SHRINK WRAP PACKAGING OF SELECTED TROPICAL FRUITS

By

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THESIS

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DECLARATION

I hereby declare that the thesis entitled "**Shrink wrap packaging of selected tropical fruits**" is a bonafiderecord of research work done by me during the course of research and the thesis has not previously formed the basis for the award to me of any degree, diploma, associateship, fellowship or other similar title, of any other university or society.

Vellanikkara,

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CERTIFICATE

Certified that the thesis entitled **"Shrink wrap packaging of selected tropical fruits"** is a record of research work done independently by **Ms. Aiswarya T.** under my guidance and supervision and that it has not previously formed the basis for the award of any degree, diploma, fellowship or associateship to her.

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Introduction

1. INTRODUCTION

Mango, banana and pineapple are tropical fruits grown widely in Kerala. These tropical fruits are rich in nutrients and are relished by consumers across the State. These fruits are commercially grown in Kerala, due to their high economic value in both domestic and export markets. Post harvest losses of these fruits are major problems encountered by growers and traders alike. Suitable post harvest techniques for prolonging shelf life and maintenance of quality during storage, are of considerable importance to the economy of our State, so as to fetch premium prices for these commodities. Adoption of improved post harvest handling, packaging, transportation and storage techniques can reduce the post harvest losses and thereby helps to improve the shelf life and quality of fruits. Good post harvest management practices can prevent the existing wide gap between production and availability of fruits to consumers.

Packaging is one of the important post harvest management practices adopted in fruits. Packaging helps to assemble the produce in convenient units and protects fruits from deterioration during handling from farm gate to consumer's house. Among the different packaging techniques, shrink-wrap packaging is one of the novel techniques being adopted in fruits as a post-harvest handling practice. The commercial use of this technology provides a means to slow the processes of ripening and senescence by retarding the rate of respiration, transpiration, ethylene evolution, reduced microbial contamination and subsequently resulting in better quality retention during storage, transport and marketing.

Shrink wrap packaging is a type of modified atmosphere packaging which provides low concentration of oxygen in the package and thereby reduces the rate of respiration of the fruit within the package. Shrink wrapping of fruits with polymeric films reduces shrinkage and mechanical damage and will also protect them from post

harvest diseases. The main advantages of film wrapping of fruits and vegetables are reduced weight loss and extended shelf-life, besides minimising fruit deformation, reducing chilling injury and decay by preventing secondary infection of fruits packed in the same box and will also provide a good surface for stick-on labels. The principle behind shrink wrap packaging is stretching the plastic film under controlled temperature and tension so that the film which is wrapped over the produce stretches and then contracts by cooling.

Shrink-wrapping has been used successfully to package apples, mangoes, papaya, pomegranate and vegetables like summer squash, watermelon, bell pepper *etc.* Shrink wrap packaging has been found to have some desirable qualities like enhanced shelf life, reduced physiological loss in weight (PLW), retention of biochemical constituents like TSS, titratable acidity, vitamin C, sugars *etc.*

Mango variety Prior, banana variety Grand Naine and pineapple variety Mauritius are increasingly being grown and consumed by people all over Kerala. Efforts to make these fruits available for extended periods have not yielded considerable success. Moreover, there exists a huge demand for these commodities in those countries where sizeable expatriate population resides, particularly in the Gulf countries. Therefore, an attempt was made to prolong the shelf life and also, for maintaining quality of these fruits through shrink wrap packaging so as to test the efficacy of this technique on three tropical fruits grown widely in Kerala.

Hence, the study 'Shrink wrap packaging of selected tropical fruits', has been carried out with the objective of extending shelf life and to maintain quality of mango, banana and pineapple during storage.

Review of Literature

2. REVIEW OF LITERATURE

Mango, banana and pineapple are the main fruit crops grown in Kerala. These are commercially important tropical fruits cultivated for their economic importance. Highly perishable nature and inadequate post harvest management techniques results in reduced shelf life and decreased availability of fruits. According to Roy *et al.*(2000) there is an urgent need to overcome the post harvest losses by adopting new post harvest management practices like improved packaging, handling and efficient transportation methods.

Shrink wrap packaging is one of the new packaging technologiessuccessfully adopted in a variety of fruits like apple, guava, papaya, pomegranate, kinnow *etc.* Shrink wrap packaging is a type of modified atmosphere packaging, which reduced weight loss and extended shelf-life, minimized fruit deformation, reduced chilling injury and reduced decay by preventing secondary infection of fruits packed in the same box. Individual shrink wrapping adds value to fruits and vegetable and maintains freshness for long time without affecting quality. Shrink wrap packaging is an alternative to prevent post harvest losses in fruits. An attempt has been made to review the literature on the research topic "Shrink wrap packaging on selected tropical fruits".

Mango

Mango(*Mangifera indica*), the king of the fruits, is grown in almost all states in India. Mango is also known as apple of tropics and is one of the most commonly consumed fruits in tropics and all over the world.

Harvest maturity of mango is mainly determined on the basis of shoulder growth and TSS (Kudachikar *et al.*, 2001). Mature mango fruits are harvested by using a long pole with a cutting blade/ knife and a small bag under the blade.

Optimum picking should be done with shear and cutting the stem 1to 2 cm away from the fruit. This technique permitsthe reduction of latex exudation and staining ofthe skin and the entrance of fungal diseases. Desapping is an important method to reduce the latex content. Washing the harvested fruits to prevent microbial infection followed by pretreatment with 100 ppm sodium hypochlororite is essential. Chlorination with sodium or calcium hypochlorite, used as a disinfectant, prevents microbial infection (Hong and Gross, 1998). Surface air drying is a mould control practice that should be done after washing and before packing.

Banana

Banana(*Musa* sp) is widely grown in India with great socio- economic significance, interwoven in the cultural heritage of the country. Banana is the fourth important food crop in terms of gross value exceeded only by paddy, wheat and milk products and forms an important crop for subsistence farmers. Banana is a staple food owing to rich source of carbohydrates, vitamin C and minerals and makes healthy and salt free diet.

Banana is harvested before full maturity in a green and hard condition. There is no definite way of determining maturity and growers and exporters rely mainly on fruit diameter and angularity of fingers (Jain *et al.*, 2004).

Banana is separated into hands and desapping done for reducing latex content. Chlorine based chemicals, particularly liquid chlorine and hypochlorite, are probably the most widely used sanitizers for decontaminating fresh produce. Hudder *et al.*(1990) reported that calcium chloride treatment advanced ripening in banana.

Pineapple

Pineapple (*Ananas comosus*) is an important fruit crop in India. From Brazil, it has spread to other tropical parts of the world. Pineapple is a good source of

vitamin A and B and fairly rich in vitamin C, calcium, magnesium, potassium and iron. Bromelin is a digestive enzyme present in the pineapple.

Harvesting of pineapple is to be done using a sharp knife by giving a smooth cut and the stem end should not be more than 2 cm long (PRS, 2010). In pineapple maturity index, the yellowish colour increases starting from peduncle and progress to the upper part of fruit as the maturity stage increases (Rohana *et al.*, 2009). Decrowning was done for packing the pineapple.

2.2 Shrink wrap packaging

Shrink wrap packaging is one of the recent approaches is for the post harvest handling of fruits and vegetables. Individual shrink wrapping is considered as modified atmosphere packaging for individual fruits, which is used to enhance the storage life and maintain freshness of fruits and vegetables. When individual shrink wrapping is applied to fruit, the selective permeability of the film, and the interplay of the fruit physiology and the physical environment produce a change in the initial atmospheric conditions to a desirable atmosphere within the package. Individually shrink wrapping of fruits with plastic film reduces moisture loss, modify surrounding atmosphere and may lead to lower respiration rate due to low oxygen availability within the package and increased shelf life of fruits.

Individual shrink wrapping reduces postharvest losses and extends the shelf life of a number non-climacteric fruits and vegetables such as citrus, pepper and cucumber, but also some climacteric fruits such as apple and papaya. In other climacteric fruits, including tomato and melon, individual shrink wrapping was not fully successful since it enhances undesirable flavour changes or impaired ripening. Individual shrink wrapping adds value to fruit and vegetable products, maintaining their freshness for longer period because of a reduced moisture loss, chilling injury, firmness and decay, as well as increased protection from mechanical damage during

handling and transport. Such coatings/wrapping can be effective in maintaining quality under ordinary storage conditions.

Principle involved is plastic film like polyethylene, poly styrene, polyvinyl chloride, polyester, poly olefin film etc have heat shrinkable nature. By stretching the film under controlled temperature and tension, the film which is wrapped over the produce stretches and then contracts by cooling.

2.3 Qualitative changes of shrink wrapped fruits during storage

2.3.1 Shelf life

Heaton*et al.*(1990) reported that the apple fruits cv. Starcrimson showed acceptablequalities for a period of 38 weeks while packed in shrink wrap packaging followed by storage at26^0C and 40-42% RH.

McCollum *et al.*(1992) evaluated the effects of individual shrink film wrapping (60gauge) on shelf-life and quality of mangoes, and observed that wrapped fruits showed more decay than non-wrapped one.

Shrink-wrapped green papaya(*Carica papaya*) cv. 'Solo' fruits could be stored for 10 days at ambient temperature which ripened normally in 5 days with firm texture and good flavour after unwrapping, whereas the non-wrapped fruits ripened within 7 days beyond which they became unmarketable (Singh and Rao, 2005).

Fully mature Royal Delicious apples shrink- wrapped with cryovac(9 μ) film could be stored in zero energy cool chamber for 45 days without any adverse effect on quality parameters (Sharma *et al.*, 2010).Ding and Muhammad(2013) conducted a studyto determine the effects of modified atmosphere packaging on postharvest life extension of 'Frangi' papaya (*Carica papaya* L.). Shrink film wrapped fruit had better postharvest quality where the fruits were well-preserved compared to the other two

packaging materials. In conclusion, shrink film can be used to prolong 'Frangi' papaya postharvest life.

Studies conducted by Rao and Shivashankara (2015) revealed that shrink wrapped mangoes of 'Banganapalli' and 'Alphonso' cultivars packed in D-955 (15 µm thickness) film could be stored for 5 weeks at 8°C in fresh and unripe green condition. After removal from low temperature and unwrapping, shrink wrapped mangoes ripened normally within a week at ambient temperature.

Mandal(2015)suggested that individually shrink wrapped kinnow mandarin treated with citrashine and lac-wax fruits can be stored for 21 days at ambient conditions.

2.3.2 Physiological Loss in Weight (PLW)

Reduction in mass loss by shrink wrapping has also been reported byMiller *et al.* (1983) in mango,Hale et al. (1986) in Florida grapefruit,Ladaniya *et a*l. (1997) in 'Nagpur' mandarins.

Nanda *et al.*(2001) conducted an experiment on pomegranate cv. Ganesh and observed that the shrink wrapped fruits had minimum physiological loss in weight and shelf life of fruits could be extended up to 12 weeks.

Individually shrink wrapping of apple with 9µ cryovac showed leastphysiological loss in weight when stored in zero energy cool chamber compared with unwrapped apple fruit. Physiological loss in weight increased with increase in storage (Sharma *et al.*, 2010).

Individually shrink wrapped kinnow mandarin fruits registered the lowest weight loss ranged between 3.97 and 10.37 per cent with 7 to 21 days of storage at

ambient conditions, respectively as compared to control where PLW ranged from 6.55 to 16.16 per cent during same intervals (Mandal, 2015).

According to Rao and Shivashankara (2015) the mass loss in individual shrink wrapped fruit was 4 to 5 times less in 'Alphonso' cultivar and 9 to 10 times less in 'Banganapalli' cultivar compared to non-wrapped fruit, depending on the film.

2.3.3 TSS

Individual shrink-wrapped fruit showed the least increase in TSS and always scored the lowest value followed by Sta-fresh and control (Pal *et al.*, 2004)

Total soluble solids content was higher in individually shrink wrapped apple with 9μ cryovac stored in zero energy cool chamber compared to unwrapped fruits (Sharma *et al.*, 2010).

Individually shrink wrapped kinnow mandarin fruits recorded the highest TSS content (11.37%) after 7 days of storage and thereafter TSS content declined but fruits maintained the highest TSS (10.37) even after 21 days of storage (Mandal, 2015).

2.3.4 Titratable acidity

McCollum *et al.* (1992) studied the effects of individual shrink wrapping (60 gauge) on shelf-life and quality of mangoes and observed that the wrapped fruits were significantly more acidic than non-wrapped fruits, as indicated by lower pH value.

Acidity of fruits did not show any significant difference except on the 14^{th} day observation in cool chamber (Pal *et al.*, 2004)In 2015, Mandal suggested that acidity of individually shrink wrapped fruits was lower than in lac wax treated and control fruits.

2.3.5 Sugars

Individually shrink wrapped pomegranate recorded a slight decrease in total sugar content during storage at different temperatures. There were no significant differences in the total sugar content due to treatments (Nanda *et al.*, 2001).

Pal *et al.* (2004) suggested thatthe total sugars followed an increasing trend in storage.But the increase was nonsignificant in individually shrink wrapped fruits on the 7^{th} day.The increase in total sugar was rapid at ambient and slowin cool chamber stored fruits. Again the rise was significantlymore in control and it was the least in individually shrink wrapped fruits.

Total sugars of shrink wrapped fruit (D-955 and LD-935 film) stored at 8 °C were comparable with that observed by Sudhakar Rao and Gopalakrishna Rao (2008) in these cultivars, stored at optimum temperature of 13 °C. Totalsugars were significantly higher in individually shrink wrapped fruits than non-wrapped fruit.

2.3.6 Vitamin C

Loss in vitamin C content of non-wrapped fruits during storage at different temperatures was significant. It was better retained in film-wrapped fruits stored at 8 and 15°C for a period of 12 and 9 weeks, respectively, than in other treatments (Nanda *et al.*, 2001).

Pal *et al.*(2004) suggested that loss of vitamin C content was negligible in individually shrink wrapped guava fruits stored in cool chamber at the end of 14 days.Singh and Sudhakar Rao (2005) also reported the positive effect of optimum MA packing conditions on retention of ascorbic acid immature green 'Solo' papayas stored at 7 or 13 °C for 20 or 30 days, followed by ripening in air at 20 °C.

Stepanenko(2014) conducted a study on preserving vitamin C content in melons during long term storage by treatment with ionized air and shrink wrapping. Preservation of vitamin C was significantly better in melon fruits packed in shrink wrapping and processed by ionized air compared to without processing by air and unpackaged fruits and in control.

Vitamin C content in individually shrink wrapped mangoes cvs. Alphonso and Banganappalli was significantly higher as compared to non wrapped mangoes(Rao and Shivashankara, 2015).

2.3.7 Total carotenoids

Individually shrink wrapped bell pepper showed no significant difference in carotenoid content after 3 weeks of storage at 2^0 C when compared with the content at the beginning of storage.After the shelf-life period (an additional 3 days at 20^0 C), the carotenoid content was significantly increased (Ilic *et al.*, 2012).

Rao and Shivashankara (2015) evaluated that the total carotenoids in terms of β-carotene content were significantly higher in shrink wrapped mango(cvs. 'Alphonso' and 'Banganappalli')fruit when compared to non-wrapped fruit.

2.3.8 Organoleptic quality

Heaton *et al.*(1990) reported that the apple fruits cv. Starcrimson showed acceptable qualities for a period of 38 weeks while packed in shrink wrap packaging followed by storage at26° C and 40-42% RH.

Shrink wrapped fruits got better scores for aril colour, juiciness and taste during sensory evaluation compared with non-wrapped and SPE-treated fruits (Nanda *et al.*, 2001).Individually shrink wrapped guava fruits scored better value of sensory

score under 12 days at ambient and 18 days in evaporative cool chamber condition (Pal *et al.*, 2004).

Shrink wrapped fruit of both cultivars registered significantly higher scores for all the sensory parameters evaluated, viz., fruit appearance, pulp colour, pulp texture and flavour qualities when compared to non-wrapped mangoes(Rao and Shivashankara, 2015).

The mean sensory quality score was significantly the highest (7.37) in individually shrink wrapped fruits. The individually shrink wrapped fruits showed the highest sensory quality (7.40) after 15 days of cold storage and the fruits were rated as like moderately (Mandal, 2015).

2.3.9 Internal quality

Miller *et al.*(1986) reported that off flavour in film wrapped fruits might be related toexcessive levels of CO_2 and reduced levels of O_2. It was found that mangoes shrink-wrapped in HDPE at soft ripe stage had off flavour and elevated CO_2 levels after 9 days of storage.

Materials and Methods

3.MATERIALS AND METHODS

Materials

The research programme "Shrink wrap packaging of selected tropical fruits" was carried out using different fruits like mango *cv.* Prior, banana *cv.* Grand Naine and pineapple *cv.*Mauritius.

Methods

The whole research programme consisted of three experiments. The first experiment was to study the "Effect of shrink wrap packaging on shelf life and quality of mango". The second experiment was to study the "Effect of shrink wrap packaging on shelf life and quality of banana". The third experiment was to study the "Effect of shrink wrap packaging on shelf life and quality of pineapple".

3.1 Effect of shrink wrap packaging on shelf life and quality of mango

Fruits

Mature green fruits of mango *cv.* Prior, were procured from Agriculture Research Station, Mannuthy. Fruits free from mechanical damage, bruises and blemishes selected from the harvested lot formed the samples for the experiment.

Post harvest treatments

Fruits weredesapped and washed in plain tap water, followed by surface sanitization with 100ppm chlorine for 15 minutes. The chlorinated fruits werespread out on blotting paper to remove excess surface moisture and kept as such overnight for air drying.

Shrink wrap packaging

Surface dried fruits were subjected to two forms of shrink wrapping i.e., fruits were individually shrink wrapped and also shrink wrapping of arecaplate, containing 4-5 fruits. The samples were initially sealed loosely using a band sealer, followed by passing these loosely sealed samples through the tunnel of the shrink wrap machine. Polyolefin film of three densities viz. 15, 19 and 25μ thickness was used for shrink wrapping of samples in each treatment.

3.1.1 Treatments

T1:Individual shrink wrapping of mango with polyolefin film of 15μ

T2:Individual shrink wrapping of mango with polyolefin film of 19μ

T3:Individual shrink wrapping of mango with polyolefin film of 25μ

T4:Shrink wrapping of areca plate containing mangoes with polyolefin film of 15 μ

T5:Shrink wrapping of areca plate containing mangoes with polyolefin film of 19 μ

T6:Shrink wrapping of areca plate containing mangoes with polyolefin film of 25 μ

T7:Unwrapped mango (control)

3.1.2 Design

The experiment was laid out in a Completely Randomized Design (CRD) with three replications each.

3.1.3 Observations

Observations on qualitative changes during storage were taken as described below.

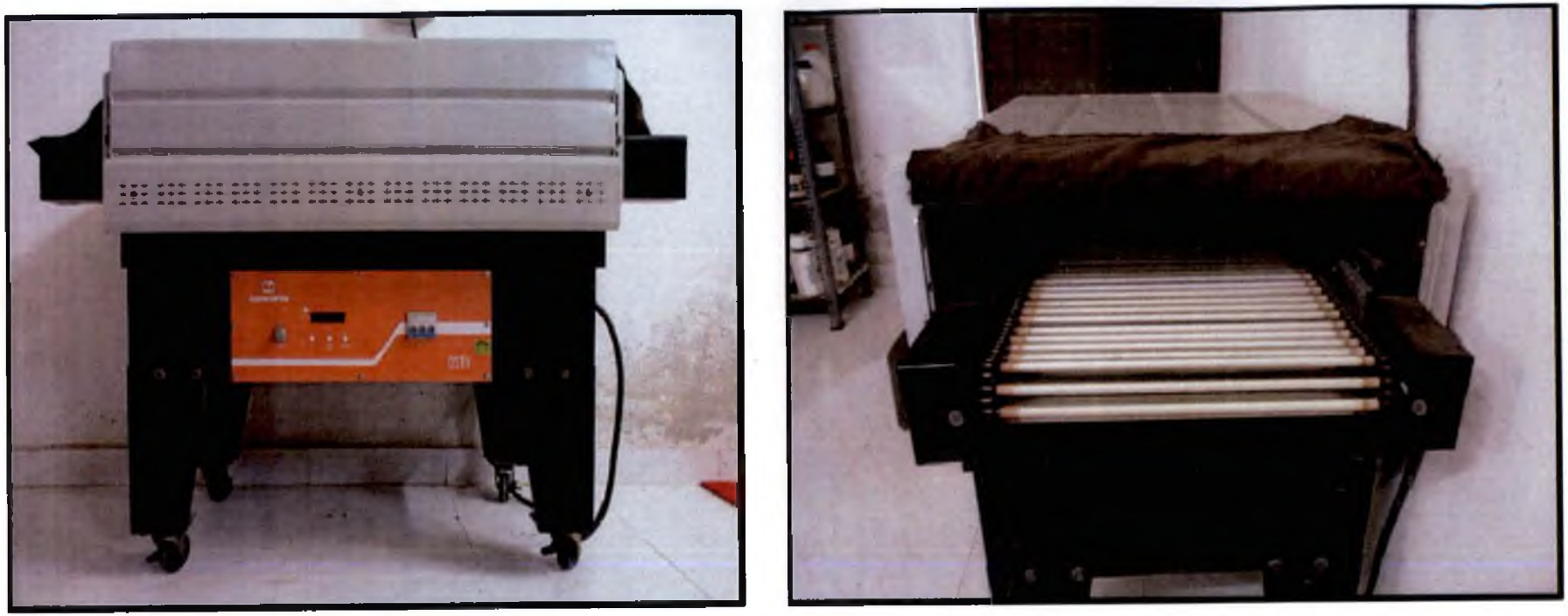


Plate 1. Shrink wrap packaging machine

Freshly harvested mangoes

Desapping

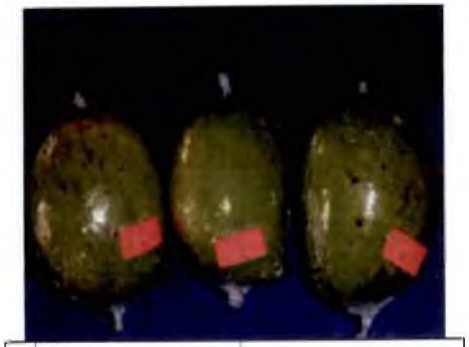
Chlorination

Surface drying

Shrink wrapped areca plate containing fruits

Individually shrink wrapped fruits

Plate 2. Shrink wrap packaging of mango



T1

Individual shrink wrapping of mango (15μ)

T2

Individual shrink wrapping of mango (19μ)

T2

Individual shrink wrapping of mango (25μ)

T4

Shrink wrapping of areca plate containing mangoes (15μ)

T5

Shrink wrapping of areca plate containing mangoes (19μ)

T6

Shrink wrapping of areca plate containing mangoes (25μ)

Plate 3. Shrink wrapped mangoes

3.1.3.1 Shelf life (days)

Shelf life of fruits was calculated in terms of number of days up to which the fruits could be marketed taking into account spoilage, physiological loss in weight and shrivelling.

3.1.3.2 Physiological loss in weight(PLW) (%)

PLW was expressed in terms of percentage. PLW was calculated at three days interval on the basis of initial weight of fruits (Srivastava and Tandon, 1968) and the weight on the particular day of measurement.

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

3.1.3.3 Total Soluble Solids (TSS) (^{0} Brix)

TSS was measured using a hand refractometer (range 0-32°brix), followed by temperature correction and the values were expressed in degree brix.

3.1.3.4 Titratable acidity (%)

The titratable acidity was estimated by titrating with 0.1N sodium hydroxide (NaOH) solution using phenolphthalein as an indicator and expressed as per cent of predominant acid present in the fruit. A known weight of sample was ground using distilled water and made upto 100ml in a standard flask. An aliquot of 10 ml from this was titrated against 0.1N NaOH (AOAC, 1998).

$$\text{Acidity}(\%) = \frac{\text{Normality} \times \text{Titre value} \times \text{Equivalent weight} \times \text{Volume made up} \times 100}{\text{Weight of sample} \times \text{aliquot of sample} \times 1000}$$

3.1.3.5 Reducing, non- reducing and total sugars (%)

Reducing and total sugars were estimated by titrimetric method using Fehling's solution and expressed as percentage (Ranganna, 1997). Non-reducing sugars were obtained from percent of total and reducing sugars by subtraction.

Reducing sugars

A known weight of sample was ground in a pestle and mortar and transferred to a 100 ml conical flask. About 100ml of distilled water was added followed by 2 ml pre- standardized 45 percent neutral lead acetate for clarification. Excess lead acetate was neutralized by the addition of 2 ml pre- standardized 22 percent potassium oxalate solution. The clarified solution was filtered and transferred to 250 ml volumetric flask and made up the volume. The reducing sugars were determined by titrating the clarified filtrate against standard Fehling's solution using methelene blue as an indicator. The reducing sugar was calculated by the formula as given below.

$$\text{Reducing sugars}(\%) = \frac{\text{Fehling's factor x Dilution}}{\text{Titre value x Weight of sample}} \times 100$$

Total sugars

Filtrate (50 ml) used in the estimation of reducing sugars was taken in a 250 ml conical flask. Add 5 g of citric acid and 50 ml of water and boil gently for 10 minutes to complete the invention of sucrose and then cool. Transferred the contents to a 250 ml volumetric flask and neutralized with 1N sodium hydroxide using phenolphthalein as the indicator and made up to volume. The total sugars were estimated by titrating made up solution against standard Fehling's solution using methelene blue as an indicator. The total sugar was calculated by the formula as given below.

$$\text{Total sugars(\%)} = \frac{\text{Fehling's factor x 250 x Dilution}}{\text{Titre value x 50 x Weight of sample}} \times 100$$

Non –reducing sugars

The non- reducing sugarsin the samples were determined by deducting the reducing sugar content from total sugar content(Ranganna, 1997).

Non- reducing sugars(%) = Total sugars (%) – Reducing sugars(%)

3.1.3.6 Vitamin C (mg $100g^{-1}$)

Vitamin C was determined by titrating a known weight of sample with 2, 6-dichlorophenol indophenol dye, using metaphosphoric acid as stabilizing agent(AOAC, 1998).

A known weight of sample was ground using 3 percent metaphosphoric acid and the volume was made up to 100 ml. After filtration, 10 ml of aliquot was titrated against 2,6 –dichlorophenol indophenol dye. The dye factor was calculated by titrating standard ascorbic acid solution against dye and ascorbic acid content of sample was expressed as

$$\text{Ascorbic acid (mg } 100g^{-1}) = \frac{\text{Titre value x Dye factor x Volume made up x 100}}{\text{Weight of sample x Aliquot of sample}}$$

3.1.3.7 Total carotenoids (mg $100g^{-1}$)

A known weight of sample was ground in a pestle and mortar with acetone. The extract was poured into a conical flask. Extraction was continued till the residue became colourless. The extract was transferred to a separating funnel and then 10- 15 ml of petroleum ether, little amount of distilled water and a little amount of

anhydrous sodium sulphate was added. Then it was shaken well. The upper layer was collected and the lower layer was re-extracted. Extraction of acetone phase was repeated with small volume of petroleum ether till it became colourless. The extract was collected into a volumetric flask by passing through cotton containing small amount of anhydrous sodium sulphate and then thevolume was made up with petroleum ether. The colour was measured at 452 nm using petroleum ether as blank in spectrophotometer. Results were expressed as mg $100g^{-1}$ of material(Ranganna, 1997).

$$\text{Total carotenoids (mg } 100g^{-1}) = \frac{3.857 \times \text{Optical density} \times \text{Volume madeup} \times 100}{\text{Weight of the sample}}$$

3.1.3.8 Organoleptic analysis (Hedonic scale 1 to 9)

A panel of judges of different age groups judged the products for appearance, colour, flavour, texture, odour, taste, after taste and overall acceptability based on a 9-point Hedonic scale rating, at weekly intervals during storage.

(1= dislike extremely , 2= dislike very much, 3= dislike moderately, 4= dislike slightly, 5= neither like nor dislike, 6= like slightly, 7= like moderately, 8= like very much, 9= like extremely).

3.1.3.9 Internal quality

Internal quality of the fruits was assessed taking into account signs of browning and development of off flavor.

3.2 Effect of shrink wrap packaging on shelf life and quality of banana

Fruits

Bunches of mature green banana, *cv.* Grand Naine were harvested from the Department of plant biotechnology. Those bunches were separated out into hands.

Post harvest treatments

Separated hands were kept for desapping.Banana hands were washed in plain water, after which they were surface sanitized with 100 ppm chlorine for 15 minutes. Chlorinated hands were spread out in perforated trays/ blotting paper to remove excess surface moisture.

Shrink wrap packaging

Surface dried hands weresubjected to two forms of shrink wrapping i.e, hands were individually shrink wrapped and also shrink wrapped banana hands master packed in CFB boxes. The samples were initially sealed loosely using a band sealer, followed by passing these loosely sealed samples through the tunnel of the shrink wrap machine. Polyolefin films of three densities viz. 15, 19, and 25 μ thickness were used for shrink wrapping of samples in each treatment.

3.2.1 Treatments

T1: Shrink wrapping of banana hands with polyolefin film of 15μ

T2: Shrink wrapping of banana hands with polyolefin film of 19μ

T3: Shrink wrapping of banana hands with polyolefin film of 25μ

T4: Shrink wrapped banana hands (15μ) master packed in CFB boxes

T5: Shrink wrapped banana hands (19μ) master packed in CFB boxes

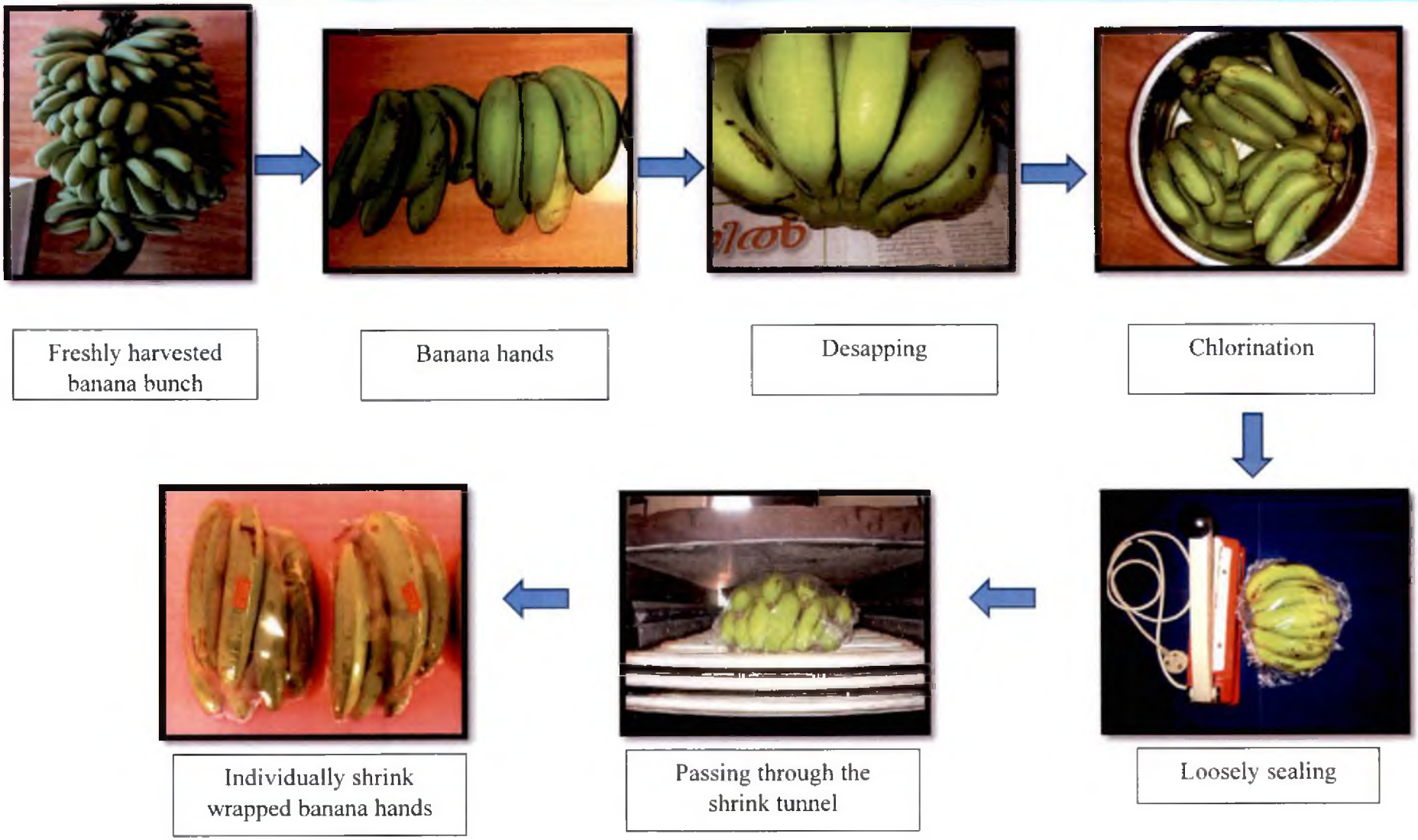


Plate 4. Shrink wrap packaging of banana

T1

Shrink wrapping of banana hands with polyolefin film of 15μ

T2

Shrink wrapping of banana hands with polyolefin film of 19μ

T3

Shrink wrapping of banana hands with polyolefin film of 25μ

T4

Shrink wrapped banana hands (15μ) master packed in CFB

T5

Shrink wrapped banana hands (19μ) master packed in CFB

T6

Shrink wrapped banana hands (25μ) master packed in CFB

Plate 5. Shrink wrapped banana hands

T6: Shrink wrapped banana hands (25μ) master packed in CFB boxes

T7: Unwrapped hands (control)

3.2.2 Design

The experiment was laid out in a Completely Randomized Design (CRD) with three replications each.

3.2.3 Observations

Observations on qualitative changes during storage were taken as described below.

3.2.3.1 Shelf life

Shelf life was determined as mentioned in 3.1.3.1.

3.2.3.2 Physiological loss in weight(PLW)

PLW wascalculated as mentioned in 3.1.3.2.

3.2.3.3 Reducing, non- reducing and total sugars

Reducing, non-reducing and total sugars were estimated as in 3.1.3.3.

3.2.3.4 Vitamin C

Vitamin C content was obtained as mentioned in 3.1.3.4.

3.2.3.5 Titratable acidity

Titratable acidity was estimated as mentioned in 3.1.3.6.

3.2.3.6 Organoleptic analysis

Organoleptic analysiswas conducted as mentioned in 3.1.3.7.

3.2.3.7 Total Soluble Solids (TSS)

TSS was measured as mentioned in 3.1.3.8.

3.2.3.8 Internal quality

Internal qualitywas observed as mentioned in 3.1.3.9.

3.3 Effect of shrink wrap packaging on shelf life and quality of pineapple

Fruits

Mature, firm, ripe fruits of pineapple *cv.*'Mauritius', when half of the fruit surface turned yellow,were procured from the Pineapple Research Station, Vellanikkara.

Post harvest treatments

The fruits were cleaned dry followed by removal of crowns from the fruits.

Shrink wrap packaging

Surface dried fruits were subjected to two forms of shrink wrapping i.e, fruits were individually shrink wrapped and also shrink wrapped pineapple master packed in CFB boxes. The samples were initially sealed loosely using a band sealer, followed by passing these loosely sealed samples through the tunnel of the shrink wrap machine. Polyolefin films of three densities viz. 15, 19, and 25 μ thickness were used for shrink wrapping of samples in each treatment.

3.3.1 Treatments

T1:Individually shrink wrapped pineapple(15μ)

T2:Individually shrink wrapped pineapple(19μ)

T3:Individually shrink wrapped pineapple(25μ)

T4:Individually shrink wrapped pineapple(15μ) master packed in CFB box

T5:Individually shrink wrapped pineapple(19μ) master packed in CFB box

T6:Individually shrink wrapped pineapple(25μ) master packed in CFB box

T7:Unwrapped pineapple (control)

3.3.2 Design

The experiment was laid out in a Completely Randomized Design (CRD) with seven number of treatments and three number of replications.

3.3.3 Observation

Observations are same as that of 3.2.2.

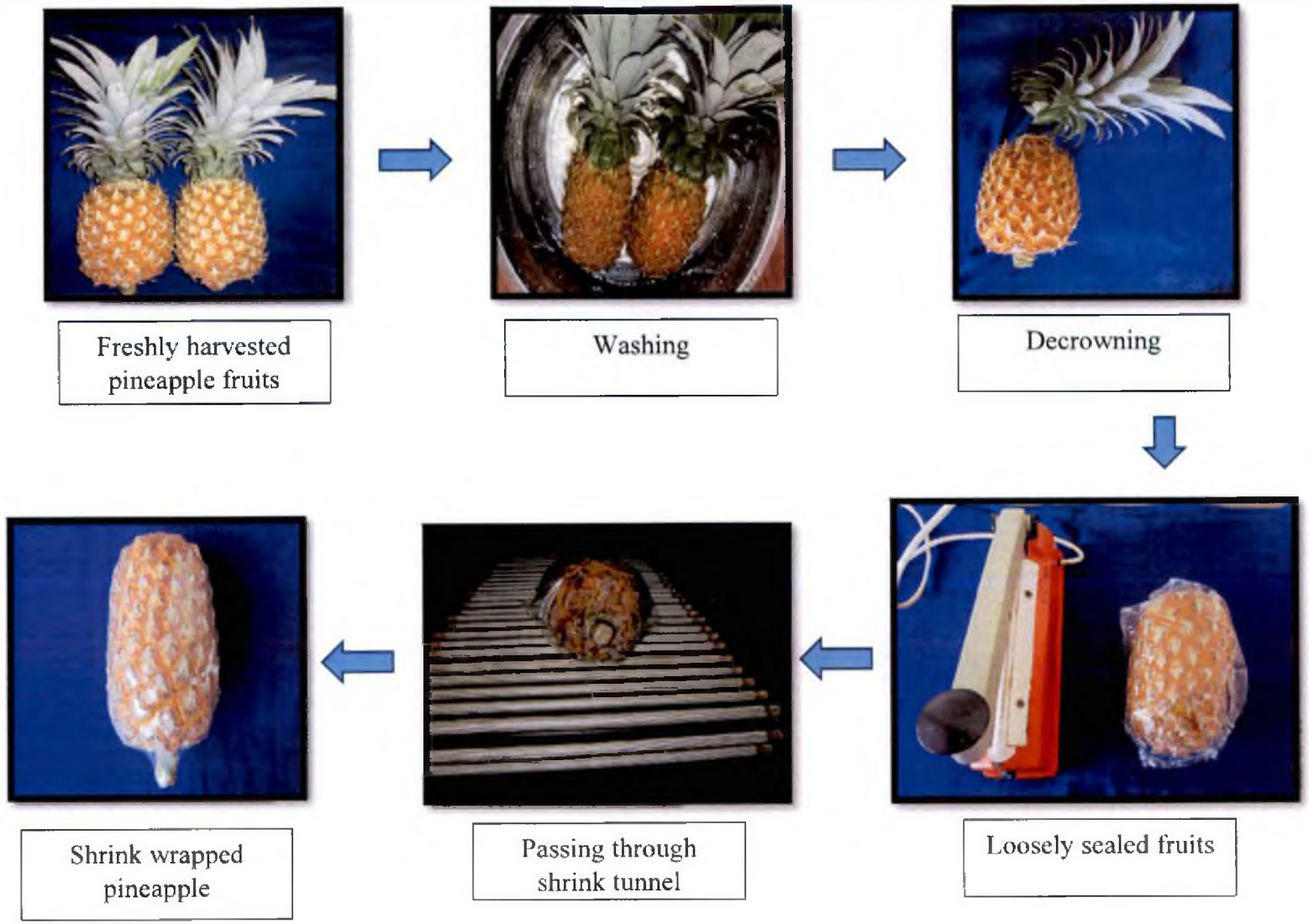


Plate 6. Shrink wrap packaging of pineapple

T1

Individually shrink wrapped pineapple (15μ)

T2

Individually shrink wrapped pineapple (19μ)

T3

Individually shrink wrapped pineapple (25μ)

T4

Individually shrink wrapped pineapple (15μ)master packed in CFB box

T5

Individually shrink wrapped pineapple (19μ)master packed in CFB box

T6

Individually shrink wrapped pineapple (25μ) master packed in CFB box

Plate 7. Shrink wrapped pineapple fruits

3.4 Tabulation and statistical analysis

The data obtained were statistically using analysis of variance (ANOVA) technique. The critical difference value at five percent was used for making comparison among different treatments. Kendall's coefficient of concordance was used for the sensory evaluation.

Results

4. RESULTS

The results obtained in the present investigation titled "Shrink wrap packaging of selected tropical fruits" are presented below.

4.1 EFFECT OF SHRINK WRAP PACKAGING ON SHELF LIFE AND QUALITY OF MANGO

4.1.1 Observations

4.1.1.1 Shelf life (Days)

Shelf life of shrink wrapped mango fruits is given in Fig 1. Shelf life of individually shrink wrapped mango was higher than the fruits shrink wrapped in areca plates and control (unwrappedfruits). Percentage of spoilage was higher in the fruits wrapped in areca plates. Individually shrink wrapped mangoes in 25 μ polyolefin film had the longest shelf life (18 days) and the fruits in shrink wrapped in areca plates with 19 μ polyolefin film had the shortest shelf life(8 days). Shelf life of control (unwrapped) samples was 12 days.

4.1.1.2 Physiological loss in weight(PLW)(%)

PLW of all the samples increased during storage (Table 1). Control (unwrapped) samples had maximum PLW as compared to the fruits subjected to shrink wrap packaging. After 12 days of storage, control (unwrapped) fruits had significantly higher PLW (3.1 %) compared to shrink wrapped fruits and individually shrink wrapped mango in 25μ polyolefin film had the lowest PLW (0.73 %)

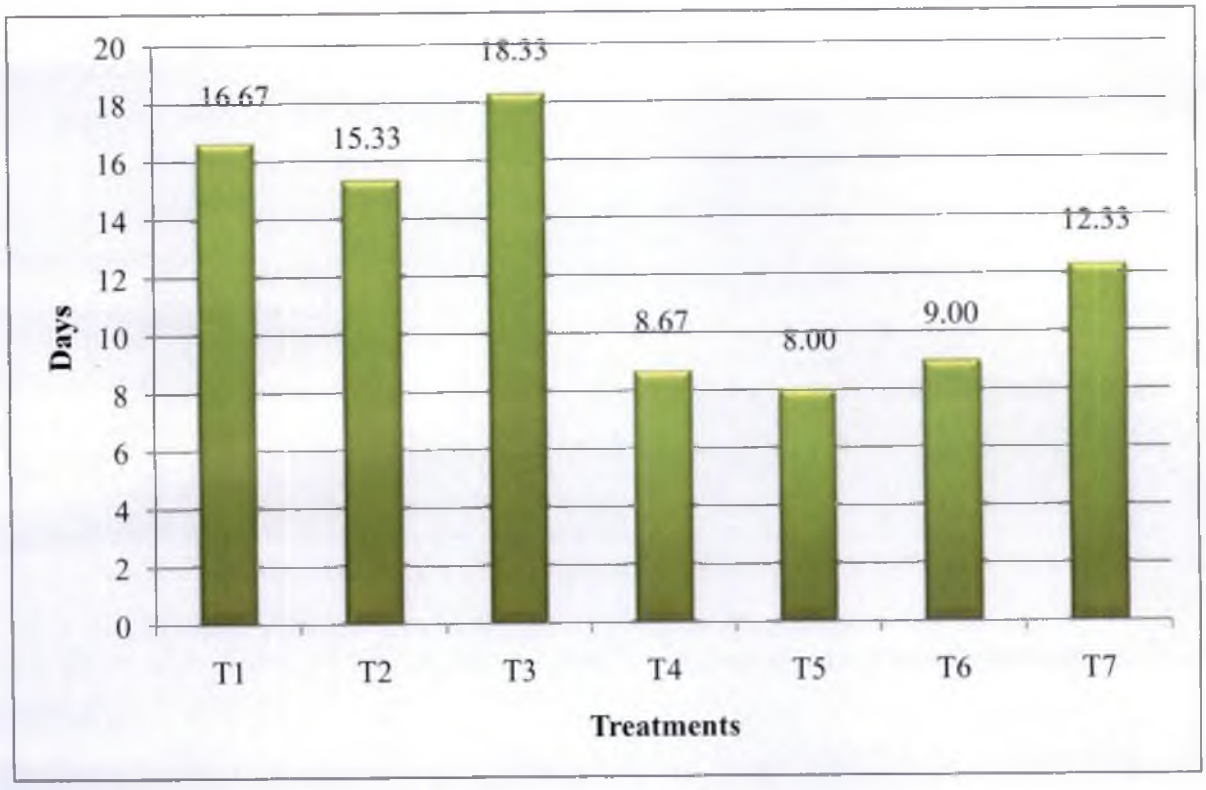


Figure 1. Effect of shrink wrap packaging on shelf life of mango

T1:Individual shrink wrapping of mango with polyolefin film of 15μ

T2:Individual shrink wrapping of mango with polyolefin film of 19μ

T3:Individual shrink wrapping of mango with polyolefin film of 25μ

T4:Shrink wrapping of areca plate containing mangoes with polyolefin film of 15 μ

T5:Shrink wrapping of areca plate containing mangoes with polyolefin film of 19 μ

T6:Shrink wrapping of areca plate containing mangoes with polyolefin film of 25 μ

T7:Unwrapped mango (control)

Table 1. Effect of shrink wrap packaging on physiological loss in weight (PLW)(%) of mango

Treatments	Physiological loss in weight (PLW)(%)						
	0 DAS	3 DAS	6 DAS	9 DAS	12 DAS	15 DAS	18 DAS
T1	0.00	0.00	0.05	0.42	0.77	1.04	-
T2	0.00	0.00	0.08	0.50	0.97	1.41	-
T3	0.00	0.00	0.06	0.37	0.77	1.26	1.80
T4	0.00	0.06	0.52	0.77	1.27	-	-
T5	0.00	0.04	0.39	0.72	1.23	-	-
T6	0.00	0.03	0.15	0.56	1.09	-	-
T7	0.00	0.57	1.14	2.37	3.1	-	-
CD		0.06	1.56	0.23	0.36		

T1:Individual shrink wrapping of mango with polyolefin film of 15μ

T2:Individual shrink wrapping of mango with polyolefin film of 19μ

T3:Individual shrink wrapping of mango with polyolefin film of 25μ

T4:Shrink wrapping of areca plate containing mangoes with polyolefin film of 15 μ

T5:Shrink wrapping of areca plate containing mangoes with polyolefin film of 19 μ

T6:Shrink wrapping of areca plate containing mangoes with polyolefin film of 25 μ

T7:Unwrapped mango (control)

4.1.1.8 Total Soluble Solids (TSS)(° Brix)

TSS of mango increased throughout the storage period (Table 2). Control(unwrapped) sample had significantly higher TSS as compared to the shrink wrapped fruits. After one week of storage, the unwrapped fruits retained the highest(16.20° B) TSS while in shrink wrapped fruits, it ranged from 12.56 to 14.03 °B. After two weeks of storage, among the individually shrink wrapped fruits samples wrapped with 25μ polyolefin film had the highest TSS (17.90 °B) while the lowest (17.13 °B) was seen in the fruits wrapped with 19μ film. Type of film did not have any significant influence on TSS content of shrink wrapped mangoes.

4.1.1.6 Titratable acidity(%)

Titratable acidity of mango declined during storage(Table 2). The decline was significantly higher in the control (unwrapped) fruits as compared to the shrink wrapped samples. After one week of storage, the control (unwrapped) samples retained significantly lower acidity (0.07 %) while in the shrink wrapped samples it ranged from 0.12 to 0.16 percent. After two weeks of storage, among the individually shrink wrapped fruits, the samples wrapped with 25μ polyolefin film had the lowest (0.07 %) acidity while the fruits wrapped with both 15 and 19μ films had the same titratable acidity(0.09 %)

Table 2. Effect of shrink wrap packaging on TSS and titratable acidity of mango during storage

Treatments	TSS(°Brix)			Titratable acidity (%)		
	Initial	1WAS	2WAS	Initial	1WAS	2WAS
T1	8.50	13.80	17.33	0.73	0.16	0.09
T2	8.50	13.13	17.13	0.73	0.15	0.09
T3	8.50	14.03	17.90	0.73	0.14	0.07
T4	8.50	12.73	-	0.73	0.14	-
T5	8.50	12.57	-	0.73	0.14	-
T6	8.50	13.30	-	0.73	0.12	-
T7	8.50	16.20	-	0.73	0.07	-
CD		1.59			NS	

T1:Individual shrink wrapping of mango with polyolefin film of 15μ

T2:Individual shrink wrapping of mango with polyolefin film of 19μ

T3:Individual shrink wrapping of mango with polyolefin film of 25μ

T4:Shrink wrapping of areca plate containing mangoes with polyolefin film of 15 μ

T5:Shrink wrapping of areca plate containing mangoes with polyolefin film of 19 μ

T6:Shrink wrapping of areca plate containing mangoes with polyolefin film of 25 μ

T7:Unwrapped mango (control)

4.1.1.3 Reducing, non- reducing and total sugars(%)

4.1.1.3.1 Reducing sugars

Reducing sugars increased with increase in storage period(Table 3). After one week of storage, unwrapped (control) samples had significantly higher(3.07 %) reducing sugar content than shrink wrapped samples. Film thickness did not influence the reducing sugar content of fruits significantly. However, after two weeks of storage fruits shrink wrapped in 25μ polyolefin film retained the highest (3.09 %) reducing sugar content.

4.1.1.3.2Non –reducing sugars

Non-reducing sugars also showed an increasing trend during storage (Table 3). After one week of storage, control (unwrapped) samples had significantly higher non reducing sugars as compared to shrink wrapped samples (8.17 to 8.56 %). Film thickness did not significantly influence the non- reducing sugar content in mango. However, after two weeks of storage, individually shrink wrapped mango in 25μ polyolefin film had the highest (10.98 %) non- reducing sugar while the lowest (10.69 %) was recorded in the fruits shrink wrapped in 15μ polyolefin film.

4.1.1.3.3 Total sugars

Total sugars in mango fruits increased during storage(Table 3). After one week of storage, control(unwrapped)samples had the highest total sugars (12.53 %), while it ranged from 10.93 to 11.28 % in shrink wrapped fruits. Total sugar content of mango did not vary significantly with respect to film thickness. However, after two weeks of storage, fruits shrink wrapped with 25μ had the highest total sugars(14.07%) while the lowest (13.76%) was recorded in the fruits shrink wrapped with 15μ polyolefin film.

Table 3. Effect of shrink wrap packaging on reducing, non-reducing and total sugars of mango during storage

Treatments	Reducing sugars (%)			Non-reducing sugars (%)			Total sugars (%)		
	Initial	1WAS	2WAS	Initial	1WAS	2WAS	Initial	1WAS	2WAS
T1	2.23	2.76	3.07	4.64	8.17	10.69	6.87	10.94	13.76
T2	2.23	2.62	3.08	4.64	8.56	10.92	6.87	11.18	14.00
T3	2.23	2.73	3.09	4.64	8.55	10.98	6.87	11.28	14.07
T4	2.23	2.65	-	4.64	8.46	-	6.87	11.11	-
T5	2.23	2.76	-	4.64	8.21	-	6.87	10.97	-
T6	2.23	2.61	-	4.64	8.52	-	6.87	11.13	-
T7	2.23	3.07	-	4.64	9.49	-	6.87	12.55	-
CD	-	0.22		-	0.65		-	0.68	

T1:Individual shrink wrapping of mango with polyolefin film of 15μ

T2:Individual shrink wrapping of mango with polyolefin film of 19μ

T3:Individual shrink wrapping of mango with polyolefin film of 25μ

T4:Shrink wrapping of areca plate containing mangoes with polyolefin film of 15 μ

T5:Shrink wrapping of areca plate containing mangoes with polyolefin film of 19 μ

T6:Shrink wrapping of areca plate containing mangoes with polyolefin film of 25 μ

T7:Unwrapped mango (control)

4.1.1.4 Vitamin C (mg $100g^{-1}$)

Vitamin C content of mango decreased during storage (Table 4). After one week of storage, shrink wrapped mango retained significantly higher vitamin C (42.86 to 44.88mg $100g^{-1}$) as compared to unwrapped (control) fruits (37.79mg $100g^{-1}$). Film thickness did not significantly influence the vitamin C content of the fruits. However after two weeks of storage, fruits shrink wrapped with 25µ polyolefin film retained the highest (43.5mg $100g^{-1}$) vitamin C whereas the lowest (42.89mg $100g^{-1}$) was observed in the fruits shrink wrapped with 15µ polyolefin film.

4.1.1.5 Total carotenoids(mg $100g^{-1}$)

Total carotenoids in mango increased during storage(Table 4). After one week of storage, unwrapped (control) fruits retained significantly higher total carotenoids(8.26mg $100g^{-1}$) as compared to shrink wrapped samples (3.24 to 4.85mg $100g^{-1}$). After two weeks of storage, individually shrink wrapped mango with polyolefin film of 19µ thickness retained the highest (6.21mg $100g^{-1}$) total carotenoids while the lowest (5.93mg $100g^{-1}$) was retained by the fruits wrapped with 15µ film. Film thickness did not alter significantly the total carotenoid content of shrink wrapped mango fruits.

Table 4. Effect of individual shrink wrap packaging on vitamin C and total carotenoids of mango during storage

Treatments	Vitamin C (mg $100g^{-1}$)			Total carotenoids(mg $100g^{-1}$)		
	Initial	1WAS	2WAS	Initial	1WAS	2WAS
T1	54.82	44.49	42.88	1.98	3.937	5.93
T2	54.82	42.86	41.67	1.98	4.190	6.21
T3	54.82	44.89	43.50	1.98	4.153	6.15
T4	54.82	43.50	-	1.98	3.977	-
T5	54.82	43.15	-	1.98	3.237	-
T6	54.82	43.22	-	1.98	4.847	-
T7	54.82	37.79	-	1.98	8.257	-
CD		2.35			1.268	

T1:Individual shrink wrapping of mango with polyolefin film of 15μ

T2:Individual shrink wrapping of mango with polyolefin film of 19μ

T3:Individual shrink wrapping of mango with polyolefin film of 25μ

T4:Shrink wrapping of areca plate containing mangoes with polyolefin film of 15 μ

T5:Shrink wrapping of areca plate containing mangoes with polyolefin film of 19 μ

T6:Shrink wrapping of areca plate containing mangoes with polyolefin film of 25 μ

T7:Unwrapped mango (control)

4.1.1.7 Organoleptic analysis

After one week of storage, shrink wrapped mangoes had higher organoleptic scores as compared to control (unwrapped) fruits. Individually shrink wrapped fruits obtained higher scores as compared to fruits wrapped in areca plates. After two weeks of storage, among individually shrink wrapped fruits, the samples wrapped with 25μ polyolefin film had the highest overall acceptability(5.7) as compared to the samples wrapped with 15 and 19μ films wherein the acceptability scores were 5.4 and 5.2, respectively.

4.1.1.9Internal quality

Internal quality of individually shrink wrapped fruits was better compared to the fruits shrink wrapped in areca plates and control (unwrapped) samples. Off flavour was detected in the air surrounding the shrink wrapped fruits, after opening the sealed fruits. Internal browning was not detected in any of the samples.

. Table 5 a. Effect of shrink wrap packaging on organoleptic qualities of mango during 1st week of storage

Treatments	Appearance	Colour	Flavour	Texture	Odour	Taste	After taste	Overall acceptability	Total score
T1	7.6	7.5	7.1	7.5	7	7.8	7.3	7.8	59.6
T2	7.5	7.1	7	7.5	6.9	7.7	7.2	7.4	58.3
T3	7.7	7.4	7.1	7.2	6.7	7.8	7.3	7.7	58.9
T4	6.8	7.1	5.9	6.6	6.4	6.9	6.5	6.5	52.7
T5	7.1	7.1	6.7	7	6.9	7.5	6.9	7.3	56.5
T6	6.9	6.9	6.6	6.5	6.2	6.7	6.6	6.7	53.1
T7	6.7	6.9	5.9	6.4	6.5	6.6	6.5	6.7	52.2
Kendal's W test	0.67	0.659	0.501	0.617	0.570	0.301	0.657	0.426	

T1:Individual shrink wrapping of mango with polyolefin film of 15μ

T2:Individual shrink wrapping of mango with polyolefin film of 19μ

T3:Individual shrink wrapping of mango with polyolefin film of 25μ

T4:Shrink wrapping of areca plate containing mangoes with polyolefin film of 15 μ

T5:Shrink wrapping of areca plate containing mangoes with polyolefin film of 19 μ

T6:Shrink wrapping of areca plate containing mangoes with polyolefin film of 25 μ

T7:Unwrapped mango (control)

Table 5b. Effect of shrink wrap packaging on organoleptic qualities of mango during 2nd week of storage

Treatments	Appearance	Colour	Flavour	Texture	Odour	Taste	After taste	Overall acceptability	Total score
T1	6.60	7.50	6.00	5.70	4.50	5.00	4.40	5.40	45.10
T2	6.60	7.30	5.80	5.30	4.70	4.90	4.40	5.20	44.20
T3	7.00	7.50	5.90	5.20	4.80	5.10	4.50	5.70	45.70
Kendal's W test	0.27	0.13	0.04	0.35	0.12	0.04	0.03	0.38	

T1:Individual shrink wrapping of mango with polyolefin film of 15μ

T2:Individual shrink wrapping of mango with polyolefin film of 19μ

T3:Individual shrink wrapping of mango with polyolefin film of 25μ

Wrapped fruit

Wrap removed fruit

Wrapped fruit

Wrap removed fruit

Plate 8. Spoilage of shrink wrapped mangoes during storage

4.2 EFFECT OF SHRINK WRAP PACKAGING ON SHELF LIFE AND QUALITY OF BANANA

4.2.1Observations

4.2.1.1 Shelf life (Days)

Shelf life of shrink wrapped banana hands is given in Fig 2. Shelf life of individually shrink wrapped banana hands was lower than control (unwrapped) fruits. Percentage of spoilage was higher in theshrink wrapped banana hands master packedin CFB box than individually shrink wrapped banana hands. Among the individually shrink wrapped banana hands, samples wrappedin 25 μ polyolefin film had the longest shelf life (5 days) and the ones wrapped with 19 μ polyolefin film master packed in CFB box had the shortest shelf life (4 days). Shelf life of control (unwrapped) samples was 7 days.

4.2.1.2 Physiological loss in weight(PLW)(%)

PLW of all the samples increased during storage (Table 6). Control (unwrapped) samples had maximum PLW as compared to the fruits subjected to shrink wrap packaging. After 3 days of storage, control (unwrapped) fruits had significantly higher PLW (5.55%) as compared to shrink wrapped fruits and individually shrink wrapped banana hands in 15μ polyolefin film had the lowest PLW (1.47 %).

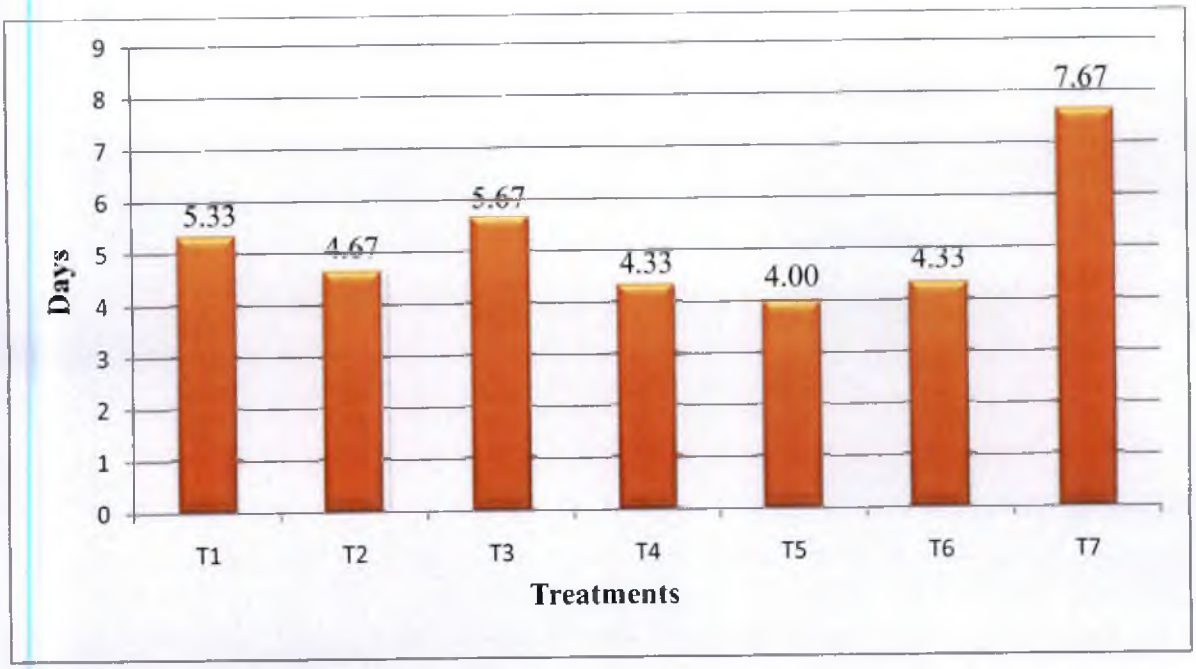


Figure 2. Effect of shrink wrap packaging on shelf life of banana

T1: Shrink wrapping of banana hands with polyolefin film of 15µ

T2: Shrink wrapping of banana hands with polyolefin film of 19µ

T3: Shrink wrapping of banana hands with polyolefin film of 25µ

T4: Shrink wrapped banana hands (15µ) master packed in CFB boxes

T5: Shrink wrapped banana hands (19µ) master packed in CFB boxes

T6: Shrink wrapped banana hands (25µ) master packed in CFB boxes

T7: Unwrapped hands (control)

Table 6. Effect of shrink wrap packaging on physiological loss in weight (PLW) of banana during storage

Treatments	PLW(%)		
	0 DAS	3 DAS	6 DAS
T1	0.00	1.47	-
T2	0.00	1.90	-
T3	0.00	1.69	-
T4	0.00	2.14	-
T5	0.00	2.26	-
T6	0.00	2.29	-
T7	0.00	5.55	9.06
CD		0.58	

T1: Shrink wrapping of banana hands with polyolefin film of 15μ

T2: Shrink wrapping of banana hands with polyolefin film of 19μ

T3: Shrink wrapping of banana hands with polyolefin film of 25μ

T4: Shrink wrapped banana hands (15μ) master packed in CFB boxes

T5: Shrink wrapped banana hands (19μ) master packed in CFB boxes

T6: Shrink wrapped banana hands (25μ) master packed in CFB boxes

T7: Unwrapped hands (control)

4.2.1.3 Total Soluble Solids (TSS)(° Brix)

TSS of banana increased throughout the storage period (Table 7). Control(unwrapped) fruits had significantly higher TSS as compared to the shrink wrapped fruits. After4 days of storage, the unwrapped (control) fruits retained the highest (16.87°B) TSS, while in shrink wrapped fruits, it ranged from 14.2 to 16 °B. Among the individually shrink wrapped banana hands, samples wrapped with 25µ film recorded higher TSS(15.87°B) which was on par (15.00°B) with the hands wrapped with 15µ film. After 7 days of storage, the unwrapped (control) fruits retained the highest TSS of 18.67 °B. Type of film did not have any significant influence on TSS content of shrink wrapped banana hands.

4.2.1.4 Titratable acidity (%)

Titratable acidity of bananadeclined during storage(Table 7). The decline was significantly higher in the control (unwrapped) fruits as compared to the shrink wrapped samples. After 4 days of storage, the control (unwrapped) samples recorded the lowest acidity (0.18 %),while in the shrink wrapped samples it ranged from 0.19 to 0.24 percent.Among the samples(hands) wrapped individually, fruits wrapped with 25µ film had the highest acidity (0.20 %) while the ones wrapped with 15µ film had an acidity of 0.18 % which was on par(0.17 %) with the control samples.

4.2.1.5 Vitamin C (mg $100g^{-1}$)

Vitamin C content of banana decreased during storage (Table 7). After 4 days of storage, shrink wrapped banana retained higher vitamin C (16.32to 18.65mg $100g^{-1}$) as compared to unwrapped (control) fruits (16.2mg $100g^{-1}$). The vitamin C content of banana hands wrapped with 15 and 25µ films were 17.93 and 18.01mg $100g^{-1}$ respectively, which were on par with each other even though the content was higher than the control samples, which had a vitamin C content of 16.04mg $100g^{-1}$. Film thickness did not significantly influence the vitamin C content of the fruit.

Table 7. Effect of shrink wrap packaging on TSS, titratable acidity and vitamin C of banana during storage

Treatments	TSS (° Brix)				Titratable acidity (%)				Vitamin C (mg $100g^{-1}$)			
	Initial	4 DAS	5 DAS	7 DAS	Initial	4 DAS	5 DAS	7 DAS	Initial	4 DAS	5 DAS	7 DAS
T1	13.33	14.20	15.00	-	0.45	0.22	0.18	-	18.69	18.65	17.93	-
T2	13.33	14.57	-	-	0.45	0.24	-	-	18.69	18.19	-	-
T3	13.33	14.23	15.37	-	0.45	0.24	0.20	-	18.69	18.46	18.01	-
T4	13.33	14.97	-	-	0.45	0.22	-	-	18.69	17.93	-	-
T5	13.33	15.43	-	-	0.45	0.19	-	-	18.69	16.32	-	-
T6	13.33	16.00	-	-	0.45	0.21	-	-	18.69	17.04	-	-
T7	13.33	16.87	17.53	18.67	0.45	0.18	0.17	0.09	18.69	16.32	16.04	15.88
CD		1.53				NS				NS		

T1: Shrink wrapping of banana hands with polyolefin film of 15µ

T2: Shrink wrapping of banana hands with polyolefin film of 19µ

T3: Shrink wrapping of banana hands with polyolefin film of 25µ

T4: Shrink wrapped banana hands (15µ) master packed in CFB boxes

T5: Shrink wrapped banana hands (19µ) master packed in CFB boxes

T6: Shrink wrapped banana hands (25µ) master packed in CFB boxes

T7: Unwrapped hands (control)

4.2.1.6 Reducing , non- reducing and total sugars

4.2.1.6 .1 Reducing sugars(%)

Reducing sugars increased with increase in storage period(Table 8). After 4 days of storage, unwrapped (control) samples had higher(7.57) reducing sugars than shrink wrapped samples(5.83 to 7.43). Reducing sugars of hands wrapped with 15 and 25μ films were 6.27 and 6.95, respectively and the contents were lower than that of the unwrapped samples, which had a reducing sugar content of 8.07 % after 5 days of storage. After 7 days of storage, unwrapped (control) samples had higher reducing sugar content of 8.79 percent.

4.2.1.6 .2 Non –reducing sugars(%)

Non-reducing sugars also showed an increasing trend during storage (Table 8). Control fruits retained higher non reducing sugars than shrink wrapped fruits throughout storage. After 5 days of storage, unwrapped fruits had the highest non reducing sugars(3.62) while the content in hands wrapped with 15 and 25μ films were 2.68 and 1.18 % respectively.After 7 days of storage, control (unwrapped) samples had higher non reducing sugar of 3.76 percent. Film thickness did not significantly influence the non- reducing sugar content in banana hands.

4.2.1.6 .3 Total sugars (%)

Total sugars in banana hands increased during storage(Table 8). Control fruits retained higher total sugars than shrink wrapped fruits throughout storage. After 5 days of storage, unwrapped fruits had the highest total sugars (11.68 %) while the content in hands wrapped with 15 and 25μ films were 8.95 and 8.13% respectively.After 7 days of storage, control(unwrapped) samples had the highest total sugar content of 12.55 percent.

Table 8. Effect of shrink wrap packaging on reducing sugars (%),non-reducing sugars (%) and total sugars (%) during storage

Treat ments	Reducing sugars (%)				Non reducing sugars (%)				Total sugars (%)			
	Initial	4 DAS	5 DAS	7DAS	Initial	4 DAS	5 DAS	7 DAS	Initial	4 DAS	5 DAS	7 DAS
T1	3.62	5.83	6.27	-	2.32	3.13	2.68	-	5.94	8.63	8.95	-
T2	3.62	6.56	-	-	2.32	1.98	-	-	5.94	8.74	-	-
T3	3.62	6.48	6.95	-	2.32	1.40	1.18	-	5.94	7.92	8.13	-
T4	3.62	6.07	-	-	2.32	1.03	-	-	5.94	7.10	-	-
T5	3.62	7.43	-	-	2.32	1.52	-	-	5.94	8.95	-	-
T6	3.62	7.18	-	-	2.32	1.30	-	-	5.94	8.56	-	-
T7	3.62	7.57	8.06	8.79	2.32	3.58	3.62	3.76	5.94	11.15	11.68	12.55
CD		NS				0.52				0.98		

T1: Shrink wrapping of banana hands with polyolefin film of 15μ

T2: Shrink wrapping of banana hands with polyolefin film of 19μ

T3: Shrink wrapping of banana hands with polyolefin film of 25μ

T4: Shrink wrapped banana hands (15μ) master packed in CFB boxes

T5: Shrink wrapped banana hands (19μ) master packed in CFB boxes

T6: Shrink wrapped banana hands (25μ) master packed in CFB boxes

T7: Unwrapped hands (control)

4.2.1.6 Organoleptic analysis

Shrink wrapped banana hands had lower organoleptic scores as compared to control (unwrapped) fruits (7). After 4 days of storage, individually shrink wrapped fruits (5.6 to 6.3) obtained higher scoresas compared to shrink wrapped fruits (4.2 to 6.3)master packed in CFB box.

4.2.1.8 Internal quality

Off flavour was detected in the fruits after removing the seal. Development of off flavour was more in fruits which were individually shrink wrapped followed by master packing in CFB boxes.

Table 9 a. Effect of shrink wrap packaging on organoleptic analysis of banana after 4 days of storage

Treatments	Appearance	Colour	Flavour	Texture	Odour	Taste	After taste	Overall acceptability	Total score
T1	7.10	6.60	5.80	6.30	5.40	5.70	4.90	6.00	47.80
T2	6.70	6.30	5.10	5.70	5.50	5.40	4.70	5.60	45.00
T3	6.70	6.50	5.30	6.00	5.70	5.50	5.00	6.30	47.00
T4	6.00	6.00	4.20	4.40	4.50	4.50	3.70	6.30	39.60
T5	5.80	6.00	4.20	4.20	4.80	4.70	3.60	4.20	37.50
T6	5.80	5.80	4.60	5.20	4.80	5.20	4.10	4.70	40.20
T7	7.50	7.50	6.30	7.00	6.40	6.50	5.70	7.00	53.80
Kendal's W test	0.76	0.58	0.65	0.83	0.53	0.64	0.88	0.70	

T1: Shrink wrapping of banana hands with polyolefin film of 15μ

T2: Shrink wrapping of banana hands with polyolefin film of 19μ

T3: Shrink wrapping of banana hands with polyolefin film of 25μ

T4: Shrink wrapped banana hands (15μ) master packed in CFB boxes

T5: Shrink wrapped banana hands (19μ) master packed in CFB boxes

T6: Shrink wrapped banana hands (25μ) master packed in CFB boxes

T7: Unwrapped hands (control)

Table 9 b. Effect of shrink wrap packaging on organoleptic analysis of banana after 5 days of storage

Treatments	Appearance	Colour	Flavour	Texture	Odour	Taste	After taste	Overall acceptability	Total score
T1	6.80	6.40	5.40	5.80	5.30	5.50	4.70	5.80	45.70
T3	6.60	6.30	5.50	5.50	5.80	5.50	4.80	5.90	45.90
T7	8.00	7.50	6.60	6.90	6.70	6.90	6.40	6.90	55.90
Kendal's W test	0.75	0.87	0.63	0.65	0.79	0.82	0.71	0.0.5	

T1: Shrink wrapping of banana hands with polyolefin film of 15µ

T3: Shrink wrapping of banana hands with polyolefin film of 25µ

T7: Unwrapped hands (control)

Wrapped banana hands

Wrap removed banana hands

Plate 9. Spoilage of shrink wrapped banana hands during storage

4.3 EFFECT OF SHRINK WRAP PACKAGING ON SHELF LIFE AND QUALITY OF PINEAPPLE

4.3.1 Observations

4.3.1.1 Shelf life (Days)

Shelf life of shrink wrapped pineapple fruits isgiven in Fig 3. Shelf life of individually shrink wrapped pineapple was higher than shrink wrapped fruits master packed in CFB box and control (unwrapped fruits). Percentage of spoilage was higher in the shrink wrappedfruits master packed in CFB boxes. Individually shrink wrapped pineapples in 25 μ polyolefin film had the longest shelf life (16 days) and thefruits shrink wrappedwith 25 μ polyolefin film master packed in CFB box had the shortest shelf life (9 days). Shelf life of control (unwrapped) samples was 12 days.

4.3.1.2 Physiological loss in weight(PLW) (%)

PLW of all the samples increased during storage (Table 10). The PLW of all shrink wrapped samples remained significantly lower compared to the control (unwrapped) fruits. After 12 days of storage, control (unwrapped) fruits had significantly higher PLW (16.52 %) compared to shrink wrapped fruits and individually shrink wrapped pineapple in 19μ polyolefin film had the lowest PLW (2.35 %).

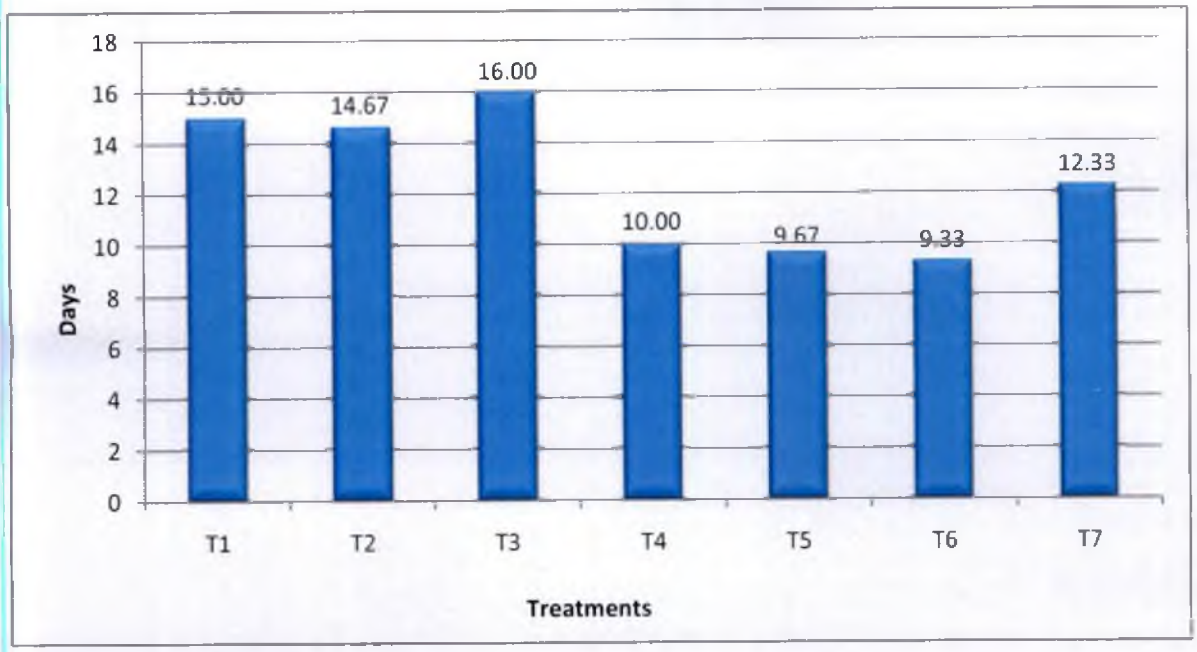


Figure 3. Effect of shrink wrapping packaging on shelf life of pineapple

T1:Individually shrink wrapped pineapple(15μ)

T2:Individually shrink wrapped pineapple(19μ)

T3:Individually shrink wrapped pineapple(25μ)

T4:Individually shrink wrapped pineapple(15μ) master packed in CFB box

T5:Individually shrink wrapped pineapple(19μ) master packed in CFB box

T6:Individually shrink wrapped pineapple(25μ) master packed in CFB box

T7:Unwrapped pineapple (control)

Table 10.Effect of shrink wrap packaging on physiological loss in weight (PLW) of pineapple during storage

Treatments	PLW (%)					
	0 DAS	3 DAS	6 DAS	9 DAS	12 DAS	15 DAS
T1	0.00	0.00	0.51	1.10	2.56	4.23
T2	0.00	0.00	0.52	1.13	2.35	-
T3	0.00	0.00	0.44	1.04	2.86	4.34
T4	0.00	0.03	0.87	2.75	-	-
T5	0.00	0.20	0.65	2.92	-	-
T6	0.00	0.05	0.62	2.61	-	-
T7	0.00	2.90	4.17	10.11	16.52	-
CD		0.27	0.28	0.32	0.56	

T1:Individually shrink wrapped pineapple(15µ)

T2:Individually shrink wrapped pineapple(19µ)

T3:Individually shrink wrapped pineapple(25µ)

T4:Individually shrink wrapped pineapple(15µ) master packed in CFB box

T5:Individually shrink wrapped pineapple(19µ) master packed in CFB box

T6:Individually shrink wrapped pineapple(25µ) master packed in CFB box

T7:Unwrapped pineapple (control)

4.3.1.3Total Soluble Solids (TSS)(°B)

TSS of pineapple increased throughout the storage period (Table 11). Control(unwrapped) sample had significantly higher TSS as compared to the shrink wrapped fruits. After one week of storage, the unwrapped fruits retained the highest(14.43° B) TSS while in shrink wrapped fruits, it ranged from 13.03 to 13.60 °B. After two weeks of storage, among the individually shrink wrapped samples, fruits wrapped with 19μ polyolefin film had the highest TSS(16.23 °B) while the lowest (16.10 °B) was seen in the fruits wrapped with 15μ film. Type of film did not have any significant influence on TSS content of shrink wrapped pineapple.

4.3.1.4 Titratable acidity (%)

Titratable acidity of pineappledeclined during storage(Table 11). The decline was significantly steeper in the control (unwrapped) fruits as compared to the shrink wrapped samples. After one week of storage, the control (unwrapped) samples retained significantly lower acidity (0.16%) while in the shrink wrapped samples it ranged from 0.29 to 0.50 percent. After two weeks of storage, among the individually shrink wrapped fruits, the samples wrapped with 25μ polyolefin film had the lowest (0.23%) acidity while the highest (0.34 %) was noticed in the fruits wrapped with 19μ film.

4.3.1.5Vitamin C(mg $100g^{-1}$)

Vitamin C content of pineapple decreased during storage (Table 11). After one week of storage, shrink wrapped banana hands retained higher vitamin C (12.41 to 14.81 mg $100g^{-1}$) as compared to unwrapped (control) fruits (12.13 mg$100g^{-1}$). Film thickness did not significantly influence the vitamin C content of the fruits. However after two weeks of storage, fruits shrink wrapped with 19μ polyolefin film retained the highest (12.05 mg $100g^{-1}$) vitamin C whereas the lowest (11.72mg $100g^{-1}$) was observed in the fruits shrink wrapped with 15μfilm.

Table 11. Effect of shrink wrap packaging on TSS, titratable acidity and vitamin C content of pineapple during storage

Treatments	TSS(°Brix)			Titratable acidity (%)			Vitamin C (mg $100g^{-1}$)		
	Initial	1WAS	2WAS	Initial	1WAS	2WAS	Initial	1WAS	2WAS
T1	12.17	13.03	16.10	0.66	0.32	0.29	19.29	14.55	11.72
T2	12.17	13.10	16.23	0.66	0.32	0.34	19.29	14.64	12.05
T3	12.17	13.23	16.20	0.66	0.29	0.23	19.29	13.81	12.00
T4	12.17	13.60	-	0.66	0.50	-	19.29	14.81	-
T5	12.17	13.33	-	0.66	0.50	-	19.29	14.10	-
T6	12.17	13.50	-	0.66	0.41	-	19.29	12.41	-
T7	12.17	14.43	-	0.66	0.16	-	19.29	12.13	-
CD		0.82			0.13			NS	

T1:Individually shrink wrapped pineapple(15μ)

T2:Individually shrink wrapped pineapple(19μ)

T3:Individually shrink wrapped pineapple(25μ)

T4:Individually shrink wrapped pineapple(15μ) master packed in CFB box

T5:Individually shrink wrapped pineapple(19μ) master packed in CFB box

T6:Individually shrink wrapped pineapple(25μ) master packed in CFB box

T7:Unwrapped pineapple (control)

4.3.1.6Reducing , non- reducing and total sugars

4.3.1.6.1 Reducing sugars(%)

Reducing sugars increased with increase in storage period(Table 12). After one week of storage, unwrapped (control) samples had significantly higher(3.82 %) reducing sugars than shrink wrapped samples (3.52 to 3.66%). Film thickness did not influence the reducing sugar content of fruits significantly. However, after two weeks of storage, fruits shrink wrapped in 19 and 25μ polyolefin film retained the same (3.75%) reducing sugar content, which was the highest while the lowest (3.46 %) was recorded in the samples wrapped with 15μ film.

4.3.1.6 .2 Non –reducing sugars (%)

Non-reducing sugars also showed an increasing trend during storage (Table 12). After one week of storage, control (unwrapped) samples had significantly higher non reducing sugar as compared to shrink wrapped samples (8.97to 9.15%). Film thickness did not significantly influence the non- reducing sugar content in pineapple. However, after two weeks of storage, individually shrink wrapped pineapple in 25μ polyolefin film had the highest (9.15%) non-reducing sugars while the lowest (9.08 %)was recorded in the fruits shrink wrapped in 15μ film.

4.3.1.6.3 Total sugars(%)

Total sugars in pineapple fruits increased during storage(Table 12). After one week of storage, control (unwrapped) samples had the highest total sugar(12.98 %) while it ranged from 12.48to 12.78% in shrink wrapped fruits. Total sugar content of pineapple did not vary significantly with respect to film thickness. However, after two weeks of storage, fruits shrink wrapped with 25μ had the highest total sugars(12.89%) while the lowest (12.54 %) was recorded in the fruits shrink wrapped with 15μ film.

Table 12.Effect of shrink wrap packaging on reducing, non-reducing and total sugar content of pineapple during storage

Treatments	Reducing sugars (%)			Non-reducing sugars (%)			Total sugars (%)		
	Initial	1WAS	2WAS	Initial	1WAS	2WAS	Initial	1WAS	2WAS
T1	3.41	3.52	3.46	8.77	8.97	9.08	12.18	12.48	12.54
T2	3.41	3.53	3.75	8.77	9.09	9.09	12.18	12.61	12.84
T3	3.41	3.62	3.75	8.77	9.03	9.15	12.18	12.67	12.89
T4	3.41	3.55	-	8.77	9.20	-	12.18	12.67	-
T5	3.41	3.63	-	8.77	9.10	-	12.18	12.78	-
T6	3.41	3.66	-	8.77	9.15	-	12.18	12.72	-
T7	3.41	3.82	-	8.77	9.16	-	12.18	12.98	-
CD	-	0.07		-	NS		-	0.18	

T1:Individually shrink wrapped pineapple(15μ)

T2:Individually shrink wrapped pineapple(19μ)

T2:Individually shrink wrapped pineapple(25μ)

T4:Individually shrink wrapped pineapple(15μ) master packed in CFB box

T5:Individually shrink wrapped pineapple(19μ) master packed in CFB box

T6:Individually shrink wrapped pineapple(25μ) master packed in CFB box

T7:Unwrapped pineapple (control)

4.3.1.7 Organoleptic analysis

After one week of storage, individually shrink wrapped pineapple fruitshad higher organoleptic scores as compared to control (unwrapped) fruits. Among shrink wrapped fruits, individually shrink wrapped fruits obtained higher scores as compared to samples shrink wrapped and master packed in CFB box. After two weeks of storage, among individually shrink wrapped fruits, the samples wrapped with 25μ polyolefin film had the highest overall acceptability(6.5) as compared to the samples wrapped with 15 and 19μ films wherein the acceptability scores were 5.7 and 5.5, respectively.

4.3.1.8Internal quality

Off flavour was detected in the fruits after removing the seal. Development of off flavour was more in fruits which were individually shrink wrapped followed by master packing in CFB boxes.

Table 13a. Effect of shrink wrap packaging on organoleptic quality of pineapple during 1st week of storage

Treatments	Appearance	Colour	Flavour	Texture	Odour	Taste	After taste	Overall acceptability	Total score
T1	7.50	7.60	7.30	7.50	7.40	7.50	7.10	7.60	59.40
T2	7.50	7.30	7.30	7.20	7.00	7.60	7.20	7.40	58.30
T3	7.70	7.80	7.50	7.60	7.20	7.50	7.30	7.60	60.20
T4	5.90	6.50	5.50	5.10	6.10	5.20	4.50	5.70	44.50
T5	6.20	6.40	5.50	5.20	6.00	5.30	4.30	5.50	44.30
T6	6.40	6.80	5.50	5.20	6.10	5.40	4.50	5.60	45.50
T7	7.60	7.60	7.40	7.50	7.00	7.90	7.30	7.30	59.50
Kendall's W test	0.61	0.26	0.40	0.79	0.30	0.91	0.78	0.82	

T1:Individually shrink wrapped pineapple(15μ)

T2:Individually shrink wrapped pineapple(19μ)

T3:Individually shrink wrapped pineapple(25μ)

T4:Individually shrink wrapped pineapple(15μ) master packed in CFB box

T5:Individually shrink wrapped pineapple(19μ) master packed in CFB box

T6:Individually shrink wrapped pineapple(25μ) master packed in CFB box

T7:Unwrapped pineapple (control)

Table 15b.Effect of shrink wrap packaging on organoleptic quality of pineapple during2 week of storage

Treatments	Appearance	Colour	Flavour	Texture	Odour	Taste	After taste	Overall acceptability	Total score
T1	6.00	6.10	5.60	5.40	5.30	5.30	4.90	5.70	38.90
T2	6.00	6.40	5.50	5.30	4.60	5.50	5.30	5.50	38.60
T3	6.00	6.50	5.90	5.80	5.60	5.50	5.70	6.50	41.10
Kendal's W test	0.35	0.22	0.16	0.23	0.23	0.60	0.53	0.47	

T1:Individually shrink wrapped pineapple(15µ)

T2:Individually shrink wrapped pineapple(19µ)

T3:Individually shrink wrapped pineapple(25µ)

Wrapped fruit

Wrap removed fruit

Plate 10. Spoilage of shrink wrapped pineapple during storage

Discussion

5. DISCUSSION

Shrink-wrap packaging is a new technique for post-harvest handling of fruits. Shrink-wrapping has been used successfully to package apples, mangoes and a variety of other fruits. Shrink-wrapping with an engineered plastic wrap can reduce shrinkage, protect the produce from disease, reduce mechanical damage and provide a good surface for stick-on labels. The main advantages of film wrapping of fruits and vegetables are-(i) reduced weight loss and extended shelf-life (ii) minimized fruit deformation (iii) reduced chilling injury and (iv) reduced decay by preventing secondary infection of fruits packed in the same box.

Mango, banana and pineapple are widely grown fruits in Kerala. Post harvest losses of these fruits are major problem that demand immediate attention. Suitable post harvest techniques to prolong shelf life and maintenance of quality during storage are of considerable importance to the economy of our state, so as to fetch premium prices to the producers and to provide quality produce to consumers. Hence, the study on "Shrink wrap packaging of selected tropical fruits" was carried out in the Department of Processing Technology, College of Horticulture, Vellanikkara during 2014-16. The discussion pertaining to the study is presented under the following heads.

5.1 Effect of shrink wrap packaging on shelf life and quality of mango

5.2 Effect of shrink wrap packaging on shelf life and quality of banana

5.3 Effect of shrink wrap packaging on shelf life and quality of pineapple

5.1 EFFECT OF SHRINK WRAP PACKAGING ON SHELF LIFE AND QUALITY OF MANGO

Mature green fruits of mango var. Prior, free of damage and bruises, were washed in plain tap water, followed by surface sanitization with 100ppm chlorine for 15 minutes. The chlorinated fruits were spread out on blotting paper to remove excess surface moisture. Surface dried fruits were subjected to two forms of shrink wrapping i.e., individual fruit

wrap and wrapping of 4-5 fruits in areca plates by using polyolefin film of three densities viz. 15, 19 and 25μ. The shrink wrap packaged fruits were stored at ambient temperature to evaluate the shelf life and PLW at an interval of three days and other biochemical observations were recorded at weekly intervals.

5.1.1 Observations

5.1.1.1. Shelf life (days)

Shelf life of individually shrink wrapped mango was higher than shrink wrapped fruits in areca plates and control (unwrapped fruits). Percentage of spoilage was higher in the fruits wrapped in areca plates. Individually shrink wrapped mangoes in 25 μ polyolefin film had the longest shelf life (18 days) and the fruits in shrink wrapped areca plates with 19 μ polyolefin film had the shortest shelf life (8 days).

Longer shelf life in individually shrink wrapped mangoes may be due to the modified atmosphere surrounding the film with elevated level of CO_2 and depleted O_2. This modified atmosphere may have reduced the respiratory activity of fruits, leading to prolonged shelf life. Higher spoilage percentage in fruits wrapped in areca plates may be due to moisture condensation inside the film which was absorbed by the areca plate, leading to spoilage of fruits.

Singh and Rao (2005) reported that shrink-wrapped green papaya(*Carica papaya*) cv. 'Solo' fruits could be stored for 10 days at ambient temperature with firm texture and good flavour after unwrapping, whereas the non-wrapped fruits ripened within 7 days beyond which they became unmarketable

Sharma *et al.*(2010)reported that fully mature Royal Delicious apples when shrink-wrapped with cryovac(9 μ) film could be stored in zero energy cool chamber for 45 days without any adverse effect on quality parameters.

5.1.1.2. PLW (physiological loss in weight)(%)

Control (unwrapped) samples had maximum PLW as compared to the fruits subjected to shrink wrap packaging. After 12 days of storage, control (unwrapped) fruits

hadsignificantly higher PLW (3.1 %) compared to individually shrink wrapped mango in 25μ polyolefin film which had the lowest PLW (0.73 %). Lower PLW in shrink wrapped mangoes may be due to lower respiratory activity owing to the modification of atmosphere in the wrapped samples.

Rao and Shivashankara, (2015) reported that shrink wrapping effectively reduced the rate of transpiration of mangoes due to the low WVTR(Water Vapour Transmission rate) of the films, thereby significantly reducing the weight loss. Plastic films used for the shrink wrap packaging have low permeablility to oxygen and carbon dioxide, this property reduced the respiration rate and ripening related physiological changes leading to less mass loss.

Reduction in physiological loss in weight by shrink wrapping was also reported by Miller *et al.*(1983) in mango, Hale *et al.*(1986) in Florida grapefruit, Ladaniya*et al.* (1997) in 'Nagpur' mandarins, Nanda *et al.* (2001) in pomegranate and Sigh and Rao(2005) in papaya. Cumulative mass loss in shrink wrapped fruits was significantly less as compared to unwrapped fruits.

5.1.1.3. TSS (Total Soluble Solids)(°Brix)

TSS of fruits increased throughout the storage period. After one week of storage, the unwrapped fruits retained the highest (16.20 °B) TSS, while in shrink wrapped fruits, it ranged from 12.56 to 14.03 °Brix. After two weeks of storage, among the individually shrink wrapped fruits samples wrapped with 25μ polyolefin film had the highest TSS (17.90 °B) while the lowest (17.13 °B) was seen in the fruits wrapped with 19μ film.

Higher TSS in control samples may be due to conversion of complex carbohydrates into simpler compounds and the rate may have been faster at ambient temperature.

Wijesinghe and Sarananda (2002) reported that increase in TSS may be due to sugar synthesis during ripening or moisture loss during storage increasing the sugar concentration available in the fruits.

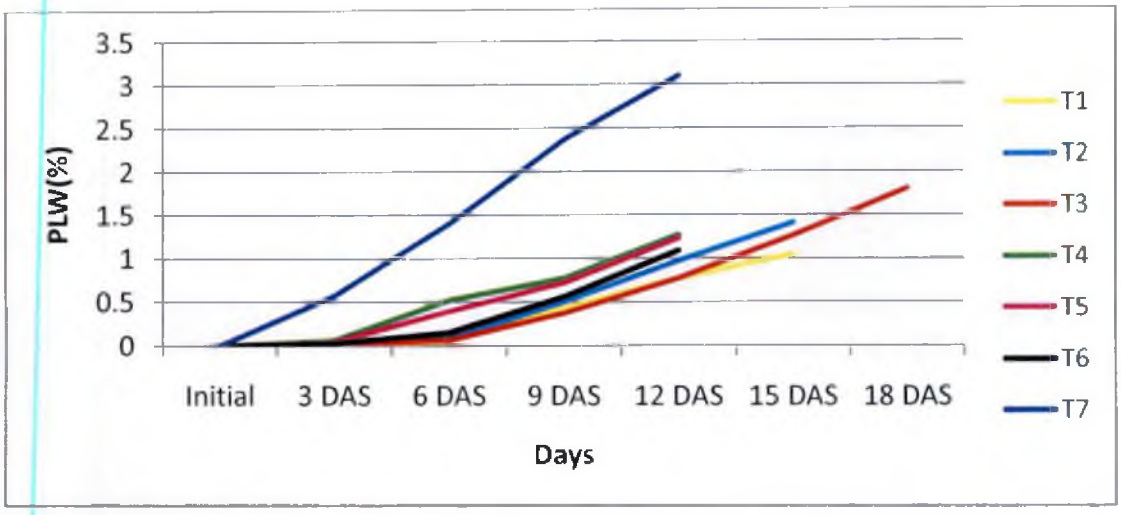


Figure 4.Effect of shrink wrap packaging on PLW of mango

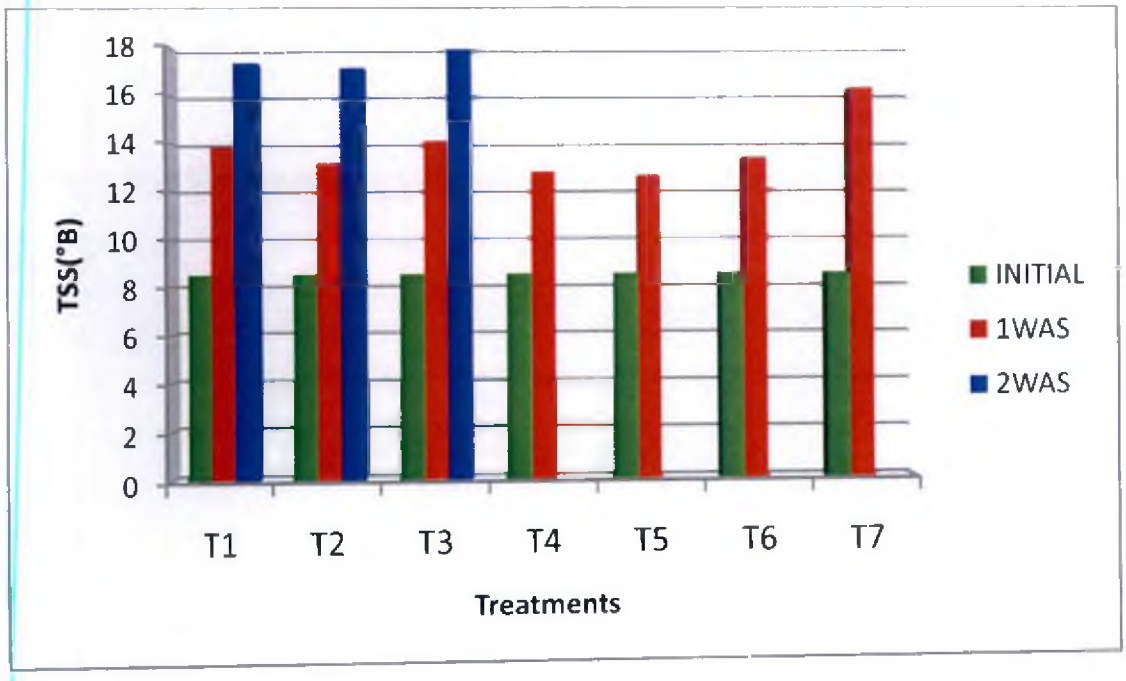


Figure 5. Effect of shrink wrap packaging on TSS of mango during storage

Dasmohapatra*et al.*(2011) noticed that the mean total soluble solids was found to be higher in unwrapped open fruits than wrapped fruits .

5.1.1.4. Titratable acidity (%)

Titratable acidity of mango declined during storage. The decline was significantly higher in the control (unwrapped) fruits as compared to the shrink wrapped samples. After one week of storage, the control (unwrapped) samples retained significantly lower acidity (0.07%) while in the shrink wrapped samples it ranged from 0.12 to 0.16 percent. After two weeks of storage, among the individually shrink wrapped fruits, the samples wrapped with 25µ polyolefin film had the lowest (0.07%) acidity while the fruits wrapped with 15 and 19µ films had the same titratable acidity(0.09%).

Decline in titratable acidity of mangoes may be due to consumption of organic acids during respiration and conversion of complex carbohydrates into simpler sugars.Gafir*et al.* (2009) suggested that during respiration,organic acid is consumed and thus decline in the organic acid content occurred during storage. Individually shrink wrapped fruits had comparatively higher titratable acidity due to lower respiration rate. Shrink wrapping did not lose the ability to metabolise acids during storage (Rao and Shivashankara, 2015).

5.1.1.5. Sugars (reducing, non-reducing and total)(%)

Sugar content of mango increased during storage. Unwrapped fruits had significantly higher reducing, non-reducing and total sugars, throughout storage. Individually shrink wrapped mangoes in 25µ polyolefin film retained the highest (3.09%, 10.98%, 14.07%) reducing, non- reducing and total sugar content respectively two weeks after storage.

Higher sugar content in control(unwrapped) fruits may be due to conversion of starch into sugars and the rate may be faster under ambient conditions. Lower sugar content

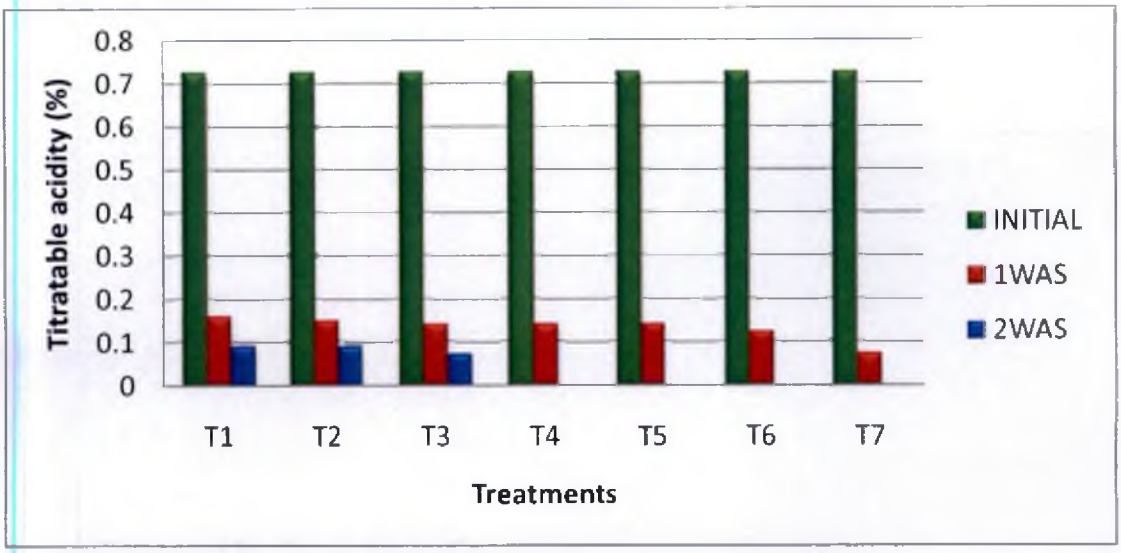


Figure 6. Effect of shrink wrap packaging on titratable acidity of mango during storage

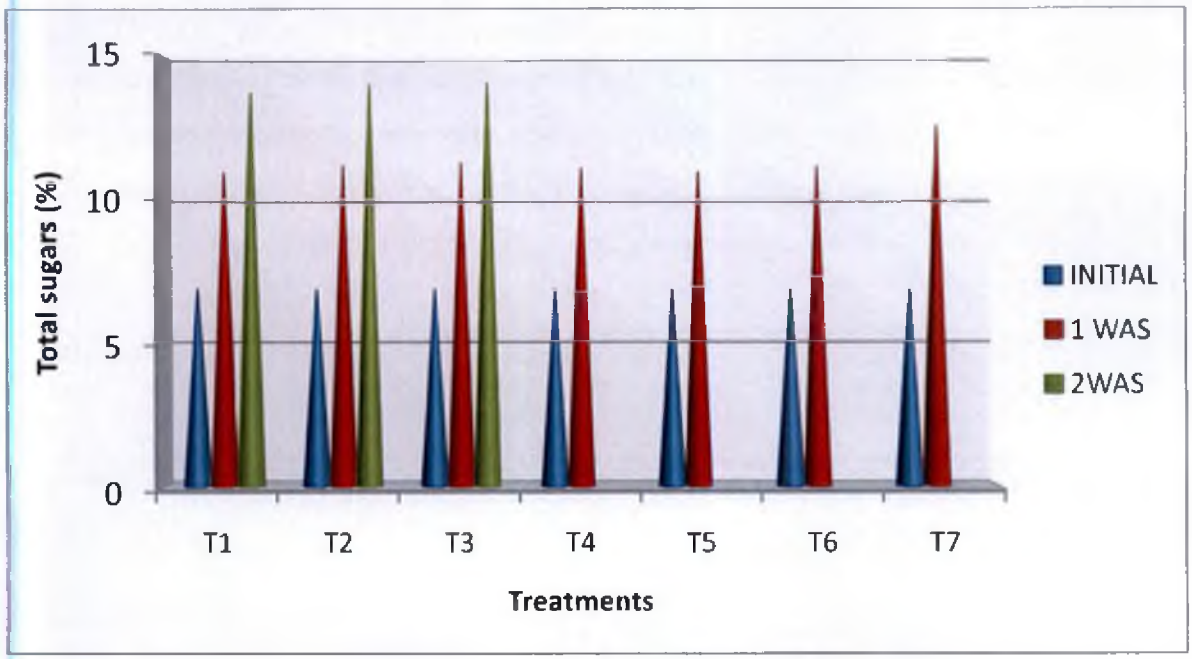


Figure 7. Effect of shrink wrap packaging on total sugars of mango during storage

in shrink wrapped fruits may be due to lower respiration and slower biochemical reactions in these fruits.

Rao and Shivashankara(2015) observed an increasing trend in sugar content on mango cvs. Alphonso and Banganappalli when stored at 8° C.

5.1.1.6. Vitamin C (mg $100g^{-1}$)

Vitamin C content of mango decreased during storage. After one week of storage, shrink wrapped mango retained significantly higher vitamin C 42.86 to 44.88 mg $100g^{-1}$ as compared to unwrapped (control) (37.79 mg $100g^{-1}$) fruits. After two weeks of storage, individually shrink wrapped fruits with 25μ polyolefin film retained the highest (43.5 mg $100g^{-1}$) vitamin C whereas the lowest (42.85 mg $100g^{-1}$) was observed in the fruits shrink wrapped with 15μ polyolefin film.

Decline in vitamin C content of mango during storage may be due to oxidative degradation. Higher retention of vitamin C in shrink wrapped samples may be due to slower rate of biochemical reactions due to the modified atmosphere surrounding the fruits.

Pal *et al.*(2004) reported that loss of ascorbic acid in individually shrink wrapped guava fruit stored in cool chamber was negligible at the end of 14 days of storage but in the case of control fruits, significant loss was observed. Modification of the atmosphere around the fruits might have resulted in checking the loss of ascorbic acid in individually shrink wrapped fruits. Low oxygen environment developed around the fruit by individual shrink wrap packaging might have reduced the activity of oxidative enzyme, which plays an important role in degradation of ascorbic acid.

Dhalla and Hanson (1988) also reported a gradual decrease in the vitamin C content of pro-long- treated 'Julie' mangoes during storage at 25°C.

5.1.1.7. Total carotenoids (mg $100g^{-1}$)

Total carotenoids of mango increased during storage. Unwrapped (control) fruits retained significantly higher total carotenoids (8.26 mg $100g^{-1}$) as compared to shrink wrapped sample (3.24 to 4.85 mg $100g^{-1}$), after one week of storage. After two weeks of storage, individually shrink wrapped mango with polyolefin film of 19μ thickness retained higher total carotenoidsas compared to those wrapped with 15 and 25μ films.

Increase in total carotenoids may be due to the ripening process in fruits. Higher reduction of total carotenoids in unwrapped (control) sample may be due to faster arrival of fruits to the climacteric stage whereas the shrink wrapped fruits remain in the pre-climateric stage for longer duration.

According to Rao and Shivashankara(2015),shrink wrapping helped in keeping the mangoes in pre-climacteric stage during the storage at 8°C for 5 weeks; thereby avoiding the effect of chilling injury on carotenoid synthesis during post storage ripening stage.

5.1.1.8. Organoleptic quality (hedonic scale of 1-9)

Organoleptic scores of individually shrink wrapped mangoes were higher than the fruits wrapped in areca plates and control (unwrapped) fruits, after one week of storage. Individually shrink wrapped mangoes with 25μ polyolefin film had the highest overall acceptability(5.7), after two weeks of storage.

Better organoleptic quality of shrink wrapped mangoes may be due to the slower biochemical reactions induced by modified atmosphere packaging.

According to Rao and Shivashankara (2015) shrink wrapped mangoescvs. Alphonso and Banganappalli registered significantly higher scores for all the sensory parameters like fruit appearance, pulp colour, pulp texture and flavour qualities as compared to control fruits.

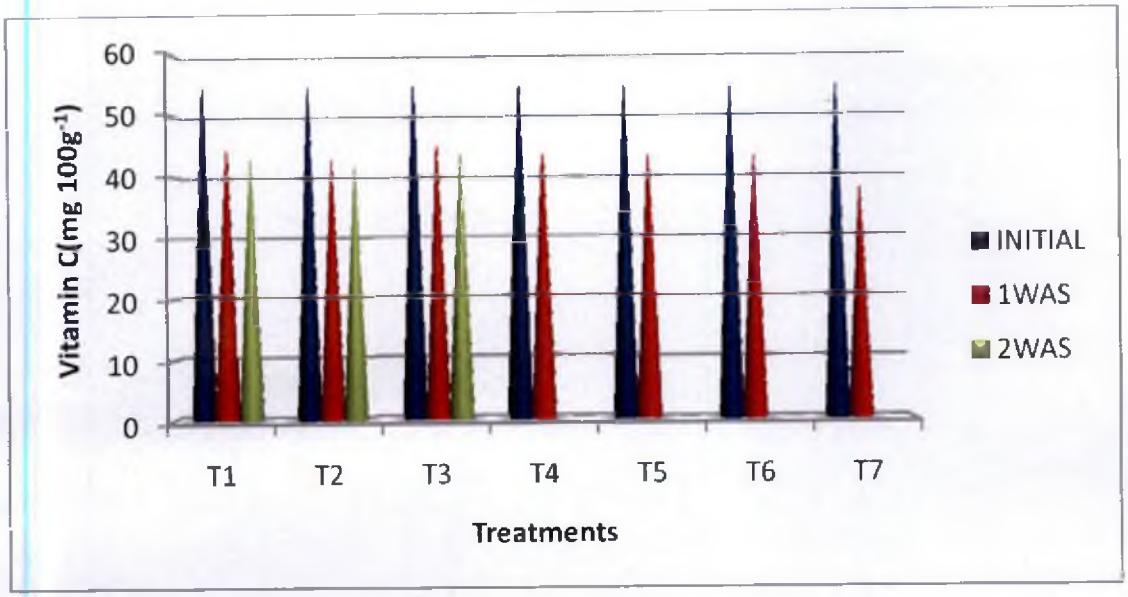


Figure 8. Effect of shrink wrap packaging on vitamin C content of mango during storage

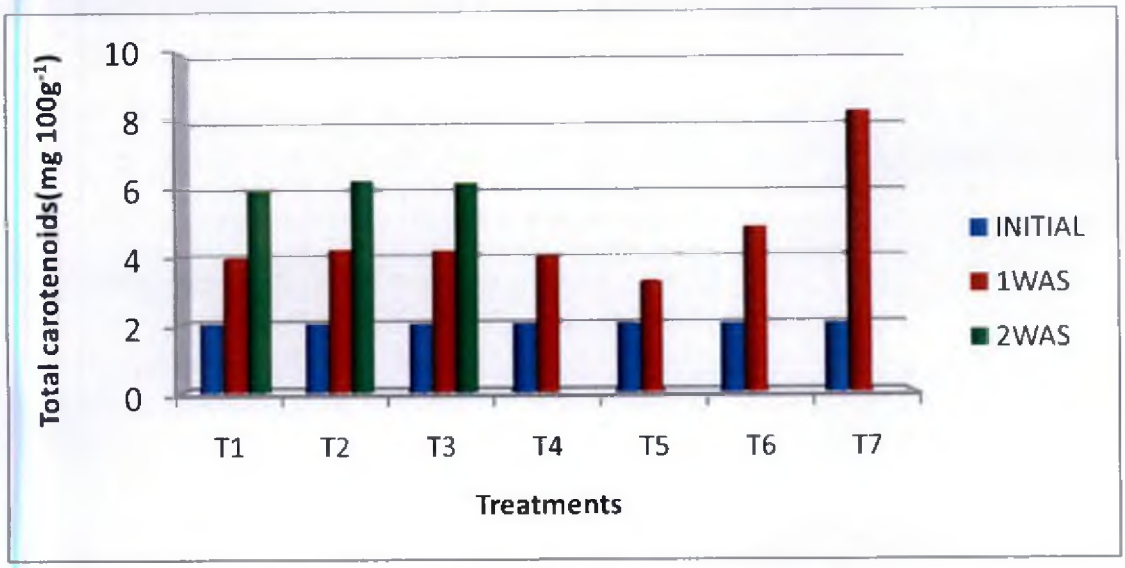


Figure 9. Effect of shrink wrap packaging on total carotenoids of mango during storage

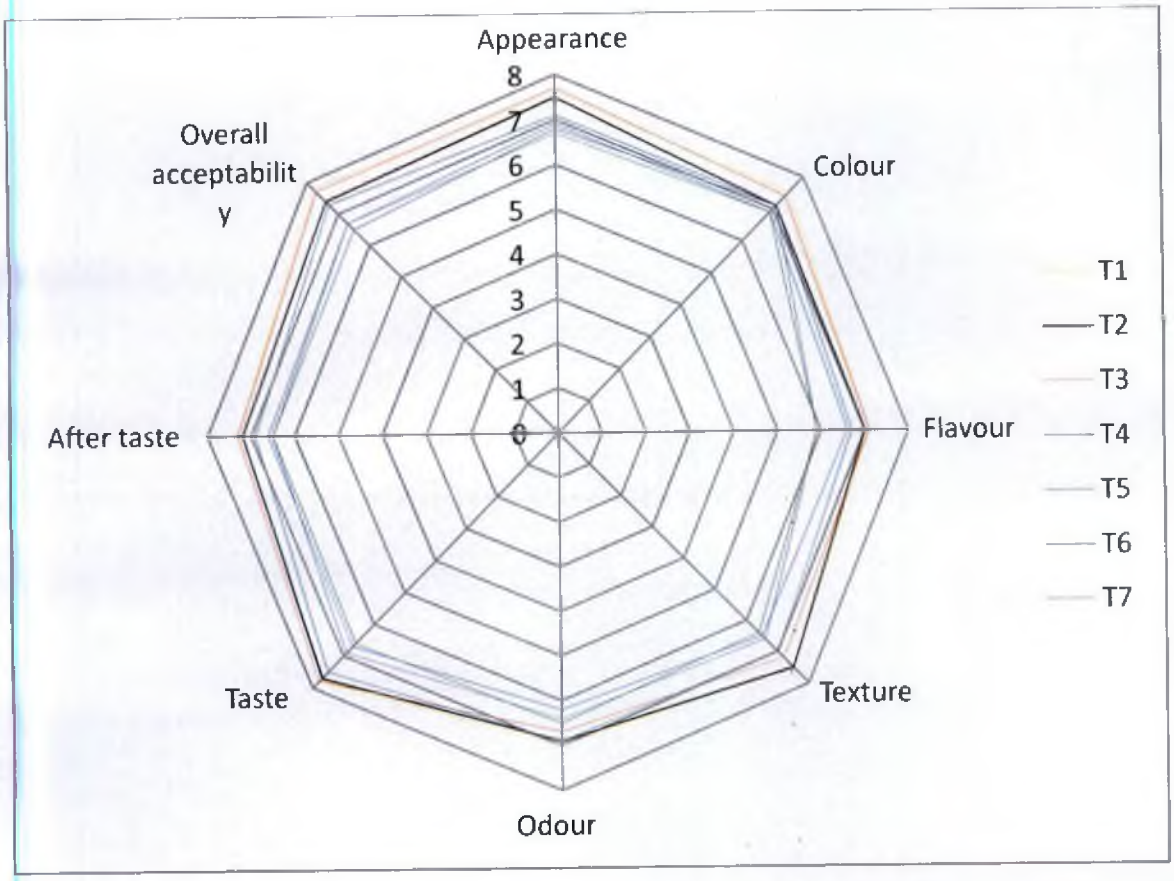


Figure 10. Effect of shrink wrap packaging on organoleptic qualities of mango during 1st week of storage

5.1.1.9. Internal quality

Off flavour was observed in the shrink wrapped mango fruits after two weeks of storage. Mangoes shrink wrapped in areca plates showed more off flavour than individually shrink wrapped mangoes with 15,19 and 25 μ polyolefin film.

Development of off flavour in the shrink wrapped fruits may be due to higher concentration of CO_2 and very low O_2 concentration around the film wrapped fruits.

Miller *et al.* (1986) reported that off flavour in film wrapped fruits might be related to excessive levels of CO_2 and reduced levels of O_2. It was found that mangoes shrink wrapped in HDPE at soft ripe stage had off flavour and elevated CO_2 levels after 9 days of storage.

5.2 Effect of shrink wrap packaging on shelf life and quality of banana

Bunches of mature green banana, cv. Grand Naine were cut into hands. Separated hands were kept for desapping. After desapping, banana hands were washed in plain water, followed by surface sanitization with 100 ppm chlorine for 15 minutes. Chlorinated hands were spread out in perforated trays/ blotting paper to remove excess surface moisture. Surface dried hands were subjected to two forms of shrink wrapping i.e, individually shrink wrapped hands and also shrink wrapped banana hands master packed in CFB boxes. Polyolefin film of three densities viz. 15, 19, and 25 μ thickness were used for shrink wrapping of samples in each treatment.

5.2.1 Observations

5.2.1.1 Shelf life (days)

Shelf life of individually shrink wrapped banana hands was lower than control (unwrapped fruits). Percentage of spoilage was higher in the shrink wrapped banana hands master packed in CFB box than individually shrink wrapped banana hands. Among individually shrink wrapped fruits,the samples wrapped with25 μ polyolefin film had the longest shelf life (5 days) and the shrink wrapped banana hands with 19 μ polyolefin film master packed in CFB box had the shortest shelf life (4 days). Shelf life of control (unwrapped) samples was 7 days.

Short shelf life of shrink wrapped banana may be due to condensation of moisture inside the film, leading to microbial spoilage, which aggravated under ambient conditions of warm temperature and high humidity. Moreover, the cut surface on the crown was not subjected to any fungicidal treatment.

5.2.1.2 PLW (physiological loss in weight) (%)

PLW of all the samples increased during storage. Control (unwrapped) samples had maximum PLW as compared to the fruits subjected to shrink wrap packaging. After 3 days of storage, control (unwrapped) fruits had significantly higher PLW (5.55 %) as compared to shrink wrapped fruits (1.47 to 2.29 %) and individually shrink wrapped mango in 15μ

polyolefin film had the lowest PLW (1.47 %). Lower PLW in shrink wrapped banana hands may be due to lower respiratory activity owing to modification of atmosphere within the film wrapped samples.

Sharma *et al.*(2010) suggested that reduction in PLW may be due to creation of modified atmosphere around the wrapped apple fruit.

5.2.1.3 TSS (°Brix)

TSS of banana increased throughout the storage period. Control (unwrapped) sample had significantly higher TSS as compared to the shrink wrapped fruits. After 4 days of storage, the unwrapped fruits retained the highest (16.87° B) TSS while in shrink wrapped fruits, it ranged from 14.57 to 16 °B. Among the individually shrink wrapped banana hands, samples wrapped with 25μ film recorded higher TSS(15.87 °B) which was on par (15.00 °B) with the hands wrapped with 15μ film. After 7 days of storage, the unwrapped (control) fruits retained the highest TSS of 18. 67 °B. Type of film did not have any significant influence in TSS content of shrink wrapped mangoes.

Higher TSS in control samples may be due to conversion of complex carbohydrates into simpler compounds and the rate may have been faster at ambient temperature. Stover and Simmonds(1987) reported that the conversion of starch into sugars was the most important change in ripening bananas.

5.2.1.4 Titratable acidity (%)

Titratable acidity of banana declined during storage. The decline was significantly higher in the control (unwrapped) fruits as compared to the shrink wrapped samples. After 4 days of storage, the control (unwrapped) samples retained lower acidity (0.18 %) while in the shrink wrapped samples it ranged from 0.19 to 0.24 percent. Among the samples (hands) wrapped individually, fruits wrapped with 25μ film had the highest acidity (0.20 %) while the ones wrapped with 15μ film had an acidity of 0.18 % which was on par(0.17 %) with the control samples.

Decline in titratable acidity of banana hands may be due to consumption of organic acids during respiration and conversion of complex carbohydrates into simpler sugars.

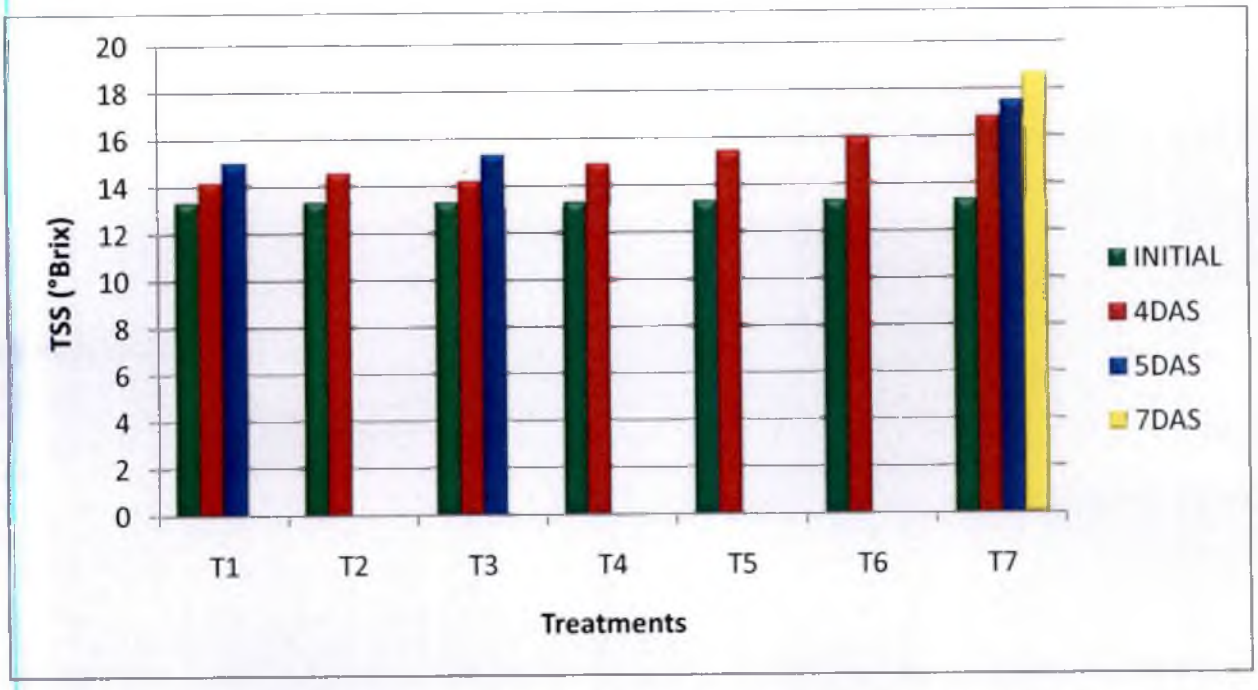


Figure 11. Effect of shrink wrap packaging on TSS of banana during storage

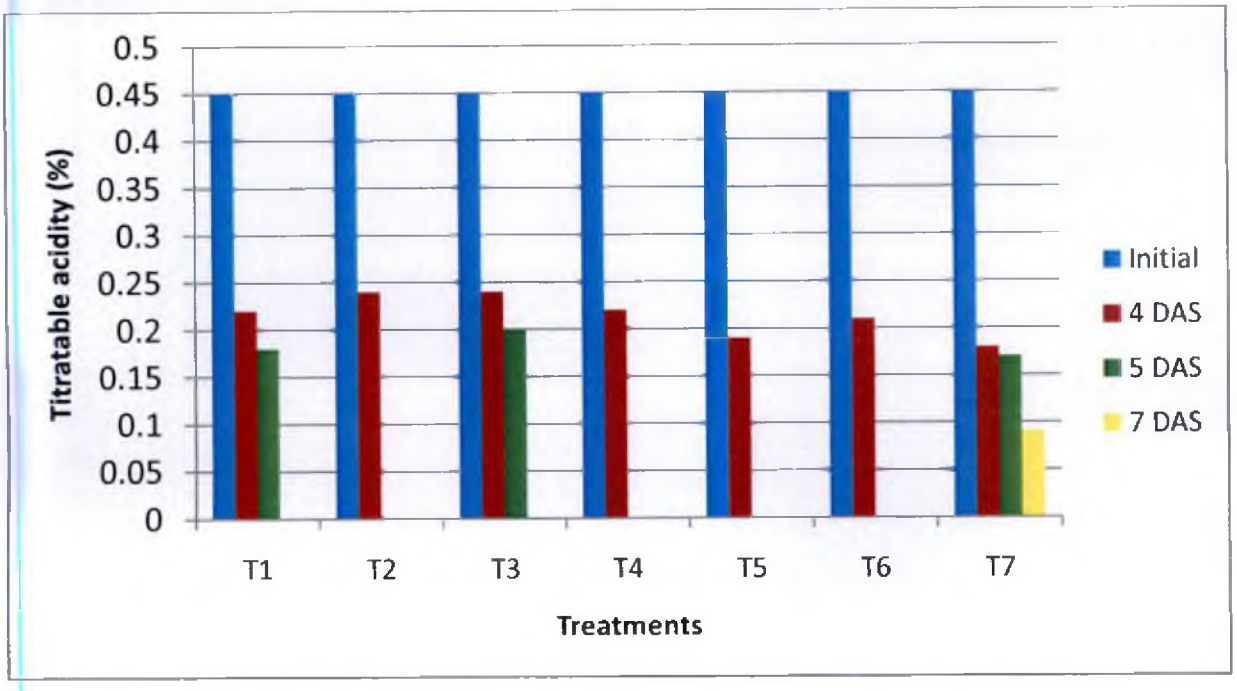


Figure 12. Effect of shrink wrap packaging on titratable acidity of banana during storage

Individually shrink wrapped fruits have comparatively higher titratable acidity due to lower respiration rate. Shrink wrapping did not lose the ability to metabolise acids during storage (Rao and Shivashankara, 2015).

5.2.1.5 Vitamin C (mg $100g^{-1}$)

Vitamin C content of banana decreased during storage. After 4 days of storage, shrink wrapped banana retained significantly higher vitamin C (15.78 to 18.19 mg 100 g^{-1}) as compared to unwrapped (control) fruits (16.2mg 100 g^{-1}).The vitamin C content of banana hands wrapped with 15 and 25µ films were 17.93 and 18.01 mg $100g^{-1}$ respectively, which were on par with each other even though the content was higher than the control samples, which had a vitamin C content of 16.04 mg $100g^{-1}$. Vitamin C content in shrink wrapped fruits retained during the storage may be due to modified atmosphere surrounding the film with elevated levels of CO_2 and depleted O_2 may have reduced the activity of oxidative enzyme, which causes degradation of ascorbic acid.

Pal *et al.*(2004) reported that loss of ascorbic acid in individually shrink wrapped guava fruit stored in cool chamber was negligible at the end of 14 days of storage but in the case of control fruits significant loss was observed. Modification of the atmosphere around the fruits might have resulted in checking the loss of ascorbic acid in individually shrink wrapped fruits. Low oxygen environment developed around the fruit by individual shrink wrap packaging might have reduced the activity of oxidative enzyme, which plays an important role in degradation of ascorbic acid.

5.2.1.6 Sugars(reducing, non-reducing and total)(%)

Reducing, non- reducing and total sugars were significantly higher in control samples as compared to shrink wrapped fruits throughout storage. Increase in sugar content may be due to the ripening process wherein complex carbohydrates are broken down into simple sugars. Higher sugar content in unwrapped samples may be due to higher rate of biochemical reactions at ambient temperature.

Robinson (1996) reported that starch is the main component of carbohydrate in unripe banana and as ripening progresses; it changes to soluble sugars. Dadzie and Orchard (1997) suggested that, the most striking post harvest chemical change which occurs during the post harvest ripening of banana is the hydrolysis of starch and accumulation of sugar(i.e., sucrose, glucose and fructose) which are responsible for the sweetening of the fruits.

According to Hailu*et al.*(2011) the rate of increase of total sugar is by far faster in the control than plastic films. The plastic films kept the sugar level at lower value than control fruits

5.2.1.7 Organoleptic quality (hedonic scale of 1-9)

Shrink wrapped banana hands had lower organoleptic scores as compared to control (unwrapped) fruits. Among shrink wrapped samples, individually shrink wrapped fruits obtained higher scores as compared to shrink wrapped fruits master packed in CFB box. After storage, among shrink wrapped banana, the samples wrapped with 25μ polyolefin film had the highest overall acceptability(5.2) as compared to the samples wrapped with 15 and 19 μ films wherein the acceptability scores were 4.6and 4.3 respectively.

5.2.1. 8 Internal quality (browning,offflavour)

Shrink wrapped banana treatments had poor internal quality than unwrapped banana during storage. After 4 days of storage, the fruits showed browning, which also affected the texture of the fruit adversely. Off flavour was also detected in the fruits. The high humidity coupled with warm temperature may have affected the texture of the fruit. Further, elevated levels of CO_2may have resulted in development of off flavour in the fruits.

Miller *et al.* (1986) reported that off flavour in film wrapped fruits might be related to excessive levels of CO_2 and reduced levels of O_2. It was found that mangoes shrink wrapped in HDPE at soft ripe stage had off flavour and elevated CO_2 levels after 9 days of storage.

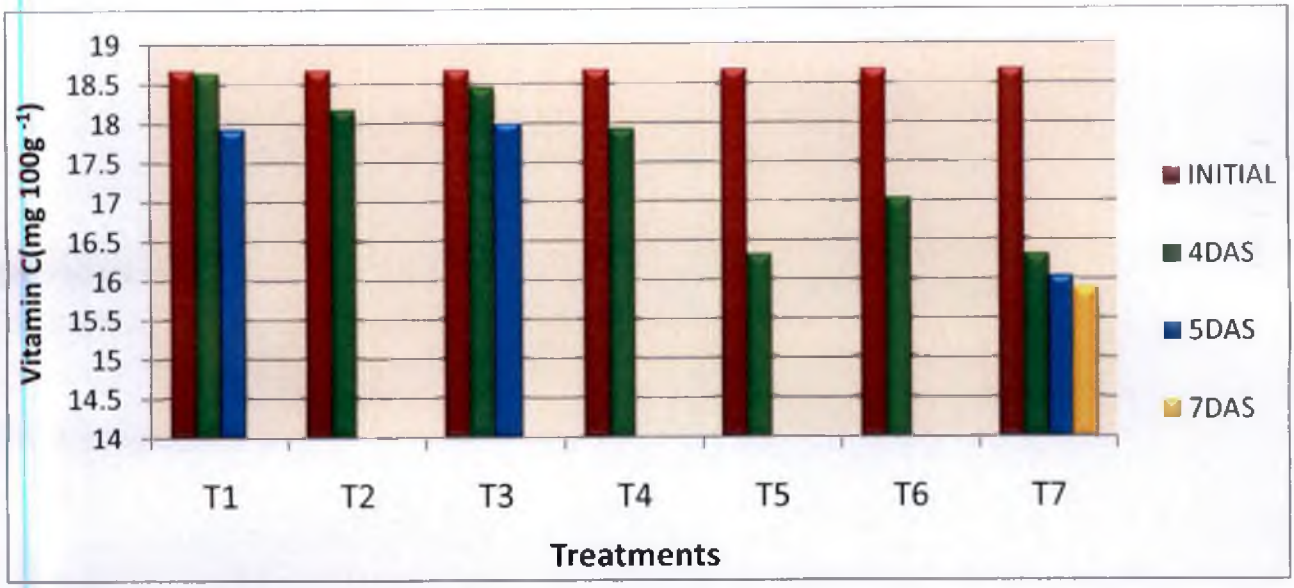


Figure 13. Effect of shrink wrap packaging on vitamin C of banana during storage

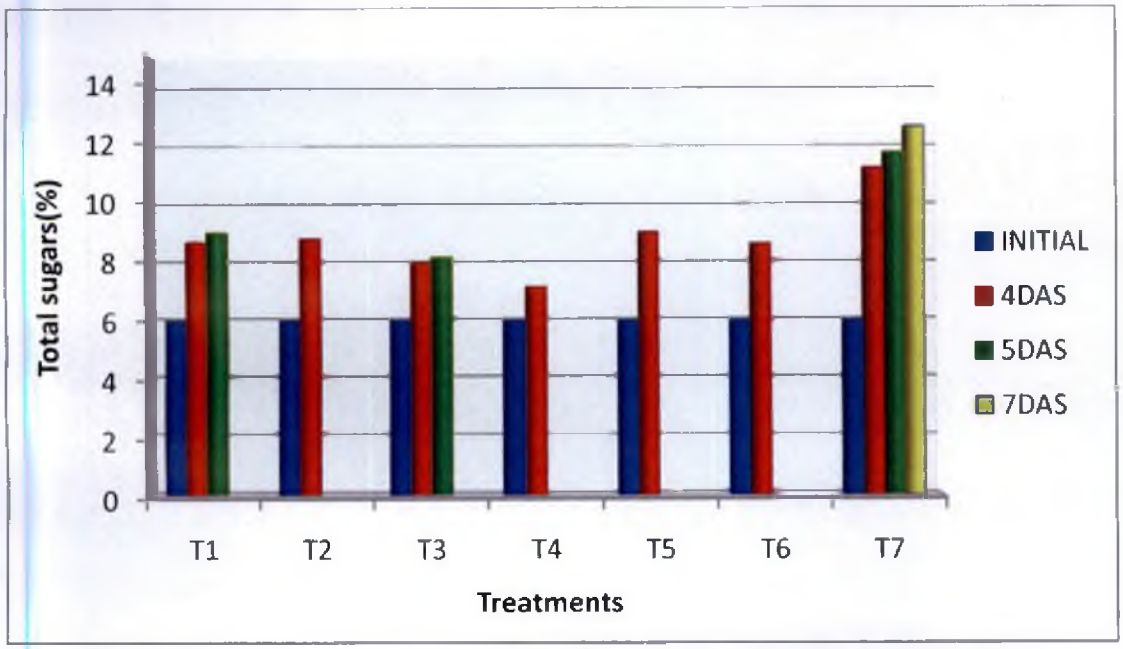


Figure 14. Effect of shrink wrap packaging on total sugars during storage

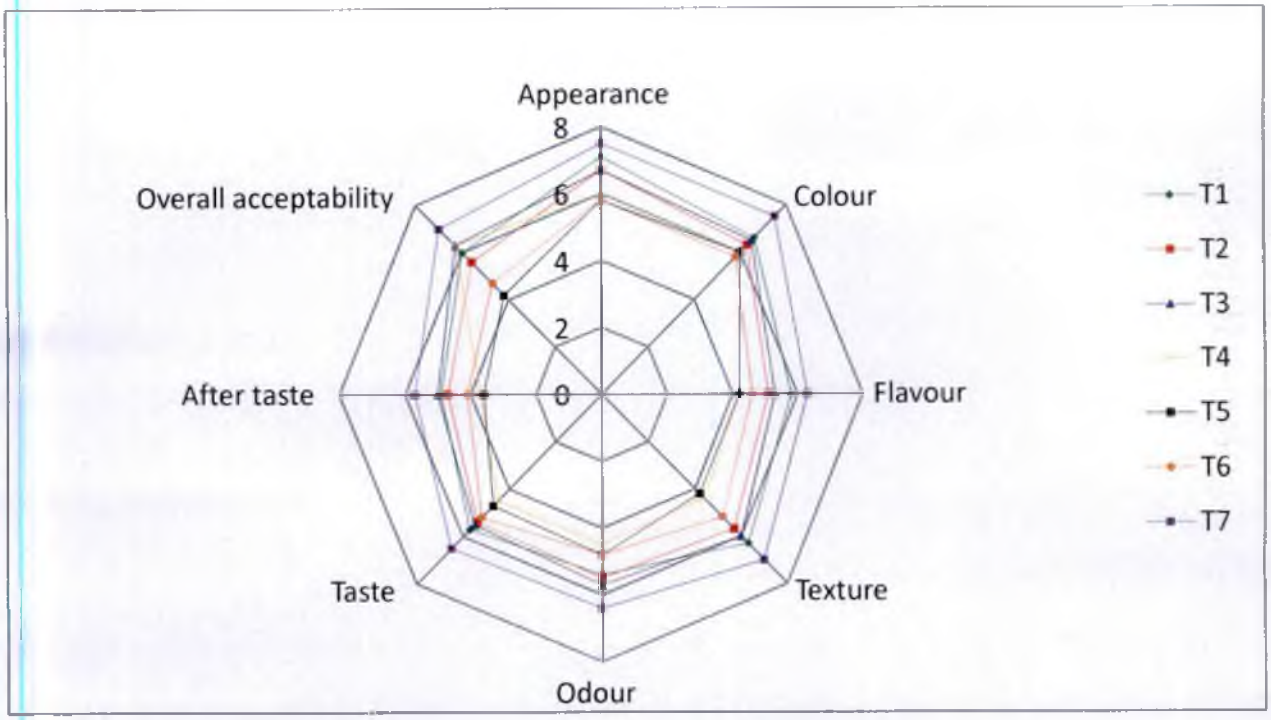


Figure 15. Effect of shrink wrap packaging on organoleptic quality of banana after 4 days of storage

5.3 Effect of shrink wrap packaging on shelf life and quality of pineapple

Mature, firm, ripe fruits of pineapple cv.'Mauritius', when half of the fruit surface turned yellow, were selected for the experiment. The fruits were cleaned dry, followed by removal of crowns from the fruits. The cleaned fruits were subjected to two forms of shrink wrapping i.e, individual shrink wrapping and master packing of individually shrink wrapped fruits in CFB boxes. Polyolefin films of three densities viz. 15, 19, and 25 μwere used for shrink wrapping of samples in each treatment.

5.3.1 Observations

5.3.1.1Shelf life (days)

Shelf life of individually shrink wrapped pineapple was higher than shrink wrapped fruits master packed in CFB box and control (unwrapped fruits). Individually shrink wrapped pineapple in 25 μ polyolefin film had the longest shelf life (16 days) and the shrink wrapped fruits with 25 μ polyolefin film followed by master packing in CFB box had the shortest shelf life (9 days). Shelf life of control (unwrapped) samples was 12 days.

Longer shelf life in individually shrink wrapped pineapple may be due to the modified atmosphere surrounding the film with elevated level of CO_2 and depleted O_2concentration. This modified atmosphere may have reduced the respiratory activity of fruits, leading to prolonged shelf life. Higher spoilage percentage in individually shrink wrapped fruits master packed in CFB boxes may be due to increased moisture condensation inside the film.

Shrink wrapping extended the shelf life both at ambient and low temperature conditions in pomegranate fruit. Individually shrink wrapped fruits showed maximum shelf life of 12 weeks at 8° C of storage. Individually shrink wrapped pomegranate fruits significantly reduced the respiration rate and ethylene production due to the low permeability of the films used for wrapping (Nanda *et al.*, 2001).

Dasmohapatra*et al.* (2011) reported that the rotting of malta lemon was reduced to $1/6^{th}$ during storage in individually shrink wrapped fruits and shelf life could be enhanced to about 60 days by storing the fruits in heat shrinkable polyolefin film with nimbecidintreatment.

Rattanpal and Trimbak (2014) reported that shrink wrap packaging inkinnow fruits with different types of heat shrinkable films like D955(12μ), D955(15μ), opi-max and xenith with or without pretreatment of sodium carbonate(3%) and thiophanate methyl(0.1%) at ambient condition wherein the individually shrink wrapped kinnow fruits recorded 60 days of shelf life under ambient conditions.

5.3.1.2 PLW (physiological loss in weight) (%)

PLW of all the samples increased during storage. Control (unwrapped) samples had maximum PLW as compared to the fruits subjected to shrink wrap packaging. After 12 days of storage, control (unwrapped) fruits had significantly higher PLW (16.52%) compared to shrink wrapped fruits. Individually shrink wrapped pineapple in 19μ polyolefin film had the lowest PLW (2.35%). Lower PLW in shrink wrapped pineapple may be due to lower respiratory activity owing to the modification of atmosphere in the wrapped samples, as a result of higher CO_2 and reduced O_2 levels surrounding the fruits.

Shrink wrapped pomegranate fruits showed reduced weight loss than control fruits during storage. Weight loss of shrink wrapped fruits was minimum observed in low temperature treatment i.e., 15° and 8° C(Nanda*et al.*, 2001). Reduction in weight loss by shrink wrapping was also reported by Hale *et al.* (1986) in Florida grapefruit and Ladaniya*et al.* (1997) in 'Nagpur' mandarins.

According to Rattanpal and Trimbak (2014), the PLW of individually shrink wrapped kinnow fruits with different heat shrinkable films showed minimum loss in weight than control fruits without any treatments.The fungicidal application coupled with xenith sealing was more effective than other treatments. It might be due to blocking of aperture on lenticels, thereby reducing rate of respiration and transpiration(Datt*et al.*, 1960 ; Mahajan *et al.*, 2013).

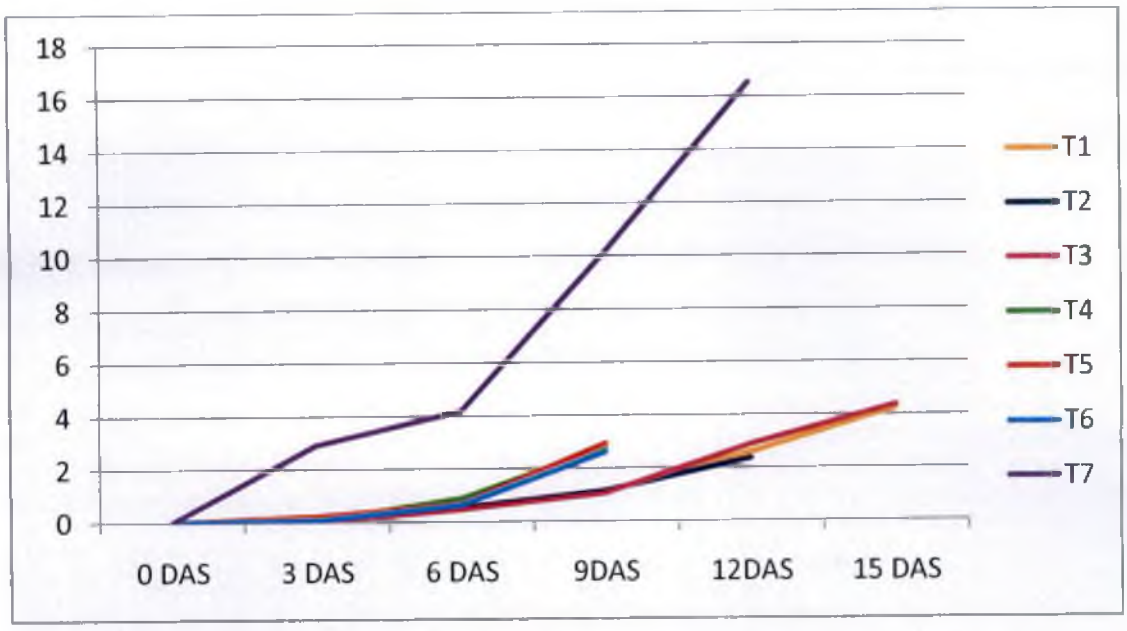
5.3.1.3 TSS (°Brix)

TSS of pineapple increased throughout the storage period. Control (unwrapped) fruits had significantly higher TSS as compared to the shrink wrapped fruits. After one week of storage, the unwrapped fruits retained the highest(14.43°B) TSS while in shrink wrapped fruits, it ranged from 13.03 to 13.6 °B. After two weeks of storage, among the individually shrink wrapped fruits, samples wrapped with 19μ polyolefin film had the highest TSS(16.23 °B) while the lowest (16.10°B) was seen in the fruits wrapped with 15μ film. Type of film did not have any significant influence in TSS content of shrink wrapped pineapple.

Shrink wrapped pomegranate showed non-significant decrease in SSC than freshly harvested fruits due to moisture loss during storage which was mainly from the rind and not from the aril of fruit (Nanda *et al.*, 2001). Koksal (1989), reported that an increase in SSC content in pomegranatecv.'GokBahce' fruit and attributed it to loss of moisture leading to concentration of the soluble solids.

In individually shrink wrapped maltalemon fruit, TSS content increased from 8.60 to 10.14 percent with the progress in storage period which might be due to hydrolysis of starch and pectic substances and accumulation of sugars (Dasmohapatra*et al.*, 2011). Similar results were reported in Kinnow with the advancement of storage period by Lotha*et al.* (1994)

TSS of fruits increased with the increase in storage. Rattanpal and Trimbak (2014) observed that the mean of TSS was lower in shrink wrapped kinnow fruits than in fruits without any treatment. Increase in TSS during storage may be due to increased hydrolysis of polysaccharides and concentration of juice due to dehydration. Increase in TSS during storage affected the quality of fruit because of disturbing TSS: acid ratio and development of off flavour.



igure 16. Effect of shrink wrap packaging on PLW of pineapple during storage

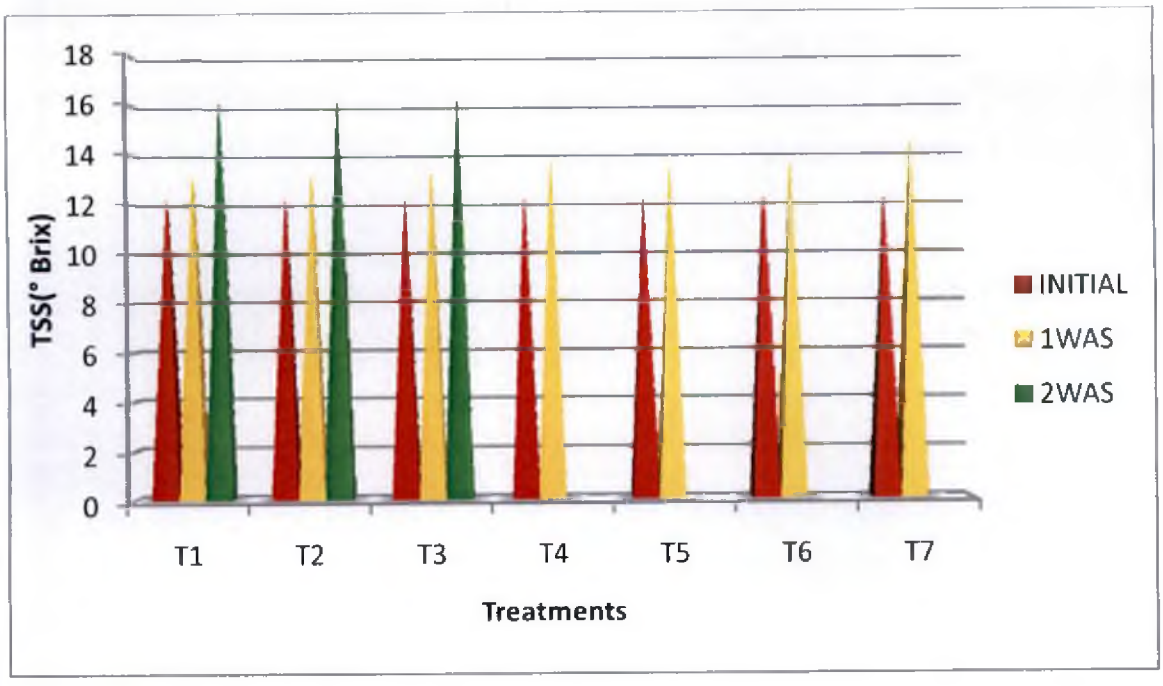


Figure 17. Effect of shrink wrap packaging on TSS of pineapple during storage

5.3.1.4 Titratable acidity (%)

Titratable acidity of pineapple declined during storage. The decline was significantly higher in the control (unwrapped) fruits as compared to the shrink wrapped samples. After one week of storage, the control (unwrapped) samples retained significantly lower acidity (0.16 %) while in the shrink wrapped samples it ranged from 0.29 to 0.50 percent. After two weeks of storage, among the individually shrink wrapped fruits, the samples wrapped with 25μ polyolefin film had the lowest (0.23 %) acidity while the fruits wrapped with 19μ film had the highest titratable acidity(0.34 %). Decline in titratable acidity of pineapple may be due to consumption of organic acids during respiration and conversion of complex carbohydrates into simpler sugars.

Rattanpal and Trimbak (2014) reported that in shrink wrapped maltalemon fruit with different heat shrinkable films maximum mean acid percentage, which was significantly higher than unwrapped fruits. The acidity decreased with prolongation of storage life. The decrease in acidity might be due to the utilization of organic acids in respiratory process.

5.3.1.5 Vitamin C (mg $100g^{-1}$)

Vitamin C content of pineapple decreased during storage. After one week of storage, shrink wrapped pineapple retained higher vitamin C (12.41 to 14.81mg $100g^{-1}$) as compared to unwrapped (control) fruits (12.13mg $100g^{-1}$). Film thickness did not significantly influence the vitamin C content of the fruits. However after two weeks of storage, fruits shrink wrapped with 19μ polyolefin film retained the highest (12.05mg $100g^{-1}$) vitamin C whereas the lowest (11.72mg $100g^{-1}$) was observed in the fruits shrink wrapped with 15μ polyolefin film.

Higher vitamin C retention in shrink wrapped fruits during storage may be due to modified atmosphere surrounding the film with elevated CO_2 and depleted O_2levels, which may have reduced the activity of oxidative enzymes, which cause degradation of ascorbic acid.

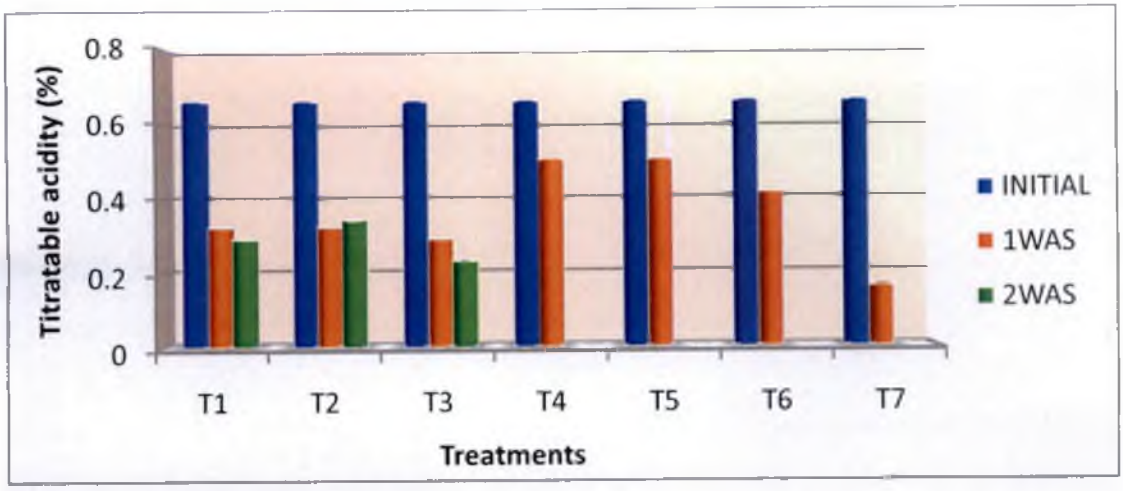


Figure 18. Effect of shrink wrap packaging on titratable acidity of pineapple during storage

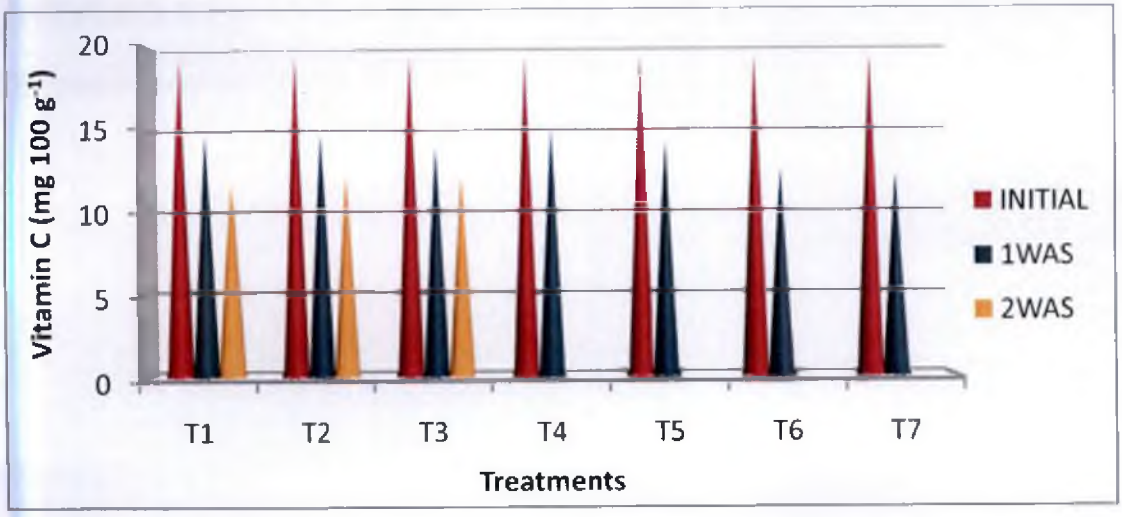


Figure 19. Effect of shrink wrap packaging on vitamin C content of pineapple during storage

According to Nanda *et al.* (2001) higher retention of vitamin C content was observed in shrink wrapped pomegranate fruit stored at 8° and 15° C for a period of 12 and 9 weeks respectively as compared to non wrapped fruits. Koksal (1989) also reported significant loss in vitamin C content in pomegranate fruits (cv. GokBahce) stored at higher temperatures. Shrink wrapped malta lemon fruits showed decreasing trend in vitamin C during 90 days of storage but retention of vitamin C content was higher than control treatment(Dasmohapatra, 2011). The vitamin C content decreased during storage due to conversion of ascorbic acid to dehydroascorbic acid (Gustafon and Cooke, 1952).

5.3.1.6 Sugars (reducing, non-reducing and total)(%)

Reducing, non-reducing and total sugars content was higher in unwrapped (control) pineapplethan shrink wrapped fruits, after one week of storage. After two weeks of storage, fruits shrink wrapped with 25μ had the highest reducing, non-reducing and total sugarscontent of 3.75,9.15, 12.89 % respectively than the fruits wrapped with 15 and 19μ films.

Increase in sugar content of pineapple during storage may be due to conversion of complex carbohydrates into simpler sugars. Higher sugar content in control samples may be due to faster rate of biochemical reactions in these samples. Shrink wrapped pomegranate fruits recorded slight decrease in total sugars content during different storage temperatures due to low respiration rate (Nanda *et al.*, 2001).

Total sugars content of fruit was increased during storage. Rattanpal and Trimbak (2014) reported that shrink wrapped kinnow with different heat shrinkable films resulted in lower total sugar percent than control. The increase in total sugar content was probably due to respiratory breakdown of polysaccharides (Datt*et al.*, 1960).

5.3.1.7 Organoleptic quality (hedonic scale of 1-9)

Individually shrink wrapped pineapples had higher organoleptic scores as compared to control (unwrapped) fruits, and also fruits shrink wrapped and master packed in CFB

boxes. After two weeks of storage, among individually shrink wrapped fruits, the samples wrapped with 25μ polyolefin film had the highest overall acceptability (6.50) as compared to the samples wrapped with 15 and 19 μ films wherein the acceptability scores were 5.70 and 5.50, respectively.

Shrink wrapped pomegranate fruits showed better scores for aril colour, juiceness and taste during sensory evaluation (Nanda *et al.*, 2001). Organoleptic score was higherin shrink wrapped malta lemon during initial days of storage. But overall acceptability of shrink wrapped malta decreased with an increase in storage days. Good organoleptic score of individually shrink wrapped fruit was due to no change in qualitative characters and palatability of fruits, which resulted in minimum PLW and helped in maintaining acidity, TSS, TSS/acid ratio and sugars in balanced form due to lesser production of CO_2 and ethylene (Dasmohapatra*et al.*, 2011)

5.3.1.8 Internal quality (browning,off flavour)

Off flavour was the main problem observed in the individually shrink wrapped pinapple fruits during storage. Off flavour was in fruits shrink wrapped followed by master packing in CFB boxes than the individually shrink wrapped pineapple fruits.

Miller *et al.* (1986) reported that off flavour in film wrapped fruits might be related to excessive levels of CO_2 and reduced levels of O_2. It was found that mangoes shrink wrapped in HDPE at soft ripe stage had off flavour and elevated CO_2 levels after 9 days of storage.

Individual shrink wrapping of mango and pineapple were superior with regard to shelf life and quality characteristics. Shrink wrap packaging was found ineffective in prolonging shelf life of banana under ambient conditions of storage. Polyolefin film of 25 μ thickness was better as compared to 15 and 19μ thick films to prolong shelf life and to retain quality of individually shrink wrapped mango and pineapple.

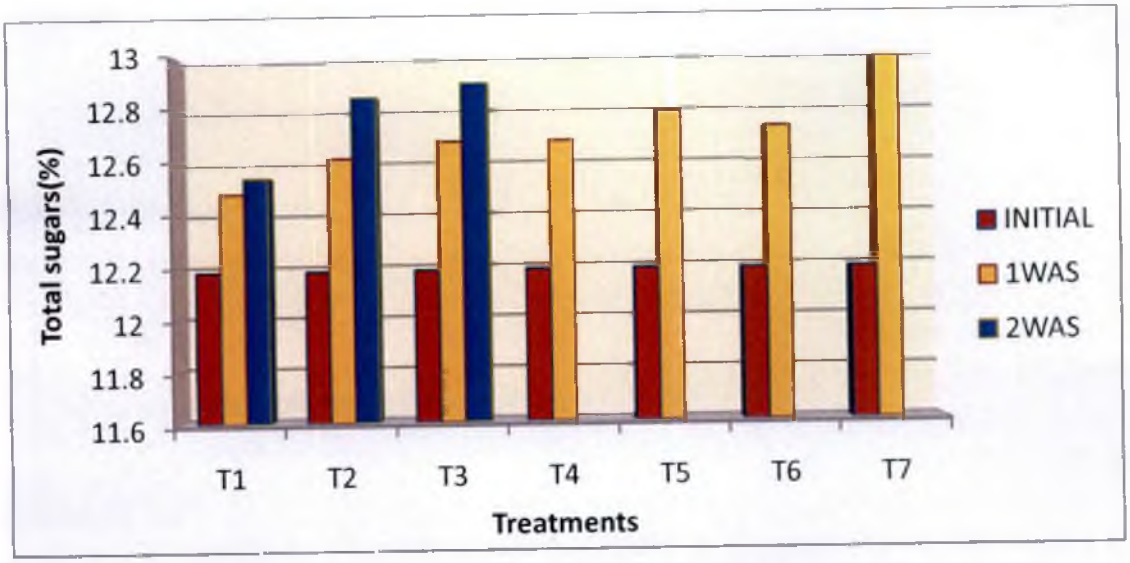


Figure 20. Effect of shrink wrap packaging on total sugar content of pineapple during storage

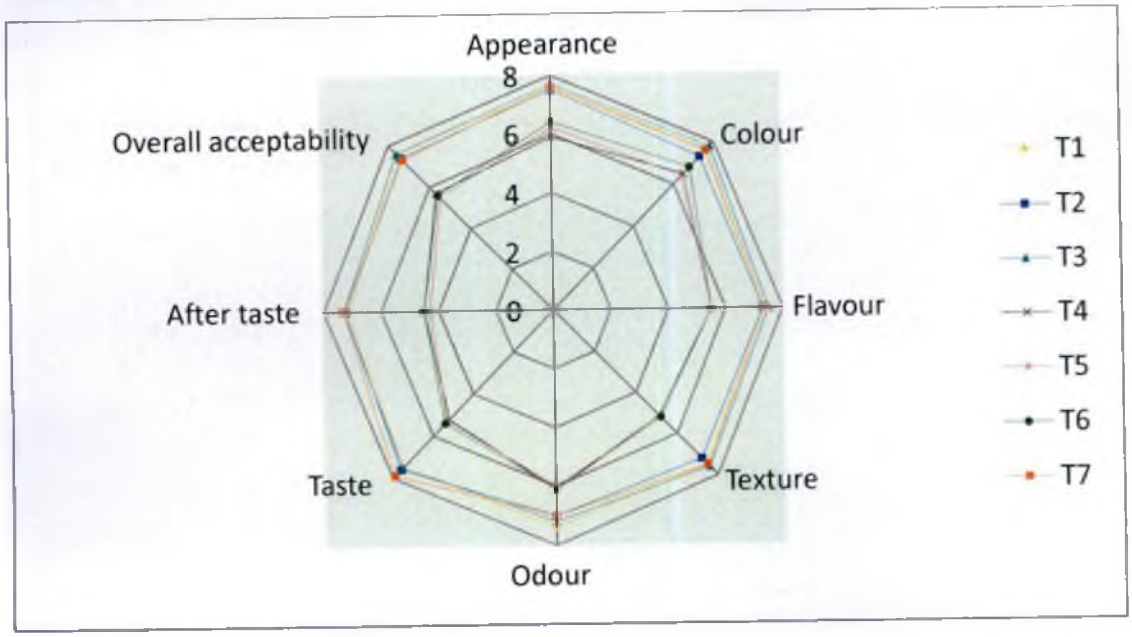


Figure 21 .Effect of shrink wrap packaging on organoleptic quality of pineapple during 1st week after storage

Summary

6. SUMMARY

The study on 'Shrink wrap packaging in selected tropical fruits' was carried out in the Department of Processing Technology, College of Horticulture,Vellanikkara during 2014-2016. The main objective wasto extend shelf life and to maintain quality of mango, banana and pineapple during storage. The study was conducted to observe shelf life and qualitative changes of shrink wrap packaged mango, banana and pineapple during storage.

Mature green fruits of mango cv. Prior, free from mechanical damage, bruises and blemishes were selected for the experiment. Fruits were washed in plain tap water, followed by surface sanitization with 100ppm chlorine for 15 minutes. The chlorinated fruits were spread out on blotting paper to remove excess surface moisture and kept as such overnight for air drying. Surface dried fruits were subjected to two forms of shrink wrapping i.e., fruits were individually shrink wrapped and also shrink wrapping of areca plates, containing 4-5 fruits with three densities of polyolefin film viz. 15, 19 and 25μ thickness.

Shrink wrap packaged fruits were stored at ambient temperature. Observations on shelf life and PLW were recorded at an interval of three days and other biochemical observations were taken at weekly intervals. The effect of shrink wrap packaging on mango was evaluated based on the shelf life and qualitative attributes of fruits.

Individually shrink wrapped mangoes with 15, 19 and 25μ polyolefin film recorded maximum shelf life and minimum shelf life was observed in mangoes shrink wrapped in areca plates with polyolefin film.Among individually shrink wrapped mangoes, maximum shelf life was recorded in individually shrink wrapped mangoes with 25μ polyolefin film (18 days) under ambient conditions of storage. PLW was significantly lower in shrink wrapped fruits than the control samples.

TSS, reducing, non-reducing,total sugars and total carotenoids in mango increased during storage whereas titratable acidity and vitamin C decreased. After one week of

storage, control samples had higher TSS, reducing, non-reducing, total sugars and total carotenoid content than shrink wrapped mangoes. After two weeks of storage, among the individually shrink wrapped fruits samples wrapped with 25μ polyolefin film had the highest TSS(17.90^{0}B), reducing (3.09 %), non-reducing (10.98 %), and total sugar(14.07 %) content than the fruits shrink wrapped with 15 and 19 μ polyolefin films. The same treatmentretained the lowest titratable acidity(0.07 %) and highest vitamin C (43.5 mg $100g^{-1}$) content after two weeks of storage.

Shrink wrapped mangoes had higher organoleptic scores as compared to control (unwrapped) fruits. After two weeks of storage, among individually shrink wrapped fruits, the samples wrapped with 25μ polyolefin film had the highest overall acceptability(5.7) as compared to the samples wrapped with 15 and 19 μ films wherein the acceptability scores were 5.4 and 5.2, respectively. Off flavour development was detected in shrink wrapped fruits due to higher concentration of CO_2 content.

Bunches of mature green banana, *cv.* Grand Naine were selected for second experiment and hands were separated followed by desapping. These hands were washed in plain water, after which they were surface sanitized with 100 ppm chlorine for 15 minutes. Chlorinated hands were spread out in blotting paper to remove excess surface moisture. Surface dried hands were subjected to two forms of shrink wrapping i.e., hands were individually shrink wrapped and also shrink wrapping of banana hands subsequently master packed in CFB boxes. Polyolefin films of three densities *viz.* 15, 19 and 25μ were used for shrink wrapping.

Shelf life of shrink wrapped banana hands was lower than control (unwrapped) fruits.Percentage of spoilage was higher in the shrink wrapped banana hands master packed in CFB box than individually shrink wrapped banana hands.The unwrapped fruits recorded a shelf life of 7 days whereas the shrink wrapped fruits master packed in CFB boxes had a shelf life of 4 days while it was 5 days in individually shrink wrapped hands. Physiological loss in weight was significantly higher in control fruits as compared to shrink wrapped samples. Retention of biochemical attributes was better in shrink wrapped samples than in

the unwrapped fruits. Organoleptic quality of unwrapped banana hands was superior than shrink wrapped fruits. Off flavour was detected in shrink wrapped fruits due to higher concentration of CO_2.

Mature, firmripe fruits of pineapple *cv.*'Mauritius', when half of the fruit surface turned yellow, were selected for the experiment. The fruits were cleaned dry, followed by removal of crowns from the fruits. Surface dried fruits were subjected to two forms of shrink wrapping i.e., fruits were individually shrink wrapped and also shrink wrapped pineapple subsequently master packed in CFB boxes.Polyolefin films of three densities viz. 15, 19, and 25 μ were used for shrink wrapping.

Shelf life of individually shrink wrapped pineapple was higher than the shrink wrapped fruits master packed in CFB box and control (unwrapped) fruits. Individually shrink wrapped pineapple in 25 μ polyolefin film had the longest shelf life (16 days) and the shrink wrapped fruits with 25 μ polyolefin film master packed in CFB box had the shortest shelf life (9 days). Physiological loss in weight of pineapple increased during storage. PLW was significantly higher in the unwrapped fruits as compared to shrink wrapped samples. Total soluble solids, reducing, non- reducing and total sugars increased during storage while titratable acidity and vitamin C decreased. After two weeks of storage, retention of biochemical quality attributes was better in shrink wrapped samples than the unwrapped fruits. However, type of film did not significantly influence the content of biochemical constituents. Individual shrink wrapping of fruits with 25 μ polyolefin film was found to be better in retention of quality than that of 15 and 19 μ films.

Individual shrink wrapping of mango and pineapple were superior with regard to shelf life and quality characteristics. Shrink wrap packaging was found ineffective in prolonging shelf life of banana under ambient conditions of storage. Polyolefin film of 25 μ thickness was better as compared to 15 and 19μ thick films to prolong shelf life and to retain quality of individually shrink wrapped mango and pineapple.

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Appendices

APPENDIX I

Score card for sensory evaluation of shrink wrapped fruits

9 point hedonic scale

Product code	Appearance	Colour	Texture	Flavour	Odour	Taste	After taste	Overall acceptability

Note: You are provided with the samples of shrink wrapped fruits and you are requested to rank them according to the scale given below as per your liking

Scale:

9	Like Extremely
8	Like Very Much
7	Like Moderately
6	Like Slightly
5	Neither Like nor Dislike
4	Dislike Slightly
3	Dislike Moderately
2	Dislike Very Much
1	Dislike Extremely

Date: Name:

Signature:

APPENDIX II

A. Mean rank scores of shrink wrap packaged mango (1WAS)

Treatments	Appearance	Colour	Flavour	Texture	Odour	Taste	After taste	Overall acceptability
T1	3.50	4.07	4.29	5.43	2.43	4.29	4.17	3.18
T2	6.64	6.93	5.21	5.21	6.00	5.50	5.36	5.23
T3	4.07	5.36	4.14	3.29	6.64	5.21	4.80	4.68
T4	6.57	4.86	5.29	6.57	3.93	3.64	2.65	6.14
T5	3.43	4.00	3.36	4.14	6.57	6.14	4.14	2.23
T6	4.64	2.93	2.50	6.03	6.79	3.71	2.41	2.81
T7	6.36	2.36	6.79	5.21	3.71	4.64	6.26	4.19
Kendal's W test	0.67	0.659	0.501	0.617	0.570	0.301	0.657	0.426

B. Mean rank scores of shrink wrap packaged mango (2WAS)

Treatments	Appearance	Colour	Flavour	Texture	Odour	Taste	After taste	Overall acceptability
T1	2.40	2.10	2.00	1.70	2.20	2.10	2.10	2.40
T2	1.80	1.80	1.85	1.85	2.05	1.90	1.95	1.65
T3	1.80	2.10	2.15	2.45	1.75	2.00	1.95	1.95
Kendal's W test	0.27	0.13	0.04	0.35	0.12	0.04	0.03	0.38

APPENDIX III

A. Mean rank scores of shrink wrap packaged banana (4DAS)

Treatments	Appearance	Colour	Flavour	Texture	Odour	Taste	After taste	Overall acceptability
T1	6.65	3.43	4.28	4.17	2.89	3.92	3.19	5.25
T2	5.23	6.00	5.26	5.36	4.68	6.56	5.63	5.96
T3	4.17	6.41	4.80	4.80	6.26	5.45	4.80	3.80
T4	6.57	3.93	2.75	2.65	3.85	4.40	3.65	4.65
T5	3.43	6.86	5.45	4.14	3.85	2.68	7.15	4.12
T6	5.64	6.14	4.75	2.41	5.47	3.56	2.41	6.36
T7	6.16	3.71	6.26	6.26	5.28	4.14	6.26	6.30
Kendal's W test	0.76	0.58	0.65	0.83	0.53	0.64	0.88	0.70

APPENDIX IV

A. Mean rank scores of shrink wrap packaged pineapple (1WAS)

Treatments	Appearance	Colour	Flavour	Texture	Odour	Taste	After taste	Overall acceptability
T1	4.82	4.86	5.09	5.50	5.32	3.50	5.64	6.95
T2	4.95	4.00	4.86	4.86	4.50	6.23	5.91	6.09
T3	5.41	4.73	4.82	5.45	4.50	6.45	6.09	5.45
T4	1.95	2.95	2.45	2.00	3.00	7.09	6.05	5.14
T5	2.59	2.55	2.82	2.27	2.86	2.00	2.14	2.23
T6	2.82	3.77	2.68	2.32	3.00	2.18	1.82	1.95
T7	5.45	5.14	5.27	5.59	4.82	2.23	6.18	2.09
Kendall's W test	0.61	0.26	0.40	0.79	0.30	0.91	0.78	0.82

B. Mean rank scores of shrink wrap packaged pineapple (2WAS)

Treatments	Appearance	Colour	Flavour	Texture	Odour	Taste	After taste	Overall acceptability
T1	1.85	1.65	2.00	1.85	1.80	3.82	2.74	1.85
T2	1.85	2.10	1.75	1.80	1.85	2.80	3.56	2.73
T3	2.30	2.25	2	2.35	2.35	2.95	2.45	2.15
Kendal's W test	0.35	0.22	0.16	0.23	0.23	0.60	0.53	0.47

SHRINK WRAP PACKAGING OF SELECTED TROPICAL FRUITS

By

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ABSTRACT OF THE THESIS

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ABSTRACT

The present study titled "Shrink wrap packaging of selected tropical fruits" was carried out in the Department of Processing Technology, College of Horticulture, Vellanikkara during 2015-2016. The objective was to extend shelf life and to maintain quality of mango, banana and pineapple during storage. The technique of shrink wrap packaging was adopted in three tropical fruits *viz.*, mango, banana and pineapple. Each experiment consisted of 7 treatments wherein shrink wrap packaged fruits along with the unwrapped (control) samples were stored under ambient conditions. Observations on shelf life and PLW (physiological loss in weight) were recorded at an interval of three days and the biochemical characteristics were analysed at weekly intervals.

Mature fruits of mango variety Prior, free of damage and bruises, were washed in plain tap water followed by surface sanitization with 100ppm chlorine for 15 minutes. The chlorinated fruits were spread out on blotting paper to remove excess surface moisture. Surface dried fruits were subjected to two forms of shrink wrapping *i.e,* individual fruit wrap and wrapping of 4-5 fruits in areca plates with polyolefin film of three densities *viz.*, 15, 19 and 25 µ. Individually shrink wrapped mangoes in 25 µ polyolefin film had the longest shelf life (18 days) and the shrink wrapped fruits in areca plates with 19 µ polyolefin film had the shortest shelf life (8 days).

An increasing trend in the PLW, TSS, total carotenoids, reducing, non- reducing and total sugars were noticed during storage whereas titratable acidity and vitamin C decreased. Individual shrink wrapping of mangoes with 25 µ polyolefin film was superior among all treatments with regard to quality retention.

Banana, cv. Grand Naine was selected for shrink wrap packaging. Desapped banana hands were chlorinated and shrink wrapped with polyolefin film of three densities *viz.,* 15, 19 and 25µ. Half of the shrink wrapped hands were further master

packed in CFB boxes. All the shrink wrapped samples along with unwrapped (control) fruits were stored at ambient temperature. Unwrapped banana hands had the longest shelf life (7 days) as compared to shrink wrapped banana (4 to 5 days). Condensation of moisture inside the film resulted in microbial growth on the surface of banana hands and thus adversely affected the shelf life of samples. Retention of biochemical constituents was better in shrink wrapped fruits than the unwrapped ones. Off flavour was observed on the shrink wrapped banana hands during storage.

Firm, ripe fruits of pineapple cv. Mauritius were cleaned dry, followed by removal of crown from these fruits. The cleaned fruits were shrink wrapped with polyolefin film of three densities. Half of the shrink wrapped fruits were enclosed in master packs of CFB boxes. The packaged fruits, along with the control samples were stored at ambient temperature. Individually shrink wrapped fruits with 25μ polyolefin film had longest shelf life (14- 16 days) and was the best treatment with regard to the retention of biochemical attributes PLW, TSS, reducing, non- reducing and total sugars increased during storage while titratable acidity and vitamin C decreased.

The results of the present investigation revealed that individual shrink wrapping of mango and pineapple was superior with regard to shelf life and quality characteristics. Shrink wrap packaging was found ineffective in prolonging shelf life of banana under ambient conditions of storage. Polyolefin film of 25μ thickness was better as compared to 15 and 19μ thick films.