EFFECT OF POSTHARVEST TREATMENTS AND MODIFIED ATMOSPHERE PACKAGE ON SHELF LIFE EXTENSION OF PASSION FRUIT (*Passiflora edulis*)

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PROJECT REPORT

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DECLARATION

We here by declare that this project report entitled **“EFFECT OF POST HARVEST TREATMENTS AND MODIFIED ATMOSPHERE PACKAGE ON SHELF EXTENSION OF PASSION FRUIT (*Passiflora edulis*)”** is a bonafide record of project work done by us during the course of study and that the report has not previously formed the basis for the award to us of any degree, diploma, associate ship, fellowship, or other similar title of another University or society.

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CERTIFICATE

Certified that this project report entitled **“EFFECT OF POSTHARVEST TREATMENTS AND MODIFIED ATMOSPHERE PACKAGE ON SHELF LIFE EXTENSION OF PASSION FRUIT (*Passiflora edulis*)”** is a record of project work done independently by **Alfiya, P. V, Ashly, K. R, and Sangeetha, P. Shenoy**, under my guidance and supervision and that it has not previously formed the basis for the award of any degree, diploma, fellowship or associate ship to them.

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We bow our heads before God Almighty for the blessing bestowed on us.

Dedicated to God

Almighty,

Our Loving Parents

And

All Members of K.C.A.E.T

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SYMBOLS AND ABBREVIATIONS

%	percentage
/	per
^{0}C	degree celcius
µL	microlitre
g	gram
kg	kilogram
h	hour
mg	milligram
mm	millimetre
I.U.	International Unit
meq	milli equivalent
MT	Metric Ton
NaClO	sodium hypochlorite
KMS	potassium metabisulphite
O_2	oxygen
CO_2	carbon dioxide
et al.	and other people
etc.	etcetera
No.	number
RH	Relative Humidity
ppm	parts per million

1 INTRODUCTION

Passion fruit grows on a vine in its native tropical and subtropical regions. Commercially, it is grown in Brazil, the Caribbean, Australia, Africa and some areas of the southern United States. Because of the beauty of its flowers and the high demand for the fruit, passion fruit is successfully cultivated in native as well as non-native areas.

Passion fruit has hundreds of medicinal properties that have been used throughout history. The natural chemicals in passion fruit are used to lower blood pressure, control spasms and treat asthma. The fruit and its leaves also work as a sedative, helping to induce sleep and calm nervousness or other mood disorders. Modern science has observed that passion fruit extracts can kill cancer cells in developing foetuses. Passion fruit is also thought to expel worms, kill bacteria and enhance the libido.

Of the estimated 500 species of *Passiflora*, in the family Passifloraceae, there are two distinct forms, the standard purple, and the yellow, distinguished as *P. edulis flavicarpa*.

1.1 Origin and Distribution

It has been stated that the yellow form is of unknown origin, or perhaps native to the Amazon region of Brazil. In many areas, the vine has run wild. The yellow form was unknown in India until just a few decades ago when it was introduced from Ceylon and proved well adapted to low elevations around Madras and Kerala. It was quickly approved as having a more pronounced flavour than the purple and producing within a year of planting heavier and more regular crops. Since the introduction of the yellow passionfruit from Brazil into Venezuela in 1954, it has achieved industrial status and national popularity.

1.2 Fruit

The nearly round or ovoid fruit, 3.8 to 7.6 cm wide, has a tough rind that is smooth and waxy and ranging in hue from dark purple with faint, fine white specks, to light yellow or pumpkin-colour. Within is a cavity more or less filled with an aromatic mass of double walled, membranous sacs containing orange-coloured, pulpy juice and as many as 250 small, hard, dark brown or black, pitted seeds. The unique flavour is appealing, musky, guava-like and sweet/tart to taste. Numerous hybrids have been made between purple and the yellow passion fruit, often yielding colours and other characteristic intermediate between the two forms. The vine, especially the yellow form, is fast-growing and will begin to bear in 1 to 3 years. Ripening occurs 70 to 80 days after pollination.

1.3 Varieties

The yellow form has a more vigorous vine and generally larger fruit than the purple, but the pulp of the purple is less acid, richer in aroma and flavour, and has a higher proportion of juice-35-38%. The purple form has black seeds, the yellow, brown seeds.

1.4 Climate

The yellow passionfruit is tropical or near-tropical. They need protection from wind. Generally, annual rainfall should be at least 90 cm. It is reported that annual rainfall in passionfruit-growing areas of India ranges from 100 to 250 cm.

1.5 Soil

Passion fruit vines are grown on many soil types but light to heavy sandy loams, of medium texture are most suitable, and pH should be from 6.5 to 7.5. If the soil is too acid, lime must be applied. Good drainage is essential to minimize the incidence of collar rot.

1.6 Seasons and Harvesting

In some areas, as in India, the vines bear throughout the year but peak periods are, first, August to December, and, second, March to May. At the latter time, the fruits are somewhat smaller, with less juice. Ripe fruits fall to the ground and will roll in between mounded rows. They do not attract flies or ants but should be collected daily to avoid spoilage from soil organisms. In India and Israel the fruits are always picked from the vine rather than being allowed to fall. It has been found that fallen fruits are lower in soluble solids, sugar content, acidity and ascorbic acid content.

The fruit will quickly turn from green to yellow (deep purple) when ripe and then fall to the ground within a few days. They can either be picked when they change colour or gathered from the ground each day. Traditionally, to store passion fruit, wash and dry them gently and place them in bags. They should last 2 to 3 weeks at 10 ^{0}C. The fruit is sweetest when slightly shrivelled. Both the fruit and the juice freeze well. The flavour of passion fruit blends well with citrus and many other fruit flavours, and is quickly appreciated by many people as they become familiar with it.

The fruits should be collected in lugs or boxes, not in bags which will cause "sweating". If not sent immediately to processing plants, the fruits should be spread out on wire racks where there will be good air circulation.

1.6.1 Harvest maturity indices

Several different indices may be used to determine harvest maturity of passion fruit, including the length of time after transplanting and the external skin colour. Initial fruit harvest from seeded yellow passion fruit plants normally begins about ten month after transplanting, with full production occurring after 18 months. The timing of initial harvest depends on the vigour of the plant and environmental growing conditions. The fruit matures in about 75 days after flowering and will naturally fall to the ground when fully coloured and matured. In order to optimize flavour quality and storage life, passion fruit should be harvested with 75% purple or yellow colour. A mature passion fruit vine normally produces two to three crops annually; one main harvest followed by several smaller crops. Therefore, passion fruits are usually available for harvest year round.

1.6.2 Harvest methods

Passion fruit is harvested manually by cutting or clipping the fruit off the vine. The recommended tools are a sharp knife or clippers with a sharp edge (Figure 1). Fruit should be picked at the stricture in the stem and not close to the shoulder of the fruit. A short piece of stem, approximately 4 cm in length should be left attached to the fruit to help prevent water loss and fungal development (Figure 2). The fruit should not be pulled from the plant.

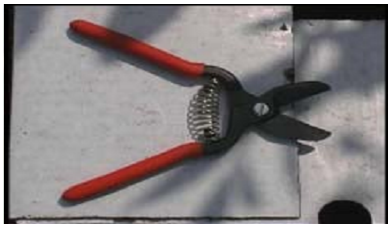

PLATE 1.1 Sharp edged clippers ideal for harvesting passion fruit

PLATE 1.2: Yellow passion fruit with short length of vine

1.7 Yield

Many factors influence the yield of passionfruit vines. In general, yields of commercial plantations range from 20,000 to 35,000 kg per ha.

1.8 Storage

Optimum storage condition for yellow passion fruit is at 7 to 10 ^{0}C and 90 to 95% RH. They will have a potential storage-life of 2 weeks (Arjona et al., 1992)Under ripe yellow passion fruits can be ripened and stored at 20 ^{0}C with relative humidity of 85 to 90%. Ripening is too rapid at 30 ^{0}C. Ripe fruits keep for one week at 2.22 ^{0}C to 7.22 ^{0}C. Fruits

stored in unperforated, sealed, polyethylene bags at 23.1 ^{0}C, have remained in good condition for 2 weeks. Coating with paraffin and storing at 5 ^{0}C to 7 ^{0}C and relative humidity of 85 to 90%, has prevented wrinkling and preserved quality for 30 days.

1.9 Respiration rates

The climacteric of this fruit normally occurs on the vine (Biale, 1975)

Temperature (^{0}C)	mg CO_2 kg^{-1} h^{-1}
5	29 to 58
10	39 to 78
20	87 to 194
25	175 to 349

TABLE 1.1 Respiration rates of passion fruit at different temperatures

1.10 Ethylene production and sensitivity

Passion fruit produce very high level of ethylene at 160 to 400 µL kg^{-1} h^{-1} at 20 ^{0}C at their climacteric peak (Shiomi *et al.*, 1996). Exposure to 100 µLL^{-1} ethylene for 24 h accelerates ripening (Arjona and Matta, 1991; Akamine *et al.*, 1957)

1.11 Food Uses

Passion fruit is either eaten fresh or used in commercial juice production. The fruit is of easy preparation. One needs only cut it in half lengthwise and scoop out the seedy pulp with a spoon. For home use, Australians do not trouble to remove the seeds but eat the pulp with cream and sugar or use it in fruit salads or in beverages, seeds and all. Elsewhere it is usually squeezed through two thicknesses of cheesecloth or pressed through a strainer to remove the seeds. Mechanical extractors are, of course, used industrially. The resulting rich juice, which has been called a natural concentrate, can be sweetened and diluted with water or other juices (especially orange or pineapple), to make cold drinks. After primary juice extraction, some processors employ an enzymatic process to obtain supplementary "secondary" juice from the double juice sacs surrounding each seed. The high starch content of the juice gives it exceptional viscosity. To produce a free flowing concentrate, it is desirable to remove the starch by centrifugal separation in the processing operation (Morton, J. 1987).

Calories	90
Moisture	75.1 g
Protein	2.2 g
Fat	0.7 g
Carbohydrates	21.2 g
Fibre	-
Ash	0.8 g
Calcium	13 mg
Phosphorus	64 mg
Iron	1.6 mg
Sodium	28 mg
Potassium	348 mg
Vitamin A	700 I.U.
Thiamine	Trace
Riboflavin	0.13 mg
Niacin	1.5 mg
Ascorbic Acid	30 mg

Source: U.S. Dept. Agr, ARS

TABLE 1.2 Food value per 100 g of edible portion (Purple passionfruit, pulp and seeds)

The yellow passion fruit has somewhat less ascorbic acid than the purple but is richer in total acid (mainly citric) and in carotene content. It is an excellent source of niacin and a good source of riboflavin. Free amino acids in purple passionfruit juice are: arginine, aspartic acid, glycine, leucine, lysine, proline, threonine, tyrosine and valine. Carotenoids in the purple form constitute 1.160%; in the yellow, 0.058%; flavonoids in the purple, 1.060%; in the yellow, 1.000%; alkaloids in the purple, 0.012%; in the yellow, 0.700% (mainly harman), and the juice is slightly sedative. Starch content of purple passionfruit juice is 0.74%; of the yellow, 0.06%.

meq/100g	Citric acid	Malic acid	Lactic acid	Malonic acid	Succinic acid	Ascorbic acid
Purple	13.1	3.86	7.49	4.95	2.42	0.05
Yellow	55	10.55	0.58	0.13	trace	0.06

TABLE 1.3 Various acid contents in meq/100g of purple and yellow passion fruit

Toxicity: A cyanogenic glycoside is found in the pulp of passion fruits at all stages of development, but is highest in very young, unripe fruits and lowest in fallen, wrinkled fruits, the level in the latter being so low that it is of no toxicological significance.

1.12 Other Uses

Commercial processing of the yellow passionfruit yields 36% juice, 51% rinds, and 11% seeds.

1.12.1 Rind: The rinds have very low pectin content–only 2.4% (14% on a dry weight basis). Nevertheless, it has been determined in Fiji that extraction of pectin from the rinds–up to 5 tons (4.5 MT) annually–reduces the otherwise burdensome problem of waste disposal. The rind residue contains about 5 to 6% protein and could be used as filler in poultry and stock feed. In Brazil, pectin is extracted from the purple form which has better quality pectin than that in the yellow. In Hawaii, the pectin is not extracted. Instead, the rinds are chopped, dried, and combined with molasses as cattle or pig feed. They can also be converted into silage.

Analyses of the fresh rind show: moisture, 78.43-85.24%; crude protein, 2.04-2.84%; fat, 0.05-0.16%; crude starch, 0.75-1.36%; sugars (sucrose, glucose, fructose), 1.64%; crude fibre, 4.57-7.13%; phosphorus, 0.03-0.06%; silica, 0.01-0.04%; potassium, 0.60-0.78 %; organic acids (citric and malic), 0.15%; ascorbic acid, 78.3-166.2%. The outer skin of the purple form contains 1.4 mg per 100 g of the anthocyanin pigment, pelargonidin 3-diglucoside. There is also some tannin.

The composition of air-dried seeds is reported as: moisture, 5.4%; fat, 23.8%; crude fibre, 53.7%; protein, 11.1%; N-free extract, 5.1%; total ash, 1.84%; ash insoluble in HC1, 0.35%; calcium, 80 mg; iron, 18 mg; phosphorus, 640 mg per 100 g.

1.12.2 Seeds: The seeds yield 23% oil which is similar to sunflower and soybean oil and accordingly has edible as well as industrial uses. Up to 13,000 litres can be obtained per year in Fiji. The seed meal contains about 12% protein and 50 to 55% fibre. It has been judged unsuitable for cattle feed.

The seed oil contains 8.90% saturated fatty acids; 84.09% unsaturated fatty acids. The fatty acids consist of: palmitic, 6.78%; stearic, 1.76%; arachidic, 0.34%; oleic, 19.0%; linoleic, 59.9%; linolenic, 5.4%.

1.12.3 Medicinal Uses: There is currently a revival of interest in the pharmaceutical industry, especially in Europe, in the use of the glycoside, *passiflorine*, especially from *P. incarnata*, as a sedative or tranquilizer. Italian chemists have extracted *passiflorine* from the air-dried leaves of *P. edulis.*

In Madeira, the juice of passion fruits is given as a digestive stimulant and treatment for gastric cancer.

With this back ground, a project was under taken at Kelappaji College of Agricultural Engineering and Technology, Tavanur with the following objectives.

1. Shelf life extension of passion fruit
2. Standardization of pre-treatments and modified atmosphere package
3. Determination of post harvest quality parameters of the stored fruit
4. Optimization of storage conditions

2 REVIEW OF LITERATURE

Plastic film reduced fresh weight loss, fruit wilting, kept higher fruit and rind weight and higher pulp osmotic potential over the period, though it was not efficient in the control of rottenness. Sparcitrus wax caused injury to the fruit, high fruit weight losses and wilting and resulted in lower pulp osmotic potential; this wax lead to a higher concentration of acid and a lower relation of soluble solids or acidity. Fruit wax (8-21% carnauba wax) was the best, promoting reduced weight loss, wilting and rottenness (Wagner Ferreira da Mota *et al*., 2003).

2.1 MODIFIED ATMOSPHERE PACKAGING

Modified Atmosphere Packaging is defined as "the packaging of a perishable product in an atmosphere which has been modified so that its composition is other than that of air" (Hintlian and Hotchkiss, 1986). MAP is a technique used for prolonging the shelf-life period of fresh or minimally processed foods. In this preservation technique the air surrounding the food in the package is changed to another composition. This way the initial fresh state of the product may be prolonged. It is used with various types of products, where the mixture of gases in the package depends on the type of product, packaging materials and storage temperature. The initial flushed gas mixture will be maintained inside the MAP. If the permeability (for $O_2$and CO_2) of the packaging film is adapted to the product's respiration, an equilibrium modified atmosphere will establish in the package and the shelf-life of the product will increase.

MAP is a dynamic system where the respiration of the packaged product and the gas permeation through the packaging films take place simultaneously. At equilibrium, the respiration rate of commodity equals the permeation rate of packaging films and it retains the desired atmosphere. The attainment of equilibrium state depends on proper design of MAP (S.Mangaraj and T.K.Goswami., 2009).

The optimum temperature for the storage of guava fruits was 6 ^{0}C and 90 to 95% relative humidity for maintaining highly acceptable sensory quality. At this temperature the fruits had attractive colour pleasant flavour and acceptable quality and can be stored up to 2-3 weeks with a post-storage shelf life of 3 days at 20 to 21 ^{0}C and 65 to 70% relative humidity (Mahajan *et al*., 2009).

The principle of MAP involves the removal of air from the pack and its replacement with a single gas or mixture of gases by either passive or active methods, depending upon the type of product.

2.1.a. Active modified atmospheric packaging

Active packaging is a group of technologies in which the package is actively involved with food products or interacts with internal atmosphere to extend shelf-life while maintaining quality and safety (Floros *et al.,* 1997*).* The potential technologies being used in active packaging are oxygen scavenging, antimicrobial packaging, ethylene control, moisture control and gas permeability control. The active MAP can be established by withdrawing air from package system with vacuumization and by back flushing with selected gas mixture. The advantages of active modification of micro atmosphere are the rapid establishment of desired gas mixtures. Adsorbents and absorbents may be included in the package system to reduce O2, CO2, ethylene and vapour. This kind of packaging is generally used in case of highly perishable goods like minimally processed vegetables and fruits (Labuza *et al.1996)*

2.1.b. GASES USED IN MAP

The basic concept of the MAP of fresh foods is the replacement of the air surrounding the food in the package with a mixture of atmospheric gases different in proportion from that of air. Gaseous composition of dry air at sea level is Nitrogen 78.03%, Oxygen 20.99%, Argon 0.94%, Carbon dioxide 0.03% and Hydrogen 0.01%.

Oxygen (O_2)

Food deteriorates due to physical, chemical and microbiological factors. Oxygen is probably the most important gas in this context being used metabolically by both aerobic spoilage micro organisms and plant tissues and taking part in some enzymatic reactions in food including the compounds such as vitamins and flavours. For these reasons, in modified atmosphere packaging, oxygen is either excluded or the levels set as low as possible. The exceptions occur where oxygen is needed for fruit and vegetable respiration, colour retention as in the case of red meat or to avoid anaerobic conditions in white fish. In MAP, oxygen levels are normally set as low as possible to reduce oxidative deterioration of foods (Isenberg 1979, Kader 1987, Solomos and Kanellis 1989, Saltveit 2005). Oxygen will generally stimulate the growth of aerobic bacteria and can inhibit the growth of strictly anaerobic bacteria, although there is a very wide variation in the sensitivity of anaerobes to oxygen.

Carbon dioxide (CO_2)

Carbon dioxide is both water and lipid soluble and although it is not a bactericide or fungicide, carbon dioxide has bacteriostatic and fungi static properties. The overall effect on micro organisms is an extension of the lag phase of growth and a decrease in the growth rate during the logarithmic growth phase. However, the former effect is greater and therefore as bacteria move from the lag to log phase of growth the inhibitory effects are reduced. Thus, the earlier the product is gas packaged, the more effective CO_2 will be. This bacteriostatic effect is influenced by the concentration of CO_2, the partial pressure of CO_2, volume of headspace gas, the type of micro organism, the age and load of the initial bacterial population, the microbial growth phase, the growth medium used the storage temperature, acidity, water activity, and the type of the product being packaged. Yeasts which produce carbon dioxide during growth are stimulated by high levels of carbon dioxide and thus for some products where they are potentially a major cause of spoilage, MAP may not be an advisable option. Also the food-associated pathogens *Clostridium perfringens* and *Clostridium botulinum* are not affected by the presence of carbon dioxide and their growth is encouraged by anaerobic conditions (Hotchkiss 1998). In general carbon dioxide is most effective in foods where the normal spoilage organisms consist of aerobic, gram-negative psychrotropic bacteria (Phillips 1996, Hotchkiss 1998). For maximum antimicrobial effect, the storage temperature of MAP product should be kept as low as possible, because the solubility of CO_2 decreases dramatically with increasing temperature. Thus, improper temperature control will usually eliminate the beneficial effects of elevated CO_2. The absorption of CO_2 is highly dependent on the moisture and fat content of the product. If product absorbs excess CO_2, the total volume inside the package will be reduced, giving a vacuum package look known as “pack collapse”. Some dairy products (e.g. cream) are very sensitive to CO_2 concentrations and will be tainted if packed in MA with high CO2 levels. Fruits and vegetables can suffer physiological damage due to high CO_2 levels (Kubo *et al*.,). For practical purposes, in most foods, gaseous CO_2 is applied to a biological tissue would exist in the liquid phase of the tissue primarily dissolved CO_2 gas and carbonic acid (about 2%). At pH 6.0, carbonic acid will dissociate to form bicarbonate and hydrogen ions, the latter of which likely causes the small pH drop often observed in muscle tissue packaged in a CO_2 atmosphere (Daniels *et al*., 1985). This minimal pH decrease would not cause any significant biostatic activity. Although the bacteriostatic effect of CO_2 has been known for many years, the precise mechanism of its action is still a subject of considerable interest.

There have been many theories regarding the way in which CO_2 exerts its influence on a bacterial cell. These can be summarized as follows (Daniels *et al*., 1985, Dickson and Kell 1989)

a) Alteration of cell membrane functions including effects on nutrient uptake and absorption

b) Direct inhibition of enzymes or decreases in the rate of enzyme reactions

c) Penetration of bacterial membranes, leading to intracellular pH changes

d) Direct changes to the physio-chemical properties of proteins

Nitrogen (N_2)

Nitrogen is an inert tasteless gas, which displays little or no antimicrobial activity on its own. Because of its low solubility in water and fat, the presence of N_2 in a MAP food can prevent pack collapse that can occur when high concentrations of CO_2 are used. In addition, N_2 by displacing O_2 in the pack, can delay oxidative rancidity and also inhibit the growth of aerobic micro organisms. In foods such as nuts, removing oxygen to less than 1% by nitrogen flushing helps to prevent oxidative rancidity of fats. Nitrogen can also indirectly influence the micro organisms in perishable foods by retarding the growth of aerobic spoilage organisms (Farber 1991, Philips 1996). The second role of nitrogen in MAP is to act as a filler gas and keeps flexible packages from developing a vacuum. Exactly what combination of gases is used depends on many factors, such as the type of the product, packaging materials and storage temperature. The packaging system selected must have sufficient headspace to provide enough gas to interact with the entire product. The headspace must contain a reservoir of CO_2 to compensate for gas absorbed by the product and lost across the packaging material (Parry 1993). The longer the required shelf-life then the larger the headspace should be.

Carbon monoxide (CO)

This has been found to be very effective in maintaining the red colour in fresh meat due to the formation of carboxymyoglobin. It has not been used commercially for this purpose however since carbon monoxide; a highly toxic gas is not approved by the regulatory authorities owing to the possible health hazard to packaging machine operatives. Its use has, however, been sanctioned in the United States to prevent browning in packed lettuce. Carbon monoxide has little inhibitory effect on micro organisms (Goodburn and Halligan 1988, Kader *et al*., 1989).

Other Gases

The potential of various other gases such as chlorine, ethylene oxide, nitrogen dioxide, ozone, propylene oxide and sulphur dioxide for modified atmosphere packaging have been investigated experimentally but their commercial use for packaging foods is unlikely to meet with approval from the regulatory authorities(Brody 1989, Day 1989).

2.1.1 PACKAGING FILMS: TYPES

Cellulose:-It is glossy transparent film which is odourless tasteless and biodegradable. It is tough and puncture resistant, although it tears easily. It is not heat sealable and dimensions and permeability vary with changes in humidity. It is used for foods that do not require a complete moisture barrier or gas barrier.

Polyethylene:-Flexible, transparent and have a perfect resistance to low temperature and impermeability to water vapour. These sheets can be heat sealed. It is good packaging material for primary protection of dehydrated products. These are further classified as low density poly ethylene (LDPE), linear low density poly ethylene (LLDPE), and high density poly ethylene (HDPE).

Polypropylene:-It is a clear glossy film with good optical properties and a high tensile strength and puncture resistance. It has moderate permeability to moisture, gases and odours which are not affected by changes in humidity.

Polystyrene:-It is a brittle clear, sparkling film, which has high gas permeability. It is rigid easy to process, has good surface finish and gives protection during transportation.

Nylon:-They have high resistance to oils, fats and chemicals and possess outstanding barrier properties to gases and vapours. They can be easily printed, laminated, metallised and biaxially oriented.

Polyester film:-It is characterised by exceptional strength over wide range of temperatures, good dielectric properties and strong resistance to solvents.

Polycarbonate:-It is one of the strongest and most rigid thermoplastics .moisture absorption is low, resulting in low shrinkage through temperature changes. It wraps to protect against damage and moisture over a long shelf life.

Stretch-cling film:-It is a cost effective and highly efficient means of unitization. Its chemical composition gives it high tensile strength providing a rubber band effect. It is a

viable alternative to shrink wrapping as no ”power” or “heat” energy is required to provide secure effect.

Shrink films:-This involves use of thermoplastic films that have been stretched or oriented during manufacturing and have property of shrinking with application of heat. This technique provides all weather protection during transit or outside storage simplifies load identification and provides a barrier against dust and humidity. Advantages of shrink package include

- Contour fit
- Appearance
- Protection and cleanliness
- Multi packing
- Immobilisation
- Economy

2.1.2 EDIBLE COATING

Edible coatings are thin layers of edible material applied to the product surface in addition to or as a replacement for natural protective waxy coatings and provide a barrier to moisture, oxygen and solute movement for the food (McHugh and Senesi, 2000; Nisperos-Carriedo *et al.*, 1992; Lerdthanangkul and Krochta, 1996; Avena-Bustillos *etal.*, 1997; Guilbert *et al.*, 1996; Smith *et al.*, 1987). They are applied directly on the food surface by dipping, spraying or brushing to create a modified atmosphere (McHugh and Senesi, 2000; Krochta and Mulder-Johnston, 1997; Guilbert *et al.*, 1996).

An ideal coating is defined as one that can extend storage life of fresh fruit without causing anaerobiosis and reduces decay without affecting the quality of the fruit (El Ghaouth *et al.*, 1992). Previously, edible coatings have been used to reduce water loss, but recent developments of formulated edible coatings with a wider range of permeability characteristics has extended the potential for fresh produce application (Avena-Bustillos *et al.*, 1994).

The effect of coatings on fruits and vegetables depends greatly on temperature, alkalinity, thickness and type of coating, and the variety of and condition of fruits (Park *et al.*, 1994). The functional characteristics required for the coating depend on the product matrix (low to high moisture content) and deterioration process to which the product is subject (Guilbert *et al.*, 1996).

Edible Coatings from Morpholine-Free Wax Micro emulsions: Edible wax coatings were made by the drying of wax micro emulsions composed of water, fatty acid, ammonia, and various combinations of candelilla wax, beeswax, carnauba wax, polyethylene wax, and petroleum wax. All coating formulations studied were effective moisture barriers, with the best being those containing candelilla wax, beeswax, and petroleum wax. Polyethylene and carnauba wax coatings had best gloss, but also were the most brittle. Emulsion clarity was improved by using some myristic or palmitic acid, rather than commercial grade oleic acid as the only source of fatty acid. Compared to wax coatings made with ammonia-based emulsions, those made with morpholine had higher permeability to oxygen and water vapour, possibly because the morpholine, being less volatile than ammonia, stayed longer in the coating. (Robert D *et al*., 1997)

Plasticized whey protein coatings have been shown to extend the shelf life of fresh produce (Sonti Sirisha, 2003)

In apples of 'Royal Delicious', the coating with 2% potato starch + 2% apricot kernel oil followed by 2% corn starch + 2% apricot kernel oil proved most effective in retaining the overall quality as it caused minimum changes in most of the physical and bio-chemical quality characteristics. Fruits stored at 2±1 ^{0}C and 85-90% relative humidity exhibited better retention of storage life for 150 days by lowering the incidence of fruit softening, spoilage, and better retention of consumer preference compared to ambient storage. Application of 2% neem oil significantly reduced the fruit rot caused by *pencillium expansum* (Wijewardane and Guleria, 2009).

2.1.2.1. Edible Films

Edible polymer film is defined as a thin layer of edible material formed on a product surface as a coating or placed (pre-formed) on or between food components (Krochta and Mulder-Johnston, 1997). Several types of edible films have been applied successfully for preservation of fresh products (Park *et al.*, 1994). Fruit based films provide enhanced nutrition for food products, while increasing their marketing allure (McHugh and Senesi, 2000).

Edible and biodegradable films must meet a number of special functional requirements, for example, moisture barrier, solute or gas barrier, water or lipid solubility, colour and appearance, mechanical and rheological characteristics, non-toxicity, etc. These

properties depend on the type of material used, its formation and application (Guilbert *et al.*, 1996).

The benefit of using selective films seems to be the reduction of water loss, which is one of the most important factors in the deterioration of highly perishables (Bussel and Kenigsberger, 1975). The films provide protection against moisture loss and maintain an attractive appearance of the product. Films may consist of single or multiple components (Guilbert *et al.*, 1996).

2.1.2.2. Types of Edible Coatings and Films

Edible coatings may be composed of polysaccharides, proteins, lipids or a blend of these compounds (Li and Barth, 1998; Park *et al.*, 1994; Guilbert *et al.*, 1996; Mahmoud and Savello, 1992; Arvanitoyannis and Gorris, 1999). Their presence and abundance determine the barrier properties of material with regard to water vapour, oxygen, carbon dioxide and lipid transfer in food systems (Guilbert *et al.*, 1996).However, none of the three constituents can provide the needed protection by themselves and so are usually used in a combination for best results (Guilbert *et al.*, 1996; McHugh and Krochta, 1994).

2.1.2.3. TYPES OF WAX

Wax can be of different types based on its origin. They can be classified as vegetable wax, animal wax, mineral wax, petroleum wax and synthetic wax.

Vegetable wax

Carnauba wax	It is obtained from leaves of carnauba palm. It has the highest melting point of all natural waxes, (82-86 ^{0}C).
Candelilla wax	It is derived from leaves of small candelilla shrub. It has a melting point of 69-70 ^{0}C.
Esparto wax	Vegetable wax extracted from esparto grass. It is hard, blends well and easy to emulsify.
Bayberry wax	It is obtained from surface wax of fruits of bayberry shrub.
Castor wax	It is obtained from catalytically hydrogenated castor oil.
Rice bran wax	It is obtained from rice bran.

TABLE 2.1 Wax types of vegetable origin

Animal wax

Bees wax	It is the natural wax produced in the beehive of honey bees. It has a melting point of 62- 64 ^{0}C. Discolouration occurs when heated above 85 ^{0}C.
Shellac wax	It is a resin secreted by female Luce bug to form a cocoon.
Spermaceti	A wax liquid at body temperature obtained from head of sperm whale.
Chinese wax	It is a white to yellowish white gelatinous crystalline water insoluble substance obtained from the wax secreted by certain insects.
Lanolin (wool wax)	It is obtained from the sebaceous glands of sheep.

TABLE 2.1 Wax types of animal origin

Mineral wax

- Ozokerite wax: -It is a naturally occurring odoriferous mineral wax or paraffin found in many localities
- Montan wax:-It is also called as lignite wax or OP wax .it is a hard wax obtained by solvent extraction of certain type of lignite or brown coal.

Petroleum wax

- Paraffin wax: - It is made of long chain alkane hydrocarbon
- Micro crystalline wax: - It is with very fine crystalline structure

Synthetic wax

- Polyethylene wax
- Fischer tropsch wax
- Chemically modified wax
- Substituted amide wax
- Polymerised alpha-olefins

Studies have been conducted by Chaim H. Mannheim and Tal Soffer, 1996 permeability of different wax coatings and their effect on citrus fruit quality: Gas and water

vapour permeability of seven coatings, used commercially for citrus, was determined by coating these on highly permeable films. Oranges and mandarins were coated with the same seven coatings, and weight loss, appearance, internal gas composition, presence of ethanol and acetaldehyde, and flavour of these fruits were determined. There was a relationship between low concentrations of oxygen, which lead to off-flavours, and the presence of ethanol and acetaldehyde in the fruit. There was also a relationship between gas and water vapour permeability and weight loss of the fruit with most coatings, but no correlation between CO_2 and O_2 permeability of the coatings and concentration of these gases in the fruit. The above findings were validated in a semi-industrial trial.

Fruits of pointed gourd treated with 200mg/l NaClO+ 500mg/l KMS+ 1:10 wax emulsions, effectively retarded respiration rates, in the studies conducted by Kumar K T *et al*., 2001. Application of 100mg/l NaClO+ 500mg/lKMS+ 1:10 wax emulsion diminished physiological loss in weight rate, retained higher hue angle and lower chroma value of the fruit throughout 10 days storage. Irrespective of treatments, total sugar content increased in stored fruits.

2.2 DISINFECTANT

Diseases of microbial origin are caused by insidious, invisible transfer of microscopic agents in air, water, food materials and from surfaces of all types. Micro-organisms are resilient, tenacious and stubbornly viable. Hence, a disinfectant should serve the following qualities:

- Broad spectrum
- Safe and non toxic to life
- Effective presence of organic matter
- Longer residual activity
- Environment friendly
- Should have minimum contact time
- Should be cost effective

Application of 2% neem oil significantly reduced the fruit rot caused by *pencillium expansum* (Wijewardane and Guleria, 2009), in apples of ‘Royal Delicious’.

3 MATERIALS AND METHODS

This chapter deals with the materials and processes undertaken for the shelf life extension of passion fruit.

3.1 Raw material

3.1.1 Biosafe

Biosafe is a safer alternative to be used in agro industries. It has an outstanding broad spectrum disinfectant capability due to synergy effect occurring between the silver and hydrogen peroxide. This synergy effect of the two disinfectants will result to generate a great disinfectant which is 20-1000 times more powerful than ordinary peroxides. It's applied to post harvested fruits and vegetables at the rate of 0.5-2% by dipping or spraying. Also, Biosafe is approved and certified under Indian Council for Agricultural Research. Here, it was applied over the passion fruit by using some cotton.

Unique attributes of Biosafe are

- Excellent disinfectant for bacteria, fungus and virus
- Provides post protection
- Effective even in low dosages of about 10-35 ppm
- Stable in a wider range of temperatures and pH
- Byproducts are non-toxic and biodegradable which decomposes to water and oxygen
- Environment friendly
- Non-carcinogenic
- Tasteless, colorless, odorless, and miscible with all ratios
- Easy to handle and store

Biosafe works as follows.

1. The silver effect: Hydrogen peroxide is stabilised over silver. The silver gives the electrostatic energy which makes it perform its role in dissolving the outer defences of micro-organisms.
2. The hydrogen peroxide effect: Hydrogen peroxide pulls away and heads towards the micro-organisms.
3. The combined effect: Used H_2O_2 disappears into environment as O_2 and H_2O.
4. The residual effect: After the reaction with micro-organisms, the unused H_2O_2 losses its kinetic energy and returns back waiting its next target.

3.1.2 Rice bran oil

A vegetable oil was required as a base to prepare the wax emulsion. Rice bran oil, a by product from rice mill, which is commercially available was used. Despite its similarities to other common vegetable oils, rice bran oil offers several unique properties that make it very interesting as specialty oil in niche markets. It has a very appealing nut-like flavour and once extracted is very stable.

3.1.3 Bee wax

Beeswax, a natural wax of animal origin was used. It has a melting point 62 to 64 ^{0}C. It was never subjected to a temperature more than 64 ^{0}C, so as to avoid a chance of discolouration at an extreme of 85 ^{0}C.

3.1.4 Polythene cover

A packaging material made of poly ethylene with 3% perforations was used. The fruits were enclosed within these covers. As they were impermeable to moisture migration and low temperature, the problem of moisture loss from fruits were solved to some extent by them.

3.1.5 Purified paraffin wax

Paraffin wax (or simply "paraffin") refers to a mixture of alkanes, which is mostly found as a white, odourless, tasteless, waxy solid, with a typical melting point between about 47 °C and 64 °C.

3.2 Standardisation of wax

A formulation of bees wax with rice bran oil was made. Various concentrations of bees wax in rice bran oil were tested to obtain a solution which remained at room temperature without solidification. Of the trails conducted, the best result was obtained when the wax to oil ratio was taken as 1:100. This standardized wax was applied over the passion fruits using some cotton. Similarly, paraffin was also standardized as 1:100.

3.3Preparation of samples

Different samples prepared were: -

1. **Controlled (T1):-** A sample was kept as such without any treatments, as controlled sample. This was to compare the performance of other samples with respect to this sample.

2. **Bees wax (T2):-** In this sample the passion fruits were coated with the bees wax emulsion alone.
3. **Biosafe (T3):-** This sample was prepared by treating the fruits with the disinfectant alone.
4. **Biosafe + bees wax (T4):-** Here, the fruits were first treated with the disinfectant and then the bees wax emulsion was coated.
5. **Polythene (T5):-** The fruits without any coating were placed in perforated polythene covers.
6. **Bees wax + polythene (T6):-** The fruits coated with bees wax emulsion were placed in the perforated polythene covers.
7. **Biosafe + polythene (T7):-** Here, the fruits were first treated with the disinfectant and then placed in the perforated polythene covers.
8. **Biosafe + bees wax + polythene (T8):-** In this sample, the fruits were treated with disinfectant and then coated with bees wax emulsion before placing in the perforated polythene covers.

All the samples above had 3 replications, which in turn, had five fruits in each. These were kept in ambient condition (35 ^{0}C and 75% RH). Also, in cold storage (7 ^{0}C and 85% RH), we had a similar set of samples.

Apart from the above, a similar study was conducted in the fruits using purified paraffin wax and the samples are as follows.

1. Purified paraffin wax (T9):- In this sample the passion fruits were coated with the purified paraffin wax emulsion alone.

2. Purified paraffin wax + polythene (T11):- The fruits coated with purified paraffin wax emulsion were placed in the perforated polythene covers.

3. Biosafe and purified paraffin wax (T10):- Here, the fruits were first treated with the disinfectant and then the purified paraffin wax emulsion was coated.

4. Biosafe + purified paraffin wax + polythene (T12):- In this sample, the fruits were treated with disinfectant and then coated with bees wax emulsion before placing in the perforated polythene covers.

For this purpose, we treated the fruits with the purified paraffin wax with a wax to oil ratio as 1:100 and it.

3.1 TSS determination

A hand refractometer was used to determine TSS of the passion fruit. The pulp of passion fruit was mashed well for one minute and a drop of it was placed on the hand refractometer and the initial value on 1st day was 8 ^{0}brix, which is the average of TSS of 12 samples.

3.2 Estimation of Acidity

The acidity of the sample passion fruits were determined by conducting the following test.

Reagents

0.1 N NaOH, phenolphthalein

Procedure

Take 5 ml of passion fruit juice from 6 g of pulp. Dilute it to 100 ml with distilled water and pipette out 50 ml of the sample. Titrate it against standard NaOH solution using phenolphthalein as the indicator. Express the acidity in percentage.

Calculation

Percentage of total acid =

$$\frac{(\text{Titre value x Normality of NaOH} \times \text{Volume made up} \times \text{Equivalent mass of acid}) \times 100}{(\text{Volume of sample taken for estimation} \times \text{Volume of sample taken})}$$

Thus, the acidity of the passion fruit on 1st day was calculated as 39 %, from the titre value.

3.3 Estimation of Ascorbic acid

The ascorbic acid content of the passion fruits calculated as follows.

Reagents

4% oxalic acid, dye solution of 2, 6- dichlorophenol indophenol

Procedure

Transfer 5 ml of passion fruit juice into a blender and blend it with 4% oxalic acid. This is made up to 100 ml in a volumetric flask. Pipette out 10 ml of the extract into a conical flask and titrate it with standard dye solution taken in the burette. The end point is the appearance of a pink colour in the solution. The ascorbic acid content is expressed in mg/ 100 g of the sample.

Calculation

$$\text{Ascorbic acid (mg/ 100 g)} = \frac{\text{(titre value} \times \text{dye factor} \times \text{volume made} \times 100)}{\text{(Volume taken} \times \text{weight of the sample)}}$$

Thus, on 1st day, the ascorbic acid content was calculated to be 28 mg/100g, from the titre value.

3.4 Colour analysis

Hunter lab colour flex meter (made by Hunter Associates Laboratory, Reston, Virginia, USA) was used for the measurement of colour. It works on the principle of focusing the light and measuring the energy reflected from the sample across the entire visible spectrum. The colour meter has filters that rely on “standard observation curves” which defined the amount of red, yellow and blue colours. It provide readings in terms of parameters L, a, and b indicating degree of brightness, degree of redness (+a) or greenness (-a) and the degree of yellowness (+b) or blueness (-b) respectively (Tayler et al., 1981).

PLATE 3.1 Hunter lab colour flex meter

3.5 Texture analysis

The textures of the passion fruits were measured with the help of TA.XT plus texture analyser (Stable micro systems Ltd.). The texture analyser is a microprocessor controlled texture analysis system. It measures force, distance and time, thus providing three dimensional

product analysis. The probe carrier contains a very sensitive load cell. Compression platens were used for conducting the test. Size of the probe used was 5 mm at test speed of 2 mm/s.

PLATE 3.2 Texture Analyser

3.6 Sensory evaluation

When the quality of a food product is assessed by means of human sensory organs, the evaluation is said to be sensory or subjective or organoleptic. Sensory quality is a combination of different senses of perception coming into play in choosing and eating a food. Appearance, flavour and mouth feel decide the acceptance of the food. Sensory analysis was done consuming the product by a sensory panel. Details of parameters are discussed below.

3.6.1 Sensory characteristics of food

3.6.1.1 Appearance

Surface characteristics of food products contribute to appearance. Sight plays an important role in the assessment of fresh fruits.

3.6.1.2 Colour

Colour is used as an index to the quality of foods.

3.6.1.3 Flavour

The flavour of foods has three components- odour, taste and mouth feel. A substance which produces flavour must be volatile and the molecules of the substance must come in contact with receptors in the epithelium of the olfactory organ. Aroma is able to penetrate even beyond the visual range when comparatively volatile compounds are abundant.

3.6.1.4 Taste

We value food for its taste. Taste sensation in which the taste buds register are categorized as sweet, salt, sour and bitter. The pleasant sensation in eating come more from odour than from taste.

3.6.1.5 Texture

Texture indicates the easiness of mouth to disintegrate and swallow the food. The brittleness of food is another aspect of the texture.

3.6.2 Conducting sensory test

We selected 25 panel members whose sensitivity and consistency have been good. They analysed the samples and made judgements on appearance, colour, odour, taste and texture were observed by a five point hedonic rating scale (excellent-5, very good-4, good-3, fair-2, poor-1). The scale was easily understood by each of the panellist and their response was converted to numerical values for computation purpose. Final results were obtained by calculating the average of all the marks given by panellist.

4 RESULTS AND DISCUSSION

Following are the results obtained under various treatments conducted on yellow passion fruit.

4.1 SAMPLES PLACED UNDER AMBIENT CONDITION (35 ^{0}C and 80 % RH)

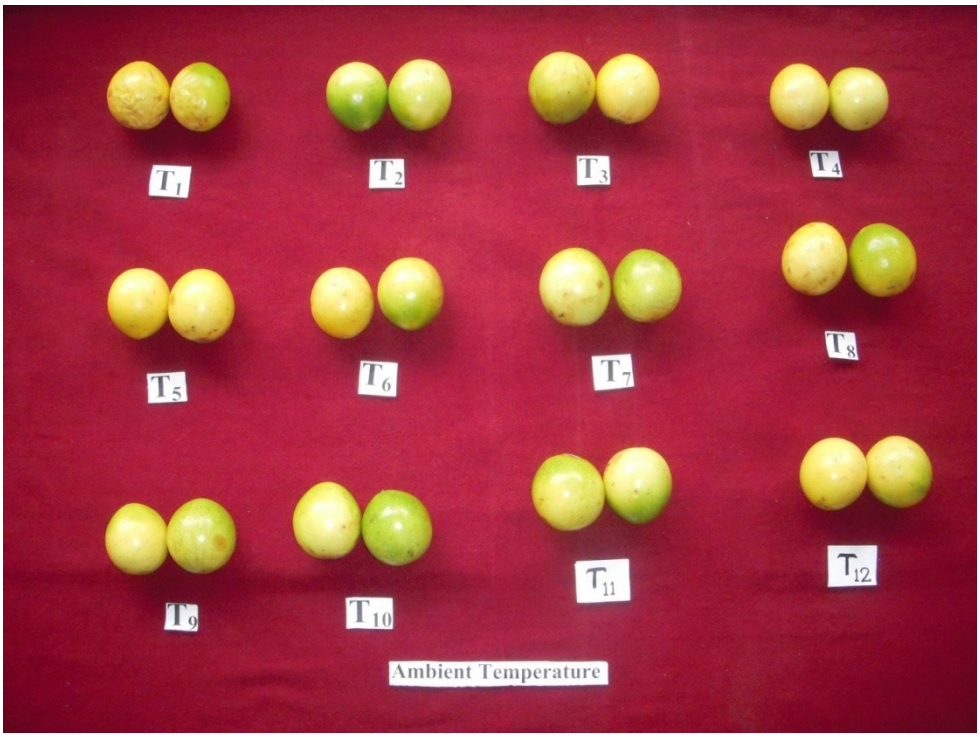

PLATE 4.1 Different samples of passion fruits at 35 ^{0}C and 80 % RH on 15th day

The samples which were kept under ambient conditions (35^{o}C, 80% RH) could last for only up to the first analysis that is, till the 15th day. The main reason for the limitation in storage life was the rapid invasion of fungal growth, which eventually lead to shrinkage and physiological loss of weight.

4.1.1 PHYSIOLOGICAL WEIGHT LOSS

Samples		**T_1**	**T_2**	**T_3**	**T_4**	**T_5**	**T_6**	**T_7**	**T_8**
Initial wt. (g)		440.00	430.20	408.50	478.80	423.50	442.30	385.90	420.30
Wt. loss as per the day (%)	1	0	0	0	0	0	0	0	0
	3	2.27	1.31	2.60	1.32	2.27	1.31	1.58	1.21
	5	3.86	2.64	4.20	2.56	3.86	2.17	2.40	1.97
	7	5.90	3.71	5.40	3.92	5.90	2.44	2.87	2.26
	9	7.27	4.86	7.95	4.97	7.27	3.23	3.86	3.16
	11	8.86	6.47	8.20	5.52	8.86	3.85	4.89	3.80
	13	10.90	7.10	9.42	6.91	10.90	4.82	5.93	4.82
	15	12.90	7.92	10.40	8.01	12.90	5.74	6.97	6.01

Samples		**T_9**	**T_{10}**	**T_{11}**	**T_{12}**
Initial wt. (g)		264.00	272.00	285.50	330.10
Wt. loss as per the day (%)	1	0.87	0	0	0
	3	2.08	1.10	1.15	0.93
	5	3.40	2.20	2.87	2.15
	7	4.90	2.94	4.72	2.75
	9	5.68	3.64	5.42	4.02
	11	6.80	4.40	6.47	5.18
	13	7.55	5.14	7.23	6.35
	15	8.32	5.88	8.42	7.60

TABLE 4.1 Physiological weight loss of samples at 35 ^{0}C and 80 % RH up to 15th day

The physiological weight loss of passion fruit occurs due to the reduction in moisture content. This leads to the formation of wrinkles on the rind and eventually increases the rate of shrinkage. Such fruits when cut into halves showed that, the pulpy region enveloped in a white sac has been concentrated and the sac has detached from the inner rind surface. From the table 4.2, we can see that T6 has lowest weight loss of 5.74% as compared to T1 with 12.9%. Close to T6, is T8 with a value 6.01%. Although T10, with a weight loss of 5.88% stands close to T6, paraffin treatment may not be accepted as an edible coating.

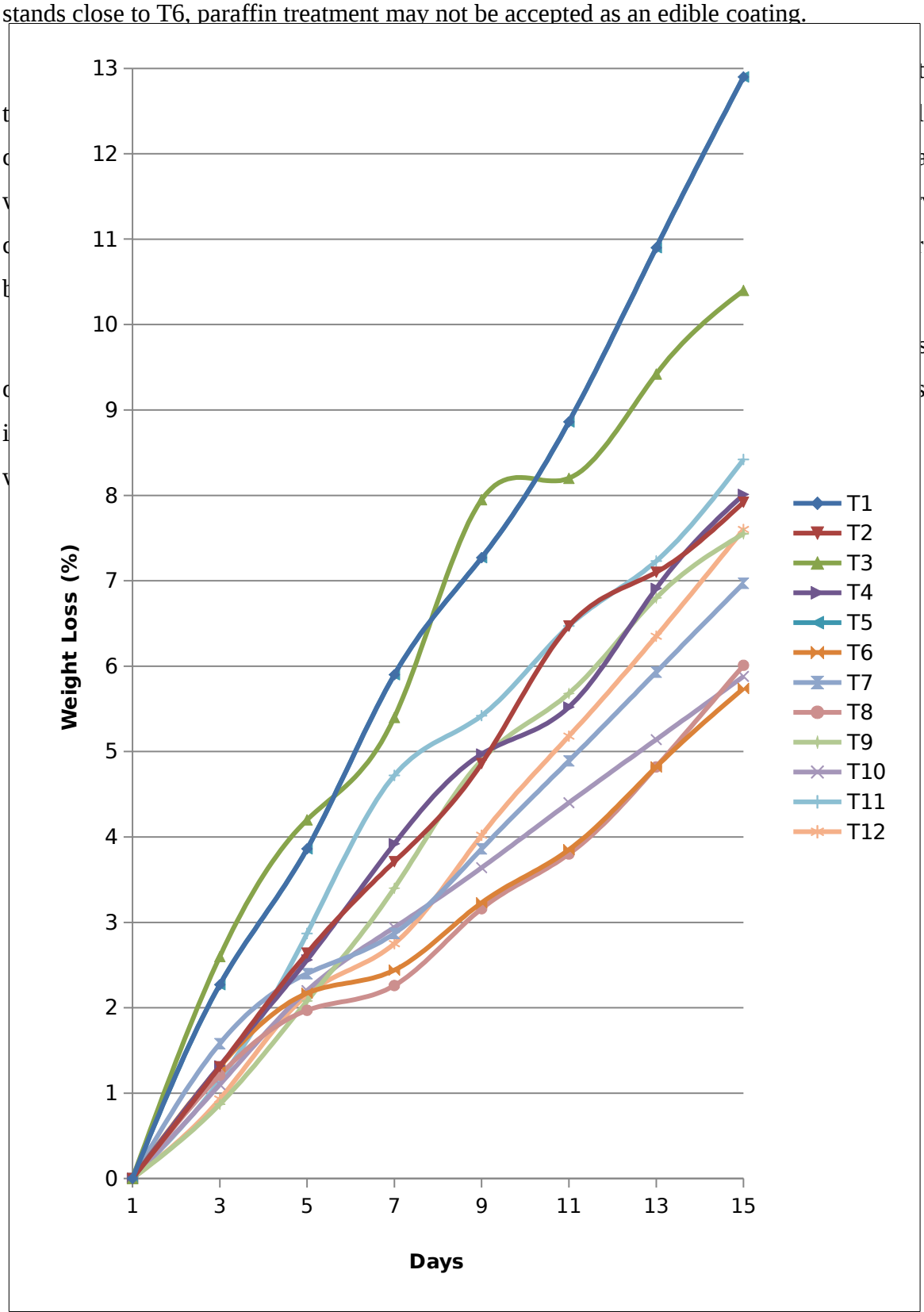

Figure 4.1 Physiological weight losses of samples at 35 ^{0}C and 80 % RH up to 15th day

4.1.2 TSS, ACIDITY AND ASCORBIC ACID

Samples	0n 15th day		
	TSS (^{0}brix)	Acidity (%)	Ascorbic acid (mg/100g)
T1	13	16	22.53
T2	11	12	24.83
T3	10	18	21.50
T4	11	16	25.08
T5	12	18	21.50
T6	10	18	25.08
T7	10	18	24.58
T8	07	18	25.34
T9	08	18	25.60
T10	09	18	24.83
T11	09	18	21.50
T12	09	18	22.53

TABLE 4.2 TSS, acidity and ascorbic acid of samples at 35 ^{0}C and 80% RH on 15th day

The TSS, acidity and ascorbic acid of different samples were analysed on 15th day. The TSS was measured as shown in table 4.1 against the average initial value of 8 ^{0} brix as measured on 1st day. TSS of t1 increased to a maximum of 13 ^{0}brix. The minimum is found to be for T8 and T9 with 7^o brix and 8^o brix respectively.

Though the initial acidity of the samples was calculated as 39%, there occurred a drastic decrease in the value up to 12% in T2 by the 15th day. This can be accounted for the degree of the ripening of the fruits.

Compared to the initial value of 28 mg/100g, the ascorbic acid content showed a reduction, as the days passed, to a minimum value of 21.50 mg/100g.

4.1.3 TEXTURE ANALYSIS

Samples	After 14 days	
	Force	Distance
T1	5.0	61.139
T2	85.4	64.709
T3	6.9	66.437
T4	36.7	63.366
T5	78.4	64.483
T6	93.4	65.914
T7	7.1	66.698
T8	64.1	59.379
T9	111.6	66.239
T10	64.0	61.218
T11	42.6	59.040
T12	108.6	64.842

TABLE 4.3 Result of texture analysis on different samples at 35 ^{0}C and 80 % RH on 15th day

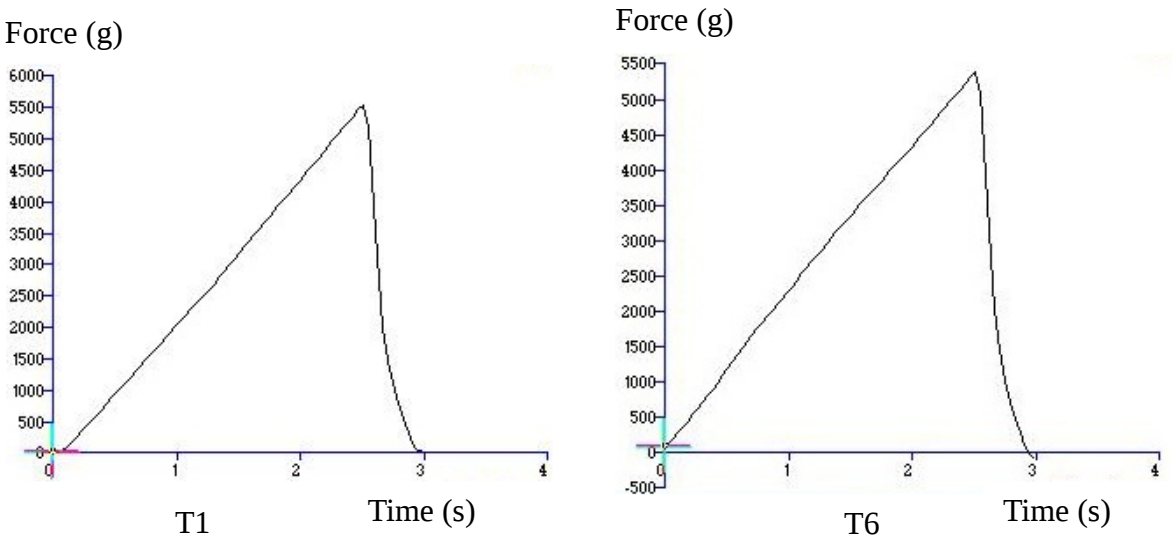

Figure 4.2 Result of texture analysis on T1 and T6 at 35 ^{0}C and 80 % RH on 15th day

From the table 4.3 the results of analysis on texture pointed that the sample T9 showed resistance to a maximum force of 111.6 g; but on analysing the results of edible coating, T6 showed resistance to a maximum force of 93.4 g followed by T2 with 85.4 g. This shows that the more pronounced effect to resist the force was observed in wax coated ones where in, the rate of respiration and evaporation was arrested to such an extent as to give shining appearance and reduced weight loss (refer section 2.1.2).

4.1.4 COLOUR ANALYSIS

Samples	After 14 days			
	D_L*	D_a*	D_b*	D_E*
T1	-0.65	-0.56	1.16	11.44
T2	7.91	0.43	1.27	8.03
T3	1.19	-5.48	-0.81	5.67
T4	11.23	-4.39	-7.96	14.44
T5	10.98	2.08	-0.08	11.18
T6	9.75	-2.98	-9.77	14.12
T7	14.12	-4.43	-5.16	15.67
T8	13.58	-2.66	-7.91	15.94
T9	-0.16	-4.80	-0.90	4.88
T10	6.81	-6.34	0.34	9.31
T11	14.78	-0.60	3.27	15.15
T12	10.26	-5.80	-4.25	12.63

TABLE 4.4 Result of colour analysis of samples at 35 ^{0}C and 80 % RH on 15th day

In the table 4.4, the negative D_a values shows the degree of greenness where as the positive D_a values shows the degree of redness. Of the D_b values, positive and negative indicates yellowness and blueness respectively. Thus it can be interpreted from the above table that, maximum yellowness can be seen associated with the sample T11 and T6 stands close to it in this respect. Since we consider the impact of edible coating, T6 remains relevant in the analysis. The transformation fro green to yellow colour is due to the conversion of chlorophyll to carotenoids (Dr. K.P.Sudheer and Dr. V. Indira)

4.1.5 SENSORY ANALYSIS

Sample	Flavour	Taste	Texture	Appearance	Total
T_1 *	0	0	0	2.56	2.56
T_2	3.20	4.25	4.15	4.17	15.77
T_3	3.08	3.30	3.21	3.27	12.86
T_4	3.76	3.78	3.80	3.83	15.17
T_5	3.15	3.20	3.12	3.26	12.73
T_6	4.20	4.15	4.60	4.80	**17.75**
T_7	3.92	4.15	4.55	4.22	16.84
T_8	4.25	4.26	4.15	4.25	17.01
T_9	3.30	3.20	3.05	4.20	13.75
T_{10}	3.76	3.85	3.24	4.25	15.10
T_{11}	3.22	3.35	3.16	4.23	13.96
T_{12}	3.23	3.38	3.74	4.28	14.63

TABLE 4.5 Result of sensory analysis of samples at 35 ^{0}C and 80% RH on 15th day

* As the fruits were over ripe and had a fungal attack, they could not be tasted. Hence, a zero score

The hedonic test of different samples at 35 ^{0}C and 80% RH were conducted and the average value of each of the sensory characteristics is given in table 4.5.

The results of organoleptic evaluation from table 4.5, shows that the sample T6 is the best with a total score of 17.75. The MAP created by the wax coating and perforated polythene

secured the quality and appearance. It was ripe enough compared to other samples whose ripening was improper. Sample T6 is closely followed by T8 (17.01) and T7 (16.84).

The paraffin coated samples, although had good scores in case of appearance, but the total score went down due to lower scores in flavour, taste and texture. Among T9, T10, T11 and T12, the sample T10 was best.T9 and T11 were over ripe and had a low value for flavour, taste and texture. In case of T12, the flavour and taste were affected due to the treatment of disinfectant.

4.2 SAMPLES PLACED UNDER COLD CONDITION (7 ^{0}C and 90% RH)

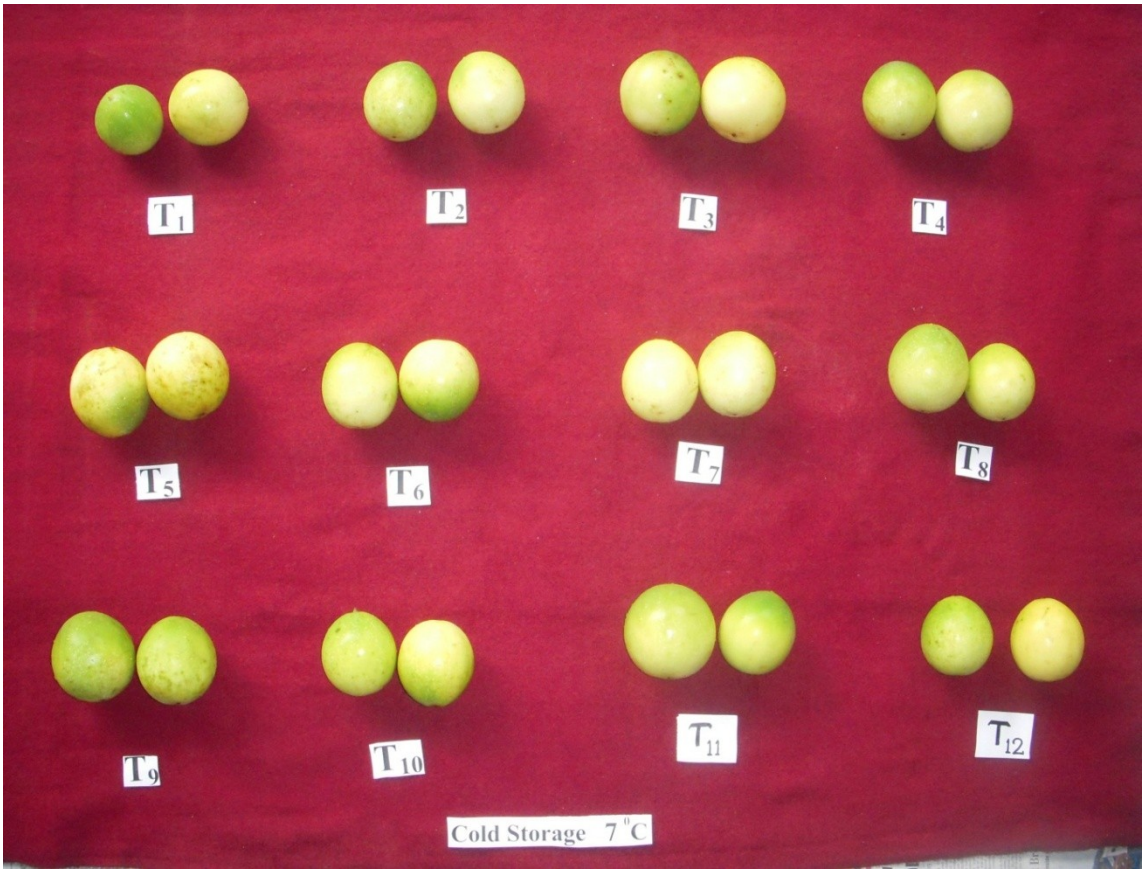

PLATE 4.2 Different samples of passion fruits at 7°C and 90% RH on 15th day

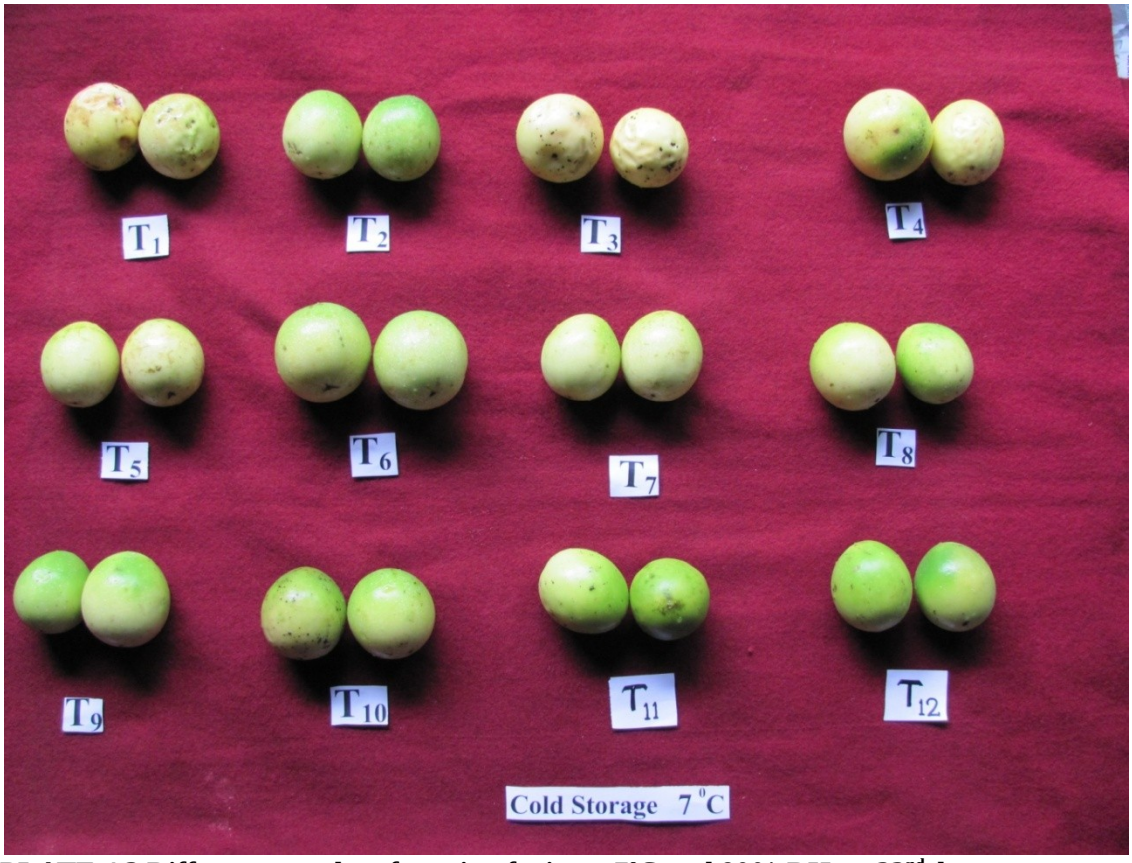

PLATE 4.3 Different samples of passion fruits at 7ºC and 90% RH on 22nd day

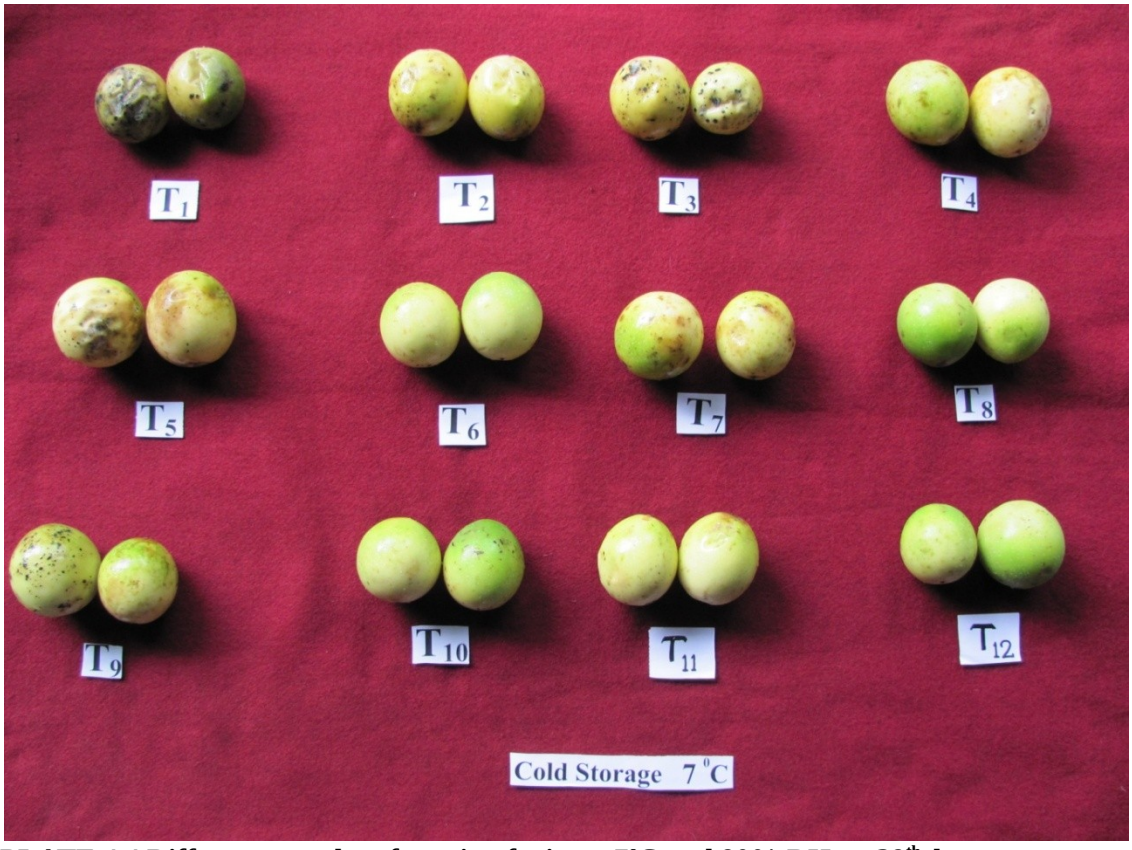

PLATE 4.4 Different samples of passion fruits at 7ºC and 90% RH on 29th day

The samples placed under cold condition (7°C and 90% RH) could extend its shelf life up to 29 days. The physical injuries that persisted in the fruits since the time of harvesting limited the further extension of the storage life. It was also noted that owing to improper draining in the trays of fruits placed in the deep freezer, there occurred some surface lesions due to condensation.

4.2.1 PHYSIOLOGICAL WEIGHT LOSS

Samples		**T_1**	**T_2**	**T_3**	**T_4**	**T_5**	**T_6**	**T_7**	**T_8**
Initial wt. (g)		484.0	378.3	492.0	464.0	464.0	532.3	492.0	465.0
Wt. loss as per the day (%)	1	0	0	0	0	0	0	0	0
	3	2.68	0	0.60	0	1.07	0.08	0.61	0.65
	5	2.89	0.03	1.02	0.17	2.58	0.55	1.22	1.50
	7	4.54	0.08	1.29	0.36	3.87	0.62	1.62	2.15
	9	7.23	0.15	1.82	0.43	5.17	1.37	2.23	3.01
	11	9.50	0.34	2.03	1.01	6.46	1.92	2.84	3.87
	13	11.36	1.13	2.23	1.50	7.52	2.31	4.26	4.52
	15	13.22	1.92	2.43	1.93	8.62	2.49	5.28	5.59
	17	15.08	2.70	2.84	2.80	9.48	2.59	6.31	6.23
	18	17.30	2.72	4.26	3.23	10.56	2.64	7.31	7.31
	21	19.20	3.25	4.87	3.87	11.80	2.70	8.33	7.95
	23	21.00	4.04	5.89	4.25	12.90	2.79	9.14	8.60
	25	23.30	4.57	6.30	5.30	14.22	2.85	9.95	9.67
	27	24.30	5.10	7.10	5.40	15.30	2.90	10.77	10.53
	29	27.80	5.60	7.70	5.43	16.16	3.08	11.55	11.39

Samples		**T_9**	**T_{10}**	**T_{11}**	**T_{12}**
Initial wt. (g)		468.0	472.0	427.0	423.0
Wt. loss as per the day (%)	1	0	0	0	0
	3	1.06	1.05	0.46	0.95
	5	1.32	1.90	0.47	2.12
	7	3.4	2.75	1.87	3.31
	9	5.34	3.81	2.30	5.20
	11	7.04	4.66	3.38	7.09
	13	8.76	5.51	4.20	8.51
	15	10.6	7.20	5.38	10.16
	17	11.9	8.68	6.08	12.29
	18	13.03	9.53	7.02	13.90
	21	14.42	10.16	8.66	15.60
	23	16.45	11.01	9.36	17.02
	25	18.16	12.28	10.77	18.67
	27	19.8	13.47	13.11	20.09
	29	21.5	14.40	15.22	21.50

TABLE 4.6 Physiological weight loss of samples at 7 ^{0}C and 90 % RH up to 29th day

The above table shows that the minimum weight loss after 29 days was observed in T6 with about 3.08%, though T4 with a PLW of 5.43% comes very close to it. The wax coating provided on the sample T6 was proved to be effective in arresting the evaporation and respiration rate, there by reducing the moisture loss and hence the PLW (refer section 2.1.2). T4 involves treatment of Biosafe along with wax, of which the former would have retarded the fungal growth that could be accounted for its shelf life extension (refer section 2.2).

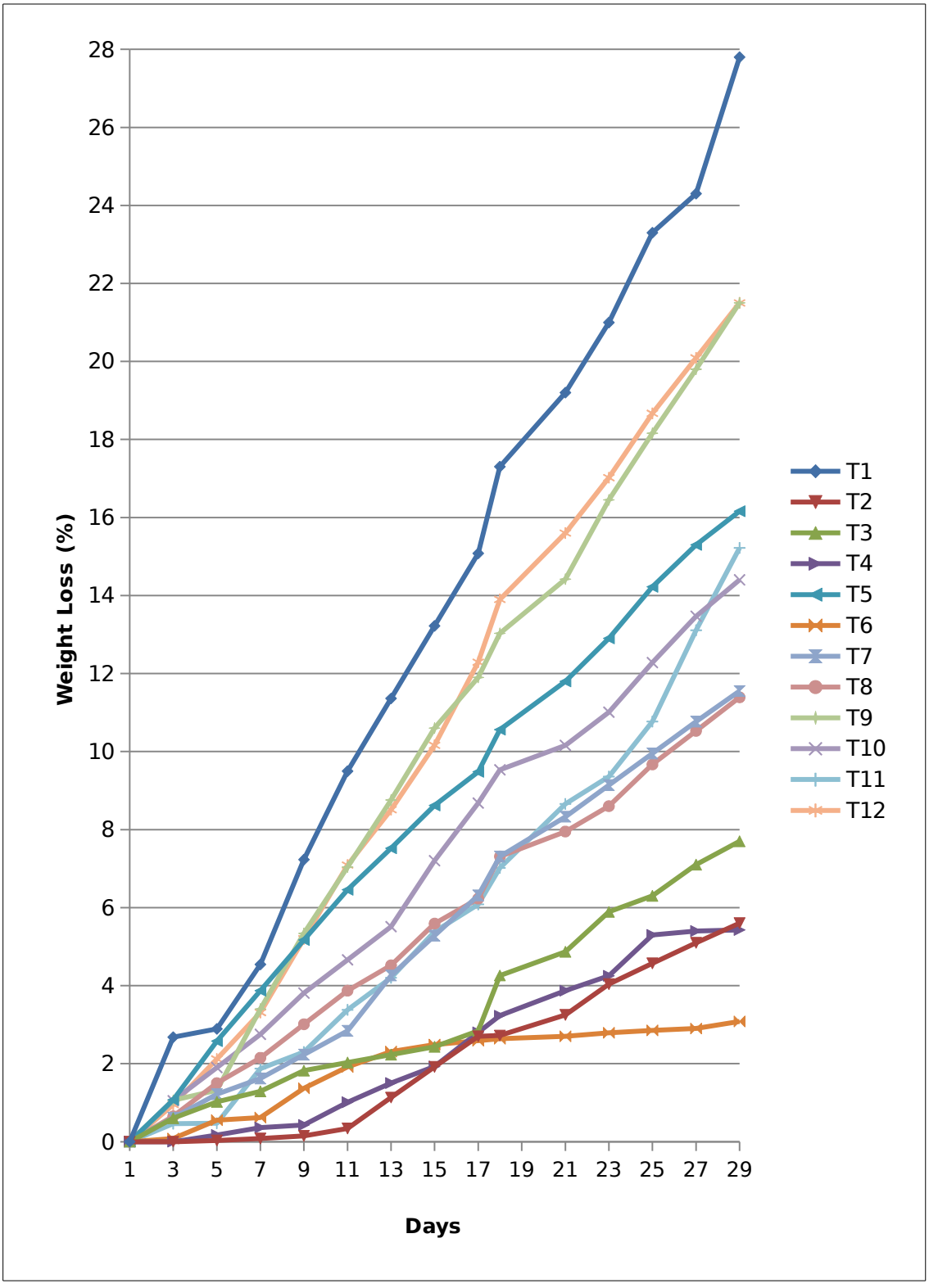

Figure 4.3 Physiological weight losses of samples at 7 ^{0}C and 90 % RH up to 29th day

4.2.2 TSS

Samples	TSS (^{0}brix)		
	After 14 days	After 21 days	After 28 days
T1	12	12	13
T2	13	13	13
T3	10	12	12
T4	10	10	11.5
T5	09	11	11.2
T6	09	11	12
T7	07	10	13
T8	09	11	12
T9	11	12	13.2
T10	11	12	12
T11	10	10	12
T12	10	11	11.5

TABLE 4.7 TSS of samples at 7 ^{0}C and 90 % RH on 15th, 22nd and 29th day

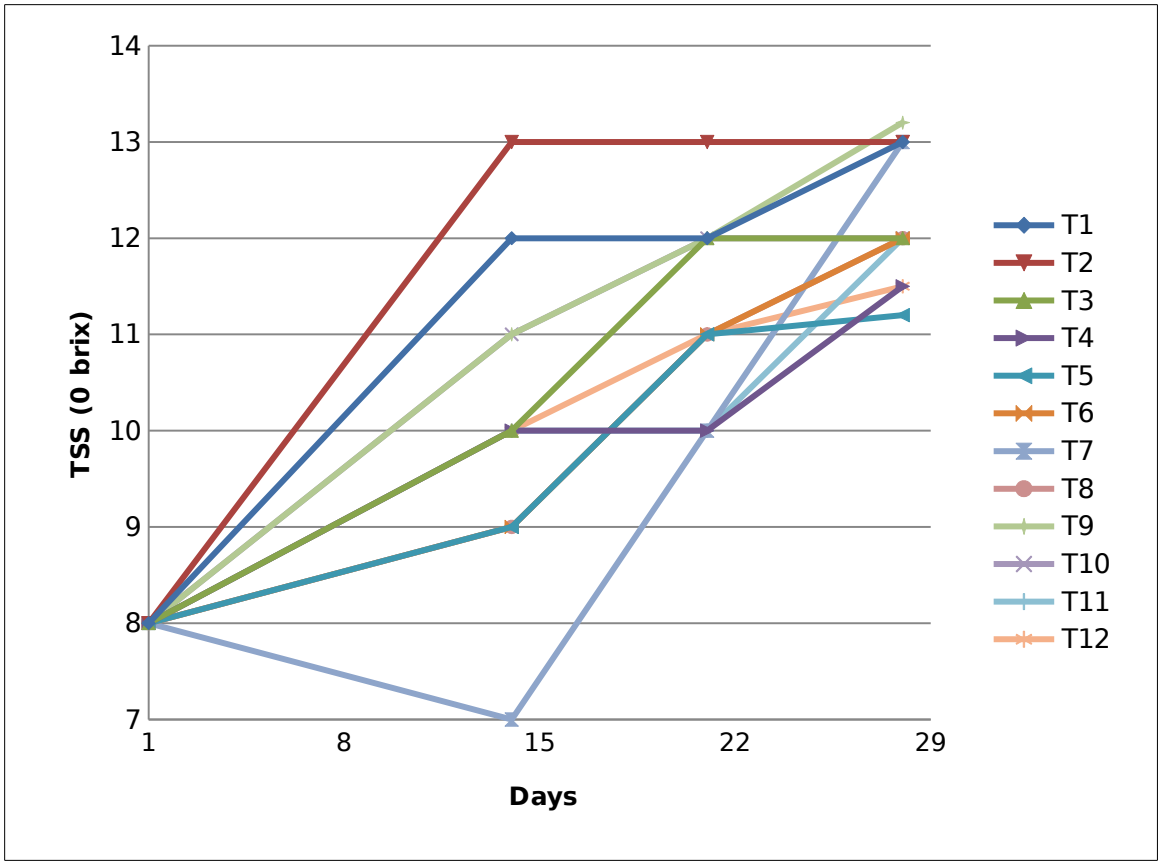

Figure 4.4 TSS of samples at 7 ^{0}C and 90 % RH on 15th, 22nd and 29th day

The trend in the increment of the TSS values in the above table can be accounted for the ripening of the fruit. It is observed that the pace of ripening was most accelerated in the samples T1, T2 and T7 (13 ^{0}brix), followed by T3, T6 and T8 (12 ^{0}brix).

4.2.3 ACIDITY

Samples	Acidity (%)		
	After 14 days	After 21 days	After 28 days
T1	33.79	33.70	33.28
T2	33.53	28.93	28.90
T3	36.86	31.00	30.72
T4	37.63	30.72	30.70
T5	32.00	28.67	28.60
T6	31.74	28.16	28.00
T7	38.14	30.97	30.90
T8	38.14	28.42	28.00
T9	37.88	34.30	33.00
T10	35.07	33.79	33.70
T11	37.12	37.10	36.35
T12	37.37	36.60	36.60

TABLE 4.8 Acidity of samples at 7 ^{0}C and 90 % RH on 15th, 22nd and 29th day

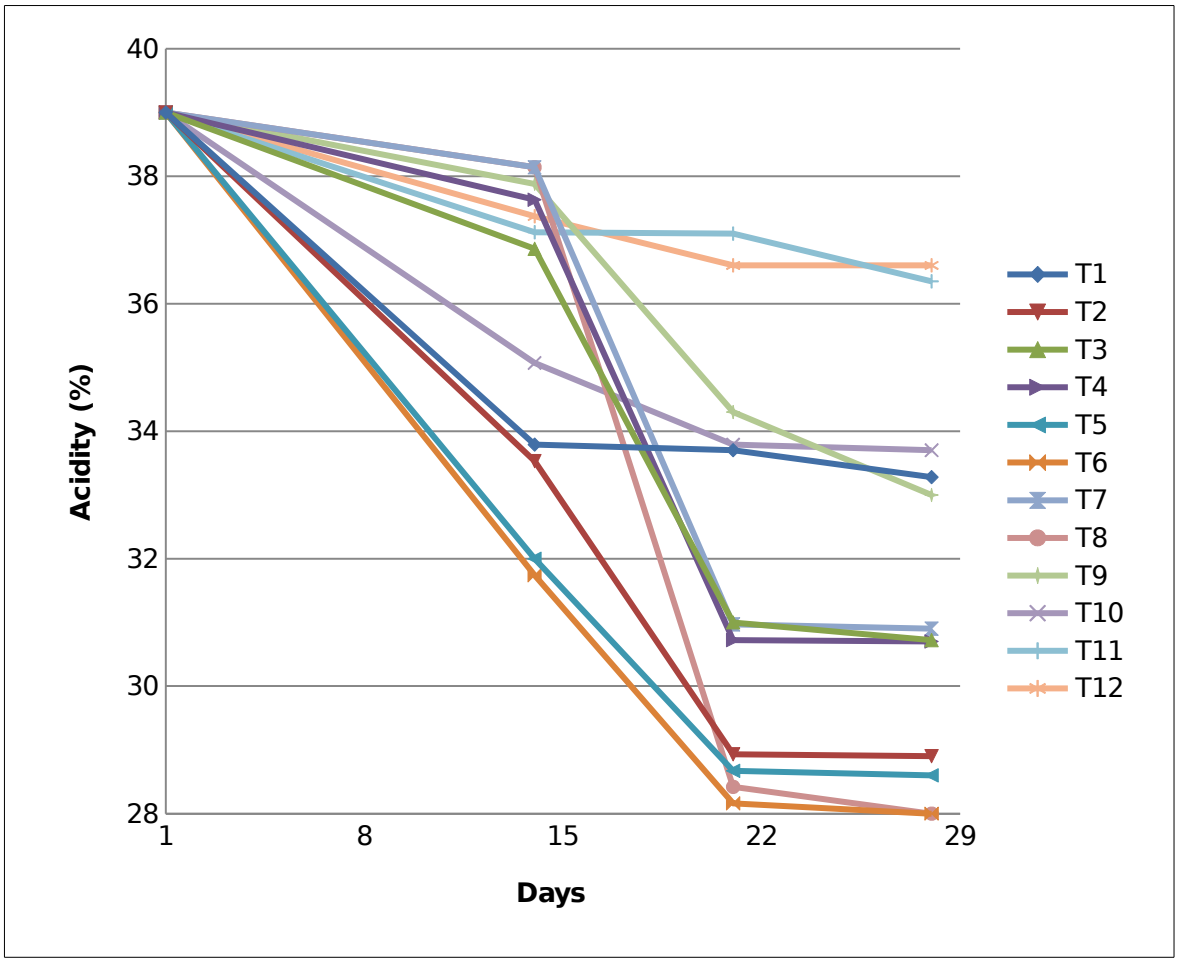

Figure 4.5 Acidity of samples at 7 ^{0}C and 90 % RH on 15th, 22nd and 29th day

There is a regular trend of decrease in the acidity of fruits with ripening.0f the samples the maximum reduction in acidity was observed in the sample T6. The reduction in acidity is due

to the breakdown of organic acid in fruits as the ripening progresses (Dr.K.P.Sudheer and Dr. V.Indira).

4.2.4 ASCORBIC ACID

Samples	Ascorbic acid (mg/100g)		
	After 14 days	After 21 days	After 28 days
T1	20	16	16
T2	18	18	18
T3	20	16	16
T4	26	26	18
T5	30	30	22
T6	22	22	22
T7	20	18	18
T8	20	16	16
T9	22	18	18
T10	22	18	18
T11	22	22	20
T12	20	18	18

TABLE 4.9 Ascorbic acid in samples at 7 ^{0}C and 90 % RH on 15th, 22nd and 29th day

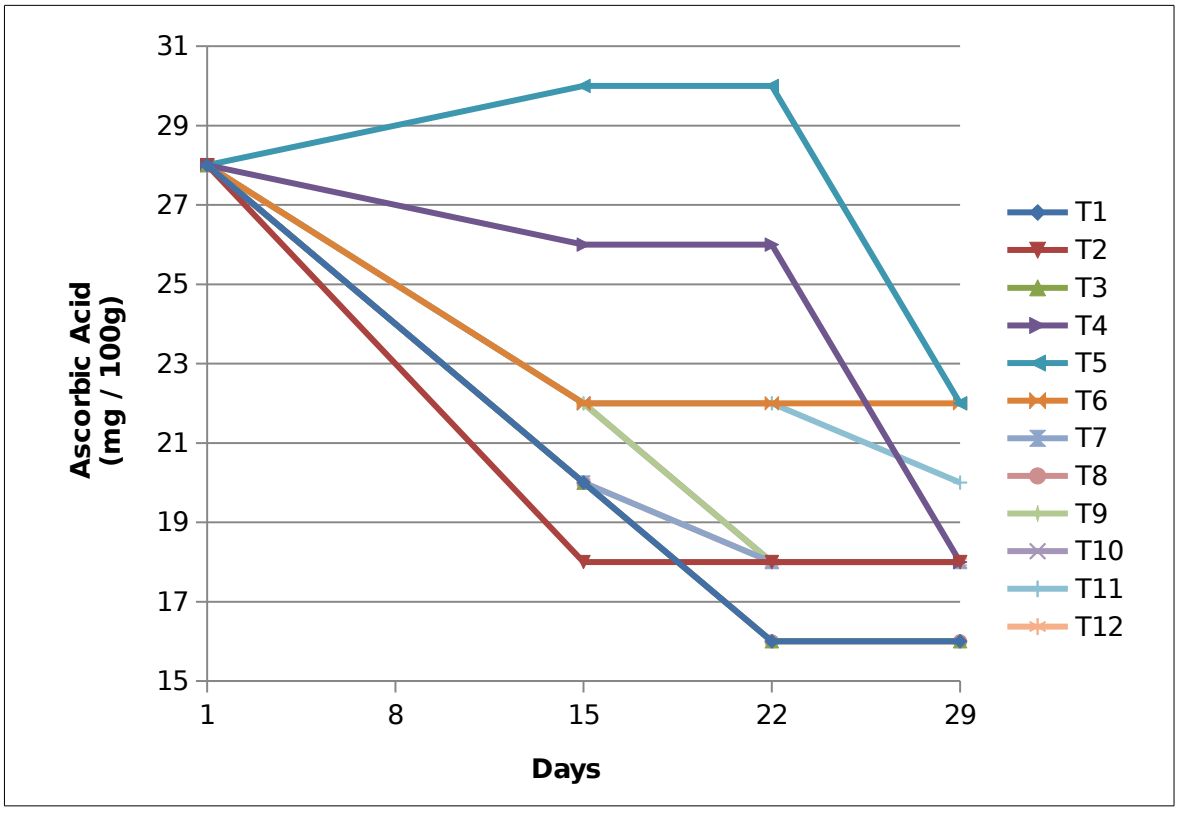

Figure 4.6 Ascorbic acid in samples at 7 ^{0}C and 90 % RH on 15th, 22nd and 29th day

The table 4.8 shows that the samples T2 and T6 remained during the entire course of storage with little variation in the ascorbic acid contents, of which T6 had highest ascorbic acid

content (22 mg/100g) on 29th day. It was followed by T7 (18 mg/100g) and samples with paraffin coating T11 (20 mg/100g), T9, T10 and T12 (18 mg/100g). As the days proceed, the ripening is also enhanced, although in a controlled manner at 7 ^{0}C and 90% RH, the vitamin C content volatilises. This volatilisation of vitamin C is controlled to some extent by the wax coating (refer section 2.1.2).

4.2.5 TEXTURE ANALYSIS

samples	After 14 days		After 21 days		After 28 days	
	Force (g)	Distance (mm)	Force (g)	Distance (mm)	Force (g)	Distance (mm)
T1	**24.5**	53.349	**6.7**	59.132	**6.3**	66.450
T2	51.5	62.864	30.0	59.909	22.7	57.430
T3	92.7	61.121	30.2	54.659	11.9	69.429
T4	65.4	56.770	65.0	57.778	15.7	66.459
T5	94.8	62.431	69.4	58.990	54.1	65.410
T6	**136.0**	55.265	**101.2**	61.859	**84.3**	55.106
T7	78.4	56.306	48.6	65.592	15.4	66.561
T8	103.0	54.816	71.1	64.336	67.6	55.008
T9	145.7	57.969	109.7	61.817	58.8	65.752
T10	97.0	57.172	64.8	58.293	29.4	67.900
T11	109.7	59.477	56.8	58.925	11.1	63.485
T12	9.1	58.009	7.6	62.166	7.1	64.166

TABLE 4.10 Result of texture analysis on samples at 7 ^{0}C and 90 % RH on 15th, 22nd and 29th day

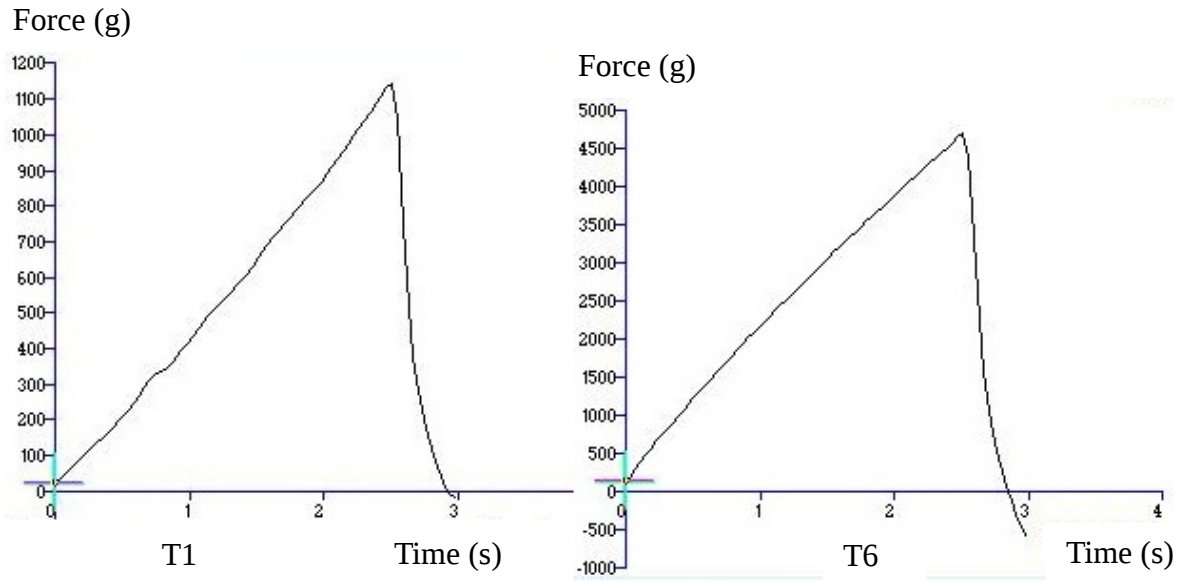

Figure 4.7 Result of texture analysis on T1and T6 at 7 ^{0}C and 90 % RH on 15th day

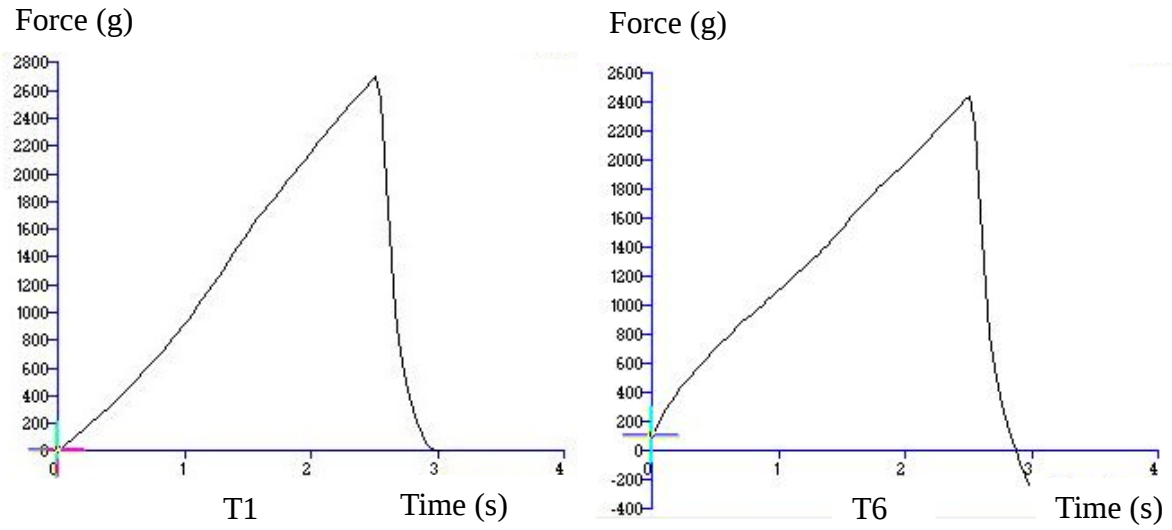

Figure 4.8 Result of texture analysis on T1and T6 at 7 ^{0}C and 90 % RH on 22nd day

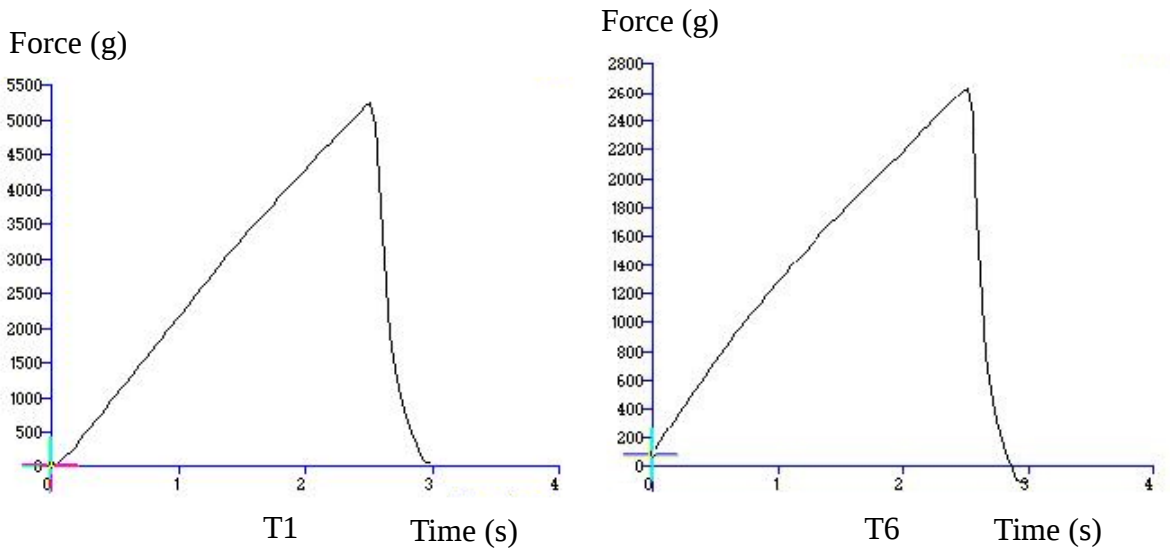

Figure 4.9 Result of texture analysis on T1and T6 at 7 ^{0}C and 90 % RH on 29th day

The results of texture analysis after 28 days showed that T6 was able to withstand resistance to a maximum force of 136 g, 101.2 g and 84.3 g after 14, 21 and 28 days respectively. These values were quite large as compared to that with T1 of 24.5g, 6.1g and 6.3g respectively after 14, 21 and 28 days.

4.2.6 COLOUR ANALYSIS

Samples	D_L*	D_a*	D_b*	D_E*
	On day 1			
standard	23.03	9.80	11.15	27.40
	(After 14 days)			
standard	15.78	1.86	14.02	21.19
T1	-0.89	0.88	-0.94	1.56
T2	14.60	3.65	8.03	17.05
T3	11.71	6.85	9.38	16.49
T4	1.24	6.33	7.38	9.8
T5	20.49	2.14	10.60	23.17
T6	23.76	5.18	7.44	25.44
T7	20.94	-0.45	18.11	27.69
T8	5.00	11.60	10.63	16.51
T9	28.66	1.87	15.06	32.53
T10	26.64	-0.84	17.19	31.38
T11	8.28	1.52	11.00	13.86
T12	31.14	0.71	13.36	33.89
	(After 21 days)			
standard	12.10	1.30	12.72	17.61
T1	-0.71	-0.14	-1.20	1.40
T2	3.79	-1.58	-2.91	5.03
T3	0.50	3.68	-6.68	7.64
T4	6.36	-0.45	-6.30	8.96
T5	1.79	2.89	-2.43	4.18
T6	-1.81	1.26	-3.09	3.80
T7	2.09	2.79	1.52	3.81
T8	5.23	-0.99	-1.06	5.42
T9	10.93	-3.55	2.62	11.78
T10	7.35	-1.31	-6.40	9.84
T11	-2.41	2.34	-5.47	6.42
T12	2.65	-2.61	1.16	3.90
	(After 28 days)			
standard	9.35	-0.26	10.57	14.11
T1	3.15	0.73	3.43	4.71
T2	2.5	-8.90	0.37	9.26
T3	-4.5	-15.15	-5.84	16.85
T4	8.73	-11.63	4.20	15.25
T5	5.75	-0.94	6.00	8.37
T6	13.58	-7.26	0.14	15.40
T7	14.74	-4.18	1.10	15.36
T8	7.68	-3.64	-2.59	8.89
T9	-4.57	-2.34	-14.49	15.38
T10	6.98	-2.03	6.74	9.91
T11	7.25	-7.77	2.85	11.00
T12	-10.82	-15.92	-3.69	19.60

TABLE 4.11 Result of colour analysis on samples at 7 ^{0}C and 90 % RH on 15th, 22nd and 29th day

The eventual increment in the yellowness of the fruits can be accounted for the ripening. But the maximum persistence of greenness was found to be for the sample T6, thus retarding ripening and gradually the physiological loss in weight.

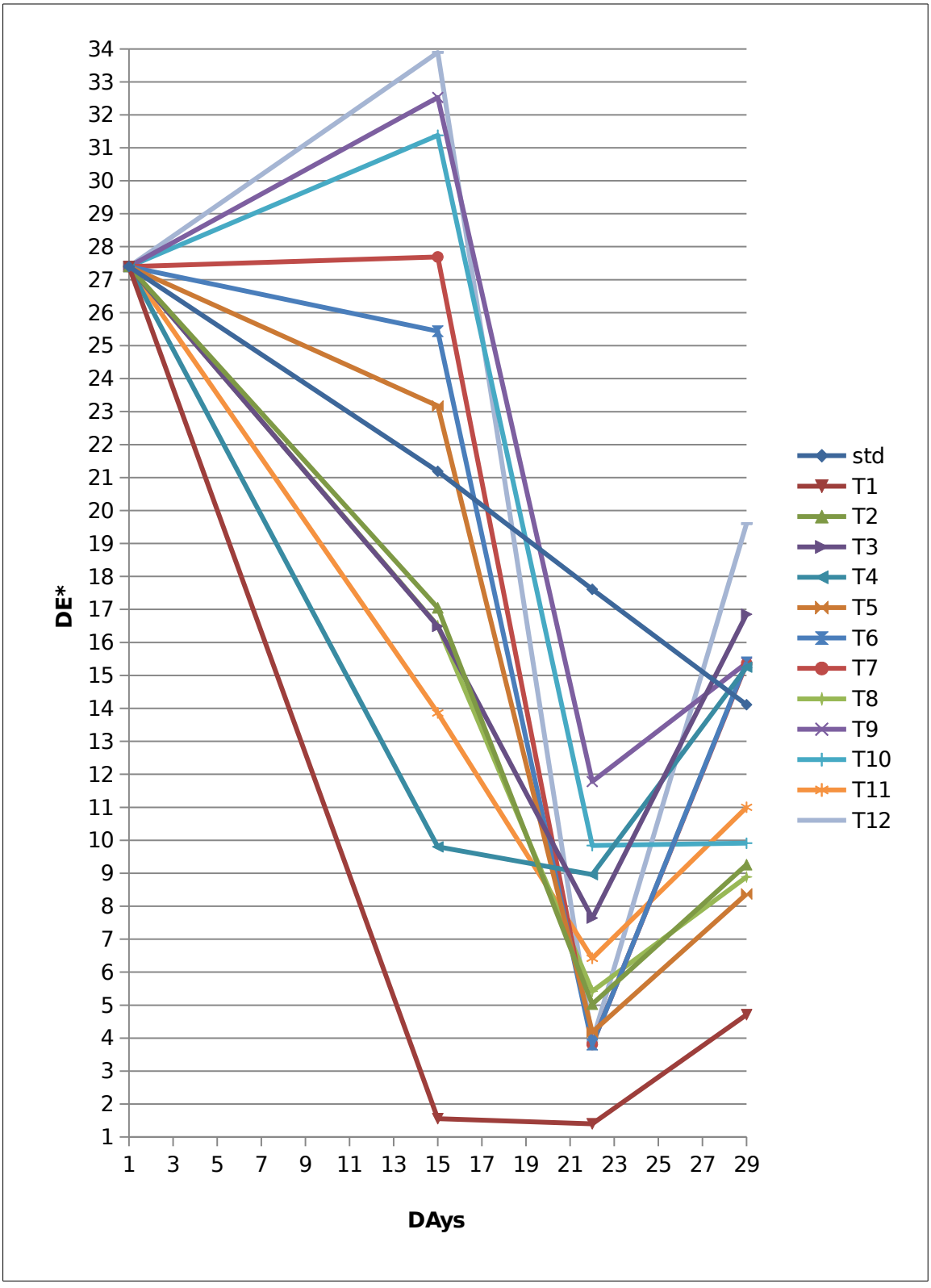

Figure 4.10 Result of colour analysis on samples at 7 ^{0}C and 90 % RH on 15th, 22nd and 29th day

4.2.6. SENSORY ANALYSIS

Sample	Flavour	Taste	Texture	Appearance	Total
T_1	3.01	3.15	3.08	3.10	12.34
T_2	3.24	3.36	3.17	3.26	13.03
T_3	3.16	3.41	3..28	3.35	13.20
T_4	3.76	3.52	3.36	3.44	14.12
T_5	3.10	3.24	3.18	3.26	12.78
T_6	4.10	4.24	4.20	4.35	**16.89**
T_7	3.24	3.52	3.61	3.75	14.12
T_8	3.82	3.64	3.52	3.35	14.33
T_9	3.12	3.24	3.10	3.20	12.66
T_{10}	3.14	3.30	3.23	3.44	13.11
T_{11}	3.13	3.28	3.20	3.35	12.96
T_{12}	3.20	3.35	3.50	3.62	13.67

TABLE 4.12 Result of colour analysis of samples at 7 ^{0}C and 90 % RH on 15th day

Sample	Flavour	Taste	Texture	Appearance	Total
T_1	1.10	1.21	1.05	1.07	4.43
T_2	3.20	3.30	3.15	3.12	12.77
T_3	3.35	3.32	2.80	2.73	12.20
T_4	3.44	3.28	2.82	2.85	12.39
T_5	3.15	3.24	3.08	3.27	12.74
T_6	4.24	4.44	4.10	4.36	**17.14**
T_7	3.93	3.73	3.84	3.26	14.76
T_8	3.56	3.35	3.22	3.75	13.88
T_9	3.12	3.20	3.75	3.70	13.77
T_{10}	3.56	3.44	3.21	3.17	13.38
T_{11}	3.42	3.36	3.14	3.08	13.00
T_{12}	3.62	3.53	3.43	3.21	13.79

Figure 4.13 Result of colour analysis of samples at 7 ^{0}C and 90 % RH on 22nd day

Sample	Flavour	Taste	Texture	Appearance	Total
T_1	0	0	0	0	0
T_2	2.10	2.27	2.56	1.93	8.86
T_3	1.95	1.73	1.65	1.50	6.83
T_4	2.50	2.62	2.10	2.03	9.25
T_5	2.44	2.35	2.05	1.94	8.78
T_6	4.10	4.15	4.08	4.17	**16.50**
T_7	4.08	3.93	3.86	3.95	15.82
T_8	3.05	3.16	3.27	3.42	12.90
T_9	3.56	3.28	3.18	3.03	13.05
T_{10}	3.60	3.35	3.29	3.16	13.40
T_{11}	3.58	3.31	3.26	3.24	13.39

T_{12}	3.60	3.42	4.30	4.25	15.57

TABLE 4.14 Result of sensory analysis on samples at 7 ^{0}C and 90% RH on 29th day

* As the fruits were over ripe and had a fungal attack, they could not be tasted. Hence, a zero score

The hedonic test of different samples at 7 ^{0}C and 90% RH were conducted and the average value of each of the sensory characteristics is given in tables 4.12, 4.13 and 4.14 respectively. The results of organoleptic evaluation from table 4.5, shows that the sample T6 is the best with a total score of 17.14, 16.89 and 16.50 on 15th, 22nd and 29th day, respectively. The MAP created by the wax coating and perforated polythene secured the quality and appearance. The cold atmosphere with 7 ^{0}C and 90% RH also enhanced the quality with regard to appearance. The samples T7 and T8 also had a good consumer appeal.

The paraffin coated samples, although had good scores in case of appearance, but the total score was low as the flavour, taste and texture was not much acceptable. Among T9, T10, T11 and T12, the sample T12 was best.

5 SUMMARY AND CONCLUSION

The creation of MAP and cold conditions were found to extend the shelf life of fruits in general. Passion fruits have an optimum storage condition of 7 ^{0}C and 85 % RH. But the ambient condition in Kerala is about 35 ^{0}C and 75% RH, under which the passion fruits starts forming wrinkles. Thus, passion fruit is highly vulnerable to loss of moisture and shrinkage within 2-3 days of harvesting, thus affecting the consumer appeal. The keeping quality can be improved, if the fruits were transported in cushioned, corrugated boxes after a proper harvesting, that is, at 75% maturity and using right methods of harvesting fruits along with a short vine attached.

The effect of MAP and edible wax coating on extending the shelf life of yellow passion fruits were studied under both ambient (35 ^{0}C and 80% RH) as well as cold (7 ^{0}C and 90% RH) conditions and were standardised. The edible wax used was bee wax which was emulsified with rice bran oil, standardised in the ratio 1:100. As an additional study, the purified paraffin emulsion was also prepared and standardised as 1:100, wax to oil ratio. Biosafe, a disinfectant, was also used (1.5% in distilled water) to reduce the risk of any fungal attack. Twelve samples were prepared based on treatment of Biosafe, wax coating (bee wax or paraffin), perforated polythene (3%) or their combination of use on fruits for the purpose of study under both ambient and cold conditions, with their initial weight, TSS, acidity, ascorbic acid content noted. All these parameters where measured and calculated in every sample, in an interval of 7 days, starting from 15th day. Colour analysis, texture analysis and sensory evaluation were carried out in the same interval. The samples under ambient conditions did not last longer than 15 days whereas that under cold condition showed a greater shelf life of 29 days (nearly a month).

Observing the results of various analysis conducted, it was concluded that the sample T6 (bee wax + perforated polythene) proved to be the best in terms of PLW, TSS, acidity, ascorbic acid content, colour texture and organoleptic characteristics. Owing to the physical injuries during harvesting and transportation, the shelf life extension was limited to one month.

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APPENDICES

APPENDIX I

Indication of different treatments

Samples	Treatments
T1	Controlled (No treatment)
T2	Bee wax coating alone
T3	Biosafe
T4	Biosafe + bee wax coating
T5	Perforated polythene alone
T6	Bee wax coating + perforated polythene
T7	Biosafe + perforated polythene
T8	Biosafe + bee wax coating + perforated polythene
T9	Purified paraffin wax coating alone
T10	Purified paraffin wax coating + perforated polythene
T11	Biosafe + purified paraffin wax coating
T12	Biosafe + purified paraffin wax coating + perforated polythene

EFFECT OF POSTHARVEST TREATMENTS AND MODIFIED ATMOSPHERE PACKAGE ON SHELF LIFE EXTENSION OF PASSION FRUIT (*Passiflora edulis*)

BY

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ABSTRACT OF THE PROJECT REPORT

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Bachelor of Technology

In

Agricultural Engineering

Faculty of Agricultural Engineering and Technology

Kerala Agricultural University

Department of Post Harvest Technology & Agricultural Processing

KELAPPAJI COLLEGE OF AGRICULTURAL ENGINEERING AND TECHNOLOGY

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ABSTRACT

The commercializing period of yellow passion fruits for fresh consumption is reduced due to rapid modifications in their appearance, resulting from immense shrivelling. This loss in quality, and consequently in commercial value, takes place because of intense respiratory activity and significant loss of water. Various samples of the passion fruit were treated with biosafe, wax and polythene package, individually and in combination to study their effect on their shelf life extension. The beeswax - rice bran oil emulsion was standardised at a ratio of 1:100. Separate samples were kept both inside and outside perforated polythene covers. The samples were kept in ambient (35 ^{0}C, 80% RH) as well as cold conditions (7 ^{0}C, 90% RH). Of these, the maximum shelf life of 29 days was obtained in passion fruits coated with bee wax emulsion placed in perforated polythene covers at 7 ^{0}C, 90% RH. Though treatments with paraffin wax coating was also analysed, they were not taken into consideration as they are non edible.