as depicted in Tables 5 and 6.

The S x P interaction was highly significant for the green life and not significant for yellow life. In the green life s_1p_1 (5.50) gave the lowest score which was on par with s_2p_2 (6.33), as depicted in Table 5. Here package p_1 and p_2 showed more or less similar effect with s_1 and s_2, whereas with package p_3 duration of ripening was mere with s_1 than s_2.

In the P x F interaction significant difference was observed only during yellow life period. The highest value was recorded by p_2f_1 (5.50) and the lowest by p_3f_1 and p_3f_2 (4.25) which was on par with p_1f_1, p_1f_2 and p_2f_2 as depicted in the Table 6. Here in p_2, f_1 was greater than f_2 while in p_1 and p_3,the effect of f_1 was on par with f_2.

Table 4. Duration of ripening

Factors	Green Life	Yellow Life
Stage		
s_1	7.31	4.94
s_1	6.44	4.33
F	11.56 **	15.26 **
SE	0.179	0.111
CD	0.508	0.313
Packing Materials		
p_1	5.21	4.54
p_2	6.13	5.13
p_3	9.29	4.25
F	95.40 **	10.82 **
SE	0.22	0.14
CD	0.62	0.38
Cushioning Material		
c_1	6.69	4.78
c_2	7.06	4.50
F	2.03	3.15
Hands / Fingers		
f_1	6.81	4.72
f_2	6.94	4.57
F	<1	<1

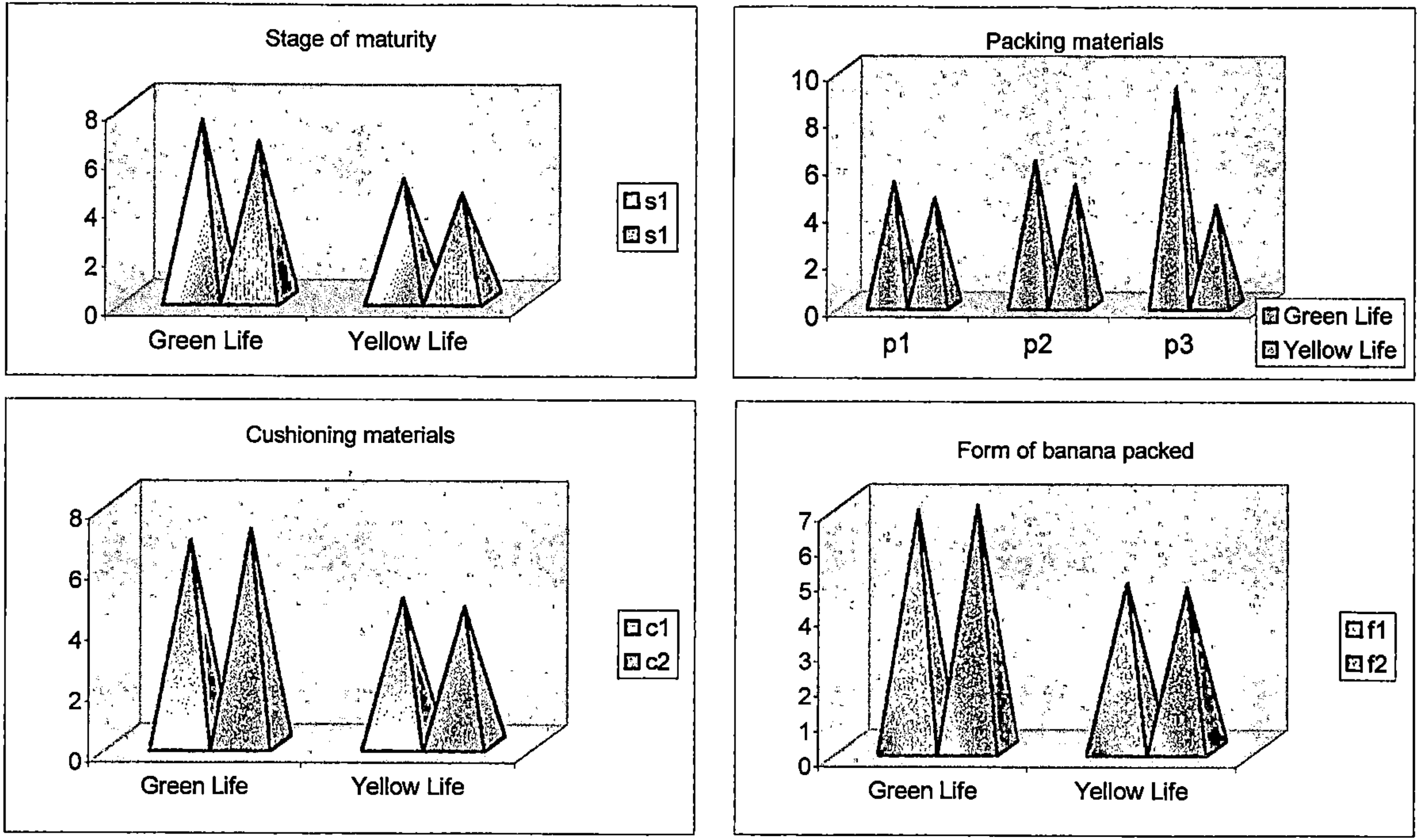
Table 5. Duration of ripening (Two factor interaction)

Interaction	Green Life	Yellow Life
s_1f_1	7.33	5.06
s_1f_2	7.28	4.83
s_2f_1	6.28	4.39
s_2f_2	6.61	4.28
F (1,56)	<1	<1
s_1c_1	6.89	5.17
s_1c_2	7.72	4.72
s_2c_1	6.50	4.39
s_2c_2	6.39	4.28
F(1,56)	3.48	1.14
c_1f_1	6.28	4.83
c_1f_2	7.11	4.72
c_2f_1	7.33	4.61
c_2f_2	6.78	4.39
F(1,56)	7.52 **	<1
SE	0.253	-
CD	0.718	-

Table 6. Duration of ripening (Two factor interaction)

Interaction	Green Life	Yellow Life
s_1p_1	5.50	4.67
s_1p_2	5.92	5.58
s_1p_3	10.50	4.58
s_2p_1	4.92	4.42
s_2p_2	6.33	4.67
s_2p_3	8.08	3.92
F (2,56)	10.73 **	1.55
SE	0.310	-
CD	0.879	-
p_1f_1	5.17	4.42
p_1f_2	5.25	4.67
p_2f_1	5.75	5.50
p_2f_2	6.50	4.75
p_3f_1	9.50	4.25
p_3f_2	9.08	4.25
F (2,56)	1.78	3.69 *
SE	-	0.192
CD	-	0.543
p_1c_1	4.58	4.58
p_1c_2	5.83	4.50
p_2c_1	5.67	5.42
p_2c_2	6.58	4.83
p_3c_1	9.83	4.33
p_3c_2	8.75	4.17
F (2,56)	8.27 **	<1
SE	0.310	-
CD	0.879	-

Fig. 1 Duration of ripening (Days)



Stage of maturity

Packing materials

Cushioning materials

Form of banana packed

Highly significant effect was observed in the P x C interaction on the green life of fruits. The highest value was recorded in p_3c_1 (9.83) and the lowest value on p_1c_1 (4.58). With packages p_1 and p_2, the duration of ripening was more when the cushioning material was c_2. But with p_3, the inverse result was observed.

The C x F interaction was found highly significant for the green life while it was not significant for yellow life. In the green life the highest score was recorded by c_2f_1 (7.33) which was on par with c_1f_2 (7.11) and c_2f_2 (6.78). The lowest score was found in c_1f_1 (6.27) which was also on par with c_2f_2 (6.78) as shown in Table 5. The effect of c_1 was profoundly seen in f_2 than f_1 whereas the effect of f_2 was greater than f_1 when c_2 was used as cushioning material.

The three factor interactions and the SPCF interaction were found to be insignificant.

4.2.2 Percentage of marketable fruits

The individual effects of stages of maturity packing materials, cushioning materials, form of banana packed showed highly significant difference on the percentage of marketable fruits are shown in the Table 7.

The percentage of marketable fruits was influenced by the stages of maturity was significant only on the 8th day of storage. Here the percentage of marketability was found to be greater in s_1 (76.92) than in s_2 (71.87). The effect of P was seen at all the periods of observations among the packing materials p_3 (96.35) gave the maximum percentage of marketable fruits

Table 7. Percentage of marketable fruits

Factors	4th day	6th day	8th day
Stages			
s_1	93.05	84.72	76.92
s_2	93.40	84.37	71.87
F	<1	<1	77.27 **
SE	-	-	0.406
CD	-	-	1.152
Packing Material			
p_1	90.10	78.65	61.22
p_2	93.23	83.33	73.96
p_3	96.35	91.66	88.02
F	49.05 **	252.91 **	725.12 **
SE	0.446	0.415	0.498
CD	1.265	1.175	1.411
Cushioning Material			
c_1	93.05	83.35	72.06
c_2	93.40	85.75	76.73
F	<1	25.11 **	66.04 **
SE	-	0.338	0.406
CD	-	0.959	1.152
Hands / Finger			
f_1	90.62	80.57	69.65
f_2	95.83	88.52	79.15
F	101.96 **	276.13 **	273.48**
SE	0.365	0.338	0.406
CD	1.033	0.959	1.152

Table 8. Percentage of marketable fruits (Two factor interaction)

Interaction	4th Day	6th Day	8th Day
s_1f_1	90.62	80.57	69.65
s_1f_2	95.83	88.52	79.15
s_2f_1	90.62	80.57	69.65
s_2f_2	95.83	88.52	79.15
F (1,56)	4.16 *	26.49 **	273.48 **
s_1c_1	94.44	96.84	78.85
s_1c_2	91.66	82.61	75.00
s_2c_1	91.66	79.86	65.28
s_2c_2	95.14	88.89	78.47
F(1,56)	36.87 **	191.69 **	219.91 **
c_1f_1	88.89	78.50	67.77
c_1f_2	97.22	88.19	76.36
c_2f_2	92.36	82.64	71.53
c_2f_2	94.44	88.86	81.94
F(1,56)	36.87 **	13.11 **	2.53
SE	0.515	0.479	0.575
CD	1.461	1.357	1.629

followed by p_2 (93.23) and then p_1 (90.10) on the 4th day. Similar trends were obtained on the 6th and 8th day as shown in the Table 7.

On the 4th day of storage cushioning materials could not effectively influence the percentage of marketable fruits. However later on the 6th and 8th day its effect was highly significant. On the both 6th and 8th day c_2 (85.75 and 76.73 respectively) recorded greater value than c_1 (83.34 and 72.06 respectively).

The form of banana packed recorded high significance throughout the storage on the percentage of marketable fruits. Fruits packed with fingers f_2 (95.83) gave higher percentage of marketability than those packed as hand f_1 (90.62) on the 4th day. Similar results were observed thereafter as seen in Table 7.

Among the two factor interaction all were found to be highly significant as shown in Table 8. In the S x F interaction s_2f_2 (96.53) gave the highest score which was on par with s_1f_2 (95.13). The lowest score was obtained in s_2f_1 (90.28) which was on par with s_1f_1 (90.97) on the 4th day. Whatever be the stages of maturity, percentage of marketable fruits remained the same when hands were taken for packing. Similar results were obtained on the following days also.

In the S x C interaction, the highest score was obtained by s_2c_2 (95.14) which was on par with s_1c_1 (94.44) and the lowest score in s_1c_2 (91.66) which was on par with s_2c_1 (91.66) on the 4th day. However on the 6th day highest score was obtained in s_1c_1 (96.84) and lowest on s_2c_1 (79.86). With s_1, c_1 was found to be the best cushioning material while with s_2, c_2 was found to be good at all stages of observation of marketable fruits. Similar result was obtained on 8th day also as depicted in Table 8.

The interaction of C x F was found to be significant only on the 4th and 6th day. The highest score on 4th day was obtained by c_1f_2 (97.22) and the lowest score by c_1f_1 (88.89). On the 6th day the highest interaction effect was obtained by c_2f_2 (88.86) and the lowest by c_1f_1 (78.51). Here c_2f_2 was on par with c_1f_2 (88.19). In both c_1 and c_2, f_2 was greater than f_1. With c_1, f_2 was better with a market increase of 100 percent fruits against the results with c_2 where the percentage of marketable fruits was reduced.

In the S x P interaction, the highest score on 4th day was obtained by s_2p_3 (98.96) and the lowest score was recorded in s_1p_1 (89.57). s_1p_1 was on par with s_2p_1 (90.62) and s_2p_2 (90.62). Similar results were obtained on 6th day, but on 8th day highest score was found in the treatment s_1p_3 (88.54) and lowest in s_1p_1 (60.98), as depicted in Table 9. When s_2 matured fruits are taken, the packages p_1 and p_2 where found to be the best, but in s_1 the package p_2 was good.

In the P x F significant interaction effect was found only on the 6th and 8th day as depicted in the Table 9. The highest value was recorded on the treatment p_3f_2 (95.83 and 91.66) on both 6th and 8th day respectively. In both these days the lowest value was recorded in p_1f_1 (76.08 and 54.77). In all the packages f_2 was found to be greater than f_1.

Table 9. Percentage of marketable fruits (Two factor interaction)

Interaction	4th day	6th day	8th day
s_1p_1	89.57	76.05	60.98
s_1p_2	95.83	88.54	81.25
s_1p_3	93.75	89.58	88.54
s_2p_1	90.62	81.25	61.46
s_2p_2	90.62	78.12	66.66
s_2p_3	98.96	93.75	87.50
F (2,56)	34.55**	110.98**	69.36**
SE	0.631	0.586	0.704
CD	1.789	1.662	1.995
p_1f_1	87.50	76.09	54.78
p_1f_2	92.70	81.21	67.67
p_2f_1	90.62	78.12	69.79
p_2f_2	95.83	88.54	78.12
p_3f_1	93.75	87.50	84.37
p_3f_2	98.96	95.83	91.66
F (2,56)	<1	10.37**	8.96**
SE	-	0.586	0.704
CD	-	1.662	1.995
p_1c_1	90.62	79.21	80.99
p_1c_2	89.57	78.08	61.46
p_2c_1	91.66	79.16	66.66
p_2c_2	94.79	87.50	81.25
p_3c_1	96.87	91.67	88.54
p_3c_2	95.83	91.66	87.50
F (2,56)	7.30**	38.88**	74.98**
SE	0.631	0.586	0.704
CD	1.789	1.662	1.995

Table 10. Percentage of marketable fruits (Three factor interaction)

Interaction	4th day	6th day	8th day
$s_1p_1f_1$	89.58	75.10	55.39
$s_1p_1f_2$	89.57	77.00	66.59
$s_1p_2f_1$	93.75	85.42	77.08
$s_1p_2f_2$	97.92	91.66	85.42
$s_1p_3f_1$	89.58	85.42	85.42
$s_1p_3f_2$	97.92	93.75	91.66
$s_2p_1f_1$	85.42	77.08	54.17
$s_2p_1f_2$	95.83	85.42	68.75
$s_2p_2f_1$	87.50	70.83	62.50
$s_2p_2f_2$	93.75	85.41	70.83
$s_2p_3f_1$	97.92	89.58	83.33
$s_2p_3f_2$	100.00	97.92	91.66
F (2,56)	21.78**	6.91**	<
SE	0.893	0.829	-
CD	2.530	2.350	-
$p_1c_1f_1$	85.42	75.10	55.39
$p_1c_1f_2$	95.83	83.33	66.59
$p_1c_2f_1$	89.58	77.08	54.17
$p_1c_2f_2$	89.57	79.09	68.75
$p_2c_1f_1$	87.50	72.92	62.50
$p_2c_1f_2$	95.83	85.41	70.83
$p_2c_2f_1$	93.75	83.33	77.08
$p_2c_2f_2$	95.83	91.66	85.42
$p_3c_1f_1$	93.75	87.50	85.42
$p_3c_1f_2$	100.00	95.83	91.66
$p_3c_2f_1$	93.75	87.50	83.33
$p_3c_2f_2$	97.92	95.83	91.66
F (2,56)	5.42**	3.65*	<1
SE	0.893	0.829	-
CD	2.530	2.350	-

The percentage of marketable fruits was found highly significant with the interaction P x C. The highest percentage of marketable fruits were recorded in p_3c_1 (96.87) and the lowest in p_1c_2 (89.57) on the 4th day. p_3c_1 was on par with p_3c_2. p_1c_2 was on par with p_1c_1. Similar results were obtained on the 6th and 8th day also as depicted in the Table 9. The cushioning material c_1 was found to give good results with p_1 and p_3 while c_2 was good with p_2.

All the three factor interactions were found to be significant on the percentage of marketability .The SPC interaction was found to be significant on the 6th and 8th day of storage. The best combination effect was observed in $s_2p_3f_2$ (100 per cent) which was on par with $s_2p_3f_1$, $s_1p_3f_2$ and $s_1p_2f_2$. $s_1p_1f_1$ gave the lowest effect of 85.42 per cent which was on par with $s_2p_2f_1$. The s_1p_1 treatment had similar effect on f_1 and f_2, whereas in s_2p_1 the effect of f_2 was greater than f_1. In p_2 package s_1p_2 obtained higher marketability with f_2 than with f_1. Similar effect were observed in s_2p_2 treatment also. In s_1p_3 and s_2p_3 also the effect on f_2 was greater than that of f_1 as shown in Table 10.

Among the PCF interactions, highest value was observed in $p_3c_1f_2$ (100 per cent) which was on par with $p_3c_2f_2$. The lowest percentage of marketability was shown in the treatment $p_1c_1f_1$ (85.42) which was on par with $p_2c_1f_1$. The package p_1c_1 rendered best effect with f_2 than in f_1 but with p_1c_2 and p_2c_2 higher effect was obtained with f_2 than in f_1. Similar was the effect of p_3c_1 and p_3c_2 on the interaction with f_1 and f_2. This effect continued for the following days also as shown in Table 10.

Table 11. Percentage of marketable fruits (Three factor interaction)

Interaction	4th day	6th day	8th day
$s_1p_1c_1$	91.67	79.26	65.72
$s_1p_1c_2$	87.48	72.84	56.25
$s_1p_2c_1$	95.83	89.58	81.25
$s_1p_2c_2$	95.83	87.50	81.25
$s_1p_3c_1$	95.83	91.67	89.58
$s_1p_3c_2$	91.67	87.50	87.50
$s_2p_1c_1$	89.58	79.17	56.25
$s_2p_1c_2$	91.67	83.33	66.67
$s_2p_2c_1$	87.50	68.75	52.08
$s_2p_2c_2$	93.75	87.50	81.25
$s_2p_3c_1$	97.92	91.67	87.50
$s_2p_3c_2$	100.00	95.83	87.50
F (2,56)	<1	6.91**	47.76**
SE	-	0.829	0.995
CD	-	2.350	2.821
$s_1c_1f_1$	90.27	83.40	75.81
$s_1c_1f_2$	98.61	90.27	81.89
$s_1c_2f_1$	91.66	80.55	69.44
$s_1c_2f_2$	91.65	84.66	80.55
$s_2c_1f_1$	87.50	73.61	59.72
$s_2c_1f_2$	95.83	86.11	70.83
$s_2c_2f_1$	93.05	84.72	73.61
$s_2c_2f_2$	97.22	93.05	83.33
F (2,56)	4.08*	<1	7.79**
SE	0.729	-	0.813
CD	2.066	-	2.303

The SPC interaction was found significant only on 6th and 8th day. On the 6th day $s_2p_3c_2$ (95.83 per cent) gave the highest marketability value, and $s_2p_1c_1$ (68.75 per cent) gave the lowest marketability value. The effect of s_1p_1 was greater on c_1 than in c_2, while in s_2p_1 the effect was greater on c_2 than in c_1. The effect of s_1p_2 was greater in c_1 than in c_2 on the 6th day and similar on c_1 and c_2 on 8th day but s_2p_2 obtained greater effect on c_2 than in c_1. In case of s_1p_3 the greatest effect was obtained from c_1 while in s_2p_3 the greatest effect was observed with c_2, as shown in Table 11.

Significant SCF interaction was observed in this character on the 4th and 8th day. The highest per cent of marketability was shown in $s_1c_1f_2$ (98.61 per cent) which was on par with $s_2c_2f_2$. The lowest marketability percentage was observed in $s_2c_1f_1$ (87.50 per cent). The effect of s_1c_1 was greater on f_2 than in f_1; while s_1c_2 gave similar effects. In case of s_2c_1, f_2 gave higher values than f_1. Similar was the effect of s_2c_2 on f; as shown in Table 11.

The SPCF interaction effect was found to be highly significant with the percentage of marketable fruits as shown in Appendix VII. The highest score was recorded in $s_1p_2c_1f_2$, $s_1p_3c_1f_2$, $s_2p_3c_1f_2$, $s_2p_3c_2f_1$, $s_2p_3c_2f_2$ i.e., 100 per cent. The lowest score was obtained in $s_2p_0c_0f_1$ (75 per cent) on the 4th day. On the 6th day highest score was obtained in s $s_2p_2c_1f_1$, $s_1p_0c_0f_1$ (58.33 per cent). The highest and lowest scores of percentage of marketable fruits on the 8th day were (91.66 per cent) $s_1p_3c_1f_2$, $s_1p_3c_2f_2$, $s_2p_3c_2f_2$ and 37.50 per cent in $s_2p_0c_0f_1$.

4.2.3 Shelf-life of fruits

Among the individual effects, stages of maturity and packing materials used were found to be highly significant and the cushioning materials and form of banana packed were non-significant as depicted in the Table 12. Shelf-life of fruits harvested at s_1 (12.25) was significantly greater than in s_2 (10.67). The packing materials were also effective and the highest shelf-life was recorded by p_3 (13.54) followed by p_2 (11.25) and the lowest shelf-life among these was noted in p_1 (9.58). Shelf-life of fruits was not influenced by cushioning material, whether they were packed as hands or fingers.

Among the two factor interaction S x F, S x C and P x F did not show any significant effect whereas C x F, S x P and P x C were highly significant. But C x F interaction, did not assume importance since the effect of C and F were not significant. The lowest score was recorded in c_1f_1 (10.89) and it was on par with c_2f_2 (11.16) as shown in the Table 13. With the effect of c_1, f_2 showed greater shelf-life than f_1 while in c_2, f_1 and f_2 were more or less similar.

In the S x P interaction, highest shelf-life was found in s_1p_3 (15.08) and the lowest in s_2p_1 (9.00). Here p_1 and p_2 gave similar results with s_1 and s_2 but in p_3, s_1 was greater than s_2. In the P x C interaction highest shelf-life was obtained in p_3c_1 (14.16) and lowest in p_1c_1 (8.83) as shown in Table 14. When the fruits were packed in p_2, the shelf-life of fruits harvested at s_1 and s_2 did not differ significantly. But s_1 harvested fruits registered more shelf-life than

Table 12. Shelf life of fruits

Factors	Shelf Life
Stage	
s_1	12.25
s_1	10.67
F	27.47 **
SE	0.214
CD	0.605
Packing Materials	
p_1	9.58
p_2	11.25
p_3	13.54
F	57.70 **
SE	0.262
CD	0.741
Cushioning Material	
c_1	11.36
c_2	11.56
F	<1
Hands / Fingers	
f_1	11.42
f_2	11.50
F	<1

Table 13. Shelf life of fruits (Two factor interaction)

Interaction	Shelf Life
s_1f_1	12.39
s_1f_2	12.11
s_2f_1	10.44
s_2f_2	10.89
F(1,56)	1.43
s_1c_1	12.06
s_1c_2	12.44
s_2c_1	10.67
s_2c_2	10.67
F(1,56)	<1
c_1f_1	10.89
c_1f_2	11.83
c_2f_1	11.94
c_2f_2	11.17
F(1,56)	8.12 **
SE	0.302
CD	0.856

Table 14. Shelf life of fruits (Two factor interaction)

Interaction	Shelf Life
s_1p_1	10.17
s_1p_2	11.50
s_1p_3	15.08
s_2p_1	9.00
s_2p_2	11.00
s_2p_3	12.00
F (2,56)	6.57 **
SE	0.370
CD	1.049
p_1f_1	9.25
p_1f_2	9.92
p_2f_1	11.25
p_2f_2	11.25
p_3f_1	13.75
p_3f_2	13.33
F (2,56)	1.09
p_1c_1	8.83
p_1c_2	10.33
p_2c_1	11.08
p_2c_2	11.42
p_3c_1	14.17
p_3c_2	12.92
F (2,56)	6.96 **
SE	0.370
CD	1.049

s_2 harvested fruits with p_1 and p_3 as packing material. Also with p_1, c_2 was found to be the best while in p_3, c_1 was the best cushioning material.

The effect of three factor interactions and the SPCF interactions were absent on the shelf-life of the fruits as shown in the Appendix VIII.

4.2.4 TSS of ripe fruit

The stages of maturity, packing materials and cushioning materials used highly influenced the TSS of ripe fruit, but the form of banana packed did not exhibit any significant variation in TSS as shown in the table 15. During the storage fruits harvested at stage s_2 recorded higher TSS than s_1 on all the days of observation.

Among the packing materials highest TSS was recorded by p_2 (22.96) followed by p_1 (22.92). p_2 was on par with p_1. The least TSS was recorded by p_3 (22.54). This result was continued for the following days. The cushioning materials also hastened the level of TSS in fruits during storage. It was observed that fruits packed with c_2 (22.97) recorded higher score than c_1 (22.64) and this trend in result was observed for the following days of observation.

Among the two factor interactions, all the interactions except S x P on the 8th day of observation were found to be insignificant on the TSS of ripe fruit as shown in table 17. In the S x P interaction significant variation was found only on the 8th day of storage. Within this interaction s_2p_2 (27.25) gave the highest value and this was on par with s_2p_1 (27.08). The lowest value was recorded in s_1p_1 and s_1p_3 (25.17). In all the packages s_2 was greater than s_1

Table 15. TSS of ripe fruits

Factors	2nd day	4th day	6th day	8th day
Stages				
s_1	22.25	23.53	24.64	25.39
s_2	23.36	24.75	25.86	26.83
F	58.33 **	57.91 **	61.04 **	95.59 **
SE	0.103	0.114	0.011	0.104
CD	0.292	0.322	0.314	0.296
Packing Materials				
p_1	22.92	24.17	25.29	26.13
p_2	22.96	24.50	25.58	26.54
p_3	22.54	23.75	24.88	25.67
F	3.32 **	7.30 **	6.90 **	11.70 **
SE	0.126	0.139	0.384	0.128
CD	0.357	0.394	0.135	0.363
Cushion Materials				
c_1	22.64	23.92	25.08	25.86
c_2	22.97	24.36	25.42	26.36
F	5.25 **	7.66 **	4.54 **	11.45 **
SE	0.103	0.114	0.111	0.104
CD	0.292	0.322	0.314	0.296
Hands / Fingers				
f_1	22.83	24.14	25.31	26.11
f_2	22.78	24.14	25.19	26.11
F	<1	<1	<1	<1

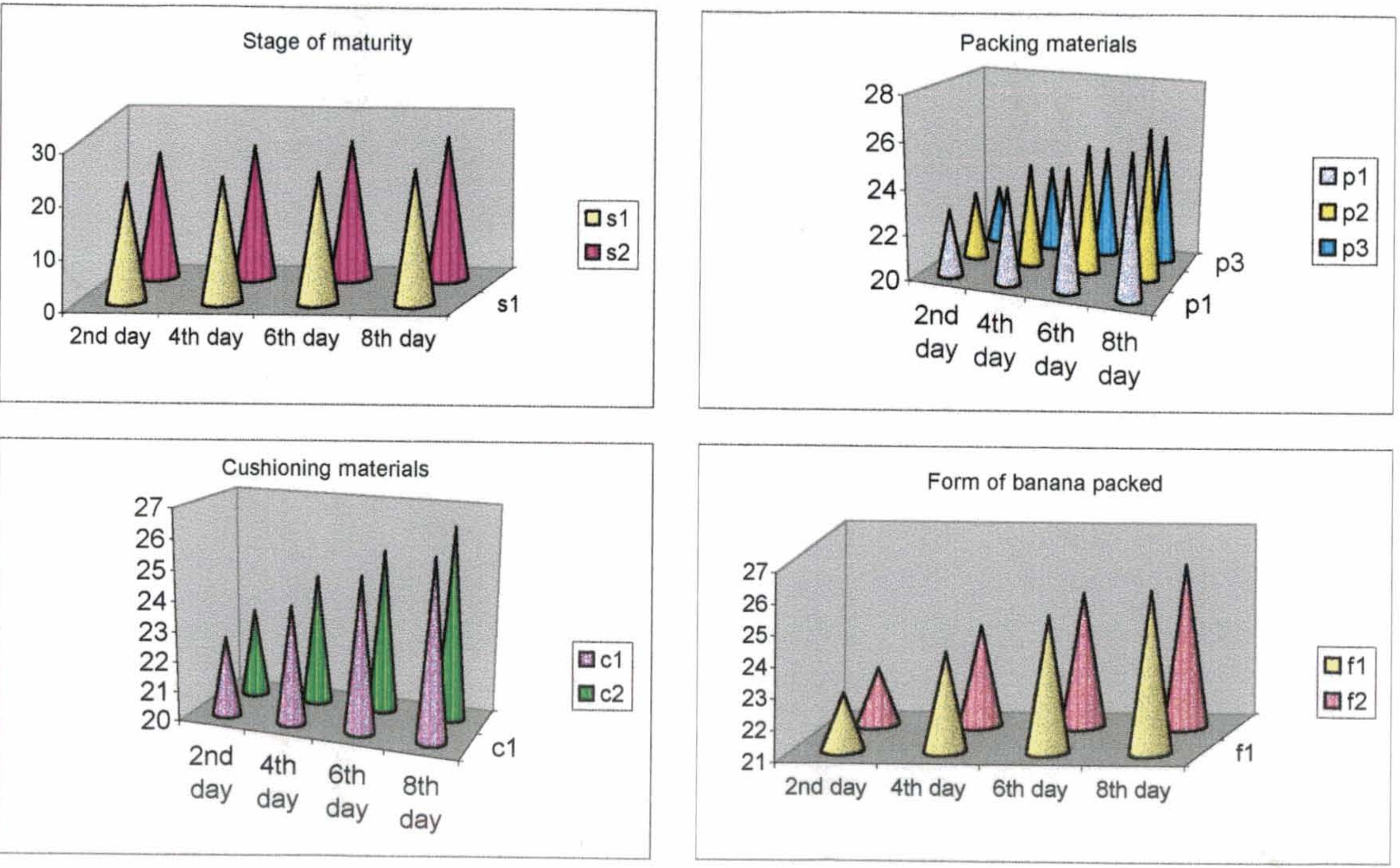
Table 16. TSS of ripe fruits (Two factor interaction)

Interaction	2^{nd} day	4^{th} day	6^{th} day	8th day
s_1f_1	22.33	23.61	24.78	25.44
s_1f_2	22.17	23.44	24.50	25.33
s_2f_1	23.33	24.67	25.83	26.78
s_2f_2	23.39	24.83	25.89	26.89
F (1,56)	<1	1.08	1.33	<1
s_1c_1	22.06	23.33	24.50	25.22
s_1c_2	22.44	23.77	24.78	25.56
s_2c_1	23.22	24.50	25.67	26.50
s_2c_2	23.50	25.00	26.06	27.17
F (1,56)	<1	<1	<1	1.27
c_1f_1	22.67	23.94	25.17	25.83
c_1f_2	22.61	23.89	25.00	25.89
c_2f_1	23.00	24.33	25.44	26.39
c_2f_2	22.94	24.39	25.39	26.33
F (1,56)	<1	<1	<1	<1

Table 17. TSS of ripe fruits (Two factor interaction)

Interaction	2nd day	4th day	6th day	8th day
s_1p_1	22.25	23.33	24.50	25.17
s_1p_2	22.50	24.08	25.08	25.83
s_1p_3	22.00	23.17	24.33	25.17
s_2p_1	23.58	25.00	26.08	27.08
s_2p_2	23.42	24.92	26.08	27.25
s_2p_3	23.08	24.33	25.42	26.17
F (2,56)	<1	2.28	1.36	3.22*
SE	-	-	-	0.181
CD	-	-	-	0.513
p_1f_1	23.00	24.17	25.42	26.17
p_1f_2	22.83	24.17	25.17	26.08
p_2f_1	22.92	24.58	25.67	26.50
p_2f_2	23.00	24.42	25.50	26.58
p_3f_1	22.58	23.67	24.83	25.67
p_3f_2	22.50	23.83	24.92	25.67
F(2,56)	<1	<1	<1	<1
p_1c_1	22.75	23.92	25.00	25.75
p_1c_2	23.08	24.42	25.58	26.50
p_2c_1	22.83	24.42	25.58	26.33
p_2c_2	23.08	24.58	25.58	26.75
p_3c_1	22.33	23.42	24.67	25.50
p_3c_2	22.75	24.08	25.08	25.83
F (2,56)	<1	<1	1.23	<1

Fig. 2 TSS of ripe fruits (Degree Brix)



With s_1 harvested fruits, maximum TSS on 8th day was registered by fruits packed with p_2 and no significant difference was seen with p_1 and p_2. .But in s_2, no significant difference was seen with p_1 and p_2 and TSS was more in these fruits than those packed with p_3.

The three factor interaction and the SPCF interaction were non-significant on the TSS of ripe fruit.

4.2.5 Degree of disease incidence

The stages of maturity, packing materials and the form of banana packed were found to have significant effect on the degree of disease incidence (Black spot) and the cushioning material was not significant as depicted in the Tables 18. The treatment effects were found ineffective in the incidence of crown rots.

The stage two was more prone to black spot than stage one. Among the packing materials p_1 (6.81) recorded the highest black spot followed by p_2 (6.00). The least black spot incidence was recorded in p_3 (3.50). So also banana packed as fingers f_2 (4.54) gave the least infestation to black spot disease. In fruits harvested at stage s_2 recorded higher degrees of back spot than those at stage one. Fruits packed at p_3 material registered less incidence of black spot. The degree of incidence of black spot was less when fingers where used for storage.

All the two factor, three factor and four factor interactions were found to be absent on the effect of disease incidence.

Table 18. Degree of disease incidence

Factors	Black spot	Crown rot
Stages		
s_1	4.42	1.00
s_2	6.46	1.17
F	29.18 **	<1
SE	0.267	-
CD	0.774	-
Packing Materials		
p_1	6.81	1.25
p_2	6.00	1.13
p_3	3.50	0.88
F	27.82 **	<1
SE	0.327	-
CD	0.948	-
Cushioning Materials		
c_1	5.63	1.21
c_2	5.25	0.96
F	<1	<1
SE	-	-
CD	-	-
Hands/Fingers		
f_1	6.33	1.13
f_2	4.54	1.04
F	22.47 **	<1
SE	0.267	-
CD	0.774	-

Table 19. Degree of disease incidence (Two factor interaction)

Interaction	Black spot	Crown rot
s_1f_1	5.17	0.92
s_1f_2	3.67	1.08
s_2f_1	7.50	1.33
s_2f_2	5.42	1.00
F (1,56)	<1	<1
s_1c_1	4.42	1.08
s_1c_2	4.42	0.92
s_2c_1	6.83	1.33
s2c2	6.08	1.00
F (1,56)	<1	<1
c_1f_1	6.83	1.17
c_1f_2	4.42	1.25
c_2f_1	5.83	1.08
c_2f_2	4.67	0.83
F (1,56)	2.73	<1

Table 20. Degree of disease incidence (Two factor interaction)

	Black spot	Crown rot
s_1p_1	6.00	1.00
s_1p_2	4.50	1.13
s_1p_3	2.75	0.88
s_2p_1	7.63	1.50
s_2p_2	7.50	1.13
s_2p_3	4.25	0.88
F (2,56)	1.62	<1
p_1f_1	7.63	1.50
p_1f_2	6.00	1.00
p_2f_1	7.25	0.75
p_2f_2	4.75	1.50
p_3f_1	4.13	1.13
p_3f_2	2.88	0.63
F (2,56)	<1	2.48
p_1c_1	6.88	1.50
p_1c_2	6.75	1.00
p_2c_1	6.38	1.25
p_2c_2	5.63	1.00
p_3c_1	3.63	0.88
p_3c_2	3.38	0.88
F (2,56)	<1	<1

4.2.6 Sensory quality

4.2.6.1 Physical evaluation of the fruits

4.2.6.1.1 Appearance of whole fruits

The appearance of whole fruits were not at all influenced by the stages of maturity, packing materials used, cushioning materials and form of banana packed as shown in Table 21.

The interaction effects of S x P, P x C, S x F and C x F were found to be non-significant, whereas P x F and S x C were highly significant on the whole fruit appearance but did not assume importance because their main effects were not significant.

All the three factor interactions were found to be not significant on the appearance of whole fruit.

4.2.6.1.2 Cut fruit appearance

Cut fruit appearance was influenced mainly by the packing material and its interaction with other factors. In packaging the best effect was recorded on p_3 (40.13) followed by p_2 (37.38) and the least effect on cut fruit appearance was shown by p_1 (36.63).

The two factor interaction S x C and P x C were highly significant and all other interaction effects were non-significant. In the S x C interaction, the cut fruit appearance was found best in s_2c_2 (39.44) which was on par with s_1c_1 (39.22) and s_1c_2 (37.56). A low scoring was obtained by s_2c_1 (35.94) as shown in the Table 22. In stage one, c_1 was greater than c_2 and in stage two, c_2 was greater than c_1.

In P x C interaction the highest scoring was found in p_3c_1 (40.17) which was on par with p_3c_2 (40.08), p_1c_2 (39.00) and p_2c_1 (38.33). Here the lowest scoring was recorded in p_1c_1 (34.25) which was on par with p_2c_2 (36.42). In p_1, c_2 was greater than c_1, in p_2, c_1 was greater than c_2 and in p_3, c_1 was equal to c_2. With p_1 and p_3, c_2 was found to be the best cushioning material while c_1 was suited for p_2. In S x P interaction the best result was obtained from s_2p_3 (40.25) which was on par with s_1p_3 (40.00), s_2p_2 (38.08) and s_1p_1 (38.50). The lowest score was obtained in s_2p_1 (34.75) which was on par with s_1p_2 (36.67) as depicted in the Table 23. In p_1, s_1 was greater than s_2, in p_2 s_2 was greater than s_1 and in p_3 s_1 was equal to s_2. When p_1 was used as packing material, s_1 was found to be good, but s_2 with p_2 and no significant difference was observed with p_3.

All the three factor interactions except SCF was found to be non-significant on the cut fruit appearance. In SCF the highest cut fruit appearance score was observed in $s_2c_2f_1$ (40.56) which was on par with $s_1c_1f_1$, $s_2c_2f_2$, $s_1c_2f_1$ and $s_1c_1f_2$. The lowest cut fruit appearance was observed in $s_2c_1f_1$ (34.67) which was on par with $s_1c_2f_1$, and $s_2c_1f_2$. Among the SC effects on F, in s_1c_1, f_1 gave greater cut fruit appearance than f_2, while in s_1c_2, f_1 gave greater score than f_1. In s_2c_1, cut fruit appearance score was higher in f_2 than in f_1 but f_1 gave greater score in s_2c_2; as shown in Table 25. The four factor interaction of 'SPCF" was found to be non-significant on the cut fruit appearance of the fruit as shown in the Appendix XI.

4.2.6.1.3 Whole fruit colour

Packing materials and the form of banana packed assumed importance as far as the whole fruit colour is concerned. Maximum score was obtained with p_2 (37.42) which was superior to p_1 (35.75) and p_3 (35.18). P_2 was on par with p_3; as shown in the Table 21. The colour of whole fruit was recorded better in banana packed as fingers f_2 (37.89) than in those packed as hands f_1 (34.33).

Among the two factor interactions S x F, S x C, P x F and P x C were found to be highly significant and C x F and S x P were recorded as non-significant on the whole fruit colour.

In the S x F interaction the whole fruit colour was found best in s_1f_2 (39.83) interaction. The least scoring was obtained in s_1f_1 (33.33), as indicated in the Table. The whole fruit colour was observed best in s_1c_1 and s_2c_2 (39.22) in the S x C interaction. The colour was least scored in s_2c_1 (32.06).

In the P x F interaction, the best scoring for whole fruit colour was obtained in p_3f_2 (39.08) which was on par with p_2f_1, p_2f_2 (37.42) and p_1f_2 (37.17). The lowest scoring was obtained in p_3f_1 (31.25) as depicted in the Table 23. When p_1 and p_3 were used as packing material, f_2 was found to be the best. The packing material p_2 did not influenced either f_1 or f_2. The whole fruit colour was found to be best in p_2c_1 (38.50) interaction among the P x C interaction. $p_2c_1$was on par with p_1c_2. The least scoring was obtained in p_1c_1

(33.50) which was on par with p_3c_1 (34.92) and p_3c_2 (35.42). In p_1 and p_3 , c_2 was greater than c_1 and in p_2, c_1 was greater than c_2.

All the three and four factor interaction were found to be highly significant on the whole fruit colour, as shown in Table 24 and 25. The SPC interaction was found to be highly significant. The highest interaction effect on the whole fruit colour was obtained in $s_1p_2c_1f_1$ and $s_2p_1c_2f_1$ (48.67). This was on par with the following interaction $s_1p_0c_0f_2$, $s_1p_1c_1f_2$, $s_1p_3c_2f_2$. The lowest interaction effect was obtained in $s_2p_1c_1f_1$ (25.33) which was on par with $s_2p_1c_1f_2$, $s_1p_3c_2f_1$, $s_1p_0c_0f_1$, $s_1p_2c_2f_1$, $s_1p_1c_2f_1$, $s_2p_0c_0f_1$ and $s_2p_3c_1f_1$as shown in Appendix XI.

Among the SPF interaction, the highest score for colour was obtained in $s_1p_1f_2$ (41.83) and the lowest score in $s_1p_3f_1$ (30.17). $s_1p_3f_1$ was on par with $s_1p_1f_1$, $s_{21}f_2$ and $s_2p_3f_1$. In s_1p_1, f_2 gave greater score for colour than f_1 and in s_2p_1, f_1 showed more colour than f_2. In the p_2 package (s_1p_2), f_1 had more colour than f_2 and in s_2p_2. f_1 and f_2 was more or less similar in appearance. But in s_1p_3 and s_2p_3, f_2 exhibited more colour than f_1.

Among the PCF interaction, the highest whole fruit colour score was obtained in $p_2c_1f_1$ and $p_3c_2f_2$ (40.00) which was on par with $p_1c_2f_1$, $p_1c_2f_2$, $p_2c_1f_2$, $p_2c_2f_2$ and $p_3c_1f_2$. The lowest score was observed in $p_1c_1f_1$ (30.33) which was on par with $p_3c_2f_1$ and $p_3c_1f_1$. In the p_1c_1 effect on f, more colour was observed in f_2 than in f_1 while in p_1c_2, f_2 gave the best colour factor. In package p_2, the effect of p_2c_1 was found best in f_1 than in f_2. In p_2c_2, f_2 gave higher score than f_1. In p_3c_1 and p_3c_2, f_2 was found better than f_1.

Among the SPC interaction, $s_2p_1c_2$ (43.67) gave the highest colour score which was on par with $s_1p_1c_1$ and $s_1p_2c_1$. The lowest score value was obtained in $s_2p_1c_1$ (25.83). In s_1p_1, the effect of c_1 was higher than c_2, while in s_2p_1, c_2 gave better score than c_1. In s_1p_2, highest score for colour was obtained in c_1 than in c_2; and in s_2p_2, c_2 gave more colour score than c_1. In s_1p_3 and s_2p_3, c_1 was found to be better than c_2.

In the SCF interaction, $s_2c_2f_1$ (41.89) gave the highest colour score value and the lowest score was obtained in $s_1c_2f_1$ (27.44) which was on par with $s_2c_1f_1$. In this interaction s_1c_1 showed similar effects on f_1 and f_2; while in s_1c_2, f_2 gave greater score than f_1. In s_2c_1, highest colour score was obtained in f_2 and in s_2c_2 it was in f_1 as depicted in the Table 25.

4.2.6.1.4 Cut fruit colour

The main effects were absent on the colour of cut fruits. The two factor interaction S x C, S x P and P x F were found to have significant difference on the effect of colour of cut fruit but assume no importance. The interaction P x C, S x F and C x F were not significant. Thus all the factors behaved independently on the colour of cut fruits.

All the three factor interaction except SCF was found to be absent on the effect of cut fruit colour. In SCF interaction the highest score for colour was obtained in $s_2c_2f_1$ (41.56) which was on par with $s_1c_1f_1$ and $s_2c_2f_2$. The lowest colour score was obtained in $s_1c_2f_1$ (34.67) which $s_2c_1f_1$, $s_2c_1f_2$ and $s_1c_2f_2$. In s_1c_1 the effect on f_1 was greater than f_2 and s_1c_2, f_2 gave high score

Table 21. **Physical evaluation of fruits**

Factors	Whole fruit appearance	Cut fruit appearance	Whole fruit colour	Cut fruit colour
Stages				
s_1	37.86	38.39	36.58	37.33
s_2	37.11	37.69	35.64	38.31
F	<1	<1	2.19	2.01
Packaging Material				
p_1	35.83	36.63	35.75	36.83
p_2	38.08	37.38	37.42	38.25
p_3	38.54	40.13	35.17	38.38
F	2.67	8.71 **	4.47 **	2.08
SE	-	0.624	0.552	-
CD	-	1.770	1.565	-
Cushioning Material				
c_1	36.67	37.58	35.64	37.44
c_2	38.31	38.50	36.58	38.20
F	2.56	1.62	2.19	1.20
Hands / Fingers				
f_1	37.22	37.86	34.33	37.81
f_2	37.75	38.22	37.89	37.83
F	<1	<1	31.08 **	<1
SE	-	-	0.451	-
CD	-	-	1.278	-

Table 22. Physical evaluation of fruits (Two factor interaction)

Interaction	Whole fruit appearance	Cut fruit appearance	Whole fruit colour	Cut fruit colour
s_1f_1	37.33	38.11	33.33	37.22
s_1f_2	38.39	38.67	39.83	37.44
s_2f_1	37.11	37.61	35.33	38.39
s_2f_2	37.11	37.78	35.94	38.22
F (1,56)	<1	<1	21.31**	<1
SE	-	-	0.638	-
CD	-	-	1.807	-
s_1c_1	38.78	39.22	39.22	38.83
s_1c_2	36.94	37.56	33.94	35.83
s_2c_1	34.56	35.94	32.06	36.06
s_2c_2	39.67	39.44	39.22	40.56
F (1,56)	11.51 **	12.84 **	95.19 **	29.95 **
SE	1.024	0.721	0.638	0.685
CD	2.901	2.043	1.807	1.942
c_1f_1	36.83	37.56	34.00	37.50
c_1f_2	36.50	37.61	37.28	37.39
c_2f_1	37.61	38.17	34.67	38.11
c_2f_2	39.00	38.83	38.50	38.28
F (1,56)	<1	<1	<1	<1

Table 23. Physical evaluation of fruits (Two factor interaction)

Interaction	Whole fruit appearance	Cut fruit appearance	Whole fruit colour	Cut fruit colour
s_1p_1	37.67	38.50	36.75	37.67
s_1p_2	37.00	36.67	37.58	37.33
s_1p_3	38.92	40.00	35.42	37.00
s_2p_1	34.00	34.75	34.75	36.00
s_2p_2	39.17	38.08	37.25	39.17
s_2p_3	38.17	40.25	34.92	39.75
F (2,56)	2.71	4.71 *	<1	3.86 *
SE	-	0.883	-	0.839
CD	-	2.503	-	2.379
p_1f_1	36.08	37.58	34.33	34.83
p_1f_2	35.58	35.67	37.17	38.83
p_2f_1	39.92	36.33	37.42	38.08
p_2f_2	36.25	38.42	37.42	38.42
p_3f_1	35.67	39.67	31.25	40.50
p_3f_2	41.42	40.58	39.08	36.25
F (2,56)	7.31 **	2.71	12.89 **	12.13 **
SE	1.254	-	0.781	0.839
CD	3.553	-	2.214	2.379
p_1c_1	33.75	34.25	33.50	35.42
p1c2	37.92	39.00	38.00	38.25
p_2c_1	38.33	38.33	38.50	38.42
p_2c_2	37.83	36.42	36.33	38.08
p_3c_1	37.92	40.17	34.92	38.50
p_3c_2	39.17	40.08	35.42	38.25
F (2,56)	1.77	7.61 **	9.23 **	2.31
SE	-	0.883	0.781	-
CD	-	2.503	2.214	-

Table 24. Physical evaluation of fruits (Three factor interaction)

Interaction	Whole fruit appearance	Cut fruit appearance	Whole fruit colour	Cut fruit colour
$s_1p_1f_1$	38.67	39.67	31.67	35.17
$s_1p_1f_2$	36.67	37.33	41.83	40.17
$s_1p_2f_1$	37.50	35.33	38.17	36.83
$s_1p_2f_2$	36.50	38.00	37.00	37.83
$s_1p_3f_1$	35.83	39.33	30.17	39.67
$s_1p_3f_2$	42.00	40.67	40.67	34.33
$s_2p_1f_1$	33.50	35.50	37.00	34.57
$s_2p_1f_2$	34.50	34.00	32.50	37.50
$s_2p_2f_1$	42.33	37.33	36.67	39.33
$s_2p_2f_2$	36.00	38.83	37.83	39.00
$s_2p_3f_1$	35.50	40.00	32.33	41.33
$s_2p_3f_2$	40.83	40.50	37.50	38.17
F (2,56)	1.38	<1	14.85**	<1
SE	-	-	1.105	-
CD	-	-	3.131	-
$p_1c_1f_1$	33.00	35.00	30.33	33.83
$p_1c_1f_2$	34.50	33.50	36.67	37.00
$p_1c_2f_1$	39.17	40.17	38.33	35.83
$p_1c_2f_2$	36.67	37.83	37.67	40.67
$p_2c_1f_1$	41.67	36.83	40.00	38.67
$p_2c_1f_2$	35.00	39.83	37.00	38.17
$p_2c_2f_1$	38.17	35.83	34.83	37.50
$p_2c_2f_2$	37.50	37.00	37.83	38.67
$p_3c_1f_1$	35.83	40.83	31.67	40.00
$p_3c_1f_2$	40.00	39.50	38.17	37.00
$p_3c_2f_1$	35.50	38.50	30.83	41.00
$p_3c_2f_2$	42.83	41.67	40.00	35.50
F (2,56)	2.11	1.86	9.34**	1.03
SE	-	-	1.105	-
CD	-	-	3.131	-

Table 25. Physical evaluation of fruits (Three factor interaction)

Interaction	Whole fruit appearance	Cut fruit appearance	Whole fruit colour	Cut fruit colour
$s_1p_1c_1$	38.67	37.83	41.17	39.17
$s_1p_1c_2$	36.67	39.17	32.33	36.17
$s_1p_2c_1$	38.67	38.00	41.83	38.50
$s_1p_2c_2$	35.33	35.33	33.33	36.17
$s_1p_3c_1$	39.00	41.83	34.67	38.83
$s_1p_3c_2$	38.83	38.17	36.17	35.17
$s_2p_1c_1$	28.83	30.67	25.83	31.17
$s_2p_1c_2$	39.17	38.83	43.67	40.33
$s_2p_2c_1$	38.00	38.67	35.17	38.33
$s_2p_2c_2$	40.33	37.50	39.33	40.00
$s_2p_3c_1$	36.83	38.50	35.17	38.17
$s_2p_3c_2$	39.50	42.00	34.67	41.33
F (2,56)	1.89	1.62	42.10**	2.67
SE	-	-	1.105	-
CD	-	-	3.131	-
$s_1c_1f_1$	39.11	40.44	39.22	39.78
$s_1c_1f_2$	38.44	38.00	39.22	37.89
$s_1c_2f_1$	35.56	35.78	27.44	34.67
$s_1c_2f_2$	38.33	39.33	40.44	37.00
$s_2c_1f_1$	34.56	34.67	28.78	35.22
$s_2c_1f_2$	34.56	37.22	35.33	36.89
$s_2c_2f_1$	39.67	40.56	41.89	41.56
$s_2c_2f_2$	39.67	38.33	36.56	39.56
F (2,56)	<1	13.96**	95.19**	8.28**
SE	-	1.020	0.902	0.969
CD	-	2.890	2.556	2.746

than f_1. In s_2c_1, the colour score of f_2 was greater than f_1 while in s_2c_2, f_1 gave more colour score than f_2.

The four factor interaction on the cut fruit colour was also found to be highly significant. The highest scoring value was obtained in $s_2p_3c_2f_1$ (46.33) which was on par with $s_1p_3c_1f_1$, $s_2p_1c_2f_2$ and $s_1p_1c_1f_2$. The lowest scoring value was obtained on $s_2p_1c_1f_1$ (31.33) which was on par with $s_1p_1c_1f_2$, $s_1p_0c_0f_2$, $s_1p_1c_2f_2$, $s_1p_2c_2f_1$, $s_1p_3c_2f_2$, $s_1p_0c_0f_2$ and $s_1p_0c_0f_1$.

4.2.6.2 Organoleptic evaluation of the fruits

4.2.6.2.1 Sweetness

Among the main effects, sweetness was not influenced by the stages of maturity and the form of banana packed. The packing materials and cushioning materials showed significant difference. Sweetness was found highest in p_3 (37.96) followed by p_2 (33.96) and lastly p_1 (32.88). p_2 was on par with p_1, as depicted in the Table 26. The cushioning material c_2 (35.78) gave greater score for sweetness than c_1 (34.08).

The two factor interaction S x F and C x F were absent while all the other interaction were found to be highly significant. The score of sweetness was greatest in the s_1c_2 (36.78) interaction of the S x C interaction and lowest in s_1c_1 (33.44) which was on par with s_2c_2 and s_1c_2 as indicated in the Table 27. In s_1, c_2 was greater than c_1 and in s_2, c_1 was equal to c_2.

In the S x P interaction sweetness score was found to be high in s_1p_3 (38.25) which was on par with s_2p_3 and s_2p_2. The lowest score was obtained from s_2p_1 (30.50) which was on par with s_1p_2, as shown in the Table 27. In p_1 and p_3, s_1 was greater than s_2 while in p_2, s_2 was greater than s_1. Among the P x F interaction p_3f_1 (41.83) scored highest sweetness and the lowest sweetness was obtained in p_1f_1 (30.42) which was on pr with p_2f_1. In p_1 and p_2, f_2 was greater than f_1. In p_3, f_1 was greater than f_2. In case of P x C interaction, the highest sweetness was obtained from p_3c_2 (39.17) and the lowest sweetness was obtained in p_1c_1 (30.58). In p_1 and p_3, c_2 was greater than c_1 and in p_2, c_1 was greater than c_2 as depicted in the Table 28. Sweetness was best in p_3 packed fruits than in p_1 and p_2 also c_2 was found to be the best. However, with p_2 both c_1 and c_2 gave more or less the same results while with p_1 and p_3, c_2 was better.

Among the three factor interaction only SPC interaction was found to be significant and all others were absent. In the SPC interaction highest score for sweetness was recorded in $s_2p_3c_2$ (40.00) which was on par with $s_2p_2c_1$, $s_1p_3c_1$ and $s_1p_1c_2$. The lowest sweetness score was obtained from $s_2p_1c_1$ (29.00) which was on par with $s_1p_1c_1$, $s_1p_2c_1$, $s_{21}c_2$ and $s_2p_2c_2$. The treatment s_1p_1 gave more sweetness in the effect with c_2 than in c_1 and the same was found in s_2p_1 also. In s_1p_2 the effect of c_2 gave more sweetness than c_1 while in s_2p_2, c_1 gave more score than c_2. In s_1p_3 the sweetness score was same for both the c_1 and c_2 effects. But in s_2p_3, c_2 gave more score than c_1.

The four factor interaction was found to be highly significant the highest sweetness was offered by the interaction $s_2p_3c_2f_1$ (47.00) which was on par with $s_1p_3c_1f_1$. The lowest sweetness was recorded in $s_1p_2c_1f_1$ (26.33)

Table 26. Organoleptic evaluation of fruits

Factors	Sweetness	Flavour	Texture	Firmness	Overall Acceptability
Stages					
s_1	35.11	33.67	36.67	38.19	36.03
s_2	34.75	34.47	36.86	38.61	37.06
F	<1	1.13	<1	<1	2.59
Packaging Material					
p_1	32.88	33.75	35.71	37.67	35.71
p_2	33.96	31.38	37.00	37.92	35.92
p_3	37.96	37.08	37.58	39.63	38.00
F	20.50 **	19.12 **	2.04	3.24 *	5.26 **
SE	0.591	0.656	-	0.592	0.553
CD	1.676	1.859	-	1.678	1.567
Cushioning Material					
c_1	34.08	33.50	35.83	37.89	35.92
c_2	35.78	34.64	37.69	38.92	37.17
F	6.16 *	2.26	5.76 *	2.26	3.84
SE	0.483	-	0.548	-	-
CD	1.368	-	1.554	-	-
Hands / Fingers					
f_1	34.72	33.78	37.47	38.97	38.22
f_2	35.14	34.36	36.06	37.83	34.86
F	<1	<1	3.34	2.77	27.73 **
SE	-	-	-	-	0.451
CD	-	-	-	-	1.279

Table 27. Organoleptic evaluation of fruits (Two factor interaction)

Interaction	Sweetness	Flavour	Texture	Firmness	Overall Acceptability
s_1f_1	35.17	33.28	37.56	38.89	37.61
s_1f_2	35.06	34.06	35.78	37.50	34.44
s_2f_1	34.28	34.28	37.39	39.06	38.83
s_2f_2	35.22	34.67	36.33	38.17	35.28
F (1,56)	<1	<1	<1	<1	<1
SE	-	-	-	-	-
CD	-	-	-	-	-
s_1c_1	33.44	34.22	37.44	38.11	36.72
s_1c_2	36.78	33.11	35.89	38.28	35.33
s_2c_1	34.72	32.78	34.22	37.67	35.11
s_2c_2	34.78	36.17	39.50	39.56	39.00
F (1,56)	5.76 **	8.83 **	19.42 **	1.59	17.09 **
SE	0.683	0.757	0.775	-	0.638
CD	1.935	2.146	2.197	-	1.809
c_1f_1	33.89	33.83	36.33	38.72	37.72
c_1f_2	34.28	33.17	35.33	37.06	34.11
c_2f_1	35.56	33.72	38.61	39.22	38.72
c_2f_2	36.00	35.56	36.78	38.61	35.61
F (1,56)	<1	2.72	<1	<1	<1
SE	-	-	-	-	-
CD	-	-	-	-	-

Table 28. Organoleptic evaluation of fruits (Two factor interaction)

Interaction	Sweetness	Flavour	Texture	Firmness	Overall acceptability
s_1p_1	35.25	33.83	36.58	38.58	36.17
s_1p_2	31.83	30.42	35.50	37.08	35.08
s_1p_3	38.25	36.75	37.92	38.92	36.83
s_2p_1	30.50	33.67	34.83	36.75	35.25
s_2p_2	36.08	32.33	38.50	38.75	36.75
s_2p_3	37.67	37.42	37.25	40.33	39.17
F (2,56)	14.50 **	<1	3.44 *	2.72	2.41
SE	0.836	-	0.950	-	-
CD	2.370	-	2.691	-	-
p_1f_1	30.42	35.17	36.08	38.25	37.00
p_1f_2	35.33	32.33	35.33	37.08	34.42
p_2f_1	31.92	28.58	38.42	38.50	37.92
p_2f_2	36.00	34.17	35.58	37.33	33.92
p_3f_1	41.83	37.58	37.92	40.17	39.75
p_3f_2	34.08	36.58	37.25	39.08	36.25
F (2,56)	35.88 **	11.39 **	<1	<1	<1
SE	0.836	0.927	-	-	-
CD	2.370	2.628	-	-	-
p_1c_1	30.58	32.92	33.50	36.17	34.42
p_1c_2	35.17	34.58	37.92	39.17	37.00
p_2c_1	34.92	31.17	37.67	38.58	35.75
p_2c_2	33.00	31.58	36.33	37.25	36.08
p_3c_1	36.75	36.42	36.33	38.92	37.58
p_3c_2	39.17	37.75	38.83	40.33	38.42
F (2,56)	7.83 **	<1	4.75 *	3.43 *	1.14
SE	0.836	-	0.950	0.837	-
CD	2.37	-	2.691	2.374	-

Table 29. Organoleptic evaluation of fruits (Three factor interaction)

Interaction	Sweetness	Flavour	Firmness	Overall acceptability
$s_1p_1f_1$	32.50	34.00	39.50	37.83
$s_1p_1f_2$	38.00	33.67	37.67	34.50
$s_1p_2f_1$	31.00	28.67	37.83	37.00
$s_1p_2f_2$	32.67	32.17	36.33	33.17
$s_1p_3f_1$	42.00	37.17	39.33	38.00
$s_1p_3f_2$	34.50	36.33	38.50	35.67
$s_2p_1f_1$	28.33	36.33	37.00	36.17
$s_2p_1f_2$	32.67	31.00	36.50	34.33
$s_2p_2f_1$	32.83	28.50	39.17	38.83
$s_2p_2f_2$	39.33	36.17	38.33	34.67
$s_2p_3f_1$	41.67	28.00	41.00	41.50
$s_2p_3f_2$	33.67	36.83	39.67	36.83
F (2,56)	1.93	3.05	<1	<1
$p_1c_1f_1$	29.00	35.33	36.50	35.17
$p_1c_1f_2$	32.17	30.50	35.83	33.67
$p_1c_2f_1$	31.83	35.00	40.00	38.83
$p_1c_2f_2$	38.50	34.17	38.33	35.17
$p_2c_1f_1$	32.00	28.17	40.00	38.00
$p_2c_1f_2$	37.83	34.17	37.17	33.50
$p_2c_2f_1$	31.83	29.00	37.00	37.83
$p_2c_2f_2$	34.17	34.17	37.50	34.33
$p_3c_1f_1$	40.67	38.00	39.67	40.00
$p_3c_1f_2$	32.83	34.83	38.17	35.17
$p_3c_2f_1$	43.00	37.17	40.67	39.50
$p_3c_2f_2$	35.33	38.33	40.00	37.33
F (2,56)	2.19	1.22	<1	1.23

Table 30. Organoleptic evaluation of fruits (Three factor interaction)

Interaction	Sweetness	Flavour	Firmness	Overall acceptability
$s_1p_1c_1$	32.17	35.67	38.83	36.50
$s_1p_1c_2$	38.33	32.00	38.33	35.83
$s_1p_2c_1$	30.00	29.67	37.17	35.83
$s_1p_2c_2$	33.67	31.17	37.00	34.33
$s_1p_3c_1$	38.17	37.33	38.33	37.83
$s_1p_3c_2$	38.33	36.17	39.50	35.83
$s_2p_1c_1$	29.00	30.17	33.50	32.33
$s_2p_1c_2$	32.00	37.17	40.00	38.17
$s_2p_2c_1$	39.83	32.67	40.00	35.67
$s_2p_2c_2$	32.33	32.00	37.50	37.83
$s_2p_3c_1$	35.33	35.50	39.50	37.33
$s_2p_3c_2$	40.00	39.33	41.17	41.00
F (2,56)	10.97**	6.01**	4.08*	<1
SE	1.183	1.312	1.184	-
CD	3.352	3.717	3.357	-
$s_1c_1f_1$	33.22	35.22	39.56	39.56
$s_1c_1f_2$	33.67	33.22	36.67	33.89
$s_1c_2f_1$	37.11	31.33	38.22	35.67
$s_1c_2f_2$	36.44	34.89	38.33	35.00
$s_2c_1f_1$	34.56	32.44	37.89	35.89
$s_2c_1f_2$	34.89	33.11	37.44	34.33
$s_2c_2f_1$	34.00	36.11	40.22	41.78
$s_2c_2f_2$	35.56	36.22	38.89	36.22
F (2,56)	<1	4.07*	2.02	12.43**
SE	-	1.071	-	0.903
CD	-	3.035	-	2.558

which was on par with $s_2p_1c_2f_1$, $s_1p_1c_1f_1$, $s_2p_1c_1f_2$ and $s_2p_1c_1f_1$ as depicted in Appendix XII.

4.2.6.2.2 Flavour

Among the main effects, only packing materials gave significant difference on the flavour of the fruit. The maturity stages, cushioning materials and the form of banana packed were non-significant. The flavour component was highest in the package p_3 (37.08), followed by p_1 (33.75) and lowest in p_2 (31.38), as shown in the Table 26.

Among the two factor interaction S x C and P x F were found highly significant and all other interaction were absent on the flavour of the fruit. In the S x C interaction, highest flavour was recorded in s_2c_2 (36.17) which was on par with s_1c_1 (34.22). The lowest flavour was obtained from s_2c_1 (32.78) which was on par with s_1c_2 (33.11). In s_1, c_1 was greater than c_2 and in s_2, c_2 was greater than c_1 as depicted in the Table 27. In the P x F interaction highest score for flavour was recorded by p_3f_1 (37.58) which was on par with p_3f_2 (36.58) and p_1f_1 (35.17). The lowest score was recorded by p_2f_1 (28.58). In p_1 and p_3, f_1 was greater than f_2 and in p_2, f_2 was greater than f_1 as shown in the Table 28.

Among the three factor interactions SPC and SCF were significant and all others were absent. In SPC interaction $s_2p_3c_2$ (39.33) gave highest flavour which was on par with $s_2p_1c_2$, $s_1p_3c_2$ and $s_1p_1c_1$. The lowest flavour was obtained from $s_1p_2c_1$ (29.67) which was on par with $s_1p_1c_2$, $s_1p_2c_2$, $s_2p_1c_1$, $s_2p_2c_1$ and $s_2p_2c_2$. In s_1p_1, the effect of c_1 was greater than c_2 while in s_2p_2 the effect of c_2 was greater on c_1. In s_1p_2, c_2 gave more effect on flavour than c_1 but in s_2p_2, the effect of c_1 and c_2 were same. In s_1p_3 the effect of c_1 was greater than c_2 while in s_2p_3, c_2 gave more effect than c_1.

In the SCF interaction, highest value was obtained in $s_2c_2f_2$ (36.22) which was on par with $s_2c_2f_1$, $s_2c_1f_2$, $s_1c_2f_2$, $s_1c_1f_1$ and $s_1c_1f_2$. The lowest value was obtained in $s_1c_2f_1$ (31.33) which was on par with $s_1c_1f_2$, $s_2c_1f_1$ and $s_2c_1f_2$. In s_1c_1, the effect of f_1 gave more flavour than f_2; while in s_1c_2, f_2 gave more effect than f_1. In s_2c_1 also f_2 gave more effect but in s_2c_2 the effects were similar.

The four factor interaction was found to be highly significant on the flavour of the fruits. The highest score value was obtained in $s_1p_3c_1f_1$ (41.00) which was on par with $s_2p_1c_2f_1$, $s_1p_3c_2f_2$, $s_1p_0c_0f_2$, $s_1p_1c_1f_1$, $s_2p_2c_2f_2$, $s_2p_3c_2f_2$, $s_1p_0c_0f_1$ and $s_2p_3c_1f_2$. The lowest score was obtained on $s_1p_2c_1f_1$ (26.33) which was on par with $s_2p_2c_2f_1$, $s_2p_1c_1f_2$, $s_1p_1c_2f_1$, $s_2p_0c_0f_1$, $s_2p_2c_1f_1$, $s_1p_2c_2f_1$ and $s_1p_2c_2f_2$ as depicted in Appendix XII.

4.2.6.2.3 Texture

The main effects of stages of maturity, packing materials and the form of banana packed were found to be non-significant on the scoring of the texture of banana. But cushioning material was found to have significant difference. The texture was greater in c_2 (37.69) than in c_1 (35.83), as depicted in the Table 26.

Among the two factor interactions S x C, S x P and P x C were found significantly different and no variations was observed in S x F, C x F and P x F interactions. In the S x C interaction higher score for texture was obtained in s_2c_2 (39.50) which was on par with s_1c_1 (37.44). The lowest score was obtained in s_2c_1 (31.22) which was on par with s_1c_2 (35.89). In s_1, c_1 was greater than c_2 and in s_2, c_2 was greater than c_1 as shown in Table 27.

In the S x P interaction highest score was obtained in s_2p_2 (38.50) which was on par with s_2p_3 (37.25), s_1p_3 (37.92) and s_1p_1 (36.58). The lowest score was obtained in s_2p_1 (34.83) which was on par with s_1p_2 (35.50). s_1p_1 (36.58) and s_2p_3 (37.25). In p_1, s_1 was greater than s_2, in p_2, s_2 was greater than s_1 and in p_3, s_1 was equal to s_2. In the P x C interaction, highest texture was recorded in p_3c_2 (38.83) which was on par with p_1c_2 (37.92), p_2c_1 (37.67), p_2c_2 and p_3c_1 (36.33). The lowest value was obtained from p_1c_1 (33.50). In p_1 and p_3 the effect of c_2 was greater than c_1 and in p_2, c_1 was greater than c_2 as shown in the Table 28.

The four factor interaction of SPCF had significant difference on the texture of the fruit. The highest value was recorded in $s_2p_3c_2f_1$ (43.00) which was on par with $s_1p_3c_1f_1$, $s_2p_2c_2f_1$, $s_2p_2c_1f_1$, $s_1p_1c_2f_1$, $s_1p_2c_1f_1$, $s_1p_0c_0f_2$, $s_2p_1c_2f_1$, $s_1p_3c_2f_2$, $s_2p_3c_2f_2$ and $s_2p_0c_0f_1$. The lowest textural score was recorded in $s_2p_1c_1f_1$ (29.67) which was on par with $s_2p_3c_1f_1$, $s_2p_1c_1f_2$, $s_1p_2c_2f_1$, $s_1p_1c_2f_2$, $s_1p_2c_1f_2$, $s_1p_2c_2f_2$ as depicted in Appendix XII.

4.2.6.2.4 Firmness

The packing materials showed significant variation on the firmness of the fruit. All other main effects were absent. Among the packing materials p_3

(39.63) gave highest firmness followed by p_2 (37.92) and p_1(37.67) as shown in the Table 26.

Among the two factor interaction all the interactions except P x C interaction were found absent on the effect of firmness. In P x C interaction p_3c_2 (40.33) gave the highest firmness which was on par with p_1c_2 (39.17), p_3c_1 (38.92) and p_2c_1 (38.58). The lowest firmness was recorded in p_1c_1 (36.17) which was on par with p_2c_2 (37.25). In p_1 and p_3 the effect of c_2 was greater than c_1 and in p_2, c_1 was greater than c_2 as depicted in the Table 28.

All the three factor interactions except SPC were absent. In SPC, the highest firmness was observed in $s_2p_3c_2$ (41.17) which was on par with $s_2p_1c_2$, $s_2p_2c_1$, $s_2p_3c_1$, $s_1p_3c_2$, $s_1p_3c_1$, $s_1p_1c_1$ and $s_1p_1c_2$. The lowest value was observed in $s_2p_1c_1$ (33.50). In s_1p_1 the firmness was found to have similar effects with c_1 and c_2, but in s_2p_1, c_2 gave higher firmness than c_1. In s_1p_2 also the effect of c_1 and c_2 were similar on the firmness of the fruit. But in s_2p_2, the effect of c_1 gave more firmness than c_2. In s_1p_3, c_2 gave more firmness than c_1, the effect was similar in s_2p_3 also.

The four factor interaction of SPCF was found to be non-significant on the effect of firmness of the fruits.

4.2.6.2.5 Overall acceptability

Packing materials and form of banana packed were highly significant on the overall acceptability and all others were absent. The packing material p_3 (38.00) gave greatest acceptability followed by p_2 (35.92) and p_1 (35.71).

Banana packed as hands f_1 (38.22) was found to be more acceptable than f_2 (34.82) as shown in the Table 26.

Except the S x C interaction all other two factor interactions were absent. The S x C interaction assumes no importance on the overall acceptability and S and C had not at all influenced the score, as shown in Table 27.

4.2.7 Reducing sugars

Reducing sugar was influenced by stages of maturity, packing materials and cushioning materials as depicted in the Tables 31. But the form of banana packed did not show any significant difference.

Reducing sugar was found to be greater at stage s_2 (14.78 per cent) than in s_1 (14.49 per cent) on the second day of storage. This result was repeatedly recorded on the following days of storage. Among the packing materials p_1 (15.59 per cent) gave the highest level of reducing sugar followed by p_2 (14.66 per cent) and lowest level was obtained in p_3 (13.65 per cent). Similar results were obtained on the following days of storage. In the cushioning materials used c_1 (14.71 per cent) was found better than c_2 (14.56 per cent) on the 2nd day. This trend in result was continued in the following too.

The SPCF and all the two factor and three factor interactions were absent in the action on reducing sugars of the fruits as shown in the Tables 32, 33 and in the Appendix XIII.

Table 31. Reducing sugar

Factors	2nd day	4th day	6th day	8th day
Stages				
s_1	14.49	14.63	14.79	14.90
s_2	14.78	14.94	15.07	15.24
F	149.17 **	130.81 **	62.85 **	108.71 **
SE	0.017	0.019	0.089	0.023
CD	0.047	0.055	0.072	0.066
Packaging Material				
p_1	15.59	15.74	15.90	16.03
p_2	14.67	14.82	14.95	15.13
p_3	13.65	13.79	13.93	14.05
F	2268.47 **	1700.12 **	996.00 **	1196.00 **
SE	0.020	0.024	0.031	0.029
CD	0.058	0.067	0.089	0.081
Cushioning Material				
c_1	14.71	14.86	15.01	15.13
c_2	14.56	14.71	14.85	15.01
F	40.91 **	31.01 **	20.26 **	12.34 **
SE	0.017	0.019	0.026	0.023
CD	0.047	0.055	0.072	0.066
Hands / Finger				
f1	14.63	14.79	14.91	15.08
f2	14.64	14.78	14.95	15.06
F	<1	<1	1.04	<1

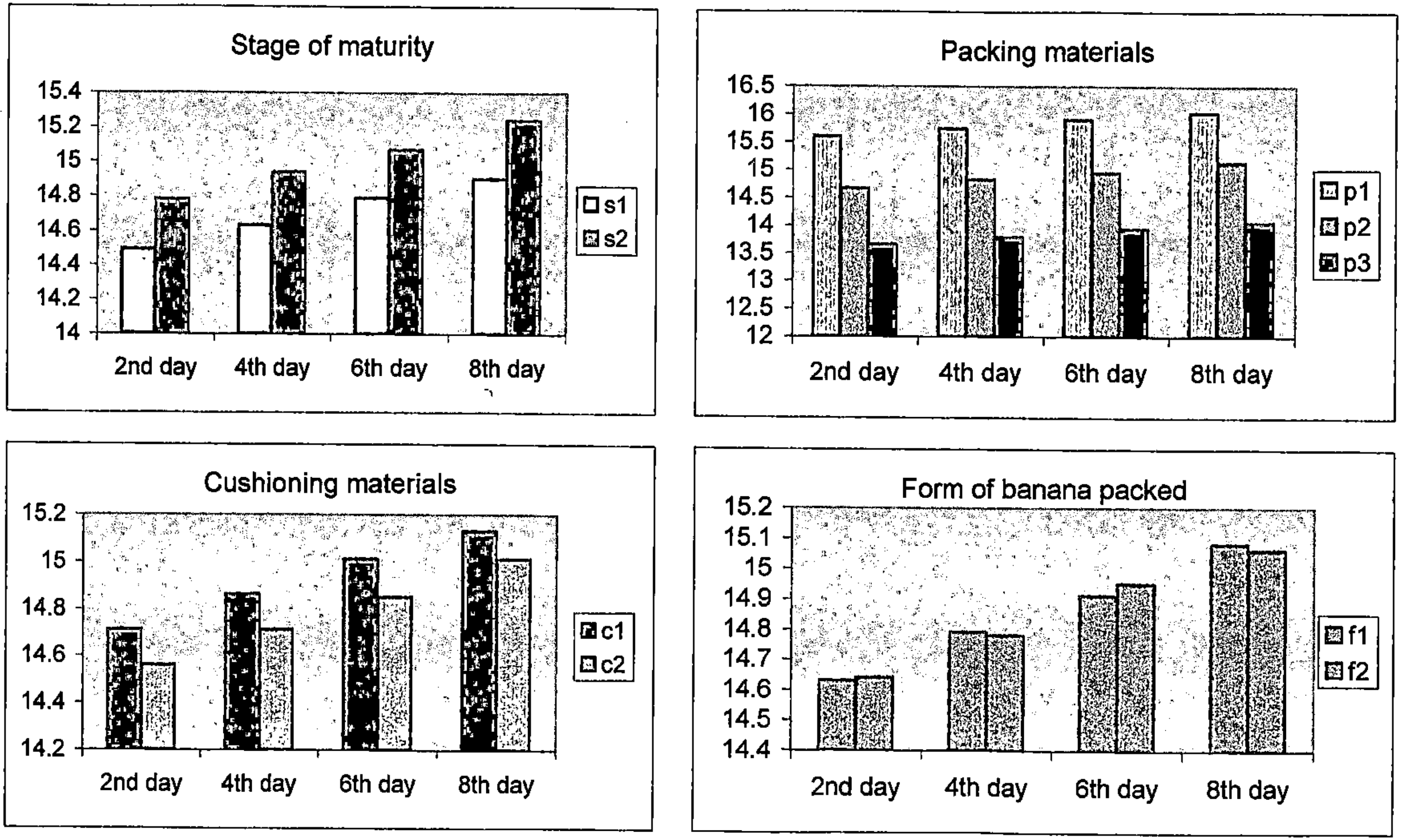
Table 32. Reducing sugar (Two factor interaction)

Interaction	2nd day	4th day	6th day	8th day
s_1f_1	14.49	14.63	14.77	14.90
s_1f_2	14.50	14.62	14.81	14.89
s_2f_1	14.78	14.94	15.05	15.25
s_2f_2	14.78	14.94	15.09	15.23
F (1,56)	<1	<1	<1	<1
s_1c_1	14.55	14.69	14.84	14.93
s_1c_2	14.44	14.56	14.73	14.86
s_2c_1	14.87	15.03	15.18	15.14
s_2c_2	14.69	14.85	14.96	15.16
F (1,56)	1.87	<1	2.66	1.14
c_1f_1	14.72	14.86	15.01	15.14
c_1f_2	14.71	14.86	15.01	15.11
c_2f_1	14.55	14.71	14.81	15.01
c_2f_2	14.57	14.70	14.88	15.01
F (1,56)	<1	<1	<1	<1

Table 33. Reducing sugar (Two factor interaction)

Interaction	2nd day	4th day	6th day	8th day
s_1p_1	15.43	15.56	15.71	15.81
s_1p_2	14.56	14.68	14.85	14.98
s_1p_3	13.50	13.64	13.79	13.91
s_2p_1	15.76	15.92	16.10	16.25
s_2p_2	14.77	14.96	15.05	15.29
s_2p_3	13.81	13.94	14.07	14.19
F (2,56)	2.41	<1	2.29	1.93
p_1f_1	15.58	15.74	15.91	16.07
p_1f_2	15.60	15.74	15.90	15.98
p_2f_1	14.68	14.85	14.93	15.15
p_2f_2	14.65	14.78	14.98	15.12
p_3f_1	13.64	13.77	13.89	14.01
p_3f_2	13.67	13.81	13.97	14.08
F (2,56)	<1	1.23	<1	1.91
p_1c_1	15.64	15.79	15.96	16.05
p_1c_2	15.54	15.68	15.85	16.00
p_2c_1	14.77	14.92	15.08	15.22
p_2c_2	14.56	14.72	14.82	15.04
p_3c_1	13.73	13.86	13.99	14.11
p_3c_2	13.58	13.72	13.87	13.99
F (2,56)	1.77	<1	1.85	1.02

Fig. 3 Reducing sugars (%)



4.2.8 Non-reducing sugars

In the individual effects, stages of maturity and packing materials were found to have significant influence on the non-reducing sugars whereas the cushioning materials and the form of banana packed recorded not significance as shown in the Tables 34.

Non-reducing sugar was found to be high in fruits harvested at stage s_2 (0.17 per cent) and low in s_1 (0.15 per cent) on the 2nd day. The results obtained on this aspect for the following days were also similar. Among the packing materials p_1 (0.17 per cent) showed the highest value followed by p_2 (0.16 per cent) and the lowest value for non-reducing sugar was recorded in p_3 (0.14 per cent). Similar results were obtained on the following days also.

Among the two factor interactions except P x C interaction all others were found to be non-significant. In P x C interaction significant variation was found only on the 2nd day. Here the highest value was recorded by p_1c_2 (0.18 per cent) which was on par with p_1c_1 (0.17 per cent), p_2c_2 (0.17 per cent) and p_2c_1 (0.16 per cent). The lowest value was recorded in p_3c_2 (0.14 per cent) as presented in the Table 36. Here in p_1 and p_2 similar effects of c_1 and c_2 were observed and in p_3, c_1 was greater than c_2.

The SPCF and all the three factor interactions were found to be ineffective on the action of non-reducing sugars in the fruits as depicted in Appendix XIV.

Table 34. Non – reducing sugar

Factors	2nd	4th	6th	8th
Stages				
s_1	0.16	0.17	0.19	0.21
s_2	0.17	0.19	0.21	0.23
F	9.89 **	28.57 **	36.65 **	32.17 **
SE	0.009	0.006	0.006	0.007
CD	0.003	0.002	0.002	0.002
Packing Material				
p_1	0.18	0.20	0.22	0.23
p_2	0.16	0.18	0.20	0.21
p_3	0.15	0.17	0.19	0.20
F	12.65 **	22.03 **	30.72 **	32.75 **
SE	0.004	0.003	0.003	0.003
CD	0.011	0.008	0.008	0.009
Cushioning Material				
c_1	0.17	0.18	0.20	0.22
c_2	0.16	0.18	0.20	0.22
F	<1	<1	<1	<1
Hands / Fingers				
f1	0.16	0.18	0.20	0.22
f2	0.17	0.18	0.20	0.21
F	<1	<1	<1	<1

Table 35. **Non – reducing sugar** (Two factor interaction)

Interaction	2nd day	4th day	6th day	8th day
s_1f_1	0.16	0.17	0.19	0.21
s_1f_2	0.16	0.17	0.19	0.20
s_2f_1	0.17	0.19	0.21	0.23
s_2f_2	0.17	0.19	0.21	0.22
F (1,56)	<1	<1	<1	<1
s_1c_1	0.16	0.18	0.19	0.21
s_1c_2	0.15	0.17	0.19	0.20
s_2c_1	0.17	0.19	0.21	0.22
s_2c_2	0.17	0.19	0.21	0.23
F (1,56)	<1	1.90	<1	<1
c_1f_1	0.16	0.18	0.20	0.21
c_1f_2	0.17	0.18	0.20	0.22
c_2f_1	0.16	0.18	0.20	0.22
c_2f_2	0.16	0.18	0.20	0.21
F (1,56)	<1	1.07	1.08	1.22

Table 36. Non – reducing sugar (Two factor interaction)

Interaction	2nd day	4th day	6th day	8th day
s_1p_1	0.17	0.19	0.20	0.22
s_1p_2	0.15	0.17	0.19	0.21
s_1p_3	0.14	0.16	0.18	0.19
s_2p_1	0.18	0.20	0.23	0.25
s_2p_2	0.17	0.19	0.20	0.22
s_2p_3	0.15	0.18	0.19	0.21
F (2,56)	<1	<1	<1	2.48
p_1f_1	0.17	0.19	0.21	0.23
p_1f_2	0.18	0.20	0.22	0.24
p_2f_1	0.17	0.18	0.20	0.22
p_2f_2	0.16	0.18	0.19	0.21
p_3f_1	0.14	0.17	0.18	0.20
p_3f_2	0.15	0.17	0.19	0.20
F (2,56)	1.44	1.10	1.41	<1
p_1c_1	0.17	0.19	0.21	0.23
p_1c_2	0.18	0.20	0.22	234.00
p_2c_1	0.16	0.18	0.19	0.21
p_2c_2	0.17	0.18	0.20	0.21
p_3c_1	0.16	0.17	0.19	0.20
p_3c_2	0.14	0.17	0.18	0.20
F (2,56)	4.05 *	1.99	1.22	<1
SE	0.006	-	-	-
CD	0.016	-	-	-

4.2.9 Total sugars

Stages of maturity, packing materials and cushioning materials were found to have significant influence on the total sugar content of the banana as depicted in the Table 37. The form of banana packed was found to be insignificant. Total sugar was greater in s_2 (14.96 per cent) than in s_1 (14.65 per cent) on the 2nd day. Similar results were obtained for the following days.

Among the packing materials p_1 (15.76 per cent) gave the highest value for the total sugars followed by p_2 (14.83 per cent) and p_3 (13.81 per cent) on the 2nd day. Similar results were obtained on the 4th, 6th and 8th day. The cushioning material c_1 (14.88 per cent) gave better levels of total sugar than c_2 (14.73 per cent). A corresponding increase as depicted in the Table 37 was observed on the 4th, 6th and 8th day.

None of the two factor and three factor interactions could significantly influence the total sugar percentage at any stages of ripening. The SPCF interaction was found to be significant on the 8th day only as depicted in Appendix XV. The maximum level of total sugar was recorded by $s_2p_0c_0f_1$ (16.82 per cent) and the minimum level was recorded in $s_1p_3c_2f_1$ (14.03 per cent). $s_1p_1c_1f_1$ was on par with $s_1p_1c_1f_2$. $s_1p_2c_1f_2$ was on par with $s_1p_2c_2f_1$. $s_2p_1c_1f_1$was on par with $s_2p_1c_1f_2$. $s_2p_1c_2f_1$ was on par with $s_2p_2c_1f_1$, $s_2p_3c_1f_1$ was on par with $s_2p_3c_1f_2$ and $s_2p_3c_2f_1$ was on par with $s_2p_3c_2f_2$,

4.2.10. Acidity

The stages of maturity and packing materials were found to have significant difference on the percentage of acidity of banana as shown in the

Table 37. Total sugars

Factors	2nd day	4th day	6th day	8th day
Stages				
s_1	14.65	14.81	14.97	15.13
s_2	14.96	15.13	15.31	15.45
F	187.76 **	168.84 **	180.08 **	246.64 **
SE	0.016	0.018	0.061	0.015
CD	0.045	0.050	0.050	0.043
Packing Material				
p_1	15.76	15.94	16.12	16.30
p_2	14.83	15.01	15.19	15.34
p_3	13.81	13.96	14.12	14.25
F	2475.80 **	2121.65 **	2175.66 **	3005.13 **
SE	0.20	0.021	0.022	0.019
CD	0.056	0.061	0.061	0.053
Cushioning Material				
c_1	14.88	15.04	15.21	15.37
c_2	14.73	14.90	15.07	15.23
F	43.83 **	33.89 **	29.57 **	42.04 **
SE	0.016	0.018	0.018	0.015
CD	0.045	0.050	0.050	0.043
Hands / Fingers				
f_1	14.80	14.97	15.14	15.29
f_2	14.80	14.97	15.15	15.30
F	<1	<1	<1	<1

Table 38. Total sugars (Two factor interaction)

Interaction	2nd day	4th day	6th day	8th day
s_1f_1	14.65	14.81	15.00	15.11
s_1f_2	14.65	14.81	14.99	115.14
s_2f_1	14.96	15.13	15.32	15.47
s_2f_2	14.96	15.13	15.30	15.46
F (1,56)	<1	<1	1.76	1.86
s_1c_1	14.71	14.86	15.03	15.19
s_1c_2	14.59	14.75	14.92	15.06
s_2c_1	15.05	15.21	15.39	15.54
s_2c_2	14.87	15.04	15.23	15.39
F (1,56)	1.48	<1	1.94	<1
c_1f_1	14.89	15.04	15.20	15.36
c_1f_2	14.87	15.04	15.21	15.38
c_2f_1	14.72	14.90	15.07	15.23
c_2f_2	14.74	14.89	15.08	15.22
F (1,56)	<1	<1	<1	1.39

Table 39. Total sugars (Two factor interaction)

Interaction	2nd day	4th day	6th day	8th day
s_1p_1	15.59	15.75	15.92	16.10
s_1p_2	14.71	14.87	15.04	15.18
s_1p_3	13.64	13.80	13.97	14.10
s_2p_1	15.94	16.12	16.32	16.50
s_2p_2	14.96	15.15	15.34	15.50
s_2p_3	13.98	14.12	14.26	14.40
F (2,56)	2.11	1.41	2.46	1.97
p_1f_1	15.75	15.93	16.12	16.30
p_1f_2	15.78	15.94	16.11	16.30
p_2f_1	14.86	15.03	15.21	15.36
p_2f_2	14.81	14.98	15.17	15.33
p_3f_1	13.80	13.94	14.08	14.21
p_3f_2	13.82	13.98	14.15	14.28
F (2,56)	1.37	<1	2.290	2.55
p_1c_1	15.81	15.99	16.17	16.36
p_1c_2	15.72	15.88	16.07	16.24
p_2c_1	14.93	15.09	15.28	15.43
p_2c_2	14.74	14.92	15.10	15.26
p_3c_1	13.89	14.04	14.18	14.31
p_3c_2	13.73	13.88	14.05	14.18
F (2,56)	1.79	<1	<1	<1

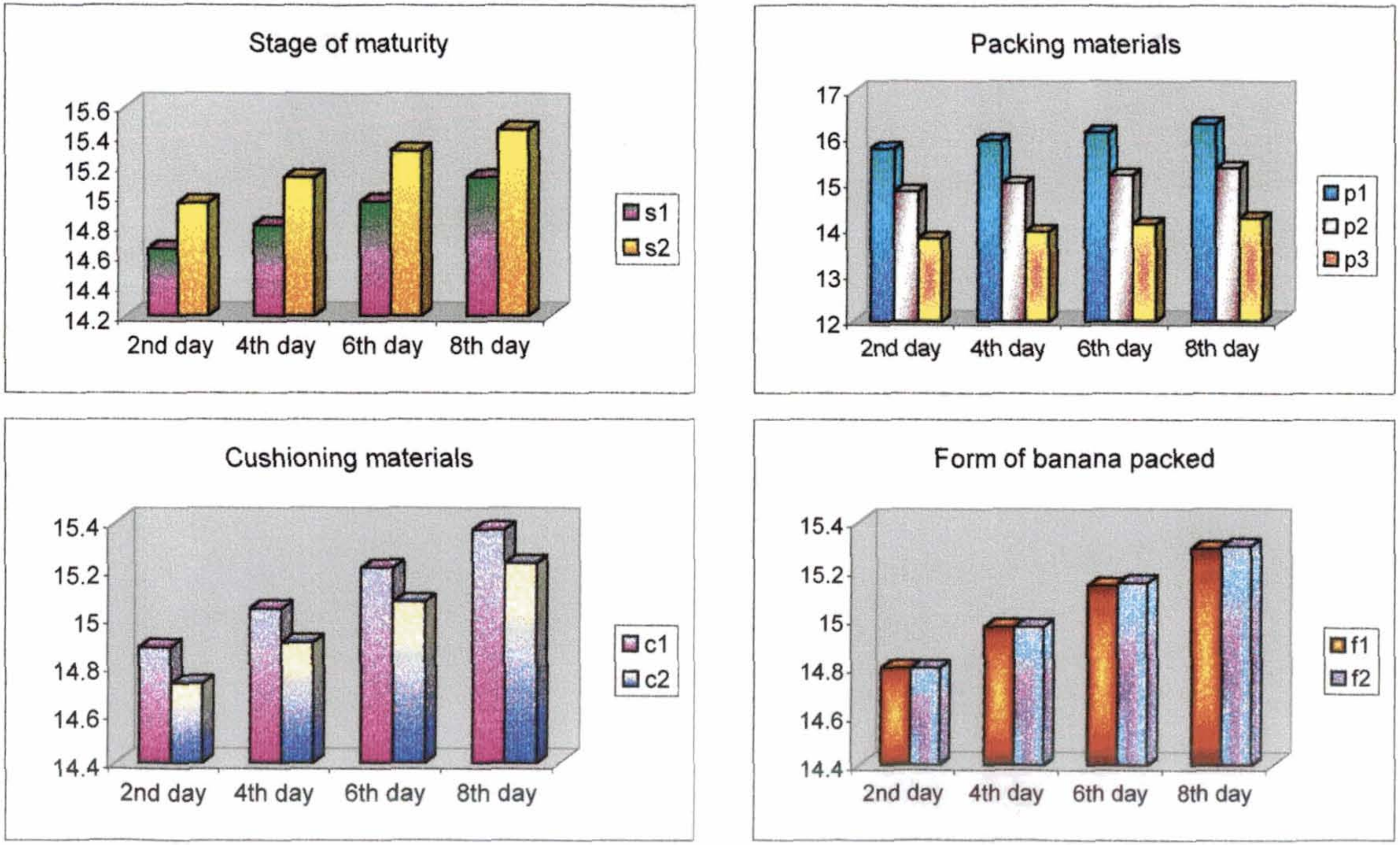


Fig. 4 Total sugars (%)

tables 40. Lower levels of acidity was obtained in s_2 (0.36 per cent) on the second day and higher levels was obtained from s_1 (0.39 per cent). Similar results were recorded on the following days.

Among the packing materials p_3 (0.39 per cent) recorded the highest acidity followed by p_1 (0.37 per cent) and p_2 (0.36 per cent) on the 2nd day. Same trend in result continued throughout the storage period. Significant difference in the cushioning material was found on the 6th day were c_2 (0.29 per cent) gave higher value than c_1 (0.28 per cent). The form of banana packed was found to be non-significant.

Among the two factor interactions S x C and S x P showed significant differences apart from all other interactions enlisted in the Table 41 and 42. S x C interaction vary from the 4th day to 8th day. In all the cases maximum variation was shown by s_1c_2 (0.35, 0.31 and 0.28 per cent) and minimum variation by s_2c_2 (0.31, 0.27 and 0.25 per cent). In all these treatments s_2c_2 was on par with s_2c_1. In s1 and s2, c1 was found to be equal to c2. If the fruits are harvested at s_2, the cushioning material did not influenced. But on s_1 fruits, acidity was found to be more in fruits packed with c_2. This result was seen from the 4th to 8th day of storage.

In the S x P interaction, highest level of acidity was recorded in s_1p_3 (0.40 per cent) and lowest level of acidity in s_2p_2 (0.35 per cent) on the 2nd day. Similar results were obtained on the following days. On the 2nd day s_2p_3 was on par with s_1p_1 and s_1p_2. On the 4th day s_1p_1 (0.34 per cent) was found to be on par with s_1p_2 (0.34 per cent) and s_1p_3 (0.35 per cent). If s_1 fruits where

Table 40. Acidity

Factors	2^{nd} day	4^{th} day	6^{th} day	8^{th} day
Stages				
s_1	0.39	0.34	0.31	0.28
s_2	0.36	0.31	0.27	0.25
F	202.78 **	191.88 **	304.70 **	436.98 **
SE	0.001	0.002	0.001	0.001
CD	0.003	0.005	0.004	0.004
Packaging Material				
p_1	0.37	0.33	0.29	0.26
p_2	0.37	0.32	0.28	0.26
p_3	0.39	0.34	0.30	0.28
F	64.49 **	22.48 **	28.40 **	46.20 **
SE	0.001	0.002	0.002	0.002
CD	0.004	0.006	0.005	0.004
Cushioning Material				
c_1	0.38	0.33	0.29	0.26
c_2	0.38	0.33	0.29	0.27
F	<1	<1	4.75 *	1.35
SE	-	-	0.001	-
CD	-	-	0.004	-
Hands/Fingers				
f_1	0.38	0.33	0.29	0.27
f_2	0.38	0.33	0.29	0.27
F	<1	<1	1.57	0.21

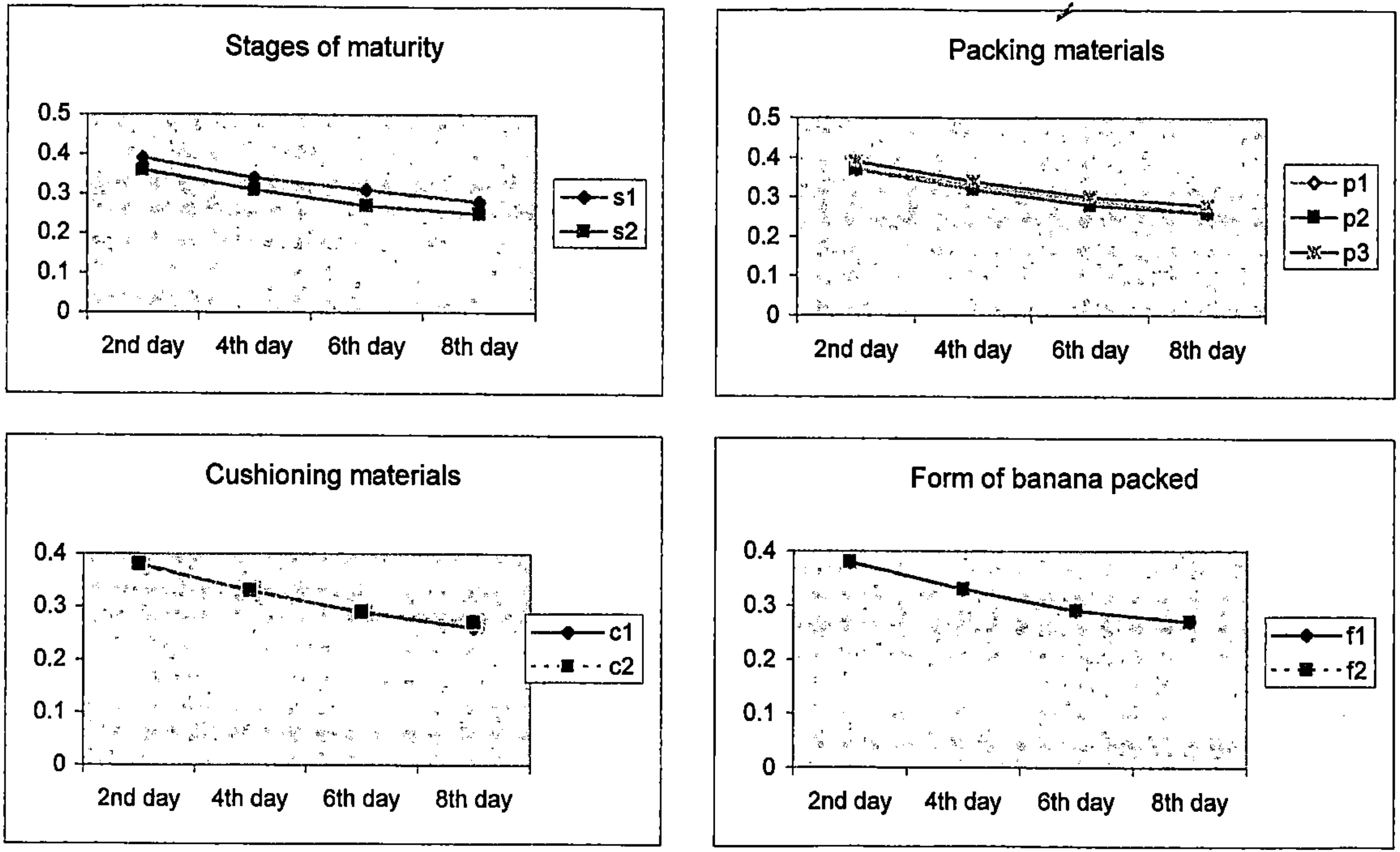
Table 41. Acidity (Two factor interaction)

Interaction	2nd day	4th day	6th day	8th day
s_1f_1	0.39	0.35	0.31	0.28
s_1f_2	0.39	0.34	0.31	0.29
s_2f_1	0.36	0.31	0.27	0.25
s_2f_2	0.37	0.31	0.27	0.25
F (1,56)	1.32	<1	<1	<1
s_1c_1	0.39	0.34	0.30	0.28
s_1c_2	0.39	0.35	0.31	0.29
s_2c_1	0.37	0.31	0.27	0.25
s_2c_2	0.36	0.31	0.27	0.25
F (1,56)	<1	5.71 *	8.17 **	8.23 **
SE	-	0.007	0.006	0.005
CD	-	0.002	0.002	0.002
c_1f_1	0.37	0.33	0.29	0.27
c_1f_2	0.38	0.33	0.29	0.26
c_2f_1	0.38	0.33	0.29	0.27
c_2f_2	0.38	0.33	0.29	0.27
F (1,56)	1.34	<1	<1	1.83
SE	0.002	0.002	0.002	0.002
CD	0.005	0.007	0.006	0.005

Table 42. Acidity (Two factor interaction)

Interaction	2nd day	4th day	6th day	8th day
s_1p_1	0.38	0.34	0.30	0.28
s_1p_2	0.38	0.34	0.31	0.29
s_1p_3	0.40	0.35	0.31	0.29
s_2p_1	0.36	0.31	0.27	0.25
s_2p_2	0.35	0.29	0.25	0.23
s_2p_3	0.38	0.33	0.29	0.26
F (2,56)	8.59 **	16.14 **	19.64 **	28.58 **
SE	0.002	0.003	0.002	0.002
CD	0.006	0.008	0.007	0.006
p_1f_1	0.37	0.33	0.29	0.26
p_1f_2	0.37	0.32	0.29	0.26
p_2f_1	0.37	0.32	0.28	0.26
p_2f_2	0.37	0.32	0.28	0.26
p_3f_1	0.39	0.34	0.30	0.27
p_3f_2	0.39	0.34	0.30	0.28
F (2,56)	<1	<1	1.81	2.80
p_1c_1	0.37	0.33	0.29	0.26
p_1c_2	0.37	0.33	0.29	0.26
p_2c_1	0.37	0.32	0.28	0.26
p_2c_2	0.37	0.32	0.28	0.26
p_3c_1	0.39	0.34	0.30	0.28
p_3c_2	0.39	0.34	0.30	0.28
F (2,56)	<1	<1	<1	<1

Fig. 5 Acidity (%)



stored in p_1, p_2 and p_3, lowest acidity value was noted in p_1 followed by p_2 and p_3. But with s_2 fruits, lowest acidity was observed in p_2. These results were seen o all days of storage.

All the three factor and SPCF interaction were found to be ineffective on the acidity levels.

4.2.11 Sugar acid ratio

Maturity stages, packing materials and cushioning materials showed significant influence on the sugar acid ratio of banana, while the form of banana packed did not show any significant difference as depicted in the Table 43.

The stages s_2 (41.12) gave higher value for the sugar acid ratio than s_1 (37.88).A corresponding increase in total sugars were recorded in the following days. Among the packing materials fruits packed in p_1 (42.46) showed the highest total sugar value followed by p_2 (40.46) and the lowest value was observed from p_3 (35.58) on the 2nd day. Similar trend was observed on the following days of storage also. In the cushioning materials fruits packed in c_1 (39.76) had better influence on the sugar acid ratio than c_2 (39.24) on the 2nd day. Corresponding results were obtained thereafter.

Among the two factor interactions only S x P and S x C were found significantly different, all other interaction effects were non-significant. In S x C significant difference was found only on 6th and 8th day. The highest value was observed in s_2c_1 (56.78,62.96) on the 6th and 8th day respectively. The lowest value was recorded in s_1c_2 (47.85and 52.47 on 6th and 8th day

Table 43. Sugar acid ratio

Factors	2nd day	4th day	6th day	8th day
Stages				
s_1	37.88	43.09	48.82	53.36
s_2	41.12	48.93	56.64	63.23
F	374.65 **	291.06 **	410.47 **	579.34 **
SE	0.118	0.242	0.273	0.290
CD	0.336	0.685	0.773	0.822
Packaging Material				
p_1	42.46	49.13	56.07	62.64
p_2	40.46	47.52	54.78	60.43
p_3	35.58	41.38	47.34	51.82
F	594.49 **	190.45 **	199.09 **	258.50 **
SE	0.145	0.296	0.334	0.355
CD	0.411	0.839	0.947	1.007
Cushioning Material				
c_1	39.76	46.35	53.29	58.61
c_2	39.24	45.67	52.17	57.99
F	9.55 **	3.89	8.43 **	2.29
SE	0.118	-	0.273	-
CD	0.336	-	0.773	-
Hands / Fingers				
f_1	39.51	46.11	52.96	58.39
f_2	39.49	45.91	52.50	58.21
F	<1	<1	1.41	<1

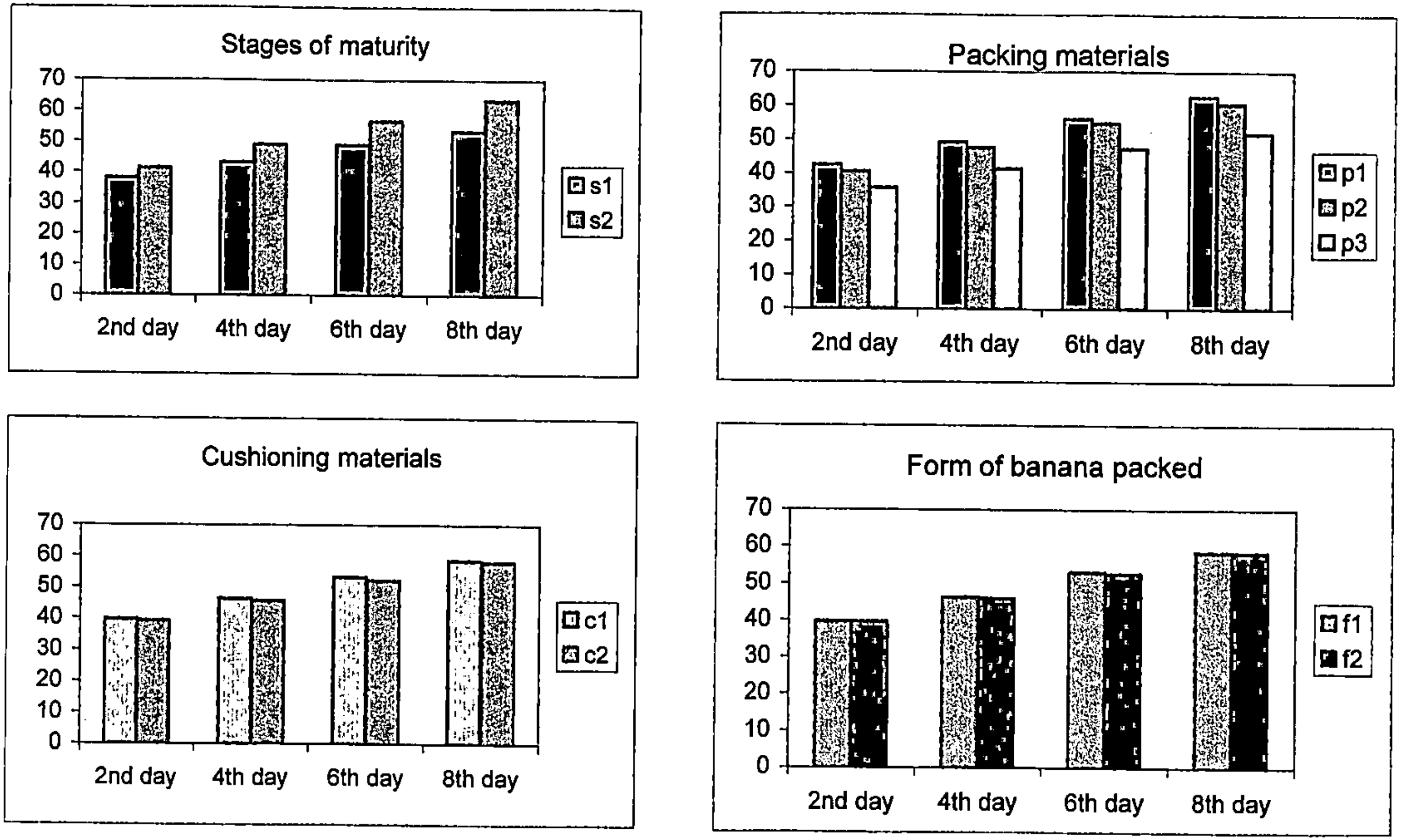
Table 44. Sugar acid ratio (Two factor interaction)

Interaction	2nd day	4th day	6th day	8th day
s_1f_1	37.77	42.98	48.85	53.45
s_1f_2	37.99	43.20	48.80	53.27
s_2f_1	41.25	49.23	57.07	63.32
s_2f_2	40.99	48.62	56.20	63.14
F (1,56)	2.04	1.46	1.11	<1
s_1c_1	38.15	43.75	49.80	54.25
s_1c_2	37.61	42.44	47.85	52.47
s_2c_1	41.37	48.95	56.78	62.96
s_2c_2	40.88	48.91	56.49	63.50
F (1,56)	<1	3.49	4.61 *	7.94 **
SE	-	-	0.386	0.410
CD	-	-	1.093	1.163
c_1f_1	39.88	46.30	53.65	58.33
c_1f_2	39.64	46.39	52.93	58.88
c_2f_1	39.14	45.92	52.27	58.44
c_2f_2	39.34	45.43	52.07	57.53
F (1,56)	1.70	<1	<1	3.08

Table 45. Sugar acid ratio (Two factor interaction)

Interaction	2nd day	4th day	6th day	8th day
s_1p_1	41.11	46.29	52.35	58.38
s_1p_2	38.38	43.21	49.07	53.16
s_1p_3	34.15	39.77	45.04	48.54
s_2p_1	43.81	51.96	59.79	66.90
s_2p_2	42.53	51.83	60.49	67.70
s_2p_3	37.02	42.99	49.64	55.11
F (2,56)	7.46 **	20.74 **	26.24 **	34.17 **
SE	0.205	0.419	0.472	0.503
CD	0.582	1.187	1.339	1.424
p_1f_1	42.42	49.05	55.95	62.47
p_1f_2	42.51	49.20	56.18	62.81
p_2f_1	40.57	47.75	55.11	60.17
p_2f_2	40.35	47.29	54.45	60.68
p_3f_1	35.55	41.52	47.81	52.51
p_3f_2	35.62	41.24	46.86	51.14
F (2,56)	<1	<1	<1	2.13
p_1c_1	42.75	49.36	56.43	62.92
p_1c_2	42.18	48.90	55.71	62.36
p_2c_1	40.73	48.00	55.44	60.92
p_2c_2	40.19	47.04	54.12	59.93
p_3c_1	35.81	41.69	47.99	51.98
p_3c_2	35.36	41.08	46.68	51.67
F (2,56)	<1	<1	<1	<1

Fig. 6 Sugar acid ratio



respectively). Sugar acid ratio was constant with s_2 fruits packed with c_1 and c_2. But with s_1 fruits sugar acid ratio was high in fruits packed in c_1.

In S x P interaction the highest value and lowest value were recorded in s_2p_1 (43.81) and s_1p_3 (34.15) respectively on the 2nd day. A corresponding result was obtained on the following days as depicted in the Table 45. In all the packages s2 was greater than s_1.

No significant difference were found in the three factor and SPCF interactions on the sugar acid ratio as shown in Appendix XVII.

4.2.12 **Physiological weight loss** (PLW in per cent)

Different stages of maturity, packing materials, cushioning materials and the form of banana packed significantly influenced the net physiological loss of weight as shown in the Table 46.

The physiological loss of weight was higher at stage 2 at all the phases of storage. Weight loss was greater in s_2 (1.96 per cent) than in s_1 (1.39 per cent) on the 2nd day. And this was continued in the following days of storage as depicted in the Table 46. Among the packing materials higher loss was recorded in p_2 (2.23 per cent) followed by p_1 (1.64 per cent). Comparatively less PLW was reflected in the package p_3 (1.18 per cent). The package p_3 was found t be the best among those used for the study with respect to PLW.

Among the cushioning materials used neither c_1 nor c_2 showed any significant difference on the PLW on 2nd day as shown in the Table 46. Later c_1 (4.83 per cent) was found to be better than c_2 (5.36 per cent) on the 4th day.

Table 46. PLW

Factors	2nd day	4th day	6th day	8th day
Stages				
s_1	1.40	4.48	7.30	8.04
s_2	1.97	5.72	9.11	9.83
F	48.29 **	36.91 **	49.06 **	56.20 **
SE	0.058	0.144	0.182	0.170
CD	0.164	0.409	0.517	0.481
Packaging Material				
p_1	1.64	5.30	8.46	9.27
p_2	2.23	6.54	10.62	11.57
p_3	1.18	3.46	5.54	5.96
F	55.00 **	76.97 **	130.16 **	184.09 **
SE	0.071	0.177	0.223	0.208
CD	0.201	0.501	0.633	0.589
Cushioning Material				
c_1	1.62	4.83	7.84	8.54
c_2	1.74	5.36	8.58	9.33
F	1.99	6.70 *	8.24 **	10.69 **
SE	-	0.409	0.517	0.481
CD	-	0.144	0.182	0.170
Hands / Fingers				
f_1	1.84	5.33	8.54	9.20
f_2	1.52	4.87	7.88	8.67
F	15.62 **	5.15 *	6.60 *	5.04 *
SE	0.058	0.144	0.182	0.170
CD	0.164	0.409	0.517	0.481

Table 47. PLW (Two factor interaction)

Interaction	2nd day	4th day	6th day	8th day
s_1f_1	1.58	4.70	7.58	8.26
s_1f_2	1.21	4.25	7.03	7.81
s_2f_1	2.10	5.96	9.50	10.15
s_2f_2	1.83	5.48	8.72	9.52
F (1,56)	<1	<1	<1	<1
s_1c_1	1.35	4.25	6.77	7.44
s_1c_2	1.44	4.71	7.84	8.63
s_2c_1	1.90	5.42	8.90	9.65
s_2c_2	2.04	6.02	9.32	10.02
F (1,56)	<1	<1	1.63	2.94
c_1f_1	1.78	4.96	8.22	8.83
c_1f_2	1.47	4.70	7.45	8.26
c_2f_1	1.91	5.70	8.86	9.58
c_2f_2	1.57	5.03	8.30	9.08
F (1,56)	<1	1.00	<1	<1

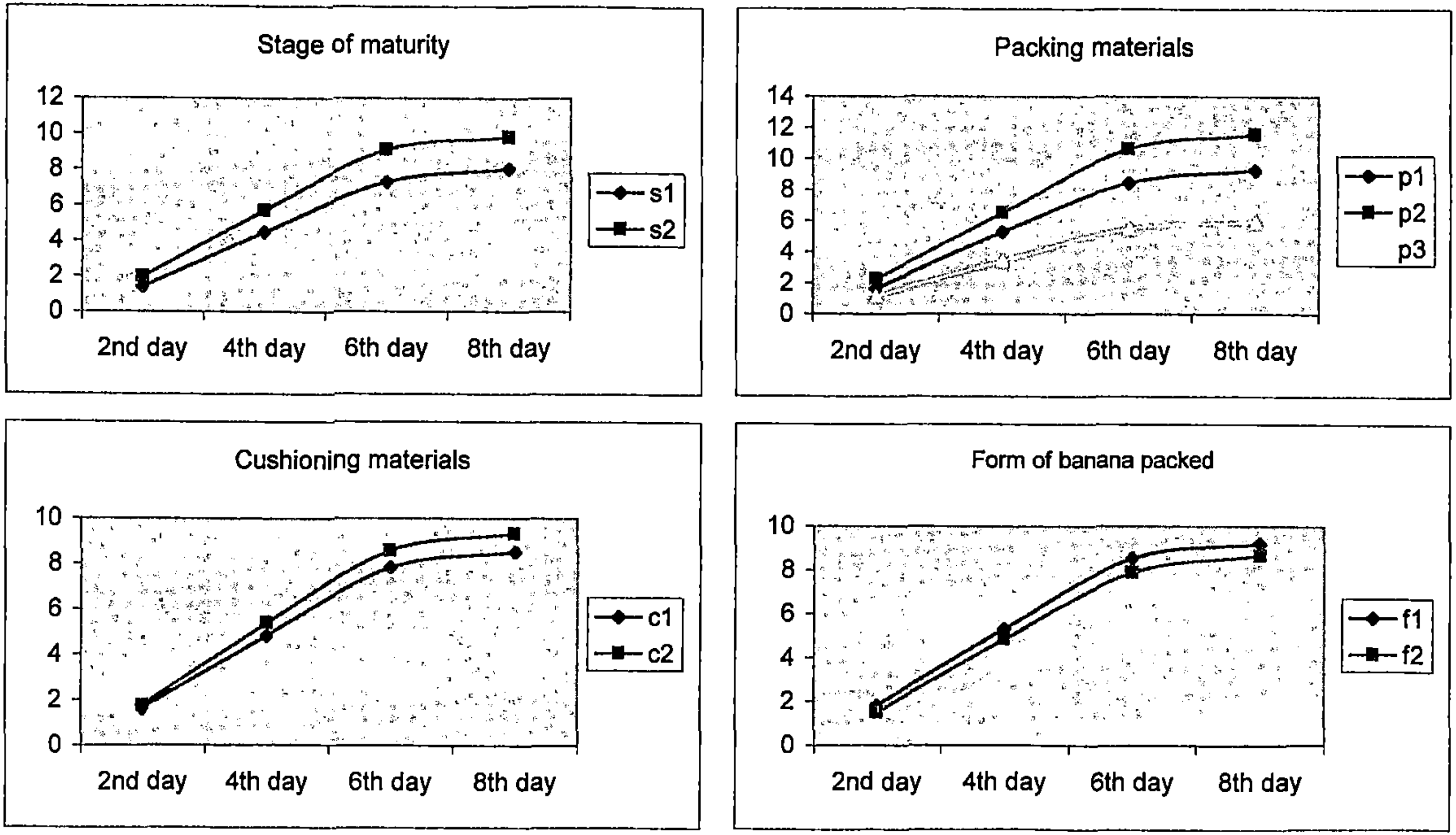
Table 48. PLW (Two factor interaction)

Interaction	2^{nd} day	4^{th} day	6^{th} day	8^{th} day
s_1p_1	1.33	4.79	7.75	8.72
s_1p_2	1.88	5.68	9.39	10.20
s_1p_3	0.98	2.97	4.77	5.18
s_2p_1	1.94	5.81	9.16	9.82
s_2p_2	2.58	7.40	11.85	12.94
s_2p_3	1.37	3.94	6.32	6.75
F (2,56)	1.30	1.39	1.64	4.13 *
SE	-	-	-	0.294
CD	-	-	-	0.833
p_1f_1	1.80	5.25	8.43	9.21
p_1f_2	1.47	5.35	8.48	9.33
p_2f_1	2.44	7.03	11.13	11.97
p_2f_2	2.02	6.04	10.12	11.18
p_3f_1	1.29	3.70	6.06	6.44
p_3f_2	1.07	3.21	5.03	5.49
F (2,56)	<1	2.37	1.89	1.95
p_1c_1	1.69	5.21	8.48	9.23
p_1c_2	1.58	5.39	8.43	9.31
p_2c_1	2.14	6.06	9.93	10.90
p_2c_2	2.32	7.01	11.32	12.25
p_3c_1	1.04	3.23	5.10	5.50
p_3c_2	1.32	3.68	5.99	6.43
F (2,56)	2.04	1.21	2.69	2.43

Table 49. PLW (Three factor interaction)

Interaction	2nd day	4th day	6th day	8th day
$s_1p_1f_1$	1.49	4.52	7.13	8.06
$s_1p_1f_2$	1.16	5.06	8.37	9.38
$s_1p_2f_1$	2.10	6.23	10.19	10.93
$s_1p_2f_2$	1.66	5.13	8.59	9.48
$s_1p_3f_1$	1.16	3.37	5.42	5.78
$s_1p_3f_2$	0.81	2.57	4.12	4.59
$s_2p_1f_1$	2.11	5.99	9.74	10.36
$s_2p_1f_2$	1.78	5.64	8.59	9.28
$s_2p_2f_1$	2.78	7.84	12.06	12.99
$s_2p_2f_2$	2.38	6.96	11.65	12.88
$s_2p_3f_1$	1.42	4.04	6.69	7.10
$s_2p_3f_2$	1.33	3.84	5.94	6.39
F (2,56)	<1	1.16	4.56*	5.55**
SE	-	-	0.447	0.416
CD	-	-	1.266	1.178
$p_1c_1f_1$	1.98	5.49	9.16	9.79
$p_1c_1f_2$	1.40	4.93	7.81	8.67
$p_1c_2f_1$	1.62	5.02	7.71	8.62
$p_1c_2f_2$	1.54	5.77	9.15	9.99
$p_2c_1f_1$	2.32	6.25	10.09	10.90
$p_2c_1f_2$	1.96	5.87	9.76	10.89
$p_2c_2f_1$	2.56	7.81	12.16	13.03
$p_2c_2f_2$	2.08	6.21	10.47	11.46
$p_3c_1f_1$	1.03	3.15	5.41	5.80
$p_3c_1f_2$	1.05	3.31	4.78	5.20
$p_3c_2f_1$	1.55	4.25	6.70	7.08
$p_3c_2f_2$	1.09	3.11	5.27	5.78
F (2,56)	3.00	4.35*	6.30**	6.58**
SE	-	0.353	0.447	0.416
CD	-	1.002	1.266	1.78
$s_1c_1f_1$	1.48	4.16	6.75	7.37
$s_1c_1f_2$	1.22	4.34	6.78	7.51
$s_1c_2f_1$	1.68	5.25	8.41	9.15
$s_1c_2f_2$	1.20	4.16	7.27	8.12
$s_2c_1f_1$	2.08	5.77	9.69	10.30
$s_2c_1f_2$	1.71	5.06	8.12	9.00
$s_2c_2f_1$	2.13	6.14	9.31	10.01
$s_2c_2f_2$	1.94	5.90	9.32	10.03
F (2,56)	1.46	4.59*	7.10*	6.73*
SE	-	0.289	0.365	0.339
CD	-	0.818	1.034	0.961

Fig. 7 PLW (%)


Stage of maturity
12
10
8
6
4
2
0
2nd day
4th day
6th day
8th day
s1
s2
Packing materials
14
12
10
8
6
4
2
0
2nd day
4th day
6th day
8th day
p1
p2
p3
Cushioning materials
10
8
6
4
2
0
2nd day
4th day
6th day
8th day
c1
c2
Form of banana packed
10
8
6
4
2
0
2nd day
4th day
6th day
8th day
f1
f2

On the 6th and 8th day c_1 recorded comparatively better scores 7.84 per cent and 8.54 per cent respectively, while c_2 gave as score of 8.58 per cent ad 9.33 per cent respectively.

The form in which the banana were packed also gave an effective result on the PLW. Banana packed as fingers gave better results than those packed as hands. PLW was loss in f_2 (1.52 per cent) and greater in f_1 (1.84 per cent) on the 2nd day. Similar results were obtained on the following days also.

All the two factor interactions were found to be in effective except the S x P interaction on the 8th day as shown in Table 48. In this interaction s_1p_3 (5.18 per cent) recorded the least PLW and s_2p_2 (12.94 per cent) gave the highest PLW. In all the packages s_2 was greater than s_1.

The three factor interactions SPF, SCF and PCF showed significant difference on the effect of PLW on the 4th, 6th and 8th day as shown in Table 49.

Among the SPF interaction, highest PLW was observed in $s_2p_2d_1$ (12.06 per cent) which was on par with $s_2p_2f_2$. The lowest PLW was obtained from $s_1p_3f_2$. The lowest PLW was obtained form $s_1p_3f_2$ (4.12 per cent). The s_1p_1 treatment gave greater PLW on f_2 than f_1; while in s_2p_1 greater PLW was obtained in f_1 than f_2. In p_2 package s_1p_2 gave greater effect on f_1 than f_2, similar trend was found in s_2p_2 also. In s_1p_3 and s_2p_3, f_1 gave greater PLW than f_2 similar results were obtained on the following day also.

Among the PCF interaction; $p_2c_2f_1$ (7.81 per cent) gave highest PLW and the lowest PLW was obtained in $p_3c_2f_2$ (3.15 per cent). This was on par with $p_3c_1f_1$ and $p_3c_1f_2$. In the p_1 package p_1c_1 treatment gave slightly higher

PLW with f_1 than in f_2; while in p_1c_2 the effect was same with f_1 and f_2. In p_2c_1 and p_2c_2, f_1 was greater than f_2. In p_3c_1 the effect was similar on f_1 and f_2 but in p_3c_2, f_1 was greater than f_2.

The SC effect on f was also found to be significant. In the interaction of SCF, the highest PLW was observed in $s_2c_2f_1$ (6.14 per cent) which was on par with $s_2c_2f_2$ and $s_2c_1f_1$. The lowest PLW was recorded in $s_1c_1f_1$ and $s_1c_2f_2$ (4.16 per cent) which was on par with $s_1c_1f_2$. The s_1c_1 effect was more or less similar with f_1 and f_2, but in s_1c_2, f_1 showed greater PLW than f_2. In s_2c_1, the loss was similar while in s_2c_2 slight difference occurred.

The SPCF interaction were absent in the action of PLW as depicted in Appendix XVIII.

DISCUSSION

5. DISCUSSION

In the present investigation, "Post-harvest handling in *Musa* AAB group var. Nendran", attempts were made to establish relevant post harvest handling techniques and treatments for providing an efficient protection for fruits during transit. Assessment of different maturity indices and various packing techniques on the efficacy of handling and storage were carried out. The results obtained in this line of work are critically discussed below under the following heads.

5.1 Transportational studies

5.1.1 Type and extent of surface injuries

Significant difference on the effect of different modes of packing and transportation of fruits on the extent of different kinds of injuries were observed. Different packing materials exhibited differences in the extent of bruising during transit. The worst affected were those fruits in control, which may be attributed to the absence of any packing / cushioning materials.

Highest resistance to bruising was observed in p_3 (tray packing). This could be due to the over wrapping of fruits in tray by polyethylene bags which immobilizes the fruits and reduce physical damage due to abrasion which may occur during transit of fruits to the destination. Resistance of CFB (corrugated fibre board boxes) to bruising was comparatively greater than that in plastic crates, presumably due to the use of corrugated pads between layers which reduced bruising. In case of plastic crates mobility was high and thus a corresponding increase in bruising was noted.

The stages of maturity also showed significant variations. Stage one exhibited greater resistance than stage two to bruising/scratch injury. In stage one ripening is yet to commence and the inner pulp is hard and outer skin intact, whereas in stage two the pulp is soft, outer skin loose and slight bruising can cause darkening of the impacted area thus reducing the market value of fruits.

In the case of pressure injury, highest resistance was offered by p_3 (tray packing) followed by p_1 (CFB) and then p_2 (plastic crates). In p_1 and p_2 vertical pressure exerted on the lower levels of fruits caused injury and this was found to be high at stage two (ripe stage). The cushioning materials also exhibited significant difference. The dried banana leaves gave better protection to pressure injury than the paper shreds.

The significance of cushioning materials in the containers could be due to holding of fruits intact and thus nullifying the effects of vibration. Yang *et al.* (1982) highlighted the effectiveness of cushion in safe guarding papaya fruits during transit. Hittalmani (1986) reported the best performance of green pongamia leaves, as cushioning materials due to its softness.

Kim (1988) reported that paddy straw was not suitable cushioning material, as it punctures the skin of soft fruits resulting in bruising and uncleaned appearance. Joshi and Paralkar (1991) reported similar results in sapota.

The magnitude of cut injury was greater in control than in packed fruits which may be attributed to the absence of packing materials.

5.1.2 Percentage of marketability of fruits

The magnitude of marketability was highly influenced by the different packing materials. Cent per cent marketability was obtained in fruits kept packed rather than simply dumping the fruits without package. The fruits lying openly, without any container or cushioning material, lost the marketability greater than those in packages.

5.2 Storage studies

5.2.1 Duration of ripening

Varying stages of maturity and packing materials influenced the duration of ripening significantly. Stage one enhanced the duration of green life and yellow life of fruits than stage two. Among the packing materials p_3 gave the highest green life but yellow life was enhanced by p_2. In all the package normal ripening occurred, while the fruits in control gave earliest ripening.

The interaction effects of stages of maturity and packing showed significant difference. The best combination for longer green life was observed in stage one and p_3 (s_1p_3), whereas in yellow life it was observed that s_1p_2 gave highest duration. Among stage two interactions also s_2p_3 gave highest green life and s_2p_2 highest yellow life. The P x C interaction was also found significant on the duration of green life. The best combination was found in p_3c_1. In the C x F combination significance was highlighted in green life period with c_2f_1 the best combination.

Shanmughavelu *et al.* (1992) reported that banana packed in 100 guage polythene bags with 0.2 per cent ventilation gave 58 per cent greenish yellow fruits with hard pulp at the end of 20 days against 50 per cent fully ripe fruits in control.

5.2.2 Percentage of marketable fruits

The percentage of marketable fruits were found to be significant on the 8th day, which was attributed to the over-ripening at stage two than in stage one. Among the packing materials p_3 gave the maximum percentage of marketable fruits followed by p_2 and then p_1. This may be attributed to the varying duration of ripening in these packages and the extend of bruises and diseases. Towards ripening on 6th and 8th day cushioning materials also influenced the percentage of marketability. Throughout the storage the fruits packed as fingers gave better results; than those packed as hands. This may be due to compactness. In hands the upper layer of fingers always exert its weight on the underlying lower layer of fingers and there is a high magnitude of bruising due to abrasion also.

Among the interaction effects of S x C, s_2c_2 combination was found the best and in S x F, s_2f_2. The C x F interaction gave the highest score on the 4th and 6th day in c_2f_2 (Table 8). In S x P interaction recorded the greatest score in s_2p_3 which the effect of packing materials on the banana form gave highest values in p_3f_2. In the P x C interaction best results were obtained from p_3c_1 (Table 9). Here the "SPCF" interaction also gave significantly high variations (Appendix VII).

5.2.3 Shelf-life of fruits

The results on the shelf-life of the fruits were influenced by the stages of maturity and the packing materials used. The stages of maturity indicated that mature green stage is more suited for long distant transit and for long duration of storage, than mature yellow stage. The ripe fruits obtained from the fruits harvested at internal colour break and external colour break stages exhibited the maximum shelf-life which was significantly longer than that exhibited by the fruits obtained at subsequent maturities. The least shelf-life corresponded to fruits harvested at 100 per cent colouration stage.

The packing materials had effective influence on the shelf-life of the fruits. Polyethylene covered tray packing gave highest shelf-life followed by plastic crates and then CFB. In CFB even with ventilation the exposure to atmosphere is less and with all the cushioning materials and the very corrugated fibre of its own structure hastened ripening. In case of plastic crates no covering of fruits with plastic or corrugated fibre is provided. The well perforated crates, open on top helps the fruits to get exposed to the varying atmospheric temperatures, thus slow ripening occurs. Apart from all these the vented polyethylene covered trays arrest all the metabolic activities to a particular stage so that ripening is cut short to that point which again increases the shelf-life of fruits.

Among the interaction effects, stages of maturity and packing material combination can provide best results on the shelf-life of the fruits. Here the best combination was observed in s_1p_3. Selection of packing and cushioning materials can also extend the shelf-life of fruits. In the present study tray packing of fruits with paper shreds as cushioning materials gave best combination for extending the shelf-life of fruits. The form of fruits packed and the cushioning material combination too proved to be significant.

Efficacy of polythene film packs has been reported to be of maximum importance in increasing the shelf-life of fruits like mandarine (Subbarao *et al.*, 1967), apple (Ryall and Uota, 1955) and sweet orange (Sadashivam *et al.*, 1973). Corroborating results were obtained by Khedkar *et al.* (1982) and Adsule and Tandon (1983); in pre-packing of fresh fruits in plastic bags to extend the shelf-life both at room temperature and cold storage.

Waskar and Roy (1996) stated that harvesting of bunches a few days before they reach full maturity, storing at reduced temperature, packing in film bags, pre-treatment with fungicide or chemicals or wax coating etc. can extend the shelf-life of banana.

5.2.4 Total soluble solids (TSS)

Varying levels of stages of maturity, packing materials and cushioning materials influenced the TSS of the fruits. The results showed that in stage two TSS was comparatively higher than that in stage one. The increase in TSS may be due to the breakdown of starch into sugars. In stage two as ripening progressed the percentage of both reducing and non-reducing sugars also increased which might have caused the hike in TSS.

In papaya fruits, the rise in TSS was related to the respiratory climacteric as observed by Veerannah and Selvaraj (1984). They reported that TSS rose and reached a value of 13 per cent at climacteric stage and the enhancement went on till two days after climacteric which later declined during post-climacteric life. Similar results were also obtained by Hulme *et al.* (1963), Maini *et al.* (1985) and Mahajan and Chopra (1994).

As ripening commences the breakdown of starch into simple sugars increases the TSS of fruits and a decrease in sugars and TSS occurs as ripening completes (This was reported by Adsule and Tandon, 1983; Dhoot *et al.*, 1984 and Vekatesha and Reddy, 1994).

Different packing materials also showed significant differences in the TSS of the fruit. TSS was found to increase progressively in all the packages during the storage life. As ripening was delayed in tray packing the minimum TSS was obtained in it and ripening was hastened in CFB and crates; and maximum TSS was obtained in these packing. If not drastic changes were not observed. This was in confirmity with the results of Barua *et al.* (1992). He did not find much difference in the TSS content of mandarine fruits after transportation in different packages to the distant markets. Significant difference were shown on the combined effect of packing and stages of maturity on the 8th day of storage. Increase in sugars during storage was due to degradation of polysaccharides into simple sugars by metabolic activities as reported by Naik *et al.* (1993). Rajamony *et al.* (1994) in an experiment with 27 banana clones of AAB group noticed a TSS variation of.22.0 per cent in mottapoovan to 30.0 per cent in kodapanillakunnan.

5.2.5 Degree of disease incidence

In case of all the pre-packaging treatments given to fruits, some extend of stalk end rot and black spot were observed. Black spot was found to be greater in stage two than in stage one. This may be attributed to the fact that in stage two the fruits are more ripe and soft for the infection of the spores. Among the packing materials tray packing gave considerably less incidence of black spot than that in CFB and crates. Banana packed as hands gave high infestation magnitude than those packed as fingers; which may be attributed to the spread through the internal peel tissues. The crown rot was found non-significant after the pre-packing dip in Bavistin as evident from Table 18.

Corroborative results were obtained by Paul Thomas *et al.* (1968). He reported that the fungicidal application at the cut ends can prevent stem end rot of banana during storage and transport. It also seals off the pores thus reducing moisture loss and entry of fungus organisms through the cut ends. Storage conditions also affected post-harvest losses. Fornaris-Rullan *et al.* (1990) reported that higher storage temperature caused some increase in anthracnose and stem end rot in mango.

5.2.6 Sensory quality

5.2.6.1 Physical evaluation of fruits

The appearance and colour of the fruits packed were effectively influenced by the packing materials used. In case of the appearance p_3 gave the best outlook whereas in case of colour p_2 gave the best result. The colour of the fruit was influenced by the form of banana packed. The best colour was given by the fruits packed as fingers.

Eskin *et al.* (1971) reported that the process of ripening is considered to be the start of senescence and the progress of senescence in plant material is accompanied by a number of changes, among which the most visible and significant is the loss of green colour (Chlorophyll) followed by the development of other characteristic colours. He also stated that the colour changes reach their full expression at the climacteric peak and are also accompanied by changes in fruit texture.

Among the interaction effects S x C interaction was highly significant for the appearance and colour of fruits, s_2c_2 was recorded as the best combination for both appearance and colour. In S x F interaction, s_2f_2 was found to be best combination on the colour of whole fruit of banana. The S x P interaction was significant for the cut fruit colour and appearance. Here s_2p_3 was found the best combination.

Among the packing material combinations P x C interaction was found significant for cut fruit appearance, whole-fruit appearance and whole fruit colour. The SPCF interaction were also significant for the cut fruit and whole fruit colour and whole fruit appearance.

The colour of the fruit in control $s_1p_0c_0f_1$ was found to be greater than that in packages especially tray packing. This may be due to the change in levels of respiration. In a study conducted by Adsule and Tandon (1983) the colour index score was found to be very low in polyethylene bagged fruits as compared to that in control. Similar observation was also made by Habeebunnisa (1971).

In the present investigation p_2 gave the best colour eventhough appearance was best in p_3. This may be due to the absence of covering material in p_2.

Hardenburg (1971) reported that throughout the storage period control fruits registered a higher colour index score, reflecting a high rate of respiration whereas, slow colour development in polyethylene packed fruits may be due to the beneficial modified atmosphere developed by increased carbondioxide and low oxygen within package which helps to retard ageing.

These findings are in line with the results obtained by Bhullar and Formahan (1980) in guava; Stead and Chithambara (1980) in mango; Krishnamurthy and Kushalappa (1985) in banana.

5.2.6.2 Organoleptic evaluation of banana

The sweetness, flavour, firmness and over-all acceptability was highly significant with the packing materials. The package p_3 was found to be best among the package on the organoleptic qualities of the fruit.

Among the interaction effects S x C was found to be significant to all the characters; whereas S x P, P x F and P x C were significant for sweetness only. For flavours P x F was significant while P x C was significant for the firmness. S x P and P x C were found significant for the texture of the fruit. The 'SPCF' interaction was found to be significant for sweetness, flavours and firmness.

Sweetness increased in all the cases as the breakdown of starch to sugar occurred at various stages of ripening.

In the case of flavours, as the fruit ripens, the specific flavour and aroma are imparted around them; due to the presence of certain esters of aliphatic alcohols and short chained fatty acids. Except for some fruits like banana in which the volatile component is isoamyl acetate. Some specific terpenoid compounds could be responsible for the odour emitted by some varieties of banana, mango and papaya (Matto *et al.*, 1975).

Whatever be the nature of the volatile compounds evolved by the fruits at the on set of ripening, the development of a pleasant flavour involves decrease in acidity with corresponding increase in sugar content as reported by Eskin *et al.* (1971).

Ueda *et al.* (1971) showed that the development of aroma in banana during ripening was aided by an ester forming enzyme.

A significant feature occurring during ripening of fruit is softness of the tissues. As the fruit proceeds towards ripening, there will be a progressive decrease in the firmness of fruit. This was attributed to the disintegration and collapse of pulp tissues due to dissolution of cell wall and middle lamella by the action of hydrolyzing enzyme. Similar results were obtained by Hulme (1958) and Anon. (1967).

Mc Cready and Mc Comb (1954) reported that they could not observe this enzyme activity in unripe and mature fruits of pears and avocado.

Kidd *et al.* (1951) reported that the decrease in firmness was attributed to breakdown of starch and pectin mainly responsible for firmness of fruit. Bartley and Knee (1982) observed that the decrease might be due to increase in soluble pectin and decrease in insoluble pectin.

Significant differences were noticed between the packed and control fruits for their overall organoleptic qualities. The control fruits recorded low scores resulting in decrease in firmness and dull appearance. The tray packed/polyethylene bagged fruits retained better qualities. Similar results were also recorded by Adsule and Tandon (1983) and Singh (1988).

5.2.7 Sugars

Reducing, non-reducing and total sugars were affected by the various stages of maturity, packing materials and cushioning materials used. In all the cases stage two showed increased rate of sugars than in stage one. A continuous and consistent increasing trend in sugars was found throughout the storage period of progressive maturity of the fruits. Among the packing materials the highest level of all these sugars were found in p_1, followed by p_2. p_3 gave lowest levels of sugars. In all these packages also a continuous increase in sugars were noted. In case of cushioning materials c_1 gave better results than c_2.

All these sugars viz., total, reducing and non-reducing were found significantly correlated with the quality of ripe fruits such that considering the contents of these sugars as one of the indices of maturity is suggested useful by Lodh *et al.* (1971) and Pantastico (1975).

The quality analysis by Rajeevan (1985) showed significant differences in TSS, total sugars and reducing sugars among the accessions of 'Palayankodan'. Later in a quality variation study in the 24 accessions of the clone of Palayankodan, Rajeevan and Mohankumaran (1993) observed a TSS of 22 to 26.17 degree brix, total sugars of 16.41 to 17.40 per cent, reducing sugars of 15.5 to 17.8 per cent and non-reducing sugars of 0.14 to 0.27 per cent.

Hittalmani (1986) reported that during the period of maturation from green to fully yellow stage, the reducing sugars surpassed the non-reducing sugars and the total sugar content was more than double in papaya.

Ram *et al.* (1994) reported the quality variation of the table varieties of banana to be 15.1-16.15 per cent for TSS, 0.22-0.37 per cent for acidity and 14.1-14.3 per cent for total sugars.

5.2.8 Acidity

The varying levels of maturity, different packing materials and cushioning materials showed significant difference in the acidity of fruits. The acidity was found to decrease continuously in all packages during the storage period. The stage one recorded greater acidity than stage two. This may be due to ripening that stage two recorded less acidity. This result can be substantiated by Matto (1969), who reported that ascorbic acid content of ripe fruits was reduced less than half of its original content before the onset of ripening in climacteric fruits like banana, pineapple, mango etc. Similar results were reported by Harding and Hatton (1967), Modi and Reddy (1967), Pantastico (1975), Bharati (1983).

Chittiraichelvan *et al.* (1984) have remarked that the decrease in the acid content could be due to there utilization during respiration in the ripening fruits and at climacteric stage, the lowest acidity was recorded.

Among the packages p_3 gave highest acidity followed by p_1 and p_2. The highest acidity in p_3 may be attributed to the slow ripening in the package. On the sixth day cushioning material c_2 showed significant influence on acidity than c_1.

The interaction of stages and packing materials also showed effectiveness on the acidity. The best combination was recorded in s_2p_2 as it gave the lowest acidity value. The S x C interaction was also effective. Here s_2c_2 gave the best effect on acidity.

The rate of decrease in titrable acidity was more in control fruits, where it was reduced to 50 per cent while retention of acid content was more in polyethylene packed fruits. These findings are in general agreement with the findings of Khedkar *et al.* (1982) and Tandon *et al.* (1984).

5.2.9 Sugar acid ratio

The sugar acid ratio of ripe banana was significantly influenced by the stages of maturity, packing and cushioning materials. Better results was observed in stage two than in stage one. Here also the ratio increased with the storage period. Among the packages used p_1 gave the highest sugar acid ratio followed by p_2 and p_3. Among the cushioning materials c_1 was found better than c_2 in influencing the sugar acid ratio.

Among the interaction effects S x P and S x C were found significantly different. s_2p_1 was the best treatment combination among the S x P interactions and s_2c_2 the best among the S x C interactions.

Magdaline and Sreenarayana (1999) reported that in banana packed under all package environment, the sugar acid ratio increased as storage progressed. This increasing trend of sugar and titrable acidity was also reported by Firmin (1991) for banana.

5.2.10 Physiological loss of weight (PLW)

The results are on the varying stage of maturity on the PLW of banana showed significant variation. It has been observed that the magnitude of PLW was comparatively higher in stage two than in stage one. This can be attributed to the increase in respiratory climacteric during the ripening phase. In stage two, since the hands are packed at mature yellow stage ripening occurs earlier than in those hands packed at mature green stage. As ripening increases, hydrolysis of starch, hemicelluloses and cellulose occurs by way of high rate of respiration (Leopold, 1964).

Among the various packing materials used, significant difference was recorded on the effect of PLW. Fruits stored in trays covered with 0.4 per cent vented polyethylene bags registered minimum loss of weight followed by CFB and plastic crates. Maximum loss was observed in control. Higher moisture loss in control can be attributed to more respiration, transpiration and absence of any physical barrier. This was in conformity with the results obtained by Adsule and Tandon (1983).

The reduction in PLW when the fruits were enclosed in thick bags with lower ventilation could be related to reduced gaseous exchange inside the bag thus, evaporation, transpiration as well as physiological activities like respiration are drastically cut down resulting in reduced PLW. This result testify the result reported by Crosby (1981).

The thickness of polyethylene bags and cumulative PLW were inversely proportional. The check in PLW may be attributed to reduced level of transpiration and respiration. Venkatesha and Reddy (1994) reported that packing of fruits in polyethylene bags had remarkable effect on reducing the PLW compared to control fruits in guava, thus confirming the study. Similar results were also obtained by Bhullar and Farmahal (1980), Habeebunnisa (1971) and Ramana *et al.* (1989).

Fruits packed in perforated plastic crates recorded higher magnitude of PLW among the three packages used. When compared to other packages in crates the fruits are subjected to external atmosphere greatly. Thus loss of water through transpiration and evaporation (in case of high atmospheric temperature) ultimately increase the PLW. A higher PLW is therefore an undesirable feature commercially, as it leads to large prediction in bunch weight during ripening as reported by Biale (1975) and Shivashankara (1999).

SUMMARY

- Shelf life was found greater in stage one and p_3 (tray) package.

- Storage studies revealed that the TSS, reducing sugar, non-reducing sugar and total sugars increased gradually as ripening progressed.

- TSS was found higher at stage 2, when packed in p_2 with c_2 as cushioning material.

- Black spot and crown rot affected the banana in storage of which the magnitude of incidence was greater in black spot.

- The package p_3 gave the best results on the physical evaluation and the over-all acceptability of organoleptic qualities of the fruits.

- Reducing sugars, total sugars and non-reducing sugars were found high in stage 2, within p_1 as packaging material and c_1 as cushioning material.

- Acidity showed a decreasing trend during storage. Here stage two with packing material p_2 was suitable.

- Sugar acid ratio also gave an increasing trend and was found best in p_1 package at s_2 stage with c_1 cushioning material.

- Physiological loss of weight increased with ripening and highest loss was found in banana packed as hands i.e., stage 2 in p_2 package with c_2 cushioning material.

6. SUMMARY

An investigation entitled " Post-harvest handling in *Musa* AAB group var. Nendran", the most commercial fruit crop of Kerala, was carried out at the Department of Processing technology, College of Agriculture, Vellayani during 1999 - 2000. Studies were conducted to find out the effects of various packaging materials and transportation on the shelf life and quality of "Nendran" during storage.

The mature fruits packed at two different stages of maturity in three different packing materials with two different cushioning materials as hands and fingers were transported over a distance of 20 Km to study the effect of package and transportation on the storage and ripening of fruits.

The salient features of the results obtained are summarized below.

- The transportational effect was assessed as the resistance to surface injuries. Highest resistance to injuries were observed at stage 1 within tray packaging.
- Marketability of fruits after transportation gave cent percent marketability for fruits in package than those in control.
- In the duration of ripening, stage one gave higher green life in p_3 package than the yellow life. The highest duration of ripening in yellow life was found at stage 1 and p_2 package.
- Highest percentage of marketability after ripening was observed in stage one with p_3 package and c_2 cushioning material. Fruits packed as fingers in the above said condition gave high marketability.

- Shelf life was found greater in stage one and p_3 (tray) package.

- Storage studies revealed that the TSS, reducing sugar, non-reducing sugar and total sugars increased gradually as ripening progressed.

- TSS was found higher at stage 2, when packed in p_2 with c_2 as cushioning material.

- Black spot and crown rot affected the banana in storage of which the magnitude of incidence was greater in black spot.

- The package p_3 gave the best results on the physical evaluation and the over-all acceptability of organoleptic qualities of the fruits.

- Reducing sugars, total sugars and non-reducing sugars were found high in stage 2, within p_1 as packaging material and c_1 as cushioning material.

- Acidity showed a decreasing trend during storage. Here stage two with packing material p_2 was suitable.

- Sugar acid ratio also gave an increasing trend and was found best in p_1 package at s_2 stage with c_1 cushioning material.

- Physiological loss of weight increased with ripening and highest loss was found in banana packed as hands i.e., stage 2 in p_2 package with c_2 cushioning material.

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* Original not seen

APPENDICES

APPENDIX – I

Score card for assessing the extend of resistance to surface injuries

Description	Scores	A	B	C	D	E	F	G	H	I	J	K	L
		$A_1A_2A_3$	$B_1B_2B_3$	$C_1C_2C_3$	$D_1D_2D_3$	$E_1E_2E_3$	$F_1F_2F_3$	$G_1G_2G_3$	$H_1H_2H_3$	$I_1I_2I_3$	$J_1J_2J_3$	$K_1K_2K_3$	$L_1L_2L_3$
Bruise / scratch injury													
Nil to 10 %	5												
10 to 25 %	4												
25 to 50 %	3												
50 to 75 %	2												
75 to 100 %	1												
Pressure injury													
Nil to 10 %	5												
10 to 25 %	4												
25 to 50 %	3												
50 to 75 %	2												
75 to 100 %	1												
Cut injury													
Nil to 10 %	5												
10 to 25 %	4												
25 to 50 %	3												
50 to 75 %	2												
75 to 100 %	1												

Name :
Date :
Time :

APPENDIX – II

Score card for assessing the degree of disease incidence

Description	Scores	A	B	C	D	E	F	G	H	I	J	K	L
		$A_1A_2A_3$	$B_1B_2B_3$	$C_1C_2C_3$	$D_1D_2D_3$	$E_1E_2E_3$	$F_1F_2F_3$	$G_1G_2G_3$	$H_1H_2H_3$	$I_1I_2I_3$	$J_1J_2J_3$	$K_1K_2K_3$	$L_1L_2L_3$
Black spot													
Nil to 10 %	0												
10 to 20 %	1												
20 to 40 %	2												
40 to 60 %	3												
60 to 80 %	4												
80 to 100 %	5												
Crown rot													
Nil to 10 %	0												
10 to 20 %	1												
20 to 40 %	2												
40 to 60 %	3												
60 to 80 %	4												
80 to 100 %	5												

Name :
Date :
Time :

APPENDIX – III

Score card for the physical evaluation of fruits

Description	Scores	A	B	C	D	E	F	G	H	I	J	K	L
		$A_1A_2A_3$	$B_1B_2B_3$	$C_1C_2C_3$	$D_1D_2D_3$	$E_1E_2E_3$	$F_1F_2F_3$	$G_1G_2G_3$	$H_1H_2H_3$	$I_1I_2I_3$	$J_1J_2J_3$	$K_1K_2K_3$	$L_1L_2L_3$
Whole fruit appearance													
Excellent	5												
Good	4												
Satisfactory	3												
Fair	2												
Poor	1												
Cut fruit appearance													
Excellent	5												
Good	4												
Satisfactory	3												
Fair	2												
Poor	1												
Whole fruit colour													
Excellent	5												
Good	4												
Satisfactory	3												
Fair	2												
Poor	1												
Cut fruit colour													
Excellent	5												
Good	4												
Satisfactory	3												
Fair	2												
Poor	1												

Name :

Date :

Time :

APPENDIX – IV

Score card for the organoleptic evaluation of fruits

Description	Scores	A	B	C	D	E	F	G	H	I	J	K	L
		$A_1A_2A_3$	$B_1B_2B_3$	$C_1C_2C_3$	$D_1D_2D_3$	$E_1E_2E_3$	$F_1F_2F_3$	$G_1G_2G_3$	$H_1H_2H_3$	$I_1I_2I_3$	$J_1J_2J_3$	$K_1K_2K_3$	$L_1L_2L_3$
Sweetness													
Excellent	5												
Good	4												
Satisfactory	3												
Fair	2												
Poor	1												
Flavour													
Excellent	5												
Good	4												
Satisfactory	3												
Fair	2												
Poor	1												
Texture													
Excellent	5												
Good	4												
Satisfactory	3												
Fair	2												
Poor	1												
Firmness													
Excellent	5												
Good	4												
Satisfactory	3												
Fair	2												
Poor	1												
Overall acceptability													
Excellent	5												
Good	4												
Satisfactory	3												
Fair	2												
Poor	1												

Name :
Date :
Time :

APPENDIX - V

Type and extent of the resistance to surface injuries

Interaction	Scratch Injury	Pressure Injury	Cut Injury
$s_1p_1c_1f_1$	48.00	42.67	49.67
$s_1p_1c_1f_2$	48.67	39.33	49.33
$s_1p_1c_2f_1$	49.33	41.67	49.33
$s_1p_1c_2f_2$	48.67	40.67	49.33
$s_1p_2c_1f_1$	46.00	38.67	49.33
$s_1p_2c_1f_2$	45.33	39.67	49.00
$s_1p_2c_2f_1$	45.67	40.33	49.00
$s_1p_2c_2f_2$	46.33	41.00	50.00
$s_1p_3c_1f_1$	48.33	47.67	49.67
$s_1p_3c_1f_2$	49.67	46.33	50.00
$s_1p_3c_2f_1$	49.67	47.67	49.33
$s_1p_3c_2f_2$	48.67	47.00	49.67
$s_2p_1c_1f_1$	45.00	39.00	49.00
$s_2p_1c_1f_2$	46.33	37.33	49.67
$s_2p_1c_2f_1$	44.00	40.33	49.00
$s_2p_1c_2f_2$	46.33	40.00	48.67
$s_2p_2c_1f_1$	44.67	39.00	49.33
$s_2p_2c_1f_2$	45.00	36.67	49.00
$s_2p_2c_2f_1$	45.33	40.67	49.33
$s_2p_2c_2f_2$	45.33	39.00	48.67
$s_2p_3c_1f_1$	47.67	47.00	50.00
$s_2p_3c_1f_2$	47.67	48.67	50.00
$s_2p_3c_2f_1$	47.67	48.00	50.00
$s_2p_3c_2f_2$	47.67	48.33	50.00
$s_1p_0c_0f_1$	45.00	38.00	44.33
$s_1p_0c_0f_2$	41.33	37.66	49.67
$s_2p_0c_0f_1$	43.00	37.66	49.33
$s_2p_0c_0f_2$	43.67	36.67	49.67
F	<1	<1	<1

APPENDIX - VI

Duration of ripening

Interaction	Green Life	Yellow Life
$s_1p_1c_1f_1$	4.00	4.33
$s_1p_1c_1f_2$	5.67	5.00
$s_1p_1c_2f_1$	6.67	4.33
$s_1p_1c_2f_2$	5.67	5.00
$s_1p_2c_1f_1$	5.00	7.00
$s_1p_2c_1f_2$	5.00	5.33
$s_1p_2c_2f_1$	6.67	5.33
$s_1p_2c_2f_2$	7.00	4.67
$s_1p_3c_1f_1$	10.00	4.67
$s_1p_3c_1f_2$	11.67	4.67
$s_1p_3c_2f_1$	11.67	4.67
$s_1p_3c_2f_2$	8.67	4.33
$s_2p_1c_1f_1$	4.00	4.67
$s_2p_1c_1f_2$	4.67	4.33
$s_2p_1c_2f_1$	6.00	4.33
$s_2p_1c_2f_2$	5.00	4.33
$s_2p_2c_1f_1$	5.67	4.67
$s_2p_2c_1f_2$	7.00	4.33
$s_2p_2c_2f_1$	5.67	5.00
$s_2p_2c_2f_2$	7.00	4.33
$s_2p_3c_1f_1$	9.00	3.67
$s_2p_3c_1f_2$	8.67	4.33
$s_2p_3c_2f_1$	7.33	4.00
$s_2p_3c_2f_2$	7.33	3.67
$s_1p_0c_0f_1$	4.33	4.00
$s_1p_0c_0f_2$	5.00	3.67
$s_2p_0c_0f_1$	3.67	3.67
$s_2p_0c_0f_2$	3.67	3.33
F	2.50	<1

APPENDIX – VII

Percentage of marketable fruits

Interaction	4th day	6th day	8th day
$s_1p_1c_1f_1$	87.50	75.19	60.78
$s_1p_1c_1f_2$	95.83	83.33	70.67
$s_1p_1c_2f_1$	91.66	75.00	50.00
$s_1p_1c_2f_2$	83.30	70.67	62.50
$s_1p_2c_1f_1$	91.66	87.50	79.16
$s_1p_2c_1f_2$	100.00	91.66	83.33
$s_1p_2c_2f_1$	95.83	83.33	75.00
$s_1p_2c_2f_2$	95.83	91.66	87.50
$s_1p_3c_1f_1$	91.66	87.50	87.50
$s_1p_3c_1f_2$	100.00	95.83	91.66
$s_1p_3c_2f_1$	87.50	83.33	83.33
$s_1p_3c_2f_2$	95.83	91.66	91.66
$s_2p_1c_1f_1$	83.33	75.00	50.00
$s_2p_1c_1f_2$	95.83	83.33	62.50
$s_2p_1c_2f_1$	87.50	79.16	58.33
$s_2p_1c_2f_2$	95.83	87.50	75.00
$s_2p_2c_1f_1$	83.33	58.33	45.83
$s_2p_2c_1f_2$	91.66	79.16	58.33
$s_2p_2c_2f_1$	91.66	83.33	79.16
$s_2p_2c_2f_2$	95.83	91.66	83.33
$s_2p_3c_1f_1$	95.83	87.50	83.33
$s_2p_3c_1f_2$	100.00	95.83	91.66
$s_2p_3c_2f_1$	100.00	91.66	83.33
$s_2p_3c_2f_2$	100.00	100.00	91.66
$s_1p_0c_0f_1$	83.30	58.33	45.83
$s_1p_0c_0f_2$	87.56	62.50	45.83
$s_2p_0c_0f_1$	75.00	58.33	37.50
$s_2p_0c_0f_2$	87.50	62.53	58.33
F	5.47 **	19.47 **	5.48 **
SE	1.263	1.173	1.408
CD	3.579	3.323	3.990

APPENDIX – VIII

Shelf life of fruits

Interaction	Shelf Life
$s_1p_1c_1f_1$	8.33
$s_1p_1c_1f_2$	10.67
$s_1p_1c_2f_1$	11.00
$s_1p_1c_2f_2$	10.67
$s_1p_2c_1f_1$	12.00
$s_1p_2c_1f_2$	10.33
$s_1p_2c_2f_1$	12.00
$s_1p_2c_2f_2$	11.67
$s_1p_3c_1f_1$	14.67
$s_1p_3c_1f_2$	16.33
$s_1p_3c_2f_1$	16.33
$s_1p_3c_2f_2$	13.00
$s_2p_1c_1f_1$	7.33
$s_2p_1c_1f_2$	9.00
$s_2p_1c_2f_1$	10.33
$s_2p_1c_2f_2$	9.33
$s_2p_2c_1f_1$	10.33
$s_2p_2c_1f_2$	11.67
$s_2p_2c_2f_1$	10.67
$s_2p_2c_2f_2$	11.33
$s_2p_3c_1f_1$	12.67
$s_2p_3c_1f_2$	13.00
$s_2p_3c_2f_1$	11.33
$s_2p_3c_2f_2$	11.00
$s_1p_0c_0f_1$	8.33
$s_1p_0c_0f_2$	8.67
$s_2p_0c_0f_1$	5.67
$s_2p_0c_0f_2$	6.33
F	2.39

APPENDIX - IX

TSS

Interaction	2nd day	4th day	6th day	8th day
$s_1p_1c_1f_1$	22.33	23.33	24.67	25.00
$s_1p_1c_1f_2$	21.67	22.67	23.67	24.67
$s_1p_1c_2f_1$	22.67	23.67	25.00	25.67
$s_1p_1c_2f_2$	22.33	23.67	24.67	25.33
$s_1p_2c_1f_1$	22.33	24.33	25.33	25.67
$s_1p_2c_1f_2$	22.67	24.00	25.00	26.00
$s_1p_2c_2f_1$	22.33	24.00	25.00	26.00
$s_1p_2c_2f_2$	22.67	24.00	25.00	25.67
$s_1p_3c_1f_1$	21.67	22.67	24.00	25.00
$s_1p_3c_1f_2$	21.67	23.00	24.33	25.00
$s_1p_3c_2f_1$	22.67	23.67	24.67	25.33
$s_1p_3c_2f_2$	22.00	23.33	24.33	25.33
$s_2p_1c_1f_1$	23.67	25.00	26.00	26.67
$s_2p_1c_1f_2$	23.33	24.67	25.67	26.67
$s_2p_1c_2f_1$	23.33	24.67	26.00	27.33
$s_2p_1c_2f_2$	24.00	25.67	26.67	27.67
$s_2p_2c_1f_1$	23.33	24.67	26.00	26.67
$s_2p_2c_1f_2$	23.00	24.67	26.00	27.00
$s_2p_2c_2f_1$	23.67	25.33	26.33	27.67
$s_2p_2c_2f_2$	23.67	25.00	26.00	27.67
$s_2p_3c_1f_1$	22.67	23.67	25.00	26.00
$s_2p_3c_1f_2$	23.33	24.33	25.33	26.00
$s_2p_3c_2f_1$	23.33	24.67	25.67	26.33
$s_2p_3c_2f_2$	23.00	24.67	25.67	26.33
$s_1p_0c_0f_1$	22.67	23.67	25.33	26.67
$s_1p_0c_0f_2$	22.00	23.00	24.67	26.00
$s_2p_0c_0f_1$	23.67	25.67	27.33	28.00
$s_2p_0c_0f_2$	24.33	25.67	27.00	27.67
F	<1	<1	<1	<1

APPENDIX - X

Degree of disease incidence

Interaction	Black spot	Crown rot
$s_1p_1c_1f_1$	8.00	1.50
$s_1p_1c_1f_2$	4.50	1.00
$s_1p_1c_2f_1$	5.50	0.50
$s_1p_1c_2f_2$	6.00	1.00
$s_1p_2c_1f_1$	6.00	0.50
$s_1p_2c_1f_2$	3.00	2.00
$s_1p_2c_2f_1$	5.00	1.00
$s_1p_2c_2f_2$	4.00	1.00
$s_1p_3c_1f_1$	3.00	0.00
$s_1p_3c_1f_2$	2.00	1.50
$s_1p_3c_2f_1$	3.50	2.00
$s_1p_3c_2f_2$	2.50	0.00
$s_2p_1c_1f_1$	9.00	2.50
$s_2p_1c_1f_2$	6.00	1.00
$s_2p_1c_2f_1$	8.00	1.50
$s_2p_1c_2f_2$	7.50	1.00
$s_2p_2c_1f_1$	9.50	1.00
$s_2p_2c_1f_2$	7.00	1.50
$s_2p_2c_2f_1$	8.50	0.50
$s_2p_2c_2f_2$	5.00	1.50
$s_2p_3c_1f_1$	5.50	1.50
$s_2p_3c_1f_2$	4.50	0.50
$s_2p_3c_2f_1$	4.50	1.00
$s_2p_3c_2f_2$	3.00	0.50
$s_1p_0c_0f_1$	9.00	3.00
$s_1p_0c_0f_2$	9.50	3.50
$s_2p_0c_0f_1$	10.50	3.50
$s_2p_0c_0f_2$	11.50	4.50
F	<1	1.19

APPENDIX - XI

Physical evaluation of fruits

Interaction	Whole fruit appearance	Cut fruit appearance	Whole fruit colour	Cut fruit colour
$s_1p_1c_1f_1$	37.33	40.33	35.33	36.33
$s_1p_1c_1f_2$	40.00	35.33	47.00	42.00
$s_1p_1c_2f_1$	40.00	39.00	28.00	34.00
$s_1p_1c_2f_2$	33.33	39.33	36.67	38.33
$s_1p_2c_1f_1$	42.67	37.00	48.67	39.33
$s_1p_2c_1f_2$	34.67	39.00	35.00	37.67
$s_1p_2c_2f_1$	32.33	33.67	27.67	34.33
$s_1p_2c_2f_2$	38.33	37.00	39.00	38.00
$s_1p_3c_1f_1$	37.33	44.00	33.67	43.67
$s_1p_3c_1f_2$	40.67	39.67	35.67	34.00
$s_1p_3c_2f_1$	34.33	34.67	26.67	35.67
$s_1p_3c_2f_2$	43.33	41.67	45.67	34.67
$s_2p_1c_1f_1$	28.67	29.67	25.33	31.33
$s_2p_1c_1f_2$	29.00	31.67	26.33	32.00
$s_2p_1c_2f_1$	38.33	41.33	48.67	37.67
$s_2p_1c_2f_2$	40.00	36.33	38.67	43.00
$s_2p_2c_1f_1$	40.67	36.67	31.33	38.00
$s_2p_2c_1f_2$	35.33	40.67	39.00	38.67
$s_2p_2c_2f_1$	44.00	38.00	42.00	40.67
$s_2p_2c_2f_2$	36.67	37.00	36.67	39.33
$s_2p_3c_1f_1$	34.33	37.67	29.67	36.33
$s_2p_3c_1f_2$	39.33	39.33	40.67	40.00
$s_2p_3c_2f_1$	36.67	42.33	35.00	46.33
$s_2p_3c_2f_2$	42.33	41.67	34.33	36.33
$s_1p_0c_0f_1$	35.00	36.67	27.33	37.33
$s_1p_0c_0f_2$	44.00	40.67	48.00	35.33
$s_2p_0c_0f_1$	32.33	34.67	29.00	35.67
$s_2p_0c_0f_2$	31.67	34.67	33.00	33.33
F	3.57 *	<1	12.07 **	8.92 **
SE	2.507	-	1.562	1.679
CD	7.105	-	4.427	4.757

APPENDIX – XII

Organoleptic evaluation of fruits

Interaction	Sweetness	Flavour	Texture	Firmness	Over all Acceptability
$s_1p_1c_1f_1$	28.33	38.33	35.67	39.67	39.33
$s_1p_1c_1f_2$	36.00	33.00	37.00	38.00	33.67
$s_1p_1c_2f_1$	36.67	29.67	40.33	39.33	36.33
$s_1p_1c_2f_2$	40.00	34.33	33.33	37.33	35.33
$s_1p_2c_1f_1$	26.33	26.33	39.33	39.00	38.33
$s_1p_2c_1f_2$	33.67	33.00	35.00	35.33	33.33
$s_1p_2c_2f_1$	35.67	31.00	32.67	36.67	35.67
$s_1p_2c_2f_2$	31.67	31.33	35.00	37.33	33.00
$s_1p_3c_1f_1$	45.00	41.00	41.33	40.00	41.00
$s_1p_3c_1f_2$	31.33	33.67	36.33	36.67	34.67
$s_1p_3c_2f_1$	39.00	33.33	36.00	38.67	35.00
$s_1p_3c_2f_2$	37.67	39.00	38.00	40.33	36.67
$s_2p_1c_1f_1$	29.67	32.33	29.67	33.33	31.00
$s_2p_1c_1f_2$	28.33	28.00	31.67	33.67	33.67
$s_2p_1c_2f_1$	27.00	40.33	38.67	40.67	41.33
$s_2p_1c_2f_2$	37.00	34.00	39.33	39.33	35.00
$s_2p_2c_1f_1$	37.67	30.00	40.67	41.00	37.67
$s_2p_2c_1f_2$	42.00	35.33	35.67	39.00	33.67
$s_2p_2c_2f_1$	28.00	27.00	41.00	37.33	40.00
$s_2p_2c_2f_2$	36.67	37.00	36.67	37.67	35.67
$s_2p_3c_1f_1$	36.33	35.00	31.33	39.33	39.00
$s_2p_3c_1f_2$	34.33	36.00	36.33	39.67	35.67
$s_2p_3c_2f_1$	47.00	41.00	43.00	42.67	44.00
$s_2p_3c_2f_2$	33.00	37.67	38.33	39.67	38.00
$s_1p_0c_0f_1$	41.33	36.00	37.67	38.00	38.00
$s_1p_0c_0f_2$	38.33	40.33	39.33	44.00	40.00
$s_2p_0c_0f_1$	29.67	29.00	34.67	32.00	29.33
$s_2p_0c_0f_2$	31.67	32.00	36.33	31.33	31.00
F	23.83 **	8.24 **	4.87 *	<1	1.65
SE	1.673	1.855	1.899	-	-
CD	4.740	5.257	5.383	-	-

APPENDIX - XIII

Reducing sugar

Interaction	2nd day	4th day	6th day	8th day
$s_1p_1c_1f_1$	15.49	15.65	15.81	15.99
$s_1p_1c_1f_2$	15.45	15.59	15.75	15.65
$s_1p_1c_2f_1$	15.33	15.47	15.63	15.80
$s_1p_1c_2f_2$	15.43	15.52	15.66	15.79
$s_1p_2c_1f_1$	14.71	14.82	14.94	15.07
$s_1p_2c_1f_2$	14.60	14.73	14.89	15.00
$s_1p_2c_2f_1$	14.44	14.60	14.73	14.84
$s_1p_2c_2f_2$	14.49	14.57	14.86	14.99
$s_1p_3c_1f_1$	13.53	13.66	13.75	13.87
$s_1p_3c_1f_2$	13.54	13.69	13.89	14.02
$s_1p_3c_2f_1$	13.44	13.60	13.73	13.85
$s_1p_3c_2f_2$	13.49	13.61	13.79	13.88
$s_2p_1c_1f_1$	15.81	15.95	16.13	16.29
$s_2p_1c_1f_2$	15.82	15.98	16.13	16.27
$s_2p_1c_2f_1$	15.69	15.86	16.07	16.20
$s_2p_1c_2f_2$	15.72	15.88	16.05	16.22
$s_2p_2c_1f_1$	14.87	15.05	15.26	15.39
$s_2p_2c_1f_2$	14.90	15.07	15.24	15.41
$s_2p_2c_2f_1$	14.71	14.94	14.78	15.28
$s_2p_2c_2f_2$	14.61	14.76	14.93	15.06
$s_2p_3c_1f_1$	13.89	14.02	14.14	14.23
$s_2p_3c_1f_2$	13.95	14.08	14.19	14.31
$s_2p_3c_2f_1$	13.70	13.81	13.94	14.10
$s_2p_3c_2f_2$	13.70	13.84	14.00	14.12
$s_1p_0c_0f_1$	15.63	15.88	16.09	16.20
$s_1p_0c_0f_2$	15.54	15.78	15.99	16.10
$s_2p_0c_0f_1$	16.04	16.28	16.47	16.58
$s_2p_0c_0f_2$	16.01	16.25	16.44	16.58
F	<1	<1	<1	1.29

APPENDIX - XIV

Non-reducing sugar

Interaction	2nd day	4th day	6th day	8th day
$s_1p_1c_1f_1$	0.16	0.18	0.20	0.21
$s_1p_1c_1f_2$	0.18	0.20	0.22	0.23
$s_1p_1c_2f_1$	0.17	0.19	0.21	0.22
$s_1p_1c_2f_2$	0.16	0.18	0.19	0.21
$s_1p_2c_1f_1$	0.15	0.17	0.19	0.21
$s_1p_2c_1f_2$	0.15	0.17	0.18	0.20
$s_1p_2c_2f_1$	0.16	0.18	0.19	0.21
$s_1p_2c_2f_2$	0.15	0.17	0.19	0.21
$s_1p_3c_1f_1$	0.15	0.17	0.18	0.19
$s_1p_3c_1f_2$	0.15	0.17	0.18	0.20
$s_1p_3c_2f_1$	0.14	0.15	0.17	0.19
$s_1p_3c_2f_2$	0.14	0.16	0.18	0.19
$s_2p_1c_1f_1$	0.17	0.19	0.22	0.24
$s_2p_1c_1f_2$	0.18	0.20	0.23	0.25
$s_2p_1c_2f_1$	0.19	0.21	0.23	0.25
$s_2p_1c_2f_2$	0.19	0.22	0.23	0.26
$s_2p_2c_1f_1$	0.18	0.19	0.21	0.22
$s_2p_2c_1f_2$	0.17	0.19	0.20	0.21
$s_2p_2c_2f_1$	0.18	0.19	0.21	0.22
$s_2p_2c_2f_2$	0.17	0.19	0.20	0.21
$s_2p_3c_1f_1$	0.17	0.18	0.20	0.21
$s_2p_3c_1f_2$	0.17	0.18	0.20	0.21
$s_2p_3c_2f_1$	0.11	0.18	0.19	0.21
$s_2p_3c_2f_2$	0.16	0.17	0.19	0.20
$s_1p_0c_0f_1$	0.22	0.23	0.25	0.26
$s_1p_0c_0f_2$	0.22	0.23	0.25	0.26
$s_2p_0c_0f_1$	0.24	0.25	0.26	0.27
$s_2p_0c_0f_2$	0.23	0.24	0.25	0.27
F	<1	<1	1.49	<1

APPENDIX – XV

Total sugars

Interaction	2nd day	4th day	6th day	8th days
$s_1p_1c_1f_1$	15.65	15.83	16.01	16.20
$s_1p_1c_1f_2$	15.63	15.79	15.96	16.18
$s_1p_1c_2f_1$	15.50	15.66	15.84	16.02
$s_1p_1c_2f_2$	15.59	15.70	15.85	16.00
$s_1p_2c_1f_1$	14.86	14.99	15.13	15.28
$s_1p_2c_1f_2$	14.75	14.90	15.06	15.20
$s_1p_2c_2f_1$	14.60	14.77	14.92	15.05
$s_1p_2c_2f_2$	14.64	14.83	15.05	15.20
$s_1p_3c_1f_1$	13.68	13.83	13.93	14.07
$s_1p_3c_1f_2$	13.68	13.85	14.07	14.22
$s_1p_3c_2f_1$	13.57	13.75	13.90	14.03
$s_1p_3c_2f_2$	13.63	13.77	13.97	14.07
$s_2p_1c_1f_1$	15.98	16.14	16.35	16.53
$s_2p_1c_1f_2$	16.00	16.18	16.36	16.52
$s_2p_1c_2f_1$	15.88	16.07	16.30	16.45
$s_2p_1c_2f_2$	15.91	16.10	16.28	16.48
$s_2p_2c_1f_1$	15.05	15.24	15.47	15.61
$s_2p_2c_1f_2$	15.07	15.25	15.44	15.62
$s_2p_2c_2f_1$	14.93	15.14	15.32	15.50
$s_2p_2c_2f_2$	14.78	14.95	15.13	15.28
$s_2p_3c_1f_1$	14.09	14.20	14.34	14.44
$s_2p_3c_1f_2$	14.12	14.26	14.39	14.52
$s_2p_3c_2f_1$	13.86	13.98	14.14	14.31
$s_2p_3c_2f_2$	13.86	14.02	14.19	14.32
$s_1p_0c_0f_1$	15.85	16.11	16.33	16.46
$s_1p_0c_0f_2$	15.76	16.02	16.24	16.36
$s_2p_0c_0f_1$	16.28	16.53	16.73	16.85
$s_2p_0c_0f_2$	16.24	16.49	16.69	16.82
F	<1	<1	<1	4.41 *
SE	-	-	-	0.053
CD	-	-	-	0.150

APPENDIX – XVI

Acidity

Interaction	2nd day	4th day	6th day	8th day
$s_1p_1c_1f_1$	0.38	0.34	0.30	0.28
$s_1p_1c_1f_2$	0.38	0.34	0.30	0.27
$s_1p_1c_2f_1$	0.38	0.35	0.31	0.28
$s_1p_1c_2f_2$	0.38	0.34	0.30	0.28
$s_1p_2c_1f_1$	0.38	0.34	0.30	0.28
$s_1p_2c_1f_2$	0.38	0.34	0.30	0.28
$s_1p_2c_2f_1$	0.39	0.35	0.32	0.29
$s_1p_2c_2f_2$	0.38	0.35	0.31	0.29
$s_1p_3c_1f_1$	0.40	0.34	0.30	0.29
$s_1p_3c_1f_2$	0.40	0.34	0.31	0.29
$s_1p_3c_2f_1$	0.40	0.35	0.31	0.29
$s_1p_3c_2f_2$	0.40	0.36	0.32	0.30
$s_2p_1c_1f_1$	0.36	0.31	0.27	0.25
$s_2p_1c_1f_2$	364.00	0.31	0.28	0.24
$s_2p_1c_2f_1$	0.37	0.31	0.27	0.24
$s_2p_1c_2f_2$	0.37	0.31	0.27	0.25
$s_2p_2c_1f_1$	0.35	0.29	0.25	0.23
$s_2p_2c_1f_2$	0.36	0.30	0.26	0.23
$s_2p_2c_2f_1$	0.35	0.29	0.25	0.23
$s_2p_2c_2f_2$	0.35	0.29	0.25	0.23
$s_2p_3c_1f_1$	0.38	0.34	0.28	0.27
$s_2p_3c_1f_2$	0.38	0.33	0.29	0.27
$s_2p_3c_2f_1$	0.38	0.32	0.29	0.26
$s_2p_3c_2f_2$	0.38	0.33	0.29	0.27
$s_1p_0c_0f_1$	0.36	0.32	0.28	0.25
$s_1p_0c_0f_2$	0.35	0.30	0.27	0.24
$s_2p_0c_0f_1$	0.32	0.28	0.24	0.21
$s_2p_0c_0f_2$	0.32	0.28	0.25	0.22
F	<1	<1	<1	<1

APPENDIX – XVII

Sugar acid ratio

Interaction	2nd day	4th day	6th day	8th day
$s_1p_1c_1f_1$	41.48	46.71	52.97	58.01
$s_1p_1c_1f_2$	41.16	46.78	52.98	60.16
$s_1p_1c_2f_1$	40.34	45.18	51.14	58.20
$s_1p_1c_2f_2$	41.47	46.51	52.32	57.14
$s_1p_2c_1f_1$	38.77	43.84	50.71	54.34
$s_1p_2c_1f_2$	38.65	44.38	50.05	54.02
$s_1p_2c_2f_1$	37.69	42.05	47.20	51.65
$s_1p_2c_2f_2$	38.42	42.58	48.33	52.61
$s_1p_3c_1f_1$	34.64	40.44	46.30	50.09
$s_1p_3c_1f_2$	34.20	40.34	45.76	48.85
$s_1p_3c_2f_1$	33.71	39.68	44.75	48.40
$s_1p_3c_2f_2$	34.04	38.62	43.33	46.82
$s_2p_1c_1f_1$	44.35	51.90	60.29	65.87
$s_2p_1c_1f_2$	44.01	52.04	59.50	67.65
$s_2p_1c_2f_1$	43.50	52.42	59.42	67.82
$s_2p_1c_2f_2$	43.40	51.48	59.94	66.27
$s_2p_2c_1f_1$	43.17	52.61	61.15	67.04
$s_2p_2c_1f_2$	42.32	51.16	59.86	68.26
$s_2p_2c_2f_1$	42.65	52.49	61.38	67.66
$s_2p_2c_2f_2$	42.00	51.04	59.56	67.82
$s_2p_3c_1f_1$	36.88	42.29	50.48	54.64
$s_2p_3c_1f_2$	37.50	43.67	49.42	54.32
$s_2p_3c_2f_1$	36.97	43.67	49.70	56.92
$s_2p_3c_2f_2$	36.73	42.35	48.94	54.54
$s_1p_0c_0f_1$	44.25	51.15	58.70	66.10
$s_1p_0c_0f_2$	45.21	52.92	60.62	67.72
$s_2p_0c_0f_1$	50.87	59.75	69.33	80.65
$s_2p_0c_0f_2$	50.23	58.97	67.30	78.10
F	<1	<1	<1	<1

APPENDIX - XVIII

PLW

Interaction	2nd day	4th day	6th day	8th day
$s_1p_1c_1f_1$	1.53	4.15	7.01	7.89
$s_1p_1c_1f_2$	1.17	4.92	7.99	8.98
$s_1p_1c_2f_1$	1.45	4.89	7.25	8.23
$s_1p_1c_2f_2$	1.15	5.19	8.76	9.78
$s_1p_2c_1f_1$	2.06	5.59	8.91	9.54
$s_1p_2c_1f_2$	1.70	5.41	8.42	9.20
$s_1p_2c_2f_1$	2.13	6.86	11.47	12.32
$s_1p_2c_2f_2$	1.62	4.84	8.76	9.75
$s_1p_3c_1f_1$	0.84	2.73	4.34	4.67
$s_1p_3c_1f_2$	0.80	2.70	3.94	4.34
$s_1p_3c_2f_1$	1.47	4.00	6.50	6.90
$s_1p_3c_2f_2$	0.83	2.44	4.29	4.83
$s_2p_1c_1f_1$	2.43	6.82	11.30	11.69
$s_2p_1c_1f_2$	1.63	4.95	7.64	8.36
$s_2p_1c_2f_1$	1.79	5.15	8.17	9.02
$s_2p_1c_2f_2$	1.92	6.34	9.53	10.20
$s_2p_2c_1f_1$	2.57	6.91	11.27	12.26
$s_2p_2c_1f_2$	2.21	6.33	11.10	12.59
$s_2p_2c_2f_1$	2.99	8.76	12.85	13.74
$s_2p_2c_2f_2$	2.55	7.58	12.19	13.18
$s_2p_3c_1f_1$	1.22	3.58	6.48	6.93
$s_2p_3c_1f_2$	1.30	3.91	5.62	6.05
$s_2p_3c_2f_1$	1.62	4.50	6.90	7.27
$s_2p_3c_2f_2$	1.35	3.78	6.25	6.73
$s_1p_0c_0f_1$	11.72	12.52	13.36	14.22
$s_1p_0c_0f_2$	11.37	12.17	13.00	13.87
$s_2p_0c_0f_1$	13.56	14.44	15.29	16.23
$s_2p_0c_0f_2$	13.42	14.25	15.13	15.97
F	<1	1.25	<1	<1

POST-HARVEST HANDLING IN *MUSA* (AAB GROUP) 'Nendran'

BY

RANI SUSEEL

ABSTRACT OF THE THESIS
SUBMITTED IN PARTIAL FULFILMENT OF THE REQUIREMENT FOR THE DEGREE
MASTER OF SCIENCE IN HORTICULTURE
FACULTY OF AGRICULTURE
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ABSTRACT

An experiment was carried out in the Department of Processing Technology, College of Agriculture, Vellayani during 1999-2000 to study the effects of post-harvest handling in *Musa* AAB group var. Nendran. Here post-harvest packaging and materials on the transportation shelf life and quality of the fruits. The fruits were harvested at two different stages and packed in three different packing materials with two different cushioning materials. The transportation effects were assessed as the resistance to surface injuries. Highest resistance was observed in fruits harvest at mature green stage within tray packs covered with 0.4 per cent ventilated polythene bags. Here the fruits within the packing materials gave cent per cent marketability than those in control.

The duration of ripening was enhanced by tray packing within the polyethylene covers. The tray packing considerably increased the green life duration of fruits harvested of mature green stage. The marketability ripe fruits was also hiked up in this packing. As the green life of fruits was increased it ultimately increased the shelf life of fruits.

An over-all increase in sugar and decrease in acidity was observed during the process of ripening. Sugar acid ratio also increased in fruits packed at mature yellow stage (s_2) within the corrugated fibre board boxes with paper shreds as cushioning materials. The physiological loss in weight increased with ripening and the highest loss was observed in fruits packed at stage two within perforated plastic crates.