

**STUDIES ON STANDARDISATION OF SWEET ORANGE  
PEEL CANDY**

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**DISSERTATION**  
*Submitted to the*  
*Vasantao Naik Marathwada Krishi Vidyapeeth, Parbhani*  
*in partial fulfillment of the requirements*  
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**COLLEGE OF AGRICULTURE, PARBHANI**  
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**PARBHANI - 431 402 (M.S.), INDIA**

**2017**

**CANDIDATE'S DECLARATION**

*I hereby declare that this dissertation or part thereof has not been previously submitted by me to any other University or institution for a degree or diploma.*

**Place:PARBHANI**

**Date :/ /2017**

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## **CERTIFICATE-I**

This is to certify that dissertation entitled “**STUDIES ON STANDARDISATION OF SWEET ORANGE PEEL CANDY**” submitted to Vasantnao Naik Marathwada Krishi Vidyapeeth, Parbhani in partial fulfillment of the requirement for the award of degree of **MASTER OF SCIENCE** in the subject of **HORTICULTURE (FRUIT SCIENCE)** embodies the results of bonafide research carried out by **Ms. TULSI BISHT**, under my guidance and supervision and that no part of this dissertation has been submitted for any degree or diploma.

The assistance and help received during the course of this investigation have been fully acknowledged.

Place : PARBHANI

**Dr. G.M.Waghmare**

Date :    /    /2017

Research Guide

## **CERTIFICATE – II**

This is to certify that the dissertation entitled "**STUDIES ON STANDARDISATON OF SWEET ORANGE PEEL CANDY** " submitted by **Ms. TULSI BISHT**, to the Vasantryao Naik Marathwada Krishi Vidyapeeth, Parbhani in partial fulfilment of the requirement for the degree of **MASTER OFSCIENCE** in the subject of**HORTICULTURE(FRUIT SCIENCE)**has been approved by the student's advisory committee after viva-voce examination in collaboration with the external examiner.

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Place :Parbhani

Date : / /2017

(TULSI BISHT)

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## ABBREVIATIONS

%	: Per cent
/	: Per/or
<sup>0</sup> C	: Degree celcius
C.D.	: Critical difference
Cm	: Centimetr (s)
ed. (s)	: editor (s) or edited or edition
et al.,	: et alia (and others)
etc.	: et cetera (and other similar missing)
fig.	: Figure
g	: gram
ha	: hectare
hrs	: hours
<i>i.e.</i>	: That is
kg	: Kilo gram
m	: meter
min	: minute
MT	: Metric tonne
MT/ha	: Metric tonne per hectare
N.S.	: Non significant
No	: Number
q	: Quintal
S.E.±	: Standard error
<i>viz,</i>	: Videlict (Namely)

## CHAPTER-I

### INTRODUCTION

Citrus fruits rank third in area and production after banana and mango in India. Sweet oranges (*Citrus sinensis*) are the second largest citrus fruits cultivated in the country. Andhra Pradesh, Maharashtra, Karnataka, Punjab, Haryana and Rajasthan are main sweet orange growing, stages. Maximum area under sweet oranges is in Andhra Pradesh, followed by Maharashtra and Karnataka. Well marked belts of sweet orange cultivation in the country are Abohar, Fazilka, Ferozepur, Faridkot and Hoshiarpur, in Punjab; Hisar in Haryana; Ganganager district in Rajasthan; Marathwada region of central Maharashtra, Ahmednagar, Pune and Nasik of western Maharashtra and Anantapur, Kodur, Cuddaph Nelgoda, Chittoor districts of Andhra Pradesh.

Among three citrus species (Mandarin, Sweet orange and Acid lime) sweet orange contribute 25% area. Sweet orange area of production in India is 334.9 ('000'HA.), production is 3886.2 ('000'MT.), 4% of total fruit production and productivity is 11.6 MT/HA (20013-14). Now the major producer of sweet orange in India is Telangana (43%) with 122.7 thousand ha area, 1656 thousand MT. production and 13.5 MT/ha productivity.

In terms of volume in production, citrus ranks after banana as the world second fruit crop with more than 108 million tons (Anon 2006 ). Sweet orange (*Citrus sinensis* L. Osbeck) commonly called orange is a member of this family and a major source of vitamins, especially vitamin C, sufficient amount of folacin, calcium, potassium, thiamine, niacin and magnesium (Angew, 2007). Economically, oranges are important fruit crops, with an estimated 60 million metric tonnes produced worldwide as at 2005 for a total value of 9 billion dollars. Of this total, half came from Brazil and the United States of America ( Bernardi *et al.* 2010). The global citrus acreage according to FAO statistics in 2009 was nine million hectares with production put at 122.3 million tons, ranking sweet oranges first among all the fruit crops (Xu *et al.*, 2013).

Oranges probably originated from south East Asia, and were cultivated in China by 2500 BC (Nicolosi *et al*, 2008), where it was referred to as “Chinese” apple (Ehler, 2011). Today, it is grown almost all over the world as a source of food for humans because of its high nutritional values, source of vitamins and other uses. Propagation through seed is associated with problems like poor pollen production, self-incompatibility and muscular embryo (Mortton, 1987). Therefore budding onto appropriate rootstocks is the common means of assuring the reproduction of cultures of known quality. Arsingrin posited the use of tissue culture to produce good quality plantlets, but are highly susceptible to root diseases, and this limits production (Katzer *et al*, 1999).

The production of sweet orange is largely favoured by dry, semi-arid to subtropical conditions. However, plants grow well under subtropical climate and can even withstand occasional light frosts. However, good results are not sure under cooler climates. Several hours of exposure to a temperature of  $-3^{\circ}\text{C}$  causes severe injury to plants. On the other hand, very high temperatures are also detrimental. The average temperature for growth is about  $16^{\circ}\text{C}$ - $20^{\circ}\text{C}$ . Hence, it can tolerate well maximum temperature of  $32^{\circ}\text{C}$ - $40^{\circ}\text{C}$  and minimum of  $17^{\circ}\text{C}$ - $27^{\circ}\text{C}$  as it exists in most of the sweet orange growing belts of the country. Being evergreen, citrus requires good amount of water and at least well-distributed annual rainfall 500-775 mm is necessary. When rainfall is unevenly distributed annual over the year, additional irrigation is often necessary. Under warmer conditions, the colour development is poor; however, excellent deep orange colour of the skin develops when grown under subtropical conditions. Quality is very good under dry semi-arid conditions, while under humid conditions fruits insipid.

Sweet orange (*Citrus sinensis* L. Osbeck) (to distinguish it from closely related species like sour orange, *C. aurantium* *C. reticulata* and mandarin orange), is a small evergreen tree 7.5 m high and in some cases up to 15 m. The fruit of sweet orange, which may be globose to oval is 6.5 to 9.5 cm wide, and

ripens to orange or yellow. Anatomically, the fruit consists of two distinct regions the pericarp also called the peel, skin or rind, and the endocarp, or pulp and juice sacs. The skin consists of an epidermis of epicuticular wax with numerous small aromatic oil glands that gives it its particular smell. Beneath the epidermis is the flavedo, with its characteristic yellow, green or orange colour. The flavedo is very fine and fragile containing oliferous vesicles on the inside which can be collected by scraping on the flavedo layer. The flavedo is a generally colorless, spongy inner layer of mesophyll that changes character and thickness throughout fruit development, properties that determine ease of peeling (Webber, 1989). The albedo or mesocarp is rich in flavonoids, which if transferred to the juice imparts a bitter taste.

The flesh or pulp of the fruit is typically juicy and sweet, divided into 10 to 14 segments (although there are seedless varieties) and ranges in color from yellow to orange to red. The ripe fruit is classified as a hesperidium which is a type of berry with multiple seeds and is fleshy.

### **1.1 Sweet Oranges, Utilization and nutrition:**

Sweet orange fruits are utilized as table purpose; fresh fruits are consumed for its juicy placental hairs. Sweet orange fruits are mainly utilized as for table purpose and for squash preparation. Sweet Orange fruits and peels are used in numerous desserts, jams and marmalades, candied peels, as well as cookies, cakes, and candies. Oil derived from orange peels, as well as flowers, leaves, and twigs is used as an essential oil in perfumes; orange seed oil may also be used in cooking or as a component in plastics.

Sweet orange fruits are the main source of important phytochemical nutrients and for long have been valued for their wholesome nutritious and antioxidant properties. It is scientifically proven that oranges being rich in vitamins and minerals have many health benefits. Moreover, it is now appreciated that other biologically active, non-nutrient compounds found in citrus fruits such as phytochemical antioxidants, soluble and insoluble dietary

fibres are known to be helpful in reducing the risk for cancers, many chronic diseases like arthritis, obesity and coronary heart diseases (Crowell, 1999).

Oranges as excellent source of vitamin C, contain powerful natural antioxidant, folate, dietary fibre and other bioactive components, like carotenoids and flavonoids that prevent cancer and degenerative diseases (Ejaz *et al.*, 2006). Citrus flavonoids can prevent cancer through selective cytotoxicity, antiproliferative actions and apoptosis (Elangovan *et al.*, 1994; Hirano *et al.*, 1994). Oranges are also rich in iron, chlorine, manganese, zinc, sodium, phosphorous, iodine, calcium, folic acid, potassium, pectin, beta-carotene and amino acids and fibre. A single orange is said to have about 170 phytonutrients and over 60 flavonoids with anti-tumor, anti-inflammatory, blood clot inhibiting and antioxidant properties. All these properties help to promote overall health (Cha *et al.* 2001).

Regular intake of orange juice reduces the chances in the formation calcium oxalate which causes kidney stones. Polyphenols present in oranges prevents viral infections. Oranges protect the skin from damage caused by free radicals, thereby helping you look young and keeps the skin fresh and glowing (Tsuda *et al.*, 2004).

The sweet orange peel contain sugars, edible fibre and many other components that offer excellent opportunities as value-added products, particularly those components that have biological activities (antioxidant, anti-cancer, cardio-protective and food/ drug-interactions) or other attributes that are useful in the development of high-value food products from citrus peel Widmer and Montanari (1994).

## **1.2 Challenges Faced by the Citrus Industry**

Citrus is the most abundant crop in the world. Its worldwide production is over 88 mil tons and one-third of the crop is processed. Oranges, lemons, grapefruits and mandarins represent approximately 98% of the entire industrialized crop, oranges being the most relevant with approximately 82% of the total. Citrus fruits are processed, mainly to obtain juice, but also, in the

canning industry, to produce marmalade, segments of mandarin and by the chemical industry to extract flavonoids and essential oils (Izquierdo & Sendra, 2003). Worldwide industrial citrus wastes may be estimated at more than 15 million tons, as the amount of residue obtained from the fruits accounts for 50% of the original whole fruit mass (Cohn & Cohn, 1997). Citrus wastes constitute a severe environmental problem (Laufenberg *et al.* 2003). They consist of peels (albedo and flavedo), which are almost one-fourth of the whole fruit mass, seeds and fruit pulp, remaining after juice and essential oil extraction (Braddock, 1999). Of the vast amount of worldwide citrus production, only one-third is processed. As related by Cohn and Cohn (1997) and Braddock (1999), the amount of residue obtained from the fruits accounts for half of the whole fruit mass.

According to Laufenberg *et al.* (2003), Mamma *et al.* (2008) citrus waste have historically been dried and used as raw materials for pectin extraction or used without treatment for the production of animal feed or fertilizers. In recent years, however, the increasing costs associated with the storage and transportation of citrus waste and the lower prices obtained from feed markets have resulted in the declining interest on the part of industry for these uses. At the same time, the necessity to prevent environmental pollution, and the need to conserve energy and raw-materials, has grown and new methods and policies for waste recovery and bioconversion for more useful, high-value, products are being introduced (Martin 1998, Laufenberg *et al.* 2003). Numerous multifunctional ingredients are being developed from citrus by-products and citrus waste, notably: peel candy, peel oil, oil and water-phase essences, pulp sacs, and Limonene.

Creating a secondary use for citrus waste through the upgrading of citrus by-products can be considered a strategic element in the reduction of waste and the optimization of the use of existing resources.

Sweet orange fruits are mainly utilized as for table purpose and for squash preparation. After extraction of juice peel is used to discard as waste

material. Peel is quite nutritious but goes waste and does not fetch any economical price to the industry. Besides the utilization of residual waste as cattle feed, some useful byproducts of commercial importance like citrus oil, citric acid and pectin etc. could be prepared. But their isolation involves highly specialized and sophisticated technologies that increase cost of production many fold there by making it a costly venture. The other useful option is to utilize waste peel for preparation of peel candy. This does not necessitate complicated equipment and technology. Hence, citrus processing industry can easily opt for making candied peel which finds a ready market in confection way.

### **1.3 Peel used for candy preparation**

Peel from sweet orange fruits can be candied for use either in baked goods or as a snack food. In addition, shreds of peel are used in marmalades and the process to make these is similar to candying. Candy is a sweet food prepared from fruits or vegetables by impregnating them with sugar syrup followed by draining of excessive syrup and then drying the product to a shelf stable state. Fruits and vegetables like Apple, Ginger, mangoes, guava, carrot and citrus peel have been used to prepare candies (Mehta and Bajaj, 1984). The sweet orange peel candy can be consumed as such or in the form of value added products like steamed pudding etc., where it can be incorporated to improve consumers acceptability of such products. The candied peel is used in the baking industry in the preparation of cakes, cookies and fruit breads. These can be marketed as mixed candied fruits and be consumed as such. The judicious processing of waste peel in to candy will not only add to the income of processing industry but it will provide remunerative price to growers as well. Keeping in view the importance of the fruit from processing angle this study is undertaking.

**OBJECTIVES:-**

1. To study the effect of concentration of sugar syrup and period of dipping for preparation of sweet orange peel candy.
2. To study the effect on quality of sweet orange peel candy during storage.

## CHAPTER-II

### REVIEW OF LITERATURE

Very few studies are available on sweet orange peel candy although work on all citrus fruits processing into various products such as juice, squash, ready to serve drinks, jam has been reported by some workers. Not much work have been reported on the processing of sweet orange peel in the form of candy, which may reduce the bitterness of peel resulting in a value added product, thereby increasing its acceptability.

Work done in India and abroad on citrus peel candy preparation and storage studies reviewed under following heads:

- 2.1 Physico-Chemical composition of citrus peel
- 2.2 Processing of peel candy
- 2.3 Effect of storage on peel candy

#### **2.1 Chemical composition of citrus peel**

Citrus fruit processing produces many by product with significant value. These by-products are considered to be rich source of edible and health promoting agents as polymethoxylated flavonoids, many of which are found exclusively in citrus peel.

Syed *et al.*, (2012) studied the value added products from sweet orange. The physical characteristics of sweet orange fruit were determined. The physicochemical characteristics of sweet orange juice were found pH (3.7), total soluble solids (100Bx), acidity (0.41%), moisture (88.4%), protein (0.6%), fat (0.05%), carbohydrate (10.5%), fiber (0.12%) and ash (0.3%).

Siddiqi, (2005) reported that the chemical composition of sweet orange shows that it contains water (86-92%), sugar (5-8%), pectin (1-2%), glycosides (0.1-1.5%), pentosans (0.8-1.2%), citric acid (0.4 to 1.5%), fibre (0.6-0.9%), proteins (0.6-0.8%), fat (0.2-0.5%), minerals (0.5-0.9%) and essential oils (0.2-0.5%) (Siddiqi, 2005).

Aggarwal and Sandhu (2003) reported that the kinnow peel is rich in pectin, cellulose and hemicelluloses. On an average, kinnow peel contains 22.45% total solids, 12.50°Bx TSS, 1.38% acidity, 41.57 mg/100g ascorbic acid, 6.23% total sugars, 5.99% reducing sugars, 0.67% ash, 13.65 mg/100g carotenoids, 7.43 mg/100g  $\beta$ -carotene, 1.85% pectin and 0.77% fat. It also contains 0.42 mg/g approximately naringin and 4.69 mg/g of approximately limonin Premi *et al.*, (1994).

Verma *et al.*, (2006) reported the moisture content of fresh peel was 89.46% whereas acidity as percent citric acid was recorded as 0.40%. Total and reducing sugars were 12.17% and 9.28%, respectively. The ascorbic acid content was 87.49 mg / 100 g.

## **2.2 Processing of peel candy**

Mehta *et al.*, (2005) was carried out the study to investigate the suitability of two Galgal varieties for preparation of candy and investigate the physicochemical changes during storage in order to assess acceptability as well as shelf life of the product. Out of three level tested, the 8% brine treatment was found optimum for getting desired results. Ascorbic acid was totally losses during treatment and product preparation. After storage period of 24 weeks, overall acceptability, sensory scores were found in the following pattern: treated K-1(7.9) >treated GS-6(7.1) >untreated K-1(6.7) > untreated GS-6(6.4). The product fro treated K-1 was found superior, shelf stable and most acceptable on the basis of physicochemical and sensory analysis among the treated and untreated products of either variety.

Bhatlu *et al.*, (2014) reported that the kinnow peel is a waste from citurs processing industries and it can be utilized for preparation candy. This will not only reduce the waste but also add value to citrus fruit and benefit to growers and country as well. Kinow peel candies were prepared by varying the sugar concentration. Three different samples of kinnow peel under 3 different treatments (50°C for 15minutes cooked in 40°B sugar syrup solution, 60°C for 20minutes cooked in 50°B sugar syrup solution and 70°C for 25minutes cooked

in 60°B sugar syrup solution) has been prepared. The samples were tested on the basis of hedonic scale tested on panel of 7experts. These candies after taste is acceptable so consumers not to some others due to bitterness. The third experimental trial gives very much acceptable color due to caramalization of sugar.

Shamrez *et al.*, (2013) studied the preparation of citron peel candy and it was prepared with four different combinations of T0(control), slice citron peel+30% sugar+ potassium metabisulphite, T2(sliced citron peel + 40% sugar + potassium metabisulphite) and T3( sliced citron peel + 50% sugar+ potassium metabisulphite). To establish the best product sensory evaluation was done on 9-point hedonic scale. T2 was found to be most proffered candy. These were assessed for organoleptic quality during storage at room temperature (25-30°) for six months. Candy can be preserved safely for six months in polythene bags.

Kumar *et al.*, (2015) reported that in preparation of citrus peel candy cut rectangular suitable size cube from the fully mature ripe washed peeled fruits the peels were than blanched in water for 10 minutes. 330g of sugar were dissolved in 500ml of distilled water & syrup concentration was 40% and the syrup solution was filtered the pieces were then dipped in syrup solution for a night. In the next day the syrup was boiled and concentration of sugar solution raised up to 60% and peels where dipped in it over night the third day, the syrup was again boiled to raise the concentration of syrup to 75% 0Brix the peels where then dipped in it for a week. The peels (pieces) were then dried in shade and then wrapped with powdered sugar than they were packaged and stored. From the experiment it was concluded that T2 candy blanched first in water for 10 min. & then steeped in 40% sugar syrup was better in quality attributes & retained good Organoleptic attributes for up to 60 days.

Sidhu *et al.*, (2015) reported that kinnow peel is a rich source of ascorbic acid, pectin, naringin and limonin that goes waste during processing and utilization of kinnow into various products. Kinnow peel candy and peel

powder prepared by osmotic dehydration retain color, aroma, taste and nutritional components of the peel for longer duration. In this present investigation, products were packed in four different packaging materials (HDPE, LDPE, laminate bag and glass jar) and stored under ambient (37-44°C, relative humidity 56%) and refrigerated conditions (4-6°C, relative humidity 95%) for 60 days to study the effect of storage conditions and packaging material. The acceptability of the products was tested through biochemical, microbiological analysis and sensory evaluation of the peel candy and powder at regular intervals (0, 30 and 60 days) during storage. All packaged materials were capable of maintaining the microbial load below the limits. The candy packed in HDPE bag and peel powder packed in laminate bag was overall acceptable and microbiologically stable till storage of 60 days under both (ambient and refrigerated) conditions.

Aggarwal and Michael (2014) studied the effect of substitution of sucrose with fructose on the physico-chemical composition and sensory characteristics of kinnow candy. Candy was prepared with peel using sucrose and fructose at the ratio of 100:0, 0:100, 75:25, 50:50, and 25:75 with 70 °B of TSS. Organoleptically, the candy prepared with 100% fructose proved the best but the candy prepared with 25:75 of sucrose to fructose was equally good. The least acceptable was the candy prepared with 100% sucrose, as it had a dull appearance and slight crystallisation was observed during storage. Moisture, acidity and ascorbic acid decreased while total soluble solids, reducing and total sugars and limonin increased with no change in ash content of the candies during four months of storage.

Verma *et al.*, (2006) studied the effect of method of preparation and storage on the chemical characteristics of peel candy of Danunj (*Citrus medica*). Citrus peel candy was prepared by utilizing peel of *Darunj* (*Citrus medica*) following slow and fast set methods of preparation. The prepared product was wrapped in wax paper and stored at room temperature for 18 weeks. The effect of method of preparation as well as storage intervals was

evaluated. From the results of the study it was inferred that both the method of preparation as well as storage intervals had a significant effect on the chemical parameters like moisture, acidity, sugars, ascorbic acid and energy values.

Priya and Khatkar (2013) studied the effect of different treatments and storage (90 days) on various physicochemical, sensory and microbial properties of aonla preserve was investigated. TSS, pH, reducing sugars, total sugars and browning of the preserves increased during storage irrespective of different methods employed for preparation of the preserves. Moisture, ascorbic acid, tannin and titratable acidity of the preserves decreased during storage in all the samples. The “no-cooking method” at sugar syrup of 70°B was found most effective in retention of ascorbic acid and tannins in the preserves and showed low microbial-load. Preserves with initial sugar concentration of above 60°B can be stored safely at room temperature for 90 days.

Rao N. *et al.*, (2016) studied the preparation of a crystalline candies made from lemon peel and jaggery. The high dietary fibre powder from lemon peel was made by two methods washing and oven drying and evaluation was done for fiber content of the obtained powder. The washed method powder was rich in high dietary fiber (59g) and vitamin C (112.82mg). Hard candies were prepared from this powder. Jaggery was included in the candies to reduce the bitterness of the powder. Candies with different concentrations (5g,7.5g,10g) of this powder were developed. Sensory evaluation was done by both hedonic score. Results revealed that the hard candy prepared with 5g of lemon peel powder were most acceptable. The candy provides (3.2g) of fibre and Vitamin C (5.2mg) in 50 grams of candies.

Benjamin C. *et al.*, (2007) determined the fresh peel and the stored peel powders were used to flavour cupcakes, and the effects of processing and storage conditions on sensory quality of the cupcakes. Yield of oil extract was significantly affected by moisture content, length of storage, storage gas atmosphere and light. The rates of extraction in increasing order were: fresh peel < peel powder stored in N<sub>2</sub> in light < fresh peel powder < peel powder

stored in N<sub>2</sub> in the dark < peel powder stored in air in the dark. There were differences in concentrations of sabinene, limonene, decanal, octanal, myrcene, linalool, ethyl butyrate, geranyl acetate and neral in the peels due to differences in storage conditions of the peel powders and stability of the compounds. The compounds which appeared to have affected cake flavour significantly included myrcene, limonene, octanal, linalool and decanal.

Hiremath and Rokhade (2012) studied the preparation of sapota candy. Sapota candy was prepared with initial steeping in different concentration of syrup (40, 50 and 60°Brix) with or without citric acid with or without blanching. The mean maximum scores for colour and appearance, taste, flavour and overall acceptability was recorded in the candy prepared with initial syrup strength of 60°Brix with one per cent citric acid, whereas maximum score for texture was observed in candy with initial syrup strength of 40°Brix with one per cent citric acid with or without blanching.

Pawar and Patil (2013) studied on evaluation of different aonla [*Emblica officinalis*] varieties for osmodehydrated candy product processing. Keeping the varieties V1 (Gujarat aonla-1), V2 (Krishna), V3 (NA-7), V4 (Chakaiya) and V5 (Kanchan) in Complete Randomized Design with four repetitions. The nutritional value *viz.*, TSS (per cent), acidity (per cent), ascorbic acid (mg/100g), total sugar (per cent), reducing sugar (per cent) and moisture (per cent) was carried out. The acidity of candy was found lower in NA- 7 while higher in Krishna variety. Ascorbic acid was significantly maximum in NA-7 and Krishnawhile lower in Kanchan variety. In respect of total and reducing sugar content, it was found maximum in NA-7 and lowest in Kanchan and Krishna variety. However, TSS was significantly highest in NA-7while the lowest in Chakaiya. It was equivalent in Kanchan variety. On the other hand moisture was found significantly maximum in Gujarat aonla-1 while the lowest in NA-7.

Nayak *et al.*, (2012) studied on changes of nutritional and organoleptic quality of flavored candy prepared from aonla (*Emblica officinalis* G.) during

storage. The aonla fruits of each cultivar (Krishna, NA-7, NA-10 and Chakkaiya) were washed and blanched in boiling water containing 2% alum for 8 to 10 min. The segments were separated after cooling the fruits in tap water. The segments were steeped for 24 h in successively increasing concentration of sugar syrup (50 to 700B); added flavors of ginger and cardamom in syrup having 700B for three days. The excess syrup drained out and the segments were dried in cabinet drier. The segments were packed and stored under ambient conditions. The nine months storage study revealed that the moisture content in the candy was found to decrease with storage. It decreases from an initial value of about 16% to a final value of about 14% at the end of storage. All the treatments reduced vitamin C content candy. The tannin content of the various aonla candies was statistically significant with respect to aonla varieties. Total soluble solids, acidity, total reducing and browning was found to increase with storage period, while the non reducing sugar was decreased with storage period. On the basis of organoleptic evaluation and biochemical characters concluded that the candy prepared from cv. Krishna and flavored with cardamom powder found to be the best aonla candy.

Jothi *et al.*, (2014) studied the Development and Shelf-Life Prediction of Pineapple (*Ananas comosus*) Preserve and Candy. The candies were processed with 65° Brix, 70° Brix and 75° Brix sugar syrup. Initially the composition of pineapple preserves processed with different level of sugar were found in the range as moisture content 33.09-35.65%, ash 1.36-1.42%, protein 1.01-1.07%, fat 0.61-0.66%, total sugar 61.37-63.73% and reducing sugar 30.52-31.46% and pineapple candies were found in the range as moisture content 19.05-20.88%, ash 1.52-1.58%, protein 1.15-1.21%, fat 0.72-0.77%, total sugar 75.70-77.35% and reducing sugar 45.16-46.39%. The sensory results showed that color, flavor, texture, taste and overall acceptability scores differed significantly ( $p < 0.05$ ).

Priyadarshini (2013) studied the preparation of apple candy. Apple candy were prepared by steeping in 2% salt solution (blanching with

erythrosine colour (T1), green colour (T2), with water (T3), with lime orange (T4)) and 2% lime solution (T5-blanching with erythrosine colour, T6 green colour, T7 with water, T8-with lime orange) and candy was stored for 2 months. Various Organoleptic properties & shelf life were tested at 0, 20, 40 and 60 days after storage. Statistical analysis and sensory evaluation of the data was carried out and it was observed for organoleptic attributes of apple candy during storage. On the basis of investigation it was concluded that better quality candy obtained by steeping of the fruit pieces in 2% lime solution and blanching with erythrosine colour T7 followed by T6. The candy prepared with pretreatment of 2% lime solution and blanching with erythrosine colour T7 was rated best (8.0) in colour and appearance which was significantly superior to other candies in T6 (7.86), T8 (7.76), T5(7.03) ,T3(6.63), T2(6.30), T4(6.53) and T1(6.16). T7 was rated maximum score of (8.85) followed by the candy prepared by treatment T6 (7.8). Texture in T7 and T6 might be due to the better lime treatment (hardens the tissue) in preparation of apple whey candy.

Patil *et al.*, (2014) studied on preparation of karonda candy. It was carried out in Factorial Complete Randomized Design consisting of seven treatments and three replications with two drying methods (cabinet drying and solar drying). From the findings it was observed that, there was a gradual increase in TSS, titratable acidity, reducing sugars and total sugars content of the candy irrespective of drying methods and recipes used in experimentation. However, non-reducing sugars, ascorbic acid and moisture content of candy found to decreased with the advancement of storage period.

Gupta and Kaul (2013) studied the preparation of a candy like product (*chuhara*) from *ber* (*Zizyphus mauritiana*) by osmo-air drying process. The pretreatments like dipping in boiling NaOH (5%) solution for 5 min. followed by rinsing in water along with citric acid (5%) and finally dipping in KMS solution (4000 ppm) for 12 h accelerated the rate of osmosis. Pretreated *ber* fruits were then dipped in different sugar concentrations of 40, 50, 60 and 70°Brix at 24, 48 and 72 h. The treated fruits were then air-dried at  $52 \pm 2^\circ\text{C}$ .

With the increase in storage period, the moisture, ascorbic acid and tannin contents decreased, whereas, total sugars increased. On the basis of quantitative parameters and sensory traits it was found that *ber chuhara* prepared with 60°Brix steeping for 72 h rated the best, followed by those prepared with 70 or 50°Brix sugar syrups.

Mishra *et al.*, (2011) studied the prepare amla candy with rose extract, to assess its sensory properties, to determine the nutritive value and to calculate the cost of the prepared product. Amla candy was prepared by using rose extract in the proportion of 20 ml, 15 ml, 10 ml, and 5 ml and sugar in the proportion of 100 percent, 80 percent, 70 percent, and 60 percent which were represented as treatments T1, T2, T3, and T4 respectively and T0 served as control (50 percent sugar without rose extract). Sensory evaluation of the prepared product was carried out using the nine point hedonic scale. The highest score of amla candy was found in T1 (100 percent sugar and 20 ml rose extract) in terms of taste, flavour, colour, texture, overall acceptability. The calculated nutritive value of product showed that as the percentage of sugar increased the amount of energy and carbohydrate increased, but the amount of protein and fibre decreased. The other treatments also yielded acceptable results. The highest cost, calculated as basis of raw materials only, at prevailing prices amla candy was obtained in T1 as compared to other treatment. Overall it was concluded that the treatment T1 of amla candy with rose extract 100 percent sugar and 20 ml rose extract was found to be most acceptable.

Sachin *et al.*, (2016) studied that the osmotic treatment could be a feasible technology for impregnation of bioactive compounds for candy making without significantly altering the cellular integrity of the solid food matrix. When the surrounding solution concentration was minimum (0° Brix) the infusion of anthocyanin was higher (3.15 mg/100 g). The values of moisture, solids and anthocyanins diffusion coefficients during infusion process were found to decrease with increase in concentration from 0° Brix to 20° Brix. The infused amla pieces were further subjected to higher osmotic

solution concentration (30-70° Brix) for candy making. The entire process for anthocyanin infused amla candy could be achieved in 24 h of immersion time compared to conventional method of candy making 120 h (5 days). The resulting product had higher retention of nutrients like vitamin C, with softer texture, reduced lightness and high anthocyanin content as a result of infusion. The product was highly acceptable with higher sensory attributes compared to control sample.

Kamble and Lavande (2014) studied aonla candy with respect to ambient temperature during the course of drying. The temperature variation in the drying trays of the dryer was found in the range of 23 to 36 °C, 31 to 48 °C and 38 to 55 °C in bottom, middle and top trays of dryer, respectively. The flakes were exposed to open air under shade for 24 h. This was followed by osmotic dehydration of flakes for next 18 hours using sugar syrup (70 °Brix) in proportion of 500 g of flakes into 1000 ml of syrup, maintained at temperature of 85°C. The moisture content was reduced from 36.38 to 8.62 per cent (wb) in four days in solar drying method; whereas eight days were required for the same in conventional method of drying. The drying period was reduced by 50 per cent compared to the conventional shade drying method. Appearance, taste and flavour of aonla berry candy dried in farm solar dryer were superior to conventional drying.

Ahmad and Kumaran (2015) studied on the effects of honey incorporation on quality and shelf life of aonla preserve. Keeping in view the nutritional and therapeutic values of aonla fruit and honey, aonla preserve was prepared by incorporating 7.5 and 15% of honey into them. The quality of the products was evaluated based on the physicochemical (moisture, ash, pH, TSS, browning index and Vitamin C content), it was observed that the physicochemical characteristics of the aonla preserve improved upon incorporation of honey. There was improved retention of moisture content, increased ash content, reduced browning and reduced loss of Vitamin C due to incorporation of honey. The Vitamin C content in the aonla preserve (15%

honey incorporation) was 133.56 mg/100 g at the end of storage. The aonla preserve sample incorporated with 15% honey was nutritionally better as compared to samples incorporated with 7.5% honey due to its better Vitamin C retention, higher mineral content, tenderness and tangy taste. The yeast and the mould detected were few to count in the control sample. Shelf life of the product was 90 days.

Nath *et al.*, (2013) studied on effect of slice thickness and blanching time on different quality attributes of instant ginger candy. The experimental parameters considered were slice thickness (5.0–25.0 mm) and blanching duration (10–30 min) followed by dipping in 40°B and 75°B sugar solutions containing 2.0% citric acid respectively, for 1 and 2 h at 95 °C and dried at 60 °C for 1 h. Final products were evaluated for their textural properties, TSS, acidity, TSS: acid ratio, taste score and overall acceptability. The optimum product qualities in terms of hardness (2.08 kg), TSS (73.4%), acidity (1.31%), TSS: acid ratio (56.3), taste score (7.98) and overall acceptability (8.07) were obtained for slice thickness of 10.9 mm and blanching time of 24.9 min.

Banana slices of 10mm thick were immersed in sucrose solution as a pretreatment for drying process with concentration of 45, 55 and 65°Brix at 30, 40 and 50°C for 20, 40, 60, 120 and 240 minutes. Results suggested that a product for further drying could be obtained by treating the slices at temperature not more than 30° using osmotic solution at 55 or 60° Brix (Nowakunda *et al.*, 2004).

Ramamurthy *et al.*, (1970) dissociated osmotic dehydration step prior to drying. After cutting the fruits into pieces of suitable size, the pieces were dipped in 0.25% sodium metabisulphate solution for 12-15 min. at room temperature, soaked in 70% sugar syrup at 50° C for 2 hr and after washing, dried at (60±2)°C for 8 hr, at 736 mm vacuum and immediately packed. They reported the final products contained 3% moisture and was comparable in quality of freeze products.

Younis *et al.*,(2015) studied the influence of addition of mosambi peel powder on jam prepared from papaya. Mosambi peel powder was first analyzed for its proximate composition and other properties. Mosambi peel had high amount of crude fiber (17.6%), besides water and oil-holding capacity (2.26 and 6.82 mL/g, respectively). Mosambi peel was treated with 5% of salt and/or sodium bicarbonate overnight to remove bitterness. Different levels of treated and untreated mosambi peel powder (2.5, 5, 7.5, 10, and 12.5%) were added to papaya jam and were evaluated for texture and sensory properties. The firmness and chewiness values of the jam added with mosambi peel powder increased significantly as compared to control, whereas adhesiveness and cohesiveness values decreased with increasing levels of mosambi peel powder. Sensory evaluation showed that jam prepared by addition of peel powder was acceptable up to 5% level of incorporation. However, jam made by the addition of untreated peel powder was not acceptable due to bitterness resulted from mosambi peel powder.

Pedapati and Tiwari (2014) studied the effect of different osmotic pre treatments on weight loss, yield and moisture loss in osmotically dehydrated Guava. In the present investigation, higher weight loss and solid gain were observed in Allahabad Safeda slices than the Pink Flesh. Higher moisture loss was observed in osmosed Pink Flesh slices than Allahabad Safeda. Maximum effect on the weight loss 34.55 per cent, moisture loss 53.24 per cent, solid gain 13.97 per cent, were observed when guava slices were pre treated with 70° Brix syrup for 24 hours (T9). It was also observed that an increase in duration of osmosis and syrup concentration increased weight loss, moisture loss and solid gain in slices of both Allahabad Safeda and Pink Flesh. The osmosed slices prepared from Pink Flesh variety recorded lower (43.91%) moisture content than the Allahabad Safeda (46.81%). Dried yield was highest in Allahabad Safeda (34.73%) than Pink Flesh (33.79%). Osmotic treatment of guava slices 70° Brix syrup for 24 hours (T9) resulted in highest yield and lowest drying ratio.

Patil *et al.*, (2014) studied the sensory quality and economics of preparation of karonda candy. They found in sensory qualities of candy, the overall scores of taste and colour found to decrease in trend with the advancement of storage an interval of 30 days. The karonda candy recorded more acceptable score in cabinet drying than the solar drying. However, the treatment combination T1D1 (Fruit pieces impregnated with cane sugar (TSS 60 °Brix)+0.5% citric acid + cabinet drying) and T1D2 (Fruit pieces impregnated with cane sugar (TSS 60 °Brix)+0.5% citric acid + solar drying) recorded the maximum score at cabinet and solar drying, respectively.

Rahman and Lamb (1990) pointed out that water loss and sugar gain increased linearly with the increase of sugar concentration and temperature. The rate of sugar diffusion was a function of sugar concentration and temperature. Concentration of solution is a key factor in the osmotic dehydration process and many research workers have studied the effect of osmotic solution concentration on mass transfer of osmotic dehydration process. In general, syrup strength in the range of 60 to 70 °Brix has been found to be optimum (Chaudhary *et al.*, 1993).

Torreggiani (1993) suggested that, it was usually not worthwhile using higher concentration for osmosis process for more than 50 per cent of weight reduction because of decrease in osmotic rate with time. It was also reported that higher concentration, faster is the rate of osmosis.

Aronika. and Manimehalai (2014) studied the preparation of osmotically dehydrated papaya cubes. Experiments were carried out using 4 different osmotic solutions namely; i) sucrose, ii) sucrose:liquid glucose (70:30), iii) sucrose:invert sugar (50:50), iv) sucrose with 0.2M LA+0.2M CaCl<sub>2</sub> and v) sucrose with 2% citric acid along with the optimized process parameters. The efficiency of OD was judged by calculating water loss, solid gain and conducting sensory analysis on the osmotically dehydrated papaya cubes. The samples were packed in low density poly ethylene (LDPE) and stored at room temperature for 45 days. The colour, texture, moisture content of dehydrated

papaya cubes were periodically evaluated. Results showed that storage time has significant effect on the product texture, colour and moisture content. With respect to texture the treatment dehydrated using combination of sucrose and invert sugar (50:50) showed better results.

Surekha *et al.*, (2016) studied Standardization of Pre-treatments for the Development of Intermediate Moisture Food Products from Papaya (*Carica papaya* L.). In this study, pre-treatments have been standardized for the preparation of intermediate moisture products from papaya viz. osmotically dried slices and candy. Out of various treatments tried, the pretreatment consisting of blanching of fruit slices for 1 minute with 0.2% citric acid followed by dipping in 0.2% KMS for 20 minutes was standardized. Osmotically dried papaya contained 5.6% moisture, 55°B TSS, 0.26% acidity, 16.4mg/100g ascorbic acid and 1395.46 µg/100g carotenoids whereas candied papaya contained 16.13% moisture, 46.8°B TSS, 0.12 % acidity, 16.5mg/100g ascorbic acid and 1543 mg /100gm carotenoids content. A slight increase in moisture and reducing sugar took place whereas decrease in total sugar, ascorbic acid and carotenoids was noticed during storage. The developed products remained shelf-stable for 6 months at ambient temperature with minimum changes in their physico-chemical and sensory attributes.

Chauhan *et al.*, (2014) studied the effect of different citric acids levels on quality papaya candy prepared by various methods. The citric acid levels of 0.5%, 0.75% and 1.0% were used for all three processing methods. Here Papaya pieces were dipped in final strength 75° Brix for 3 days. After preparation of papaya candy, the finished products were packed in three packaging materials viz; glass jars, PET jars and PP pouches and stored at room temperature for quality evaluation at 30, 60 and 90 days interval. The data obtained for acidity of fresh samples of papaya candy indicated that with increase in citric acid levels, the acidity increased in processing method.

Phattanapa and Therdthai (2009) investigated the effect of osmotic agents on osmotically dehydrated product. Orange mandarin cv. Sai-Namphaung was peeled and osmotically dehydrated in three types of osmotic agents *i.e.*, 60 per cent sucrose, 60 per cent glycerol and 60 per cent sucrose-glycerol (1:1) at  $55 \pm 50^{\circ}\text{C}$ . From sensory evaluation using a 9-point hedonic scale, the use of sucrose solution as osmotic agent produced a dried product with the lowest liking score on colour attribute. Adding glycerol solution into sucrose solution in the osmotic agent could improve the liking score on texture attribute. However, liking scores on sweetness and bitterness attributes were decreased by using only glycerol solution. For overall, the dried orange product prepared from the mixture of glycerol and sucrose presented the highest liking score in all attributes.

### **2.3 Effect of storage on candy**

A declining trend in tannin content was observed in aonla preserve (Jain *et al.*, 1983; Sethi and Anand, 1983; Priya and Khatkar, 2013). Tripathi *et al.* (1988) also reported a decrease in tannin content in aonla preserves, jam and candy due to leaching out of tannins from tissue into the suspension medium. Kaushik *et al.* (2002) reported a significant reduction in tannin content of bael preserve during storage. Similar results were observed by Kumar and Singh (2001) in aonla products. The tannin content of the various aonla candies was statistically significant with respect to aonla varieties and decreased during nine months of storage (Nayak *et al.*, 2012).

Rani and Bhatia (1986) observed loss of moisture in intermediate moisture bagugosha samples from 42.6 to 28.1% during storage of 16 weeks. A drop in moisture content was also observed with the storage intervals in osmotically dehydrated banana slices by Hussain *et al.* (2004)

Durrani *et al.*, (2011) studied on Development and quality evaluation of honey based carrot candy. Candy was prepared with 3 different combinations of honey and carrot by using 750 g honey+1,000 g carrot (T1), 1,000 g honey+1,000 g carrot (T2) and 1,250 g honey+1,000 g carrot (T3). To establish

the best product, sensory evaluation was done on 9-point Hedonic scale. T1 was found to be most preferred candy. Further the T1 candy was assessed for overall quality during storage at room temperature (25–30 °C) for 6 months. Candy can be preserved safely for 6 months in both glass and LDPE packaging materials.

Dar *et al.*, (2011) studied on Effect of CaCl<sub>2</sub>, Citric Acid and Storage Period on Physico-Chemical Characteristics of Cherry Candy. Cherry cultivar Misri (*Bigarreau Noir Grossa*) was used for making candy. Pitting of fruit was done manually and KMS (0.2%) was added for bleaching. The fruit was pretreated using 4 levels of CaCl<sub>2</sub> (C0 = 0%, C1 = 1%, C2 = 1.5%, C3 = 2%) and stored in jars for 4 weeks. Thereafter, application of colour was done using Erythrosine (0.05%) followed by dipping pitted fruits in sugar syrup for 24 hours. The samples were treated with 4 levels of citric acid (T0 = 0%, T1 = 1%, T2 = 1.5%, T3 = 2%) and then concentrated subsequently till desired TSS of 70° Brix was attained. Results revealed that there was gradual increase in reducing sugars (%), total sugars (%) during storage while as moisture content (%) decreased. The product developed was found economically profitable and viable for commercial production.

Choudhary *et al.*, (2012), studied on aonla (*Emblica officinalis*) nectar and biochemical changes with advancement of storage period. The prepared nectar was kept at ambient condition for storage study. The nectar remained acceptable upto 240 days at ambient condition. The nectar prepared from T3 (20 per cent juice, 20 per cent TSS and 0.3 per cent acidity) recorded maximum organoleptic score than other recipe treatments. The biochemical composition in aonla nectar prepared from T6 (35 per cent juice, 20 per cent TSS and 0.3 per cent acidity) had the maximum retained acidity, TSS, total sugar, reducing sugar than rest of the recipes and their increasing trend with advancement of storage period upto 240 was recorded under ambient condition. On the other hand, the nectar prepared with T6 (35 per cent juice, 20 per cent TSS and 0.3 per cent acidity) had maximum ascorbic acid, non-reducing sugar, TSS /

acidity ratio, pH and organoleptic score and these traits showed decreasing trend with advancement of storage period upto 240 days under ambient condition.

Balaji *et al.*, (2014) studied to assess impact of varieties, honey coating and storage durations on *aonla* candy. The parameters like TSS, acidity, pH, ascorbic acid and optical density were analyzed before the segment impregnation into sugar, so that after product preparation the values may be evaluated as the impact of variety, honey and storage duration. Amongst varieties NA-6 proved much better with respect quality parameter studied. There was increase in the level of total soluble solids, acidity and browning and decrease in pH, ascorbic acid, and organoleptic taste during storage. The highest TSS was recorded in NA-6 (76.7%) and the lowest value was (75.9%) in Kanchan at 90 days of storage. Acidity was recorded highest in Kanchan (0.68%) and the lowest (0.58%) in NA-6 after 90 days of candy storage. The maximum pH (4.28) was observed in Krishna, while the minimum (4.23) was NA-6. The highest ascorbic acid (102.15 mg /100 g) was recorded in NA-6 and the lowest was (90.10 mg /100 g) with Kanchan. The organoleptic quality was best (7.19 score) in NA-6 at 90 days of storage. All the qualitative parameters were significantly superior with honey coated candy as compared to cane sugar prepared candy.

Deepika *et al.*, (2016) studied the evaluation of packaging materials to maintain quality of enriched fruit bars during storage. Blending of *aonla* pulp with pulp of pro vitamin A rich fruits viz. mango, papaya and jackfruit in different ratios was carried out and its effect on the quality of resultant fruit bars in different packaging materials was evaluated during storage for a period of 6 months. A declining trend in moisture, acidity, non-reducing sugars and ascorbic acid and total carotenoids was observed whereas Total Soluble Solids, total sugars, reducing sugars and non-enzymatic browning showed an upward trend. High Impact Polystyrene boxes were found to be more effective in reduction of non-enzymatic browning as compared to LDPE and areca plate

overwrapped with cling film. Enriched fruit bars contained three vital antioxidants viz. Vitamin C, carotenoids and polyphenols.

Pawar and Patil (2013) studied Sensory attributes changes in aonla (*Emblica officinalis*) candy during the storage. Keeping the varieties V1 (Gujarat aonla-1), V2 (Krishna), V3 (NA-7), V4 (Chakaiya) and V5 (Kanchan) in Complete Randomized Design with four repetitions. The sugar syrup having 70°B strength with 2% citric acid was prepared in and the blanched pieces were immersed into the syrup for 3 days for impregnation of sugar into flesh of segment and coating. The nutritional value viz., TSS (per cent), acidity (per cent), ascorbic acid (mg/100g), total sugar (per cent), reducing sugar (per cent) and moisture (per cent) was carried out. The acidity of candy was found lower in NA-7 while higher in Krishna variety. Ascorbic acid was significantly maximum in NA-7 and Krishnawhile lower in Kanchan variety. In respect of total and reducing sugar content, it was found maximum in NA-7 and lowest in Kanchan and Krishna variety. However, TSS was significantly highest in NA-7 while the lowest in Chakaiya. It was equivalent in Kanchan variety. On the other hand moisture was found significantly maximum in Gujarat aonla-1 while the lowest in Na-7.

Jain *et al.*, (2016) studied the Physical and bio-chemical composition of value-added pomegranate toffee during storage. Toffee was prepared from dry pomegranate arils using different treatments comprising of cardamom, vanilla flavour, citric acid flavours. Treatment comprising of sulphitation + cardamom flavour was found superior with respect to different parameters. It had acceptable organoleptic quality at the end of 120 days storage at 7-10°C. An increasing trend in the pH (4.876), titratable acidity (4.876) and total sugars (8.94%) and the score for overall acceptability of value-added pomegranate toffee was recorded till 60 day of storage, whereas, it showed a decreasing trend till the end of storage (120 days).

Singh and Pathak (2016) studied the Evaluation of cultivars and packing materials during preparation and storage of ber candy. The physico-chemical

characteristics were evaluated for different cultivars viz., Illaichi, Ponda, Umran, Gola, Banarsi Karaka and Narendra Ber Sel-2. Here the blanched fruits were steeped in to 50 (per cent), and 60 (per cent) T.S.S. syrup for 24 hours there after the fruits were dipped in 70 (per cent), T.S.S. syrup for 7 days. The cultivars physico-chemical composition of ber fruit and organoleptic quality of candies Banarsi Karaka was found best suited among all cultivars for making of candy. Storage studies indicated that LDPE film was better in comparison to glass jar and plastic jar for packaging of ber candy at ambient temperature and candy was found in good condition after 9 months of storage period in LDPE film.

Bajpai *et al.*, (2015) studied the browning analysis of different Karonda processed products during storage. In this experiment, maximum browning were studied in processed products. Results showed that the maximum browning was recorded in candy and minimum in jelly and squash. It was clear from the experiment that the trend of browning was decreasing in storage.

Mir, S. K. *et al.*, (2015) studied the effect of packaging and storage on the physicochemical and antioxidant properties of quince candy. Candy was developed from quince, packaged in three different packaging materials viz. polyethylene pouch, laminate, and plastic jar and was analyzed at three storage intervals (0, 60 & 120 days). With laminate showing significantly ( $p \leq 0.05$ ) higher acceptability among various packages, the overall acceptability of quince candy decreased significantly ( $p \leq 0.05$ ) during storage. Total phenolic and flavonoid contents showed a significant ( $p \leq 0.05$ ) decrease with storage time.

The storage stability of osmotically dehydrated products varies from six months to one year. The papaya product obtained from osmotic dehydration process remains stable up to six months of storage at room temperature (Ahemed & Choudhary, 1995).

Bongirwar and Sreenivasan (1977) reported that the osmotically dehydrated banana products can be preserved up to one year or more depending

upon the storage conditions and packaging materials used. Storage studies on osmo-dehydrated mango slices showed that the keeping relative humidity between 64.8 to 75.5 per cent would be conducive for the retention of colour, flavour, texture and taste.

Kumar *et al.*, (2015) studied the quality attributes comprised of moisture content, acidity, pH, optical density, TSS, total plate count. The quality parameters were done for fresh as well as stored papaya leather at 0, 15, 30, 45 and 60 days of storage under the room temperature and samples were packed in PET jars and glass jars. The TSS, pH, optical density and total plate count of papaya leather increased with increase of sugar and jaggery ratio at room temperature condition. The acidity and moisture content decreased with decrease in the level of papaya ratio and acidity values after 60 days. The maximum overall acceptability score for the papaya leather prepared with sugar and jaggery ratio samples T1: sample prepared papaya pulp with sugar (650 gm), 7.1 in glass jar and the minimum score T1 6.8 in pet jar at room temperature. It was concluded that papaya leather prepared with sugar and jaggery ratio of T1, T2, and T3 samples was found to be superior of glass jar as compared to other samples.

Babariya *et al.*, (2014) studied the Standardization of a recipe for the preparation of candy (tuti fruiti) from unripe papaya. The experiment consisted of 18 treatments *viz.*, NaCl (10 %, 20 %, 30 % and 40 %), Ca(OH)<sub>2</sub> (0.5 % and 1.0 %) and sea water (15 ppt, 25 ppt and 35 ppt) and each level with sugar (add direct sugar and add 50 °Brix sugar syrup). The treatment T3 (20 % NaCl and add direct sugar) recorded the maximum total sugar, non reducing sugar and sensory evaluation (colour, texture, flavour, taste and overall acceptability) during entire period of storage (Six months).

Pandey *et al.*, (2014) studied the Shelf-life and microbiological safety studies of refrigerated petha sweet. The physiochemical analysis and sensory evaluation were performed at 15 days interval upto 90 days for storage study in both Kashi Petha and crystallized petha, while microbial observation was

recorded up to 90 days in crystallized petha and up to 50 days Kashi Petha. They reported the continuous increase in moisture (25.79- 26.80 % and 31.68- 32.63 %) and titratable acidity (0.022- 0.029 %) and (0.022-0.030 %) and reduction in ascorbic acid content (5.50-5.00 mg/100 g and 5.12-4.84 mg/100 g), respectively in crystallized and Kashi petha. The increasing trend in microbial population was more pronounced in Kashi petha in comparison to crystallized petha.

Muzzaffar *et al.*, (2016) studied the effect of storage on physicochemical, microbial and antioxidant properties of pumpkin (*Cucurbita moschata*) candy. Pumpkin and its candy were analyzed for the physicochemical characteristics like moisture content, ash, total soluble solids (TSS), titratable acidity, total sugar, reducing sugar, and color. During storage, a significant increase in TSS while a non-significant increase in titratable acidity, reducing and total sugars was observed.

## **CHAPTER-III**

### **MATERIALS AND METHODS**

The present investigation entitled “Studies on Standardisation of Sweet Orange Peel Candy” was carried out during 2016-17. The details of the materials used and methods adopted during the course of the investigation are described in this chapter under different headings.

#### **3.1 General**

#### **3.2 Experimental details**

#### **3.3 Procurement of raw material**

#### **3.4 Preparation of sweet orange peel candy**

#### **3.5 Physico-chemical and organoleptic studies of candy**

#### **3.6 Statistical analysis**

#### **3.1 General**

##### **3.1.1 Location**

Geographically Parbhani district lies between 18.45 and 20.10 North Latitudes and 76.13 and 77.39 East Longitude and has an elevation of 347 meter above the Mean Sea Level where the present investigation was carried out.

#### **3.2 Weather conditions of the experimental site**

Climate of Parbhani district (tropical) is hot and dry, which is situated in the Deccan plateau. The mean annual rain fall of the area is ranges from 1159.5 mm. The mean maximum temperature varied between 34.3 to 38.9<sup>0</sup>C and the average minimum temperature varied between 20.6 and 24.2<sup>0</sup>C. Relative humidity observed was 65 to 79 per cent in morning hour and 45 to 65 per cent in afternoon.

### 3.2 Experimental details:

- a. Name of crop : Sweet Orange (*Citrus sinensis*)
- b. Product : Candy
- c. Location : Laboratory, Department of Horticulture.
- d. Year of experiment : 2016-2017.
- e. Experimental Design : FRBD.
- f. Number of Replications : Three (3).
- g. Number of Treatment : Nine (9).

The details of treatments are given in Table no. 1.

**Table 1. Details of treatments**

S. No.	Treatments	Treatment Detail
1.	T1S1	12 hr in 50% sugar concentration
2.	T1S2	12 hr in 60% sugar concentration
3.	T1S3	12 hr in 70% sugar concentration
4.	T2S1	24 hr in 50% sugar concentration
5.	T2S2	24 hr in 60% sugar concentration
6.	T2S3	24 hr in 70% sugar concentration
7.	T3S1	36 hr in 50% sugar concentration
8.	T3S2	36 hr in 60% sugar concentration
9.	T3S3	36 hr in 70% sugar concentration

### 3.3 Procurement of raw material

Fresh sweet orange peel was collected from sweet orange juice processors in Parbhani where the peel is a waste material. Other ingredients like sugar and salts and chemicals were provided by Department of Horticulture, Parbhani.

### 3.4 Preparation of sweet orange peel candy

The dried and bruised peels were thoroughly sorted out manually. Peels of almost same size were selected for processing. The graded peels were washed thoroughly under running tap water to remove dust and dirt from the surface. Extra white part rags that were attached to the inner surface were

removed manually. Cleaned peels were then dried under fan to remove adhering moisture. Then the sweet orange peels were cut according to the



**Plate 1. Sweet Orange peel**



**Plate 2. Sweet Orange Peel after dipping in sugar solution.**



**Plate 3. Drying of Sweet Orange Peel Candy in Cabinet Dryer.**

desired shape and size. The peels were cut uniformly about 2 to 3 cm length and 0.5 to 0.8 cm breadth.

#### **3.4.1. Pre-treatment**

After cutting in uniform size, peels were blanched in 8% salt solution for 10 mins in 100° C temperature. The blanched peels were washed with several changes of fresh water.

#### **3.4.2. Method of preparation**

Sweet orange peel candy was prepared by combining two treatments *viz.* concentration of sugar syrup i.e. 50%, 60% and 70% and dipping time i.e. 12hrs, 24hrs and 36hrs.

After washing blanched peels, sugar syrup of different concentration was prepared. After preparation of sugar syrup, peels were steeped in sugar syrup and boiled for 2-3 mins and then kept it for 12hrs, 24hrs and 36hrs according to the treatment combination.

After completion of steeping time, sugar syrup was drained and peels were spread out on trays. Then peels were kept for drying in cabinet dryer for 7-8 hrs at 60° C temperatures. After drying samples were collected and packed in LDPE bags for storage purpose. Candies were stored at room temperature for 4 months for storage studies.

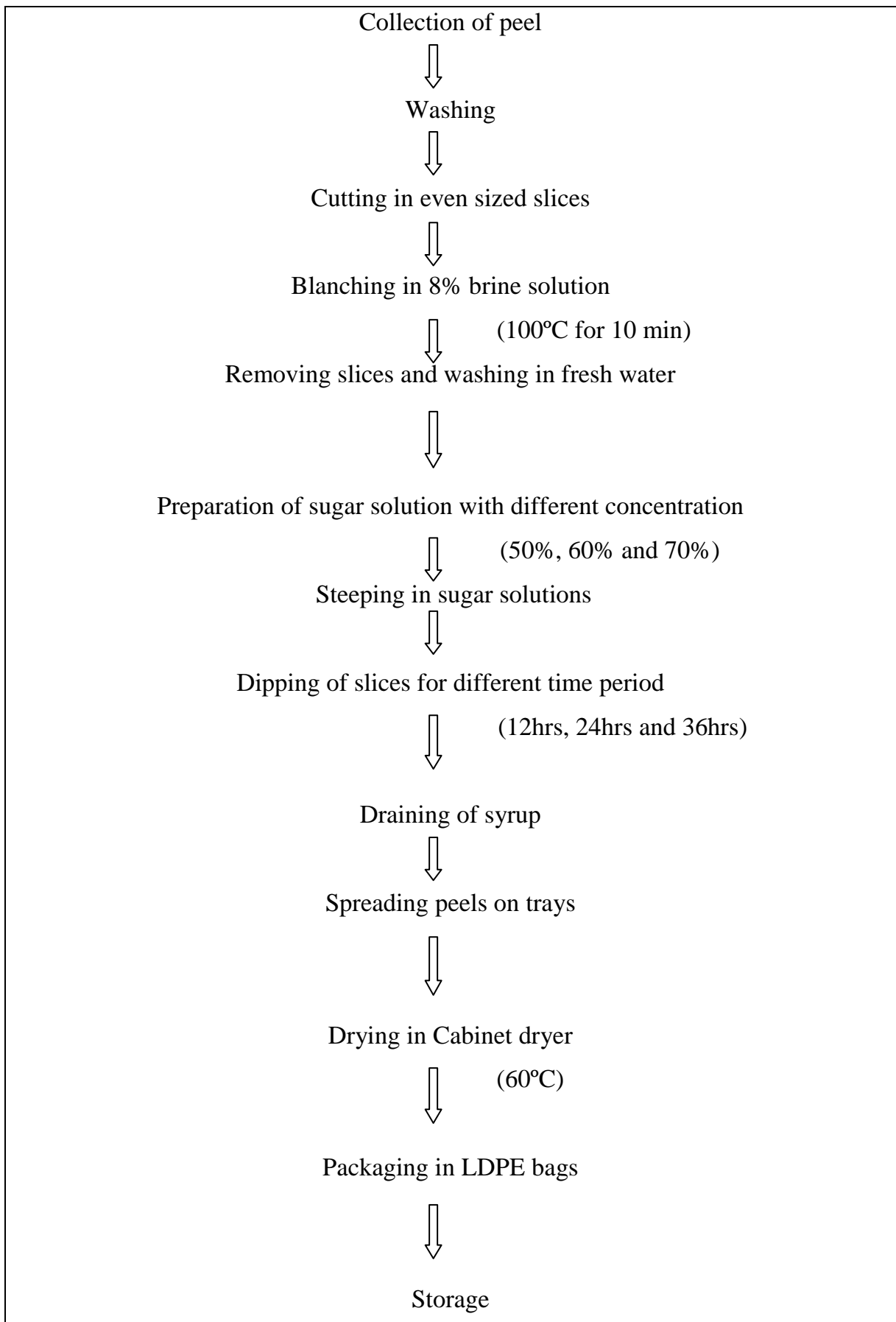


**Plate 4. Sweet Orange Peel Candy after drying.**



**Plate 5. Packaging of Sweet Orange Peel Candy.**

### Flow chart of candy preparation:



### **3.5 Physico-chemical and organoleptic studies of candy**

#### **3.5.1 Moisture content (%)**

The moisture content was determined on the basis of Ranganna (2003). Weighed sample (5g) in triplicate were dried for eight hours in a hot –air oven at 105°C in pre-weighed crucibles. The crucibles were transferred immediately to desiccators, cooled, weighed and moisture content present was calculated from loss of weight.

$$\text{Moisture (\%)} = \frac{W1 - W2}{W1} \times 100$$

Where W1 is weight of sample

W2 is weight of sample after drying

#### **3.5.2 Total solids (%)**

Total solids were determined by taking 5g sample in pre-weighed crucible and dried for eight hours in a hot air oven at 105°C. The crucible was transferred immediately to desiccators, cooled and weighed the final weight of sample.

$$\text{Total solids (\%)} = \frac{W2}{W1} \times 100$$

Where W1 is weight of sample

W2 is weight of sample after drying

#### **3.5.3 Total soluble solids (%)**

Total soluble solids (TSS) were measured by using hand refractometer (Erma, Japan) and the results were expressed as percent (%) according to standard procedure as given in (Ranganna, 2003). The refractometer was calibrated with distilled water before use.

#### **3.5.4 Titratable acidity (%)**

Titrate acidity was determined by titrating a known quantity of sample (10ml) against standard solution of 0.1 N Sodium hydroxide to a faint pink colour using phenolphthalein as an indicator. The results were expressed using per cent citric acid (A.O.A.C. 1990).

$$\text{Titrateable acidity \%} = \frac{\text{titre} \times \text{normality of alkali used} \times \text{equivqlent wt. of acid}}{\text{volume of sample} \times 100} \times 1000$$

$$\text{Vol. of aliquot (ml)} \times \text{Wt. or volume of sample (g or ml)}$$

### 3.5.5. pH

The pH was estimated with the help of Hand pH-meter. The temperature of the solution to be tested was accurately measured and the temperature control at this temperature was set. The instrument was standardised with a buffer solution of pH 7. A sample (5 g) was crushed properly and mixed with 50 ml of distilled water. Samples were properly mixed with the help of a magnetic stirrer. The hand pH meter was dipped in a beaker containing tested solution and the readings were recorded.

### 3.5.6. Ascorbic acid (mg/100 g)

Ascorbic acid was determined using 2, 6-Dichlorophenol-indophenol visual titration method (A.O.A.C, 1990). Five ml of standard ascorbic acid solution was taken in a titration flask and 5ml of oxalic acid (4%) was added to it. A microburette was filled with a dye and titrated against standard ascorbic acid to a pink colour, which persisted for 15 seconds. Dye factor was determined i.e mg of ascorbic acid needed for titration per ml of the dye. Ten gm of sample was taken and blended with 4% oxalic acid and volume was made up to 100 ml with oxalic acid and filtered.

Ten ml of prepared sample was taken in a titration flask and titrated against standard dye to a pink coloured end-point, which persisted for at least 15 second. Results were expressed as mg /100g of sample.

$$\text{Ascorbic acid (mg/100g)} = \frac{(\text{Titre} \times \text{Dye factor} \times \text{Volume made up})}{\text{Aliquot of extract taken} \times \text{weight of sample}} \times 100$$

### 3.5.7. Reducing sugars (%)

The percentage of reducing sugars in sample was determined by Dinitro-salicylic acid DNSA method (Miller, 1972). A known volume of alcohol extract was allowed to evaporate the alcohol completely. Clear solution was taken for the

estimation of reducing sugar using DNSA- reagent by following the above method and values were expressed in percentage.

### **3.5.8. Total sugar (%)**

Total sugar was estimated by using following formula

Total sugars = Reducing sugars (%) + Non reducing sugars (%)

### **3.5.9. Pectin (% cal pectate)**

Total as calcium pectate was estimated by the method of Ranganna (2003). For estimation of pectin, 25g of macerated sample was taken in a flask. To this, 200 ml distilled water was added and it was kept on hot plate for an hour. The water lost during boiling was replaced simultaneously. The flask was then cooled and the volume made to 250 ml. the content of flask were filtered through Whatman filter paper No.4. To 100 ml portion of filtrate, 100 ml of distilled water and 10 ml of 1N NaOH was added and kept overnight.

Next day, 50 ml of acetic acid solution was added to it and after 5 minutes, 25 ml of 1N calcium chloride solution was added with stirring. After allowing to stand it for an hour, it was boiled for one minute and filtered through oven dried, previously weighed Whatman filter paper No.4. the precipitate were washed with distilled water until these were free from chloride (test with 1% silver nitrate solution). The precipitates were then dried at 100°C overnight, cooled in desiccator and weighed. The amount of pectin was expressed as percent calcium pectate.

$$\text{Calcium pectate (\%)} = \frac{\text{weight of calcium pectate} \times \text{volume of content}}{\text{Vol. of filtrate} \times \text{weight of sample taken for}} \times 100$$

### **3.5.10 Tannins (mg/100 g)**

Total phenols (expressed as tannins) were estimated by the method of A.O.A.C. (1990). Aliquots (0 to 10 ml) of standard tannic acid solution were pipetted into 100 ml volumetric flask and 75 ml of distilled water was added to it. After this, five ml of Folin Ciocalteu reagent and 10 ml of sodium carbonate solution was added. Its volume was then made to 100 ml with water, mixed well and the absorbance was taken after 30 minutes at 760 nm, and standard curve was prepared.

Five grams fruit pulp was boiled for 30 minutes with 400 ml of water, cooled and transferred to a 500 ml volumetric flask and diluted to 500 ml, mixed well and filtered. One ml of above aliquot was taken and followed the same procedure as for the preparation of standard curve and estimated tannic acid (mg) from the standard curve.

$$\text{Tannins as tannic acid (mg/100g)} = \frac{\text{mg of tannic acid} \times \text{dilution}}{\text{ml of sample taken for colour development} \times \text{weight of sample}} \times 100$$

### **3.5.11. Sensory evaluation**

To assess the consumer preference, sensory evaluation of the experimental sample was conducted at different intervals of storage by semi-trained taste panel of 7-8 judges. The samples were evaluated for colour, texture, taste, and overall acceptability. Samples were served on coded plates. The judges scored the quality characteristics of each sample on nine-point hedonic scale. The overall acceptability of product was based upon the mean score obtained from all those characters studied under test. The product with an overall score of 5 or above was considered acceptable.

### **3.6. Statistical analysis**

The data in respect of all the above parameters were tabulated and subjected to the statistical analysis using methods of analysis of variance (ANOVA) for Factorial randomized block design with critical difference (C.D. at 5%) was worked out.

## CHAPTER-IV

### RESULTS

The experimental results emanating from the present study entitled "Studies on standardisation of sweet orange peel candy" with the objective to study the effect of concentration of sugar syrup and period of dipping for preparation of sweet orange peel candy and to study the effect on quality of sweet orange peel candy during storage have been presented in this chapter under the following sub headings:

#### 4.1 Physico-chemical characteristics of fresh peel

#### 4.2 Changes in physico-chemical constituents and organoleptic quality of sweet orange peel candy after preparation of candy

#### 4.3 Changes in physico-chemical constituents and organoleptic quality of sweet orange peel candy during storage.

#### 4.1 Physico-chemical characteristics of fresh peel

Fresh sweet orange peel was collected and washed properly and then analysed for moisture content, total solids, TSS, pH, total acidity, ascorbic acid, reducing sugar, total sugar, pectin content and tannins.

**Table 2. Physico-chemical characteristics of fresh peel**

Parameter	Respective values
Moisture content	74.8
Total solids	25.6
TSS (%)	11.5
pH	3.88
Titration acidity (%)	0.48
Ascorbic acid (mg/100 g)	35.6
Reducing sugar (%)	4.5
Total sugar (%)	6.75
Pectin (calpectate %)	13.34
Tannin (mg/100 g)	170

The fresh sweet orange peels were evaluated for various physico-chemical characteristics and the results recorded have been presented in Table 1. On

freshweight basis, moisture content and total solids of fresh peel was found to be 74.8% and 25.6. Total soluble solids (TSS), pH, titratable acidity and ascorbic acid were analyzed to be 11.5, 3.88, 0.48% and 35.6 g/100 g, whereas, reducing sugars, total sugars, pectin and tannins and were found to be 4.5%, 6.75%, 13.34 (% calpectate) and 170 mg/100 g respectively.

## **4.2 Changes in chemical constituents and organoleptic quality of sweet orange peel candy after preparation of candy**

### **4.2.1 Physico-Chemical constituents**

#### **4.2.1.1 Moisture content (%)**

The data regarding effect of dipping time and concentration of sugar solution on moisture content in sweet orange peel candy have been shown in Table 3. The moisture content of sweet orange peel candy on zero days ranged from 12.86 to 16.90%. A significant difference in moisture content was observed in different treatments (T and S) and treatment combinations (TxS) after preparation of candy. Here in sweet orange peel candy, treatment combination 12 hrs in 50% sugar solution ( $T_1S_1$ ) showed the maximum value (16.90%) followed by 24 hrs in 50% sugar solution  $T_2S_1$ , while 36 hrs in 70% sugar solution ( $T_3S_3$ ) showed minimum value (12.86%).

#### **4.2.1.2 Total solids (%)**

The data regarding effect of dipping time and concentration of sugar solution on Total solids in sweet orange peel candy have been shown in Table 3. The Total solids of sweet orange peel candy on zero days ranged from 83.09 to 87.15%. A nonsignificant difference in Total solids was observed in different treatments (T and S) and treatment combinations (TxS) after preparation of candy. In sweet orange peel candy, treatment combination 36 hrs in 70% sugar solution ( $T_3S_3$ ) showed the maximum value (87.13%) followed by 36 hrs in 6% sugar solution ( $T_3S_2$ ), while 12 hrs in 50% sugar solution ( $T_1S_1$ ) showed minimum value (83.09%).

#### **4.2.1.3 pH**

The data regarding effect of dipping time and concentration of sugar solution on pH in sweet orange peel candy have been shown in Table 3. The pH of sweet orange peel candy on zero days ranged from 2.01 to 2.84. A significant difference in pH was observed in different treatments (T and S) and treatment combinations (TxS) after preparation of candy. In sweet orange peel candy, treatment combination 36 hrs in 70% sugar solution ( $T_3S_3$ ) showed the maximum value (2.84) followed by 36 hrs in

60% sugar solution (T<sub>3</sub>S<sub>2</sub>), while 12 hrs in 50% sugar solution (T<sub>1</sub>S<sub>1</sub>) showed minimum value (2.01).

**Table no. 3 Effect of dipping time and concentration of sugar solution on moisture, total solids and pH of sweet orange peel candy.**

Treatments	Moisture (%)	Total solids	pH
<b>Time Period (T)</b>			
T1	15.58	84.40	2.12
T2	15.22	82.54	2.31
T3	14.26	83.51	2.60
<b>SE±</b>	<b>0.06</b>	<b>1.7</b>	<b>0.004</b>
<b>CD at 5%</b>	<b>0.18</b>	<b>NS</b>	<b>0.013</b>
S1	16.40	81.36	2.18
S2	14.80	82.95	2.33
S3	13.84	86.14	2.53
<b>SE±</b>	<b>0.06</b>	<b>1.7</b>	<b>0.004</b>
<b>CD at 5%</b>	<b>0.18</b>	<b>NS</b>	<b>0.013</b>
<b>Interaction TxS</b>			
T1S1	16.90	83.09	2.01
T1S2	15.51	84.44	2.10
T1S3	14.32	85.66	2.25
T2S1	16.38	83.61	2.15
T2S2	14.92	78.40	2.29
T2S3	14.36	85.62	2.50
T3S1	15.94	77.38	2.39
T3S2	13.98	86.01	2.59
T3S3	12.86	87.13	2.84
<b>SE±</b>	<b>0.10</b>	<b>2.95</b>	<b>0.007</b>
<b>CD at 5%</b>	<b>0.32</b>	<b>NS</b>	<b>0.023</b>
GENERAL MEAN	15.02	83.48	2.35

#### **4.2.1.4 Total Soluble Solids (%)**

The change in TSS of various treatments and treatment combinations of sweet orange peel candy after preparation has been summarized in Table 4. The data reveal that dipping time, sugar solution and treatment combinations had significant effect on TSS of sweet orange peel candy. In sweet orange peel candy for dipping time, T<sub>3</sub> (36hrs) showed maximum Total Soluble Solids (67.88%), while T<sub>1</sub> (12hrs) showed minimum Total Soluble Solids (62.66%) and for sugar concentration S<sub>3</sub> (70% sugar solution) showed maximum TSS (74.77%), while S<sub>1</sub> (50% sugar solution) showed minimum Total Soluble Solids (56.22%). In treatment combination, maximum Total Soluble Solids (77.33%) was observed in T<sub>3</sub>S<sub>3</sub> (36 hrs in 70% sugar solution) followed by T<sub>2</sub>S<sub>3</sub> (75.33%) and minimum (54.33%) in T<sub>1</sub>S<sub>1</sub> (12 hrs in 50% sugar solution).

#### **4.2.1.5 Titrable Acidity (%)**

The data regarding effect of dipping time and concentration of sugar solution on titrable acidity in sweet orange peel candy have been shown in Table 4. The data reveals that dipping time, sugar solution and treatment combinations had significant effect on titrable acidity of sweet orange peel candy. For sugar concentration S<sub>1</sub> (50% sugar solution) showed maximum value (0.66%), while S<sub>3</sub> (70% sugar solution) showed minimum value (0.59%). For treatment combination T<sub>1</sub>S<sub>1</sub> (12 hrs in 50% sugar solution) showed maximum value (0.68%) followed by T<sub>1</sub>S<sub>2</sub> (0.66%), while T<sub>3</sub>S<sub>3</sub> (36 hrs in 60% sugar solution) showed minimum value (0.55%).

#### **4.2.1.6 Ascorbic Acid (mg/100g)**

The data pertaining to effect of dipping time, sugar concentration and their treatments combinations on ascorbic acid in Sweet orange peel candy is given in Table 4. The ascorbic acid of sweet orange peel candy shown significant differences with dipping time and sugar concentration. Non significant differences were observed among various treatment combinations (TxS). Here, T<sub>1</sub> (12 hrs) showed maximum ascorbic acid (11.46 mg/100g), while T<sub>3</sub> (24 hrs) recorded minimum ascorbic acid (8.44 mg/100g). In treatment combinations, maximum value was observed in T<sub>1</sub>S<sub>3</sub> (11.57 mg/100g) and minimum in T<sub>3</sub>S<sub>1</sub> (8.01 mg/100g).

#### **4.2.1.7 Reducing Sugar (%)**

The data regarding effect of dipping time and concentration of sugar solution on reducing sugar in sweet orange peel candy have been shown in Table 5. The data reveals that dipping time and sugar solution had significant differences on reducing sugar during zero day of sweet orange peel candy. For sugar concentration S<sub>3</sub> showed

maximum value (18.03%), while S<sub>1</sub> showed minimum value (17.44%). Non significant differences were observed among various treatment combinations. Here, T<sub>3</sub>S<sub>3</sub> (36 hrs in 60% sugar solution) showed maximum value (19.50%) followed by T<sub>2</sub>S<sub>3</sub> (18.69%), while T<sub>1</sub>S<sub>1</sub> (12 hrs in 50% sugar solution) showed minimum value (16.24 %).

**Table no. 4** Effect of dipping time and concentration of sugar solution on Total Soluble Solids, titrable acidity and Ascorbic acid of sweet orange peel candy.

Treatments	TSS (%)	Titrable acidity (%)	Ascorbic acid (mg/100g)
<b>Time Period (T)</b>			
T1	62.66	0.64	11.46
T2	65.77	0.64	10.25
T3	67.88	0.58	8.44
<b>SE±</b>	<b>0.88</b>	<b>0.006</b>	<b>0.07</b>
<b>CD at 5%</b>	<b>2.65</b>	<b>0.01</b>	<b>0.21</b>
<b>Sugar Solution (S)</b>			
S1	56.22	0.66	9.78
S2	65.33	0.62	10.04
S3	74.77	0.59	10.33
<b>SE±</b>	<b>0.88</b>	<b>0.006</b>	<b>0.07</b>
<b>CD at 5%</b>	<b>2.65</b>	<b>0.01</b>	<b>0.21</b>
<b>Interaction TxS</b>			
T1S1	54.33	0.68	11.33
T1S2	62.00	0.66	11.50
T1S3	71.66	0.60	11.57
T2S1	56.16	0.67	10.01
T2S2	65.83	0.64	10.09
T2S3	75.33	0.61	10.67
T3S1	58.16	0.64	8.01
T3S2	68.16	0.55	8.55
T3S3	77.33	0.56	8.76
<b>SE±</b>	<b>1.53</b>	<b>0.01</b>	<b>0.12</b>
<b>CD at 5%</b>	<b>NS</b>	<b>0.03</b>	<b>NS</b>
GENERAL MEAN	65.44	0.62	10.05

#### 4.2.1.8 Total sugars (%)

The data pertaining to effect of various treatments and their combinations on total sugar on sweet orange peel candy have presented in Table 5. A significant difference was observed in sugar concentration. In sugar concentration S<sub>3</sub> showed maximum value (62.96%), while S<sub>1</sub> showed minimum value (42.64%). In treatment

combinations, T<sub>3</sub>S<sub>3</sub> (36 hrs in 60% sugar solution) showed maximum value (63.38%), while T<sub>1</sub>S<sub>1</sub> (12 hrs in 50% sugar solution) showed minimum value (42.35 %)

#### **4.2.1.9 Pectin (% calpectate)**

The data regarding effect of dipping time and concentration of sugar solution on pectin in sweet orange peel candy have been shown in Table 6. The data reveals that dipping time, sugar solution and their combinations had significant differences on Pectin during zero day of sweet orange peel candy. For dipping time T<sub>1</sub> showed maximum value (1.67%), while T<sub>3</sub> showed minimum value (1.18%) and for sugar concentration S<sub>3</sub> showed maximum value (1.51%), while S<sub>1</sub> showed minimum value (1.34%). For treatment combinations T<sub>1</sub>S<sub>3</sub> showed maximum value (1.74% calpectate), while T<sub>3</sub>S<sub>1</sub> showed minimum value (1.12 % calpectate).

#### **4.2.1.10 Tannin (mg/100g)**

The data pertaining to effect of various treatments and their combinations on tannin content of sweet orange peel candy have presented in Table 6. A significant difference was observed for dipping time, sugar concentration and their various combinations. For dipping time T<sub>1</sub> showed maximum value (73.61 mg/100g), while T<sub>3</sub> showed minimum value (54.58 mg/100g) and for sugar concentration S<sub>3</sub> showed maximum value (65.46 mg/100g), while S<sub>1</sub> showed minimum value (61.56 mg/100g). In treatment combinations, T<sub>1</sub>S<sub>3</sub> showed maximum value (74.99 mg/100g), while T<sub>3</sub>S<sub>1</sub> showed minimum value (53.06 mg/100g).

**Table no. 5 Effect of dipping time and concentration of sugar solution on reducing sugar and total sugar of sweet orange peel candy.**

<b>Treatments</b>	<b>Reducing sugar (%)</b>	<b>Total sugar (%)</b>
<b>Time Period (T)</b>		
T1	17.44	51.86
T2	17.51	52.71
T3	18.03	53.39
<b>SE±</b>	<b>0.12</b>	<b>0.41</b>
<b>CD at 5%</b>	<b>0.38</b>	<b>NS</b>
<b>Sugar Solution (S)</b>		
S1	16.37	42.64
S2	17.67	52.36
S3	18.95	62.96
<b>SE±</b>	<b>0.12</b>	<b>0.41</b>
<b>CD at 5%</b>	<b>0.38</b>	<b>1.25</b>
<b>Interaction TxS</b>		
T1S1	16.24	42.35
T1S2	17.41	51.56
T1S3	18.67	61.67
T2S1	16.28	42.40
T2S2	17.58	51.91
T2S3	18.69	63.82
T3S1	16.58	43.17
T3S2	18.01	53.62
T3S3	19.50	63.38
<b>SE±</b>	<b>0.22</b>	<b>0.72</b>
<b>CD at 5%</b>	<b>NS</b>	<b>NS</b>
<b>GENERAL MEAN</b>	17.66	52.65

**Table no. 6 Effect of dipping time and concentration of sugar solution on pectin and tannin of sweet orange peel candy.**

<b>Treatments</b>	<b>Pectin (% calpectate)</b>	<b>Tannin (mg/100g)</b>
<b>Time Period (T)</b>		
T1	1.67	73.61
T2	1.43	62.10
T3	1.18	54.58
<b>SE±</b>	<b>0.007</b>	<b>0.15</b>
<b>CD at 5%</b>	<b>0.02</b>	<b>0.47</b>
<b>Sugar Solution (S)</b>		
S1	1.34	61.56
S2	1.43	63.27
S3	1.51	65.46
<b>SE±</b>	<b>0.007</b>	<b>0.15</b>
<b>CD at 5%</b>	<b>0.02</b>	<b>0.47</b>
<b>Interaction TxS</b>		
T1S1	1.60	72.33
T1S2	1.67	73.51
T1S3	1.74	74.99
T2S1	1.30	59.29
T2S2	1.43	61.65
T2S3	1.56	65.35
T3S1	1.12	53.06
T3S2	1.19	54.64
T3S3	1.24	56.04
<b>SE±</b>	<b>0.013</b>	<b>0.27</b>
<b>CD at 5%</b>	<b>0.039</b>	<b>0.81</b>
<b>GENERAL MEAN</b>	1.42	63.43

## **4.2.2 Organoleptic quality of sweet orange peel candy**

### **4.2.2.1 Colour**

The data regarding effect of dipping time and concentration of sugar solution on colour in sweet orange peel candy have been shown in Table 7. The data reveal that the mean scores for colour in sweet orange peel candy on day zero ranged from 6.25 to 8.50. A significant difference in mean score for dipping time and sugar concentration was observed in colour of sweet orange peel candy and non significant difference was noticed in treatment combinations during zero days. In sweet orange peel candy, for dipping time  $T_3$  had the highest sensory score (7.43) followed by  $T_2$ (7.15) and  $T_1$  (5.5) while for sugar concentration  $S_3$  had the highest sensory score (8.13) followed by  $S_2$  (7.14) and  $S_1$  (6.33). In treatment combinations, maximum score (8.5) was observed in  $T_3S_3$ (36 hrs in 60% sugar solution) with minimum score (6.25) in  $T_1S_1$ (12 hrs in 50% sugar solution).

### **4.2.2.2 Texture**

The data pertaining to effect of dipping time, sugar concentration and their treatment combinations on sensory score for texture (9 point hedonic scale) in sweet orange peel candy have been shown in Table 7. The data reveal that dipping time and sugar concentrations had significant effect and non significant effect in treatment combinations on texture of sweet orange peel candy during zero days.  $T_3$ (8.02) and  $S_3$ (8.40) showed the highest texture scores, respectively. In treatment combinations,  $T_3S_3$ (36 hrs in 60% sugar solution) showed the maximum value (8.60), while  $T_1S_1$ (12 hrs in 50% sugar solution) showed the minimum value (6.00).

### **4.2.2.3 Flavour**

The data regarding effect of dipping time and concentration of sugar solution on flavour in sweet orange peel candy have been shown in Table 6. The data reveal that the mean scores for flavour in sweet orange peel candy on day zero ranged from 5.00 to 8.83. A significant difference in mean score for dipping time and sugar concentration was observed in colour of sweet orange peel candy and non significant difference was noticed in treatment combinations during zero days. In sweet orange peel candy, for dipping time  $T_3$  had the highest sensory score (7.43) followed by  $T_2$  (7.15) and  $T_1$  (5.5) while for sugar concentration  $S_3$  had the highest sensory score (8.13) followed by  $S_2$  (7.14) and  $S_1$  (6.33). In treatment combinations, maximum score (8.5) was observed in  $T_3S_3$ (36 hrs in 60% sugar solution) with minimum score (6.25) in  $T_1S_1$ (12 hrs in 50% sugar solution).

**Table no. 7 Effect of dipping time and concentration of sugar solution on colour, texture, flavour and over acceptability of sweet orange peel candy.**

Treatments	Colour	Texture	Flavour	Overall acceptability
<b>Time Period (T)</b>				
T1	7.02	6.99	6.17	5.87
T2	7.15	7.47	6.72	7.03
T3	7.43	8.02	7.43	7.90
<b>SE±</b>	<b>0.09</b>	<b>0.09</b>	<b>0.08</b>	<b>0.09</b>
<b>CD at 5%</b>	<b>0.27</b>	<b>0.28</b>	<b>0.26</b>	<b>0.27</b>
<b>Sugar Solution (S)</b>				
S1	6.33	6.50	5.40	6.00
S2	7.14	7.59	6.82	6.86
S3	8.13	8.40	8.11	7.94
<b>SE±</b>	<b>0.09</b>	<b>0.09</b>	<b>0.08</b>	<b>0.09</b>
<b>CD at 5%</b>	<b>0.27</b>	<b>0.28</b>	<b>0.26</b>	<b>0.27</b>
<b>Interaction TxS</b>				
T1S1	6.25	6.00	5.00	5.00
T1S2	7.03	7.00	6.20	5.60
T1S3	7.80	7.98	7.33	7.03
T2S1	6.21	6.50	5.50	6.00
T2S2	7.13	7.50	6.50	7.00
T2S3	8.11	8.41	8.16	8.10
T3S1	6.53	7.00	5.70	7.00
T3S2	7.26	8.28	7.76	8.00
T3S3	8.50	8.80	8.83	8.70
<b>SE±</b>	<b>0.15</b>	<b>0.16</b>	<b>0.15</b>	<b>0.15</b>
<b>CD at 5%</b>	<b>NS</b>	<b>NS</b>	<b>0.46</b>	<b>NS</b>
GENERAL MEAN	7.20	7.49	6.77	6.93

#### **4.2.2.4 Overall acceptability**

The data pertaining to effect of dipping time, sugar concentration and their treatment combinations on sensory score for overall acceptability (9 point hedonic scale) in sweet orange peel candy have been shown in Table 7. The data reveal that dipping time and sugar concentrations had significant effect and non significant effect in treatment combinations on overall acceptability of sweet orange peel candy during zero days. T<sub>3</sub>(7.90) and S<sub>3</sub>(7.94) showed the highest overall acceptability scores, respectively. In treatment combinations, T<sub>3</sub>S<sub>3</sub>(36 hrs in 60% sugar solution) showed the maximum value (8.50), while T<sub>1</sub>S<sub>1</sub>(12 hrs in 50% sugar solution) showed the minimum value (5.00).

### **4.3 Changes in physico-chemical constituents and organoleptic quality of sweet orange peel candy during storage.**

#### **4.3.1 Physico-chemical constituents of sweet orange peel candy during storage**

##### **4.3.1.1 Moisture content (%)**

The data regarding effect of dipping time and concentration of sugar solution on moisture content during storage time in sweet orange peel candy have been shown in Table 8. Sweet orange peel candy was stored for 120 days and changes were recorded. A significant decrease in moisture content was observed in different treatments and treatment combinations during storage of candy at 5% level of significance. During storage period mean value of moisture content was decreases from 14.98 to 10.97. Here, after 120 days treatment combination T<sub>1</sub>S<sub>1</sub>(12 hrs in 50% sugar solution) showed the maximum value (12.91%), while T<sub>3</sub>S<sub>3</sub> (36 hrs in 60% sugar solution) showed minimum value (8.77%).

##### **4.3.1.2 Total Solids (%)**

The data pertaining effect of dipping time and concentration of sugar solution on Total solids in sweet orange peel candy have been shown in Table 9. The Total solids of sweet orange peel candy showed a significant increase during storage period. A significant change in Total solids was observed in different treatments and treatment combinations during storage period (120 days) of candy at 5% level of significance. The mean value of total solids was increased from 84.97 to 88.92 during storage period. In sweet orange peel candy, treatment combination T<sub>3</sub>S<sub>3</sub>(36 hrs in 60% sugar solution) showed the maximum value (91.13%), while T<sub>1</sub>S<sub>1</sub>(12 hrs in 50% sugar solution) showed minimum value (87.00%) at the end of storage period.

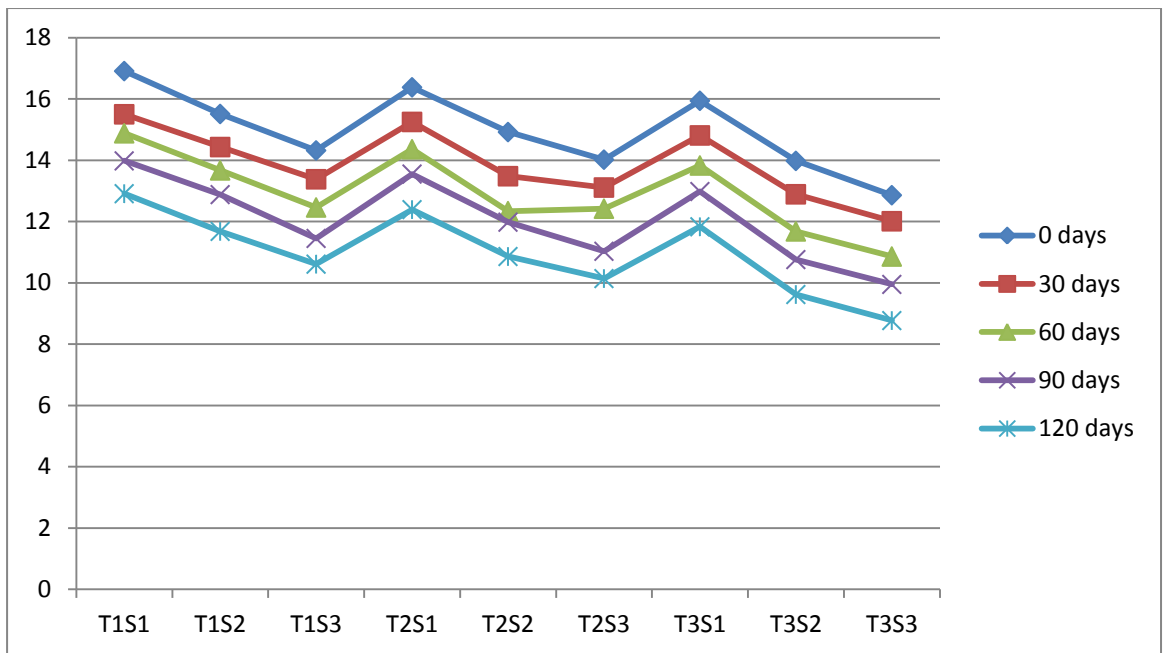
**Table no. 8: Effect of storage period on moisture content (%) of sweet orange peel candy.**

Treatments	Storage Period				
	0 days	30 days	60 days	90 days	120 days
T1S1	16.91	15.5	14.88	13.98	12.91
T1S2	15.51	14.43	13.67	12.88	11.68
T1S3	14.32	13.38	12.46	11.45	10.61
T2S1	16.38	15.25	14.36	13.55	12.39
T2S2	14.92	13.48	12.34	11.98	10.86
T2S3	14.02	13.11	12.42	11.03	10.14
T3S1	15.94	14.81	13.83	12.98	11.83
T3S2	13.98	12.89	11.68	10.76	9.62
T3S3	12.86	12.01	10.86	9.95	8.77
<b>Source</b>	<b>SE±</b>	<b>CD (at 5% level)</b>	<b>General Mean</b>	<b>12.96</b>	
<b>T</b>	0.040	0.110			
<b>S</b>	0.040	0.110			
<b>T x S</b>	0.069	0.192			

**Table no.9 Effect of storage on total solids (%) of sweet orange peel candy**

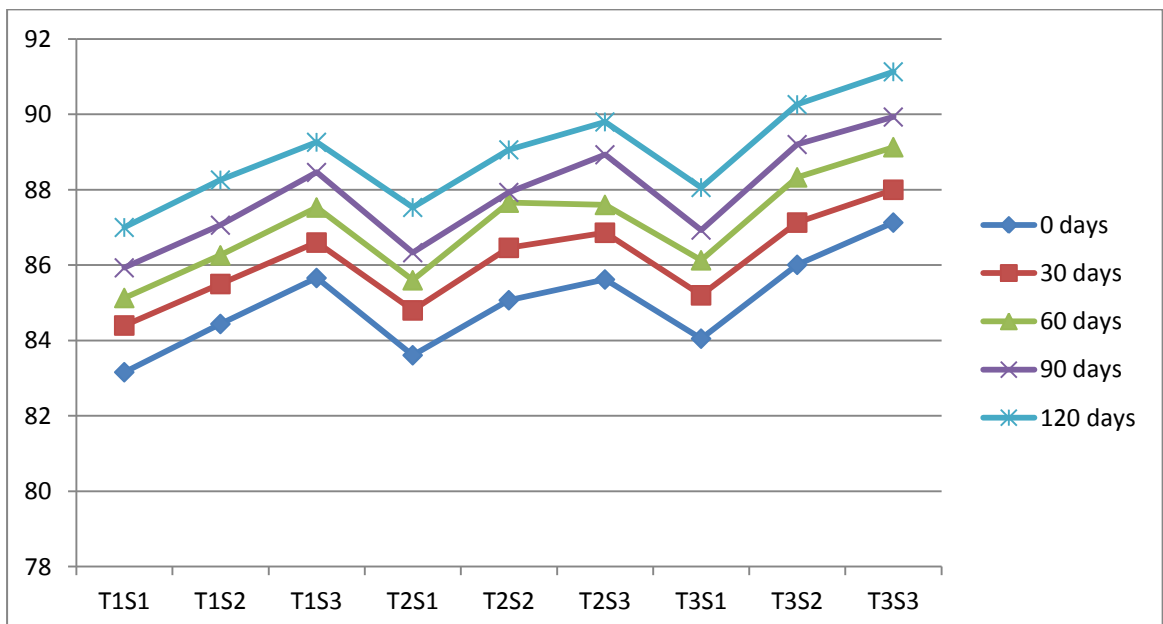
Treatments	Storage Period				
	0 days	30 days	60 days	90 days	120 days
T1S1	83.16	84.40	85.13	85.93	87.00
T1S2	84.44	85.50	86.26	87.06	88.26
T1S3	85.66	86.60	87.53	88.46	89.26
T2S1	83.61	84.80	85.60	86.33	87.53
T2S2	85.07	86.46	87.66	87.93	89.06
T2S3	85.62	86.86	87.60	88.93	89.80
T3S1	84.05	85.20	86.13	86.93	88.06
T3S2	86.01	87.13	88.33	89.20	90.26
T3S3	87.13	88.00	89.13	89.93	91.13
<b>Source</b>	<b>SE±</b>	<b>CD (at 5% level)</b>	<b>General Mean</b>	<b>86.96</b>	
<b>T</b>	0.038	0.107			
<b>S</b>	0.038	0.107			
<b>T x S</b>	0.067	0.186			

**Fig 1. Effect of storage period on moisture content of sweet orange peel candy.**



**Moisture content (%)**

**Fig 2. Effect of storage on total solids of sweet orange peel candy**



**Total solids (%)**

#### **4.3.1.3 pH**

The data regarding effect of dipping time and concentration of sugar solution on pH in sweet orange peel candy have been shown in Table 10. The pH of sweet orange peel candy after storage (120 days) ranged from 2.22 to 3.15. A significant increase in pH was observed in different treatments and treatment combinations during storage of candy. The mean value of pH during storage period increased from 2.34 to 2.54. In sweet orange peel candy, treatment combination T<sub>3</sub>S<sub>3</sub>(36 hrs in 60% sugar solution) showed the maximum value (3.15), while T<sub>1</sub>S<sub>1</sub>(12 hrs in 50% sugar solution) showed minimum value (2.22) at the end of storage period

#### **4.3.1.4 Total Soluble Solids (%)**

The change in Total Soluble Solids of various treatments and treatment combinations during storage has been summarized in Table 11. The data reveal that treatments and treatment combinations had significant effect on Total Soluble Solids of sweet orange peel candy storage period at 5% level significance. The Total Soluble Solids of candy increased significantly with the advancement of storage period and the mean value of treatments was increased from 65.95 to 71.81. T<sub>3</sub>S<sub>3</sub>(36 hrs in 60% sugar solution) showed maximum Total Soluble Solids (84.66%), while T<sub>1</sub>S<sub>1</sub>(12 hrs in 50% sugar solution) showed minimum TSS (60.33%) at the end of storage period.

#### **4.3.1.5 Titrable Acidity (%)**

The data regarding effect of dipping time and concentration of sugar solution on titrable acidity in sweet orange peel candy have been shown in Table 12. The data reveals that treatments and treatment combinations had significant effect on titrable acidity of sweet orange peel candy during storage period at 5% level of significance. During storage period (120 days) candy showed significant decrease in titrable acidity content and the mean value of treatments decreased from 0.62 to 0.54. Treatment combination T<sub>1</sub>S<sub>1</sub>(12 hrs in 50% sugar solution) showed maximum value (0.61%), while T<sub>3</sub>S<sub>3</sub>(36 hrs in 60% sugar solution) showed minimum value (0.48%) at the end of storage period.

#### **4.3.1.6 Ascorbic Acid (mg/100g)**

The data pertaining to effect of dipping time, sugar concentration and their treatments combinations on ascorbic acid in Sweet orange peel candy is given in Table 13. The ascorbic acid of sweet orange peel candy showed significant differences with dipping time and sugar concentration. Non significant differences

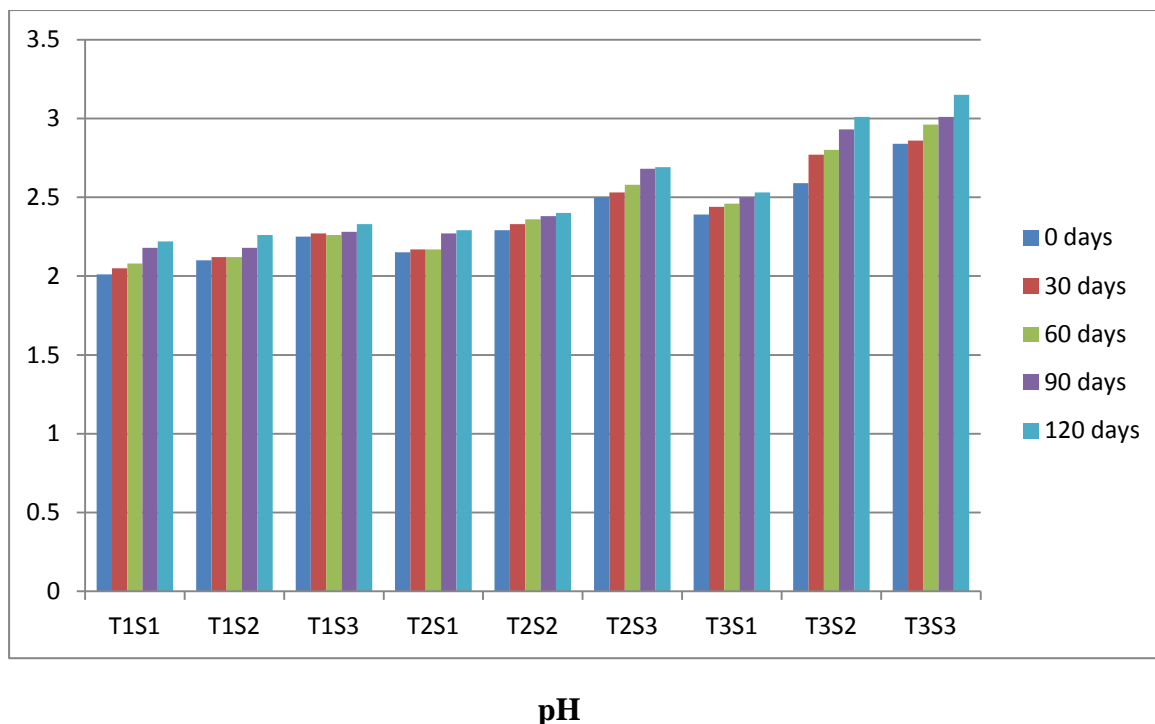
**Table no.10 Effect of storage on pH of sweet orange peel candy**

Treatments	Storage Period				
	0 days	30 days	60 days	90 days	120 days
T1S1	2.01	2.05	2.08	2.18	2.22
T1S2	2.1	2.12	2.12	2.18	2.26
T1S3	2.25	2.27	2.26	2.28	2.33
T2S1	2.15	2.17	2.17	2.27	2.29
T2S2	2.29	2.33	2.36	2.38	2.4
T2S3	2.5	2.53	2.58	2.68	2.69
T3S1	2.39	2.44	2.46	2.5	2.53
T3S2	2.59	2.77	2.8	2.93	3.01
T3S3	2.84	2.86	2.96	3.01	3.15
<b>Source</b>	<b>SE±</b>	<b>CD (at 5% level)</b>		<b>General Mean</b>	<b>2.43</b>
<b>T</b>	0.011	0.032			
<b>S</b>	0.011	0.032			
<b>T x S</b>	0.020	0.056			

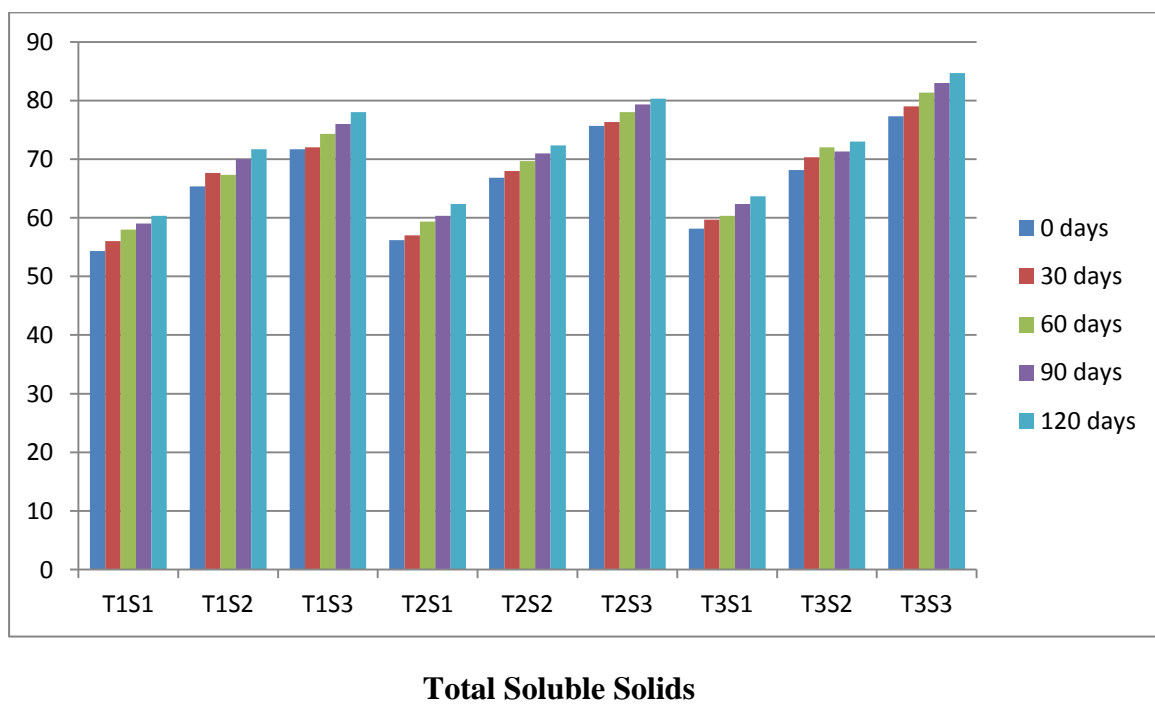
**Table no.11 Effect of storage on TSS (%) of sweet orange peel candy**

Treatments	Storage Period				
	0 days	30 days	60 days	90 days	120 days
T1S1	54.33	56.00	58.00	59.00	60.33
T1S2	65.33	67.66	67.33	69.99	71.66
T1S3	71.66	72.00	74.33	76.00	78.00
T2S1	56.16	57.00	59.33	60.33	62.33
T2S2	66.83	68.00	69.66	71.00	72.33
T2S3	75.66	76.33	78.00	79.33	80.33
T3S1	58.16	59.66	60.33	62.33	63.66
T3S2	68.16	70.33	72.00	71.33	73.00
T3S3	77.33	79.00	81.33	83.00	84.66
<b>Source</b>	<b>SE±</b>	<b>CD (at 5% level)</b>		<b>General Mean</b>	<b>68.85</b>
<b>T</b>	0.149	0.413			
<b>S</b>	0.149	0.413			
<b>T x S</b>	0.259	0.716			

**Fig 3. Effect of storage on pH of sweet orange peel candy**



**Fig 4. Effect of storage on TSS of sweet orange peel candy**



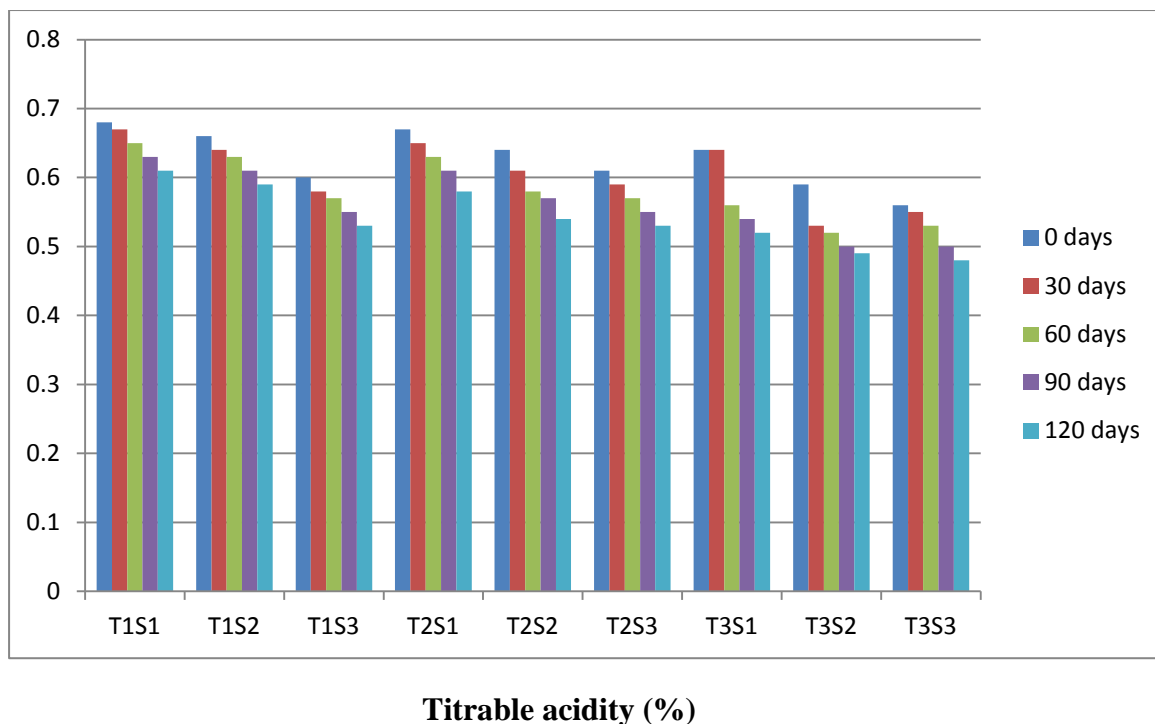
**Table no. 12 Effect of storage on titrable acidity (%) of sweet orange peel candy.**

Treatments	Storage Period				
	0 days	30 days	60 days	90 days	120 days
T1S1	0.68	0.67	0.65	0.63	0.61
T1S2	0.66	0.64	0.63	0.61	0.59
T1S3	0.60	0.58	0.57	0.55	0.53
T2S1	0.67	0.65	0.63	0.61	0.58
T2S2	0.64	0.61	0.58	0.57	0.54
T2S3	0.61	0.59	0.57	0.55	0.53
T3S1	0.64	0.64	0.56	0.54	0.52
T3S2	0.59	0.53	0.52	0.50	0.49
T3S3	0.56	0.55	0.53	0.50	0.48
<b>Source</b>	<b>SE±</b>	<b>CD (at 5% level)</b>	<b>General Mean</b>	<b>0.58</b>	
<b>T</b>	0.003	0.008			
<b>S</b>	0.003	0.008			
<b>T x S</b>	0.005	0.014			

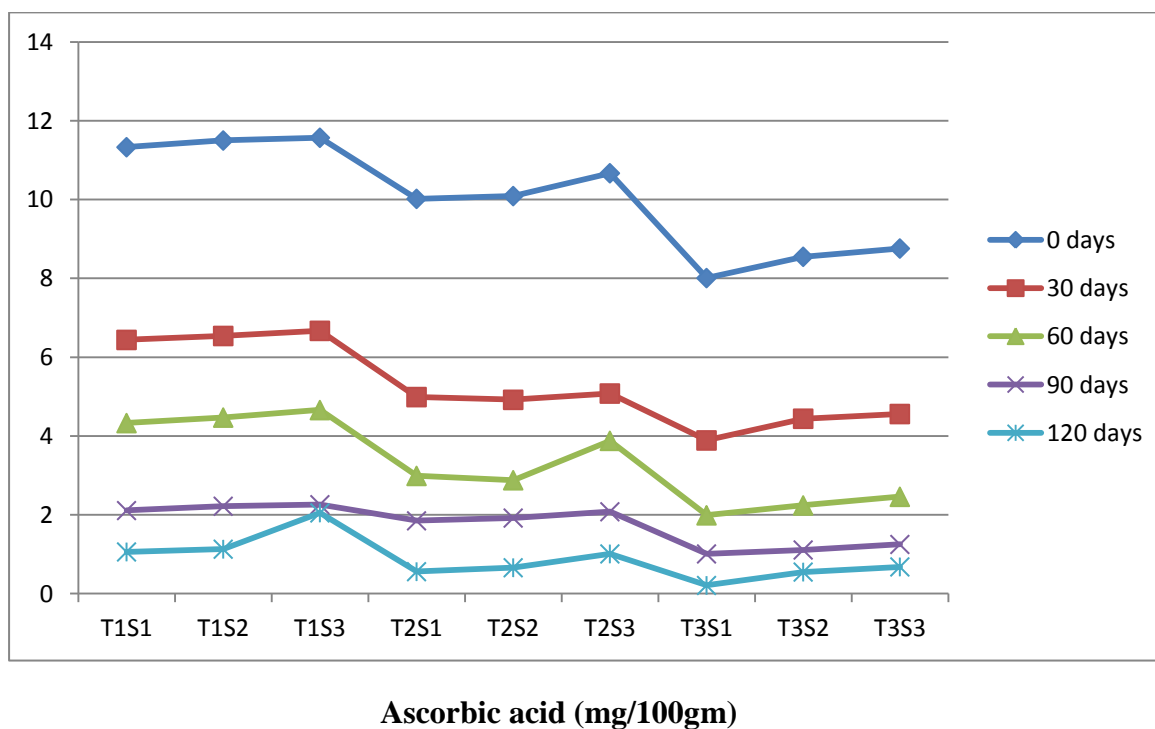
**Table no. 13 Effect of storage on ascorbic acid (mg/100 g) of sweet orange peel candy**

Treatments	Storage Period				
	0 days	30 days	60 days	90 days	120 days
T1S1	11.33	6.44	4.33	2.11	1.06
T1S2	11.50	6.54	4.47	2.22	1.13
T1S3	11.57	6.67	4.66	2.26	2.05
T2S1	10.02	4.99	2.99	1.85	0.56
T2S2	10.09	4.92	2.88	1.92	0.66
T2S3	10.67	5.08	3.88	2.08	1.01
T3S1	8.01	3.89	1.99	1.01	0.21
T3S2	8.55	4.44	2.24	1.11	0.55
T3S3	8.76	4.56	2.46	1.25	0.68
<b>Source</b>	<b>SE±</b>	<b>CD (at 5% level)</b>	<b>General Mean</b>	<b>4.25</b>	
<b>T</b>	0.114	0.316			
<b>S</b>	0.114	0.316			
<b>T x S</b>	0.198	NS			

**Fig 5. Effect of storage on titrable acidity of sweet orange peel candy.**



**Fig 6. Effect of storage on ascorbic acid of sweet orange peel candy**



were observed among various treatment combinations. During storage period candy showed decrease in mean value from 10.05 to 0.87. Sweet orange peel candy showed significant decrease in ascorbic acid content during storage (120 days). In treatment combinations, maximum value was observed in T<sub>1</sub>S<sub>3</sub> (2.05 mg/100g) and minimum in T<sub>3</sub>S<sub>1</sub> (0.21 mg/100 g) at the end of storage period.

#### **4.2.1.7 Reducing Sugar (%)**

The data with respect to effect of dipping time and concentration of sugar solution on reducing sugar in sweet orange peel candy is summarised in Table 14. The data reveals that dipping time and sugar solution had significant differences on reducing sugar during storage period (120 days) of sweet orange peel candy at 5% level of significance. Candy showed significant increase in reducing sugar during storage period and the mean value increased from 17.66 to 20.50. Non significant differences were observed among various treatment combinations. T<sub>3</sub>S<sub>3</sub> (36 hrs in 60% sugar solution) showed maximum value (22.40%), while T<sub>1</sub>S<sub>1</sub> (12 hrs in 50% sugar solution) showed minimum value (18.08 %) at the end of storage period.

#### **4.2.1.8 Total sugars (%)**

The data pertaining to effect of various treatments and their combinations on total sugar on sweet orange peel candy have presented in Table 15. A significant increase was observed in treatments (T and S) and treatment combinations (TxS) during storage period (120 days) at 5% level of significance. Candy showed significant increase in total sugar during storage period and the mean value increased from 52.65 to 56.12. Here, T<sub>3</sub>S<sub>3</sub> showed maximum value (68.54%), while T<sub>1</sub>S<sub>1</sub> (12 hrs in 50% sugar solution) showed minimum value (44.55 %) at the end of storage period.

#### **4.2.1.9 Pectin (% calpectate)**

The data regarding effect of dipping time and concentration of sugar solution on pectin in sweet orange peel candy have been shown in Table 16. The data reveals that the treatments (T and S) and treatment combinations (TxS) showed significant decrease during storage period (120 days) at 5% level of significance. Candy showed significant decrease in pectin during storage period and the mean value decreased from 1.42 to 1.19. For treatment combinations T<sub>1</sub>S<sub>3</sub> showed maximum value (1.54% calpectate), while T<sub>3</sub>S<sub>2</sub> showed minimum value (0.90 % calpectate).

#### **4.2.1.10 Tannin (mg/100g)**

The data pertaining to effect of various treatments and their combinations on tannin content of sweet orange peel candy have presented in Table 17. A significant

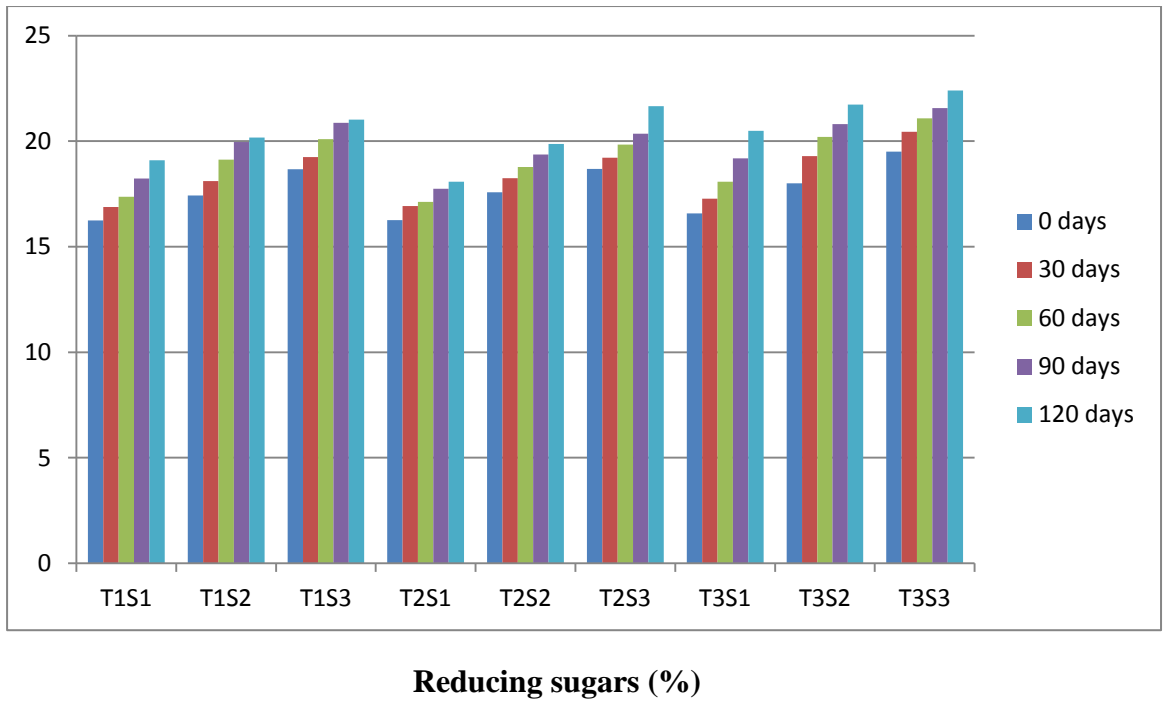
**Table no. 14 Effect of storage on reducing sugar (%) of sweet orange peel candy.**

Treatments	Storage Period				
	0 days	30 days	60 days	90 days	120 days
T1S1	16.24	16.88	17.37	18.23	19.09
T1S2	17.42	18.11	19.12	19.96	20.17
T1S3	18.67	19.24	20.1	20.87	21.02
T2S1	16.26	16.93	17.13	17.75	18.08
T2S2	17.58	18.24	18.78	19.37	19.86
T2S3	18.69	19.22	19.84	20.36	21.66
T3S1	16.58	17.27	18.08	19.19	20.49
T3S2	18.01	19.29	20.2	20.81	21.74
T3S3	19.5	20.45	21.08	21.57	22.4
<b>Source</b>	<b>SE±</b>	<b>CD (at 5% level)</b>		<b>General Mean</b>	<b>19.08</b>
<b>T</b>	0.079	0.021			
<b>S</b>	0.079	0.021			
<b>T x S</b>	0.137	NS			

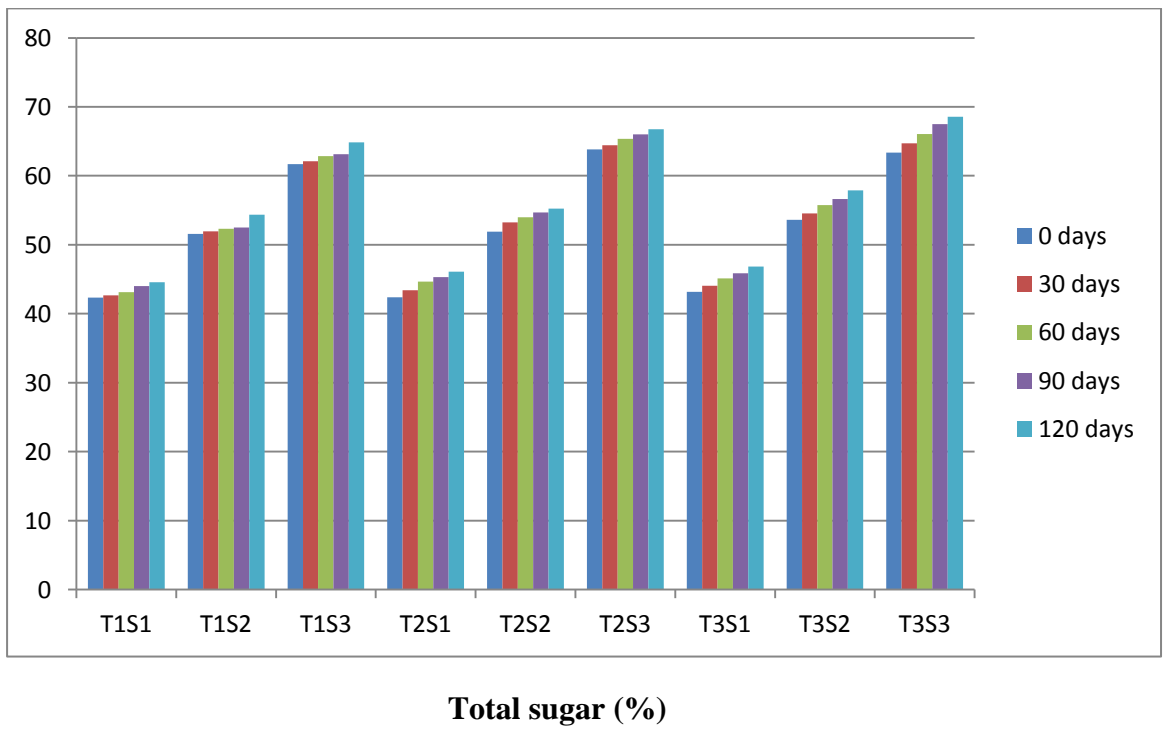
**Table no. 15 Effect of storage on total sugar (%) of sweet orange peel candy**

Treatments	Storage Period				
	0 days	30 days	60 days	90 days	120 days
T1S1	42.35	42.67	43.12	44.02	44.55
T1S2	51.56	51.93	52.31	52.49	54.38
T1S3	61.67	62.11	62.87	63.12	64.85
T2S1	42.4	43.41	44.68	45.29	46.08
T2S2	51.91	53.26	53.98	54.67	55.26
T2S3	63.82	64.45	65.38	66	66.77
T3S1	43.17	44.05	45.11	45.87	46.83
T3S2	53.62	54.55	55.75	56.65	57.88
T3S3	63.38	64.71	66.05	67.47	68.54
<b>Source</b>	<b>SE±</b>	<b>CD (at 5% level)</b>		<b>General Mean</b>	<b>54.33</b>
<b>T</b>	0.111	0.308			
<b>S</b>	0.111	0.308			
<b>T x S</b>	0.193	0.534			

**Fig 7. Effect of storage on reducing sugar of sweet orange peel candy.**



**Fig 8. Effect of storage on total sugar of sweet orange peel candy**



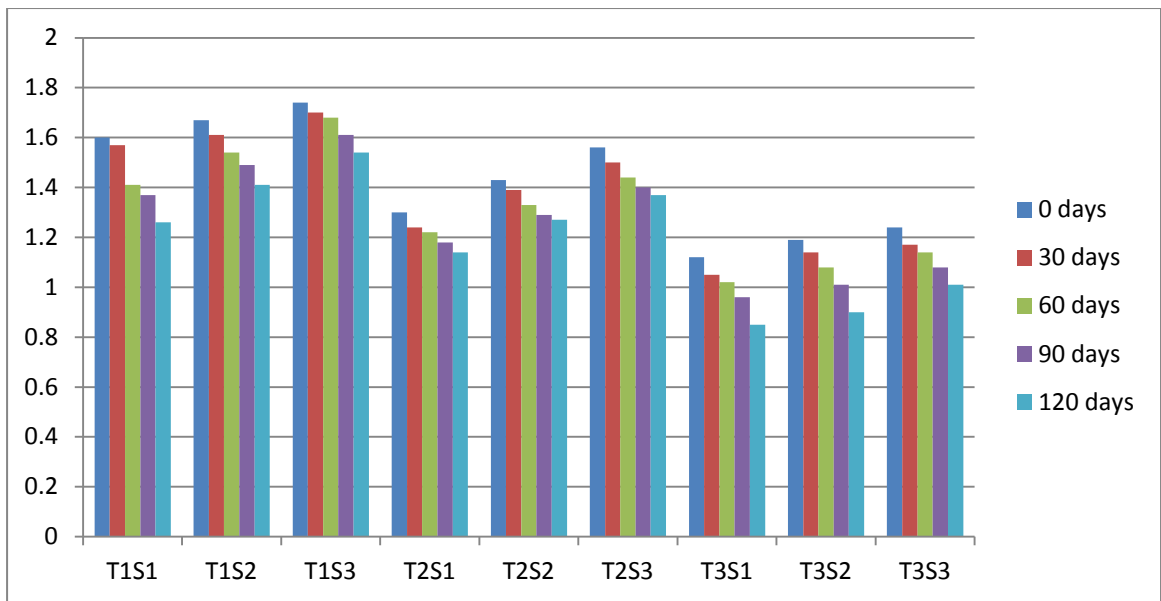
**Table no. 16 Effect of storage on pectin(% calpectate) of sweet orange peel candy**

Treatments	Storage Period				
	0 days	30 days	60 days	90 days	120 days
T1S1	1.6	1.57	1.41	1.37	1.26
T1S2	1.67	1.61	1.54	1.49	1.41
T1S3	1.74	1.7	1.68	1.61	1.54
T2S1	1.3	1.24	1.22	1.18	1.14
T2S2	1.43	1.39	1.33	1.29	1.27
T2S3	1.56	1.5	1.44	1.4	1.37
T3S1	1.12	1.05	1.02	0.96	0.85
T3S2	1.19	1.14	1.08	1.01	0.9
T3S3	1.24	1.17	1.14	1.08	1.01
<b>Source</b>	<b>SE±</b>	<b>CD (at 5% level)</b>	<b>General Mean</b>	<b>1.31</b>	
<b>T</b>	0.007	0.021			
<b>S</b>	0.007	0.021			
<b>T x S</b>	0.013	0.036			

**Table no. 17 Effect of storage on tannin content (mg/100 g) of sweet orange peel candy**

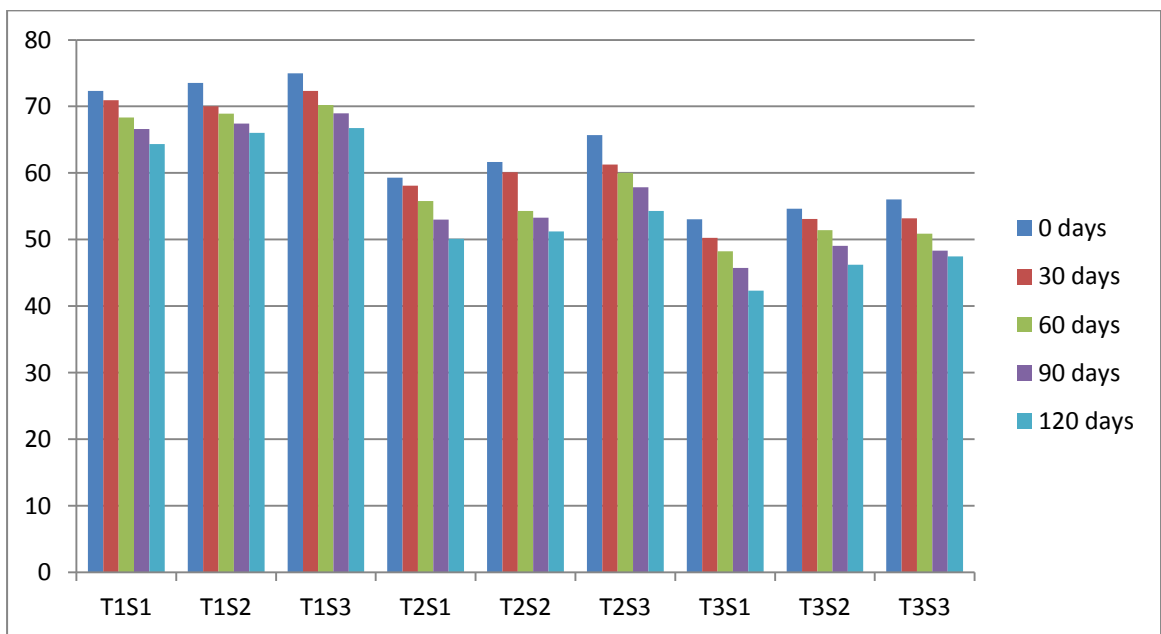
Treatments	Storage Period				
	0 days	30 days	60 days	90 days	120 days
T1S1	72.33	70.93	68.33	66.60	64.34
T1S2	73.51	70.00	68.93	67.45	66.02
T1S3	74.99	72.35	70.21	68.96	66.75
T2S1	59.29	58.10	55.77	53.02	50.14
T2S2	61.65	60.10	54.28	53.29	51.24
T2S3	65.68	61.26	60.00	57.88	54.31
T3S1	53.06	50.26	48.25	45.75	42.35
T3S2	54.64	53.11	51.41	49.04	46.23
T3S3	56.05	53.17	50.89	48.34	47.45
<b>Source</b>	<b>SE±</b>	<b>CD (at 5% level)</b>	<b>General Mean</b>	<b>57.88</b>	
<b>T</b>	0.21	0.59			
<b>S</b>	0.21	0.59			
<b>T x S</b>	0.37	1.03			

**Fig 9. Effect of storage on pectin of sweet orange peel candy**



**Pectin (cal pectate %)**

**Fig 10. Effect of storage on tannin content of sweet orange peel candy**



**Tannin (mg/100 gm)**

difference was observed for dipping time, sugar concentration and their various combinations. Candy showed significant decrease in tannins during storage period and the mean value decreased from 63.46 to 54.31. For dipping time T<sub>1</sub> showed maximum value (73.61 mg/100g), while T<sub>3</sub> showed minimum value (54.58 mg/100g) and for sugar concentration S<sub>3</sub> showed maximum value (65.46 mg/100gm), while S<sub>1</sub> showed minimum value (61.56 mg/100g). In treatment combinations, T<sub>1</sub>S<sub>3</sub> showed maximum value (74.99 mg/100g), while T<sub>3</sub>S<sub>1</sub> showed minimum value (53.06 mg/100g).

### **4.3.2 Organoleptic quality of sweet orange peel candy**

#### **4.3.2.1 Colour**

The data regarding effect of dipping time and concentration of sugar solution on colour in sweet orange peel candy have been shown in Table 18. The data reveal that the mean scores for colour in sweet orange peel candy after 120 days ranged from 3.96 to 7.00. A significant decrease in mean score for treatments (T and S) and treatment combinations (TxS) was observed in colour of sweet orange peel candy during storage period at 5% level of significance. Candy showed significant decrease in colour during storage period and the mean value decreased from 7.20 to 5.32. Here, maximum score (7) was observed in T<sub>3</sub>S<sub>3</sub> (36 hrs in 60% sugar solution) with minimum score (3.96) in T<sub>1</sub>S<sub>1</sub> (12 hrs in 50% sugar solution) at the end of storage period.

#### **4.3.2.2 Texture**

The data pertaining to effect of dipping time, sugar concentration and their treatment combinations on sensory score for texture (9 point hedonic scale) in sweet orange peel candy have been shown in Table 19. The data reveal that treatments (T and S) and treatment combinations (TxS) had significant effect on texture of sweet orange peel candy during storage period (120 days) at 5% level of significance. Candy showed significant decrease in texture during storage period and the mean value decreased from 7.48 to 6.22. Here T<sub>3</sub>S<sub>3</sub> (36 hrs in 60% sugar solution) showed the maximum value (7.83), while T<sub>2</sub>S<sub>1</sub> (24 hrs in 50% sugar solution) showed the minimum value (4.86) at the end of storage period.

#### **4.3.2.3 Flavour**

The data regarding effect of dipping time and concentration of sugar solution on flavour in sweet orange peel candy have been shown in Table 20. The data reveal that the mean scores for flavour in sweet orange peel candy after 120 days ranged

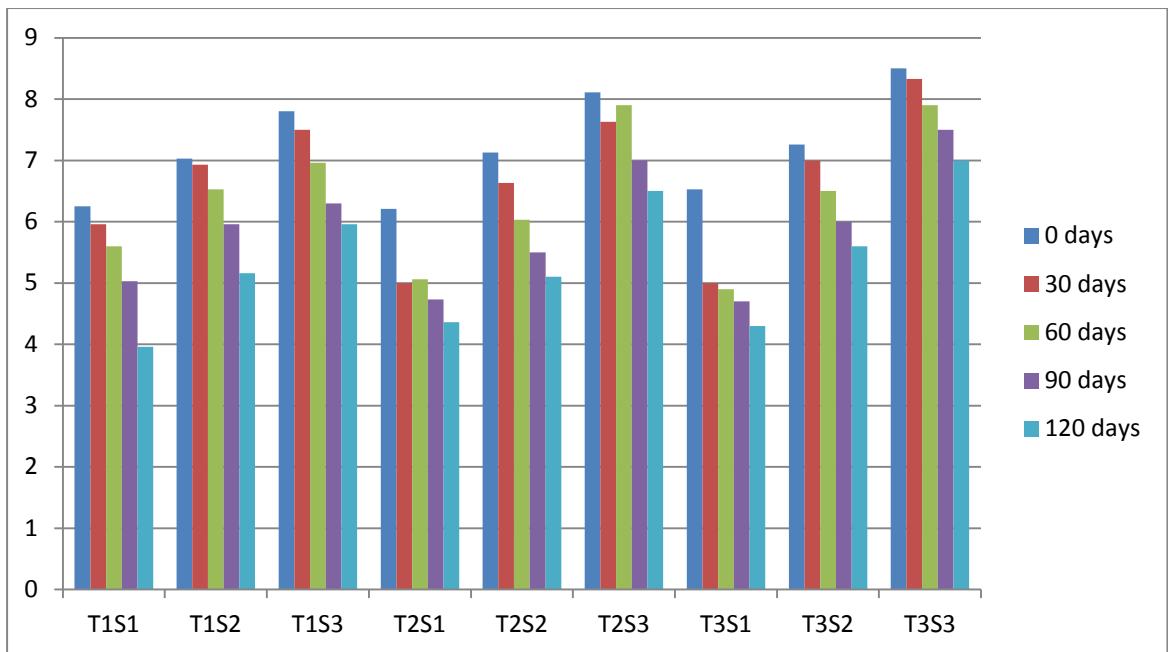
**Table no. 18 Effect of storage on colour of sweet orange peel candy**

Treatments	Storage Period				
	0 days	30 days	60 days	90 days	120 days
T1S1	6.25	5.96	5.60	5.03	3.96
T1S2	7.03	6.93	6.53	5.96	5.16
T1S3	7.80	7.50	6.96	6.30	5.96
T2S1	6.21	5.00	5.06	4.73	4.36
T2S2	7.13	6.63	6.03	5.50	5.10
T2S3	8.11	7.63	7.90	7.00	6.50
T3S1	6.53	5.00	4.90	4.70	4.30
T3S2	7.26	7.00	6.50	6.00	5.60
T3S3	8.50	8.33	7.90	7.50	7.00
<b>Source</b>	<b>SE±</b>	<b>CD (at 5% level)</b>		<b>General Mean</b>	<b>6.28</b>
<b>T</b>	0.063	0.175			
<b>S</b>	0.063	0.175			
<b>T x S</b>	0.109	0.303			

**Table no. 19 Effect of storage on texture of sweet orange peel candy**

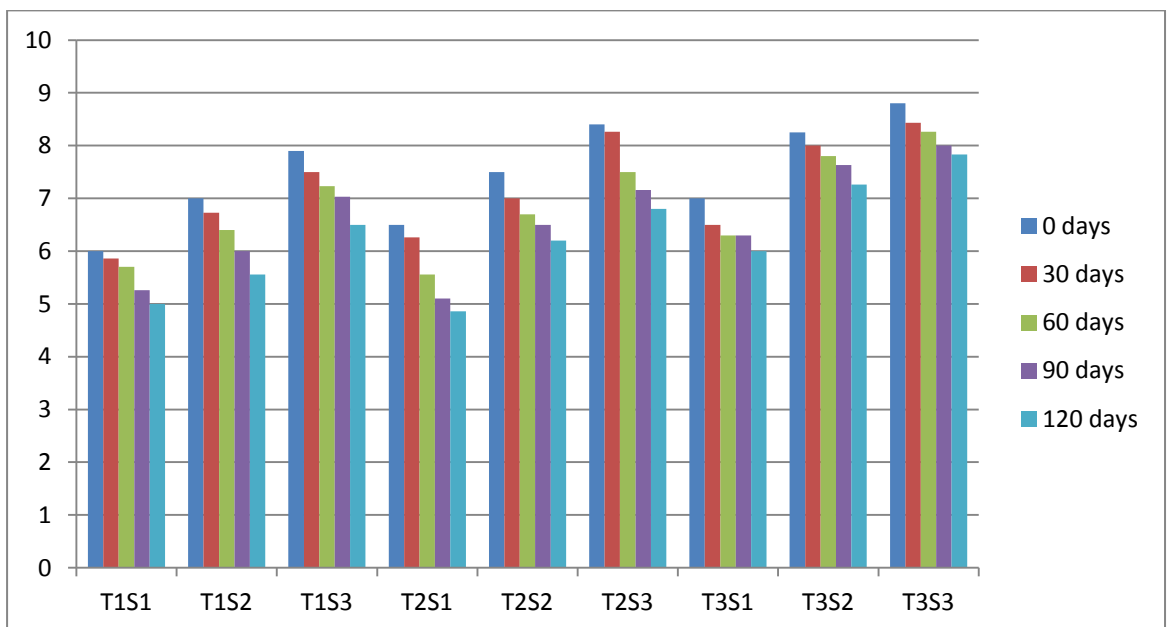
Treatments	Storage Period				
	0 days	30 days	60 days	90 days	120 days
T1S1	6.00	5.86	5.70	5.26	5.00
T1S2	7.00	6.73	6.40	6.00	5.56
T1S3	7.90	7.50	7.23	7.03	6.50
T2S1	6.50	6.26	5.56	5.10	4.86
T2S2	7.50	7.00	6.70	6.50	6.20
T2S3	8.40	8.26	7.50	7.16	6.80
T3S1	7.00	6.50	6.30	6.30	6.00
T3S2	8.25	8.00	7.80	7.63	7.26
T3S3	8.80	8.43	8.26	8.00	7.83
<b>Source</b>	<b>SE±</b>	<b>CD (at 5% level)</b>		<b>General Mean</b>	<b>6.85</b>
<b>T</b>	0.042	0.117			
<b>S</b>	0.042	0.117			
<b>T x S</b>	0.073	0.203			

**Fig 11. Effect of storage on colour of sweet orange peel candy**



**Colour**

**Fig 12. Effect of storage on texture of sweet orange peel candy**



**Texture**

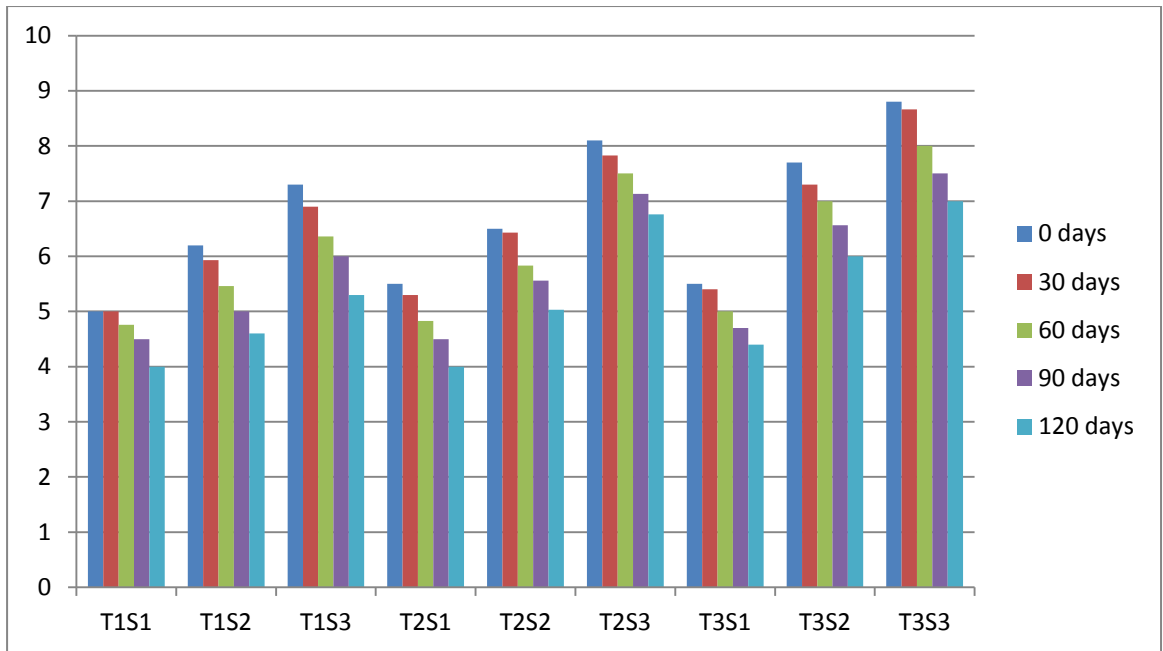
**Table no. 20 Effect of storage on flavour of sweet orange peel candy.**

Treatments	Storage Period				
	0 days	30 days	60 days	90 days	120 days
T1S1	5.00	5.00	4.76	4.50	4.00
T1S2	6.20	5.93	5.46	5.00	4.60
T1S3	7.30	6.90	6.36	6.00	5.30
T2S1	5.50	5.30	4.83	4.50	4.00
T2S2	6.50	6.43	5.83	5.56	5.03
T2S3	8.10	7.83	7.50	7.13	6.76
T3S1	5.50	5.40	5.00	4.70	4.40
T3S2	7.70	7.30	7.00	6.56	6.00
T3S3	8.80	8.66	8.00	7.50	7.00
<b>Source</b>	<b>SE±</b>	<b>CD (at 5% level)</b>		<b>General Mean</b>	<b>6.85</b>
<b>T</b>	0.035	0.098			
<b>S</b>	0.035	0.098			
<b>T x S</b>	0.061	0.171			

**Table no. 21 Effect of storage on overall acceptability of sweet orange peel candy**

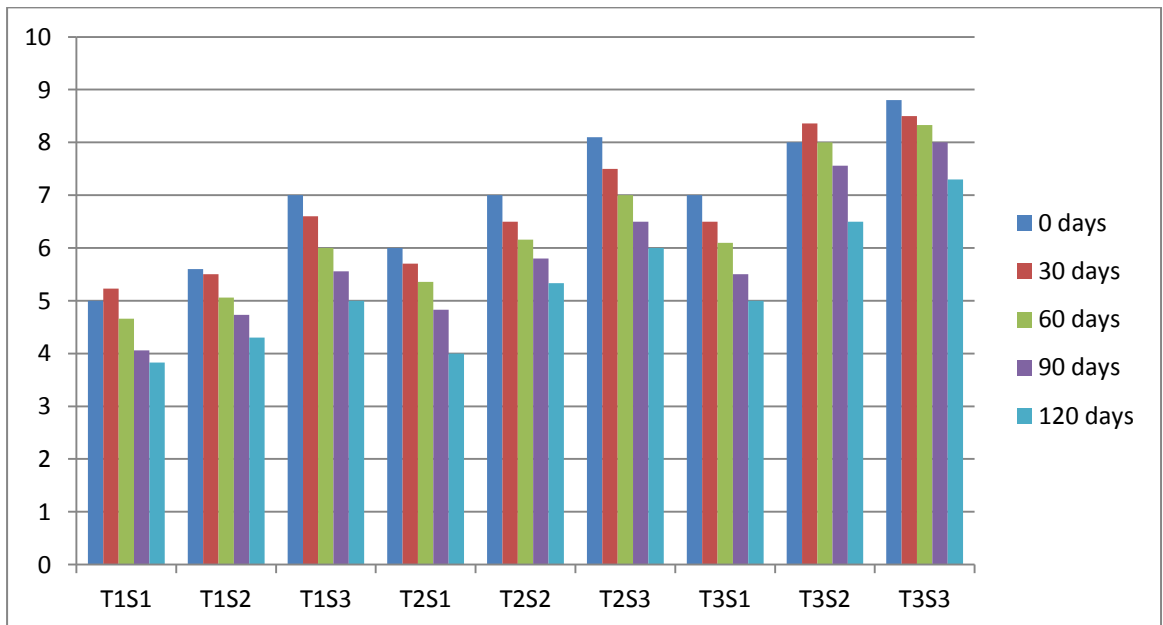
Treatments	Storage Period				
	0 days	30 days	60 days	90 days	120 days
T1S1	5.00	5.23	4.66	4.06	3.83
T1S2	5.60	5.50	5.06	4.73	4.30
T1S3	7.00	6.60	6.00	5.56	5.00
T2S1	6.00	5.70	5.36	4.83	4.00
T2S2	7.00	6.50	6.16	5.80	5.33
T2S3	8.10	7.50	7.00	6.50	6.00
T3S1	7.00	6.50	6.10	5.50	5.00
T3S2	8.00	8.36	8.00	7.56	6.50
T3S3	8.80	8.50	8.33	8.00	7.30
<b>Source</b>	<b>SE±</b>	<b>CD (at 5% level)</b>		<b>General Mean</b>	<b>6.205</b>
<b>T</b>	0.050	0.139			
<b>S</b>	0.050	0.139			
<b>T x S</b>	0.087	0.242			

**Fig 13. Effect of storage on flavour of sweet orange peel candy.**



**Flavour**

**Fig 14. Effect of storage on overall acceptability of sweet orange peel candy**

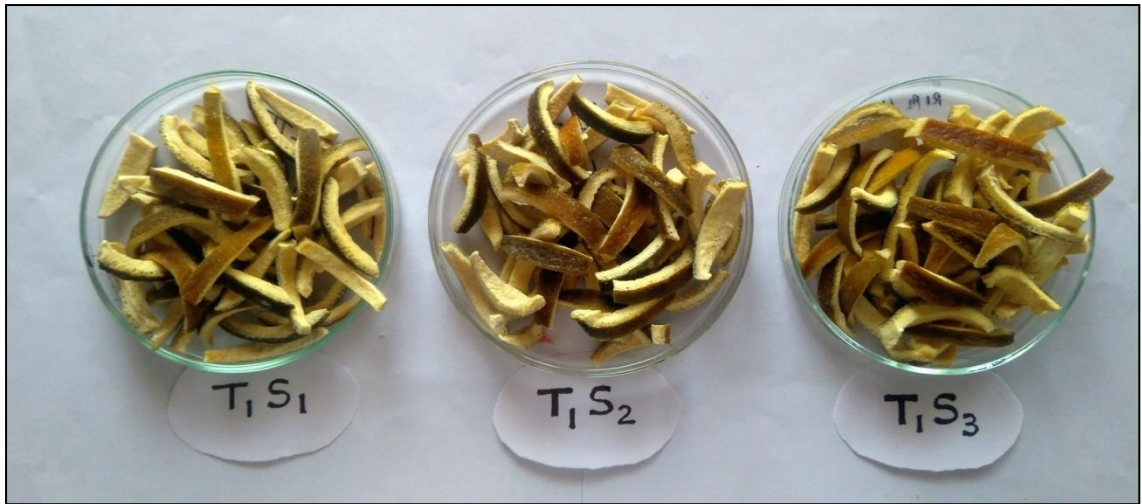


**Overall acceptability**

From 4.00 to 7.00. A significant decrease in mean score for treatments and treatment combination was observed in flavour of sweet orange peel candy during storage at 5% level of significance. Candy showed significant decrease in flavour during storage period and the mean value decreased from 6.73 to 5.23. In sweet orange peel candy, maximum score (7.00) was observed in T<sub>3</sub>S<sub>3</sub> (36 hrs in 60% sugar solution) with minimum score (4.00) in T<sub>1</sub>S<sub>1</sub> (12 hrs in 50% sugar solution) and T<sub>2</sub>S<sub>1</sub> (24 hrs in 50% sugar solution) at the end of storage period.

#### **4.4.2.4 Overall acceptability**

The data pertaining to effect of dipping time, sugar concentration and their treatment combinations on sensory score for overall acceptability (9 point hedonic scale) in sweet orange peel candy have been shown in Table 21. The data reveal that treatments and treatment combinations had significant decrease on overall acceptability of sweet orange peel candy during storage period at 5% level of significance. Candy showed significant decrease in overall acceptability during storage period and the mean value decreased from 6.94 to 5.25. T<sub>3</sub>S<sub>3</sub> (36 hrs in 60% sugar solution) showed the maximum value (7.3), while T<sub>1</sub>S<sub>1</sub> (12 hrs in 50% sugar solution) showed the minimum value (3.83).



**Plate 6. Effect of dipping time and concentration of sugar solution on quality of sweet orange peel candy.**



**Plate 7. Effect of storage period on quality of sweet orange peel candy.**

## CHAPTER-V

### DISCUSSION

The present investigation was carried out on the topic entitled “Studies on standardisation of sweet orange peel candy”. The results on physico-chemical characteristics of fresh sweet orange peel, and changes in chemical constituents and organoleptic quality of sweet orange peel candy during 120 days storage have been discussed under the following headings:

#### 5.1 Physico-chemical characteristics of fresh sweet orange peel

The fresh sweet orange peels were evaluated for various physico-chemical characteristics and the results recorded have been presented in Table 1. On fresh weight basis, moisture content and total solids of fresh peel was found to be 74.8% and 25.6. Total soluble solids (TSS), pH, titratable acidity and ascorbic acid were analyzed to be 11.5, 3.88, 0.48% and 35.6 g/100 g, whereas, reducing sugars, total sugars, pectin and tannins and were found to be 4.5%, 6.75%, 13.34 (% cal pectate) and 170 mg/100 g respectively. Similar results were also reported by Mehta *et al.* (2005), Aggrawal and Michael (2014), Sidhu *et al.* (2015), Siddiqi, (2005), Syed *et al.* (2012), Aggarwal and Sandhu (2003) and Verma *et al.* (2006) in different citrus cultivars.

#### 5.2 Changes in physico-chemical constituents and organoleptic quality of sweet orange peel candy during storage

##### 5.2.1 Physico-chemical constituents

###### 5.2.1.1 Moisture content

The moisture content of sweet orange peel candy decreased significantly during 120 days storage period. This may be due to evaporation of moisture from the samples during storage. The data reveals that the maximum moisture content at zero day was found in T<sub>1</sub>S<sub>1</sub> (16.91%), while minimum value showed by T<sub>3</sub>S<sub>3</sub> (12.86%). After completion of storage period of 120 days T<sub>1</sub>S<sub>1</sub> showed maximum moisture content (12.91%), while T<sub>3</sub>S<sub>3</sub> showed minimum value (8.77%). During storage period mean value of moisture content was decreases from 14.98 to 10.97.

There is a tendency that the higher concentration of sugar decreases the moisture content, it is because peels are soaked in sugar solution will experience osmotic pressure is the pressure of sugar molecules on the cell wall (extra cell) until

the sugar solution enter into it, as a result of water within the cells of peel out. The difference of water flow out and flow of incoming sugar will cause the cell structure and texture of the peel become hard, because of the higher flow of sugar into the osmotic pressure and consequently the stronger the water will more and more that comes out of the material. Similar results were also reported by Pedapati and Tiwari (2014) in osmotically dehydrated guava, Muzzaffar *et al.* (2016) in pumpkin candy, Kumar *et al.* (2015) in effect of sugar and jaggery on the quality characteristics of papaya leather.

#### **5.3.1.2 Total Solids (%)**

The total solids were found to increase significantly in all the treatments during storage. This may be due to natural dehydration of product during storage period.

A significant change in Total solids was observed in different treatments and treatment combinations during storage period (120 days) of candy at 5% level of significance. The mean value of total solids was increased from 84.97 to 88.92 during storage period. On zero day sweet orange peel candy showed maximum total solids in treatment combination T<sub>3</sub>S<sub>3</sub> (87.13%), while minimum value was reported by T<sub>1</sub>S<sub>1</sub> (83.16%). Sweet orange peel candy, treatment combination T<sub>3</sub>S<sub>3</sub> showed the maximum value (91.13%), while T<sub>1</sub>S<sub>1</sub> showed minimum value (87.00%) at the end of storage period. Similar results were also found by Mehta *et al.* (2005) during processing of kandi lemon peel waste for candy making.

#### **5.3.1.3 pH**

The progressive increase in pH during storage period was reported from sweet orange peel candy. A significant increase in pH was observed in different treatments and treatment combinations during storage of candy. This might be due to the decreasing acidity of candy during storage period. The mean value of pH during storage period increased from 2.34 to 2.54. Similar results were also found by Priya and Khatkar (2013) in aonla preserves, Kumar *et al.* (2015) in effect of sugar and jaggery on the quality characteristics of papaya leather and by Mehta *et al.* (2005) during processing of kandi lemon peel waste for candy making.

Maximum value during zero day was recorded from T<sub>3</sub>S<sub>3</sub> (2.84), while T<sub>1</sub>S<sub>1</sub> showed minimum value (2.01) and at the end of storage period maximum value (3.15) showed by 36 hrs dipping time in 70% sugar solution (T<sub>3</sub>S<sub>3</sub>), while minimum value (2.22) showed by 12 hrs dipping time in 50% sugar solution (T<sub>1</sub>S<sub>1</sub>).

#### **5.3.1.4 Total soluble solids**

The total soluble solids were found to increase significantly in all the treatments during storage. This might be due to conversion of polysaccharides into sugars during hydrolysis process. Increase in TSS might also be attributed to reduction in moisture content of the product during storage. The TSS of candy increased significantly with the advancement of storage period and the mean value of treatments was increased from 65.95 to 71.81. The stored IM Bagughosa suffered loss of moisture, which correspondingly increased TSS in the product (Rani and Bhatia, 1986). Ayub, *et al.* (2005) also showed an increase in TSS of intermediate moisture sweetened guava slices during storage.

In sweet orange peel candy maximum TSS value (77.33) showed during zero days by 36 hrs dipping time in 70% sugar solution ( $T_3S_3$ ), while minimum value (50.33) showed by 12 hrs dipping time in 50% sugar solution ( $T_1S_1$ ). At the of storage period maximum value (84.66) recorded by 36 hrs dipping time in 70% sugar solution ( $T_3S_3$ ) due to the high concentration of sugar solution and long duration of dipping time, while minimum value (60.33) showed by 12 hrs dipping time in 50% sugar solution ( $T_1S_1$ ) due to the low concentration of sugar solution and less duration of dipping in sugar solution. Similar results were also found by Kumar *et al.* (2015) during study on development of value added product from citrus peel and Aggrawal and Michael (2014) during study on effect of replacing sucrose with fructose on the physico-chemical sensory characteristics of kinnow candy.

#### **5.3.1.5 Titratable acidity**

A gradual and significant decrease in titratable acidity of sweet orange peel candy was observed during 120 days storage period. This gradual decrease in acidity in case of sweet orange peel candy may be attributed to the effect of salt treatment and reaction acid with basic minerals or interaction binding of acid with peel component with time. Nayak *et al.* (2011), Verma *et al.* (2006) and Kumar *et al.* (2015) reported similar observations in aonla segments in syrup, Darunj peel candy and papaya leather respectively.

In sweet orange peel candy maximum value (0.68%) of titratable acidity during zero days was reported from 12 hrs dipping time in 50% sugar solution ( $T_1S_1$ ) due to small duration of dipping time, while minimum value (0.56%) was reported from 36 hrs dipping time in 70% sugar solution ( $T_3S_3$ ) due to long duration of dipping time which leads to the leaching of acids in sugar solution. At the end of storage period 12

hrs dipping time in 50% sugar solution (T<sub>1</sub>S<sub>1</sub>) showed maximum value (0.61%), while minimum value (0.48%) was observed from 36 hrs dipping time in 70% sugar solution (T<sub>3</sub>S<sub>3</sub>). During storage period (120 days) candy showed significant decrease in titrable acidity content and the mean value of treatments decreased from 0.62 to 0.54.

#### **5.3.1.6 Ascorbic acid**

The ascorbic acid content in sweet orange peel candy decreased 120 days storage period. The possible reason of reduction in vitamin C could be due to oxidation by oxygen, which resulted in formation of dehydroascorbic acid. During storage period candy showed decrease in mean value from 10.05 to 0.87. Rani and Bhatia (1986) and Ayub *et al.* (2005) also reported a declining trend in ascorbic acid in intermediate moisture baguighosa and sweetened guava slices, respectively during storage. Significant decrease was observed from treatments i.e. dipping time and concentration of sugar solution and non significant change was observed from treatment combinations.

Sweet orange peel candy with 12 hrs dipping time and 70% concentration sugar solution showed maximum value (11.57 mg/100g) due to less duration of dipping time, while candy with 36 hrs dipping time and 50% concentration of sugar solution showed minimum value (8.01 mg/100g) due to high leaching effect during dipping time at zero days after preparation of candy. At the end of storage period of 120 days of sweet orange peel candy maximum value (2.05 mg/100g) showed by treatment with 12 hrs dipping time and 70% concentration sugar solution, while minimum value (0.21 mg/100g) was reported from treatment with 36 hrs dipping time and 50% concentration of sugar solution. This is may be due to the different duration of dipping time. Longer duration of dipping in sugar solution leads to less content of ascorbic acid in candy. Similar results were also reported from Priya and Khatkar (2013) during study on effect of processing methods on keeping quality of aonla preserve, Nayak *et al.* (2012) during study on changes in nutritional and organolaptic quality of flavoured candy prepared from aonla during storage.

#### **5.3.1.7 Reducing sugars**

Reducing sugars of sweet orange peel candy increased significantly with storage duration of 120 days. This could be due to inversion of non-reducing into reducing sugars by hydrolysis. Rani and Bhatia (1986) also showed an increase in reducing sugars during 24 weeks storage of IM Baguighosa, which was ascribed to

increased inversion of sugars. Candy showed significant increase in reducing sugar during storage period and the mean value increased from 17.66 to 20.50. Higher reducing sugars (19.50%) were found in treatment combination 36 hrs dipping time in 70% sugar solution (T<sub>3</sub>S<sub>3</sub>), which may be due to high sugar concentration, while minimum reducing sugar (16.24%) was found in treatment combination 12 hrs dipping time in 50% sugar solution (T<sub>1</sub>S<sub>1</sub>) during zero day of candy preparation. At the end of storage period reducing sugar was increased up to 19.09% from 16.24% in T<sub>1</sub>S<sub>1</sub> and 22.40% from 19.50% in T<sub>3</sub>S<sub>3</sub>.

Similar results were also found by Kumar, *et al.*, (2015) during study on development of value added product from citrus peel, Babariya *et al.* (2014) during standardisation of a recipe for the preparation of candy from unripe papaya and Mehta *et al.*, (2005) during processing of kandi lemon peel waste for candy making.

#### **5.3.1.8 Total sugars**

There was a gradual and significant increase in total sugars of sweet orange peel candy with the advancement of storage period. The increase in level of sugars can be attributed to loss of moisture from the products thereby concentrating sugars. Candy showed significant increase in total sugar during storage period and the mean value increased from 52.65 to 56.12. Babariya *et al.* (2014) reported gradual increase in total sugar during storage in papaya candy. The treatment combination 36 hrs dipping time in 70% sugar solution (T<sub>3</sub>S<sub>3</sub>) showed maximum value (63.38%), while 12 hrs dipping time in 50% sugar solution (T<sub>1</sub>S<sub>1</sub>) showed minimum value (42.35%) after preparation of sweet orange peel candy. During storage total sugar of candy increased and T<sub>3</sub>S<sub>3</sub> showed maximum value i.e. 68.54%, while T<sub>1</sub>S<sub>1</sub> showed minimum value i.e. 44.55%. This is due to the high concentration of sugar solution in T<sub>3</sub>S<sub>3</sub> treatment and low sugar concentration in T<sub>1</sub>S<sub>1</sub> treatment. Similar results were also found by Verma *et al.* (2006) during study on effect of methods of preparation and storage on the chemical characteristics of peel candy of Darunaj, Muzzaffar, *et al.* (2016) during study on effect of storage on physicochemical, microbial and antioxidant properties of pumpkin candy and by Nayak *et al.* (2012) during study on changes of nutritional and organoleptic quality of flavoured candy prepared from aonla during storage.

#### **5.3.1.9 Pectin**

There was significant decrease in pectin content of sweet orange peel candy during 120 days of storage period. This could be due to degradation of pectin into

pectic acids during storage. Candy showed significant decrease in pectin during storage period and the mean value decreased from 1.42 to 1.19. Similar findings were reported by Tripathi *et al.* (1988) in aonla candy, preserves and pickles and by Muzzaffar *et al.* (2016) and Mehta *et al.* (2005) in pumpkin candy and kandi lemon peel candy respectively. After preparation of candy, sample with 12 hrs dipping time in 70% sugar solution (T<sub>1</sub>S<sub>3</sub>) showed maximum value (1.74% cal pectate), while sample with 36 hrs dipping time in 50% sugar solution (T<sub>3</sub>S<sub>1</sub>) showed minimum value (1.12% cal pectate). At the end of storage period, T<sub>1</sub>S<sub>3</sub> showed maximum value (1.54% cal pectate), while T<sub>3</sub>S<sub>1</sub> showed minimum value (0.85% cal pectate).

#### **5.3.1.10 Tannins**

Tannins in sweet orange peel candy significantly decreased during 120 days storage. The tannins are highly volatile and are easily oxidized to give brown products of high molecular weight. The decrease in tannins during storage might be due to their condensation into brown pigments. Candy showed significant decrease in tannins during storage period and the mean value decreased from 63.46 to 54.31. Similar results were reported by Priya and Khatkar (2013) in aonla preserves and by Nayak *et al.* (2012) during study on changes of nutritional and organoleptic quality of flavoured candy prepared from aonla during storage.

After preparation of candy, treatment with 12 hrs dipping time in 70% sugar solution (T<sub>1</sub>S<sub>3</sub>) showed maximum value (74.99 mg/100g), while T<sub>3</sub>S<sub>1</sub> showed minimum value (53.06 mg/100g). At the end of storage in treatment combinations, T<sub>1</sub>S<sub>3</sub> showed maximum value (74.99 mg/100g), while T<sub>3</sub>S<sub>1</sub> showed minimum value (53.06 mg/100g).

### **5.2.2 Organoleptic evaluation of sweet orange peel candy during storage**

#### **5.2.2.1 Colour**

A significant decrease in mean score of colour in sweet orange peel candy was recorded during 120 days of storage period. This could be due to occurrence of non-enzymatic browning in candy during storage. Candy showed significant decrease in colour during storage period and the mean value decreased from 7.20 to 5.32. In treatment combinations, maximum score (8.5) was observed in T<sub>3</sub>S<sub>3</sub> with minimum score (6.25) in T<sub>1</sub>S<sub>1</sub> after preparation of candy. At the end of storage period of candy, maximum score (7.00) was observed in T<sub>3</sub>S<sub>3</sub> with minimum score (3.96) in T<sub>1</sub>S<sub>1</sub>. Candy showed chocolate colour probably due to caramelization of sugar.

Colour of treatment combination T<sub>3</sub>S<sub>3</sub> comparatively attractive during storage period at ambient temperature. Similar results have been reported by Durrani *et al.* (2011) in development and quality evaluation of honey based carrot candy and by Shamrez *et al.* (2013) in preparation and evaluation of candies from citron peel.

#### **5.2.2.2 Texture**

The mean score for texture in sweet orange peel candy decreased significantly during 120 days storage period. This could be due to loss of moisture by the candy during storage period. Candy showed significant decrease in texture during storage period and the mean value decreased from 7.48 to 6.22. The data reveals that the treatment combinations, 36 hrs dipping time in 70% sugar solution (T<sub>3</sub>S<sub>3</sub>) showed the maximum score (8.60), while T<sub>1</sub>S<sub>1</sub> showed the minimum score (6.00). At the end of storage period of 120 days, T<sub>3</sub>S<sub>3</sub> showed the maximum score (7.83), while 24 hrs dipping time in 50% sugar solution (T<sub>2</sub>S<sub>1</sub>) showed the minimum score (4.86) at the end of storage period. This is due to the high concentration of sugar solution and dipping time of candy. Similar results were also recorded by Chauhan *et al.* (2014) in papaya candy and by Shamrez *et al.* (2013) during preparation and evaluation of candies from citron peel.

#### **5.2.2.3 Flavour**

The data reveals that the sensory score for flavour of sweet orange peel candy decreases significantly during storage period (120 days). Decrease in flavour may be due to some oxidative and physic-chemical change during storage and also it is a sensory attribute it depends on human perception. Candy showed significant decrease in flavour during storage period and the mean value decreased from 6.73 to 5.23. Similar results were also found by Kumar *et al.* (2015) during study on development of value added product from citrus peel and by Jothi *et al.* (2014) during development and shelf-life prediction of pineapple preserve and candy. After preparation candy, treatment combinations T<sub>3</sub>S<sub>3</sub> showed maximum score (8.5), while treatment combination T<sub>1</sub>S<sub>1</sub> showed minimum score (6.25) and during storage period sample with treatment combination T<sub>3</sub>S<sub>3</sub> showed maximum score (7.00), while sample having treatment combination T<sub>1</sub>S<sub>1</sub> showed minimum score (4.00). Treatment combination T<sub>3</sub>S<sub>3</sub> is highly acceptable with relation to flavour and this is due to the high sugar concentration and longer dipping time duration.

#### 5.2.2.4 Overall acceptability

The decreased overall acceptability scores in sweet orange peel candy were observed during storage period. This is due to decreased scores for colour, texture and flavour of candy during storage period. Candy showed significant decrease in overall acceptability during storage period and the mean value decreased from 6.94 to 5.25. Sweet orange peel candy showed maximum score during zero day for treatment combination T<sub>3</sub>S<sub>3</sub> i.e. 8.80 and minimum score showed by treatment combination T<sub>1</sub>S<sub>1</sub> i.e. 5.00 and during storage period same results were observed i.e. maximum score from T<sub>3</sub>S<sub>3</sub> (7.3), while minimum scores from T<sub>1</sub>S<sub>1</sub> (3.83). Treatment combination T<sub>3</sub>S<sub>3</sub> remains most acceptable during the storage period due to the high sugar concentration (70%) and longer dipping time (36 hrs). Similar results were also reported by Balaji *et al.* (2014) during the comparative study of varieties, honey coating and storage duration on aonla candy, Patil *et al.* (2014) in sensory quality and economics of preparation of karonda candy and Gupta *et al.* (2013) during study of sugar concentration and time interval on quality and storability of ber chuhara.

## CHAPTER-VI

### SUMMARY AND CONCLUSIONS

The present investigation entitled, “Studies on standardization of sweet orange peel candy” was carried out at department of Horticulture V.N.M.K.V. Parbhani during 2016-17. The objectives of investigation were To study the effect of concentration of sugar syrup and period of dipping for preparation of sweet orange peel candy and also to study the effect on quality of sweet orange peel candy during storage. The salient findings of the investigation are summarized as under:

- ✓ On fresh weight basis, moisture content and total solids of fresh peel was found to be 74.8% and 25.6. Total soluble solids (TSS), pH, titratable acidity and ascorbic acid were analyzed to be 11.5, 3.88, 0.48% and 35.6 g/100 g, whereas, reducing sugars, total sugars, pectin and tannins and were found to be 4.5%, 6.75%, 13.34 (% calpectate) and 170 mg/100 g respectively.
- ✓ A significant decrease in moisture content was observed in different treatments and treatment combinations during storage of candy at 5% level of significance. After 120 days treatment combination T<sub>1</sub>S<sub>1</sub> (12 hrs in 50% concentration sugar solution) showed the maximum value (12.91%), while T<sub>3</sub>S<sub>3</sub> (36 hrs in 70% concentration sugar solution) showed minimum value (8.77%).
- ✓ A significant change in Total solids was observed in different treatments and treatment combinations during storage period (120 days) of candy at 5% level of significance. In sweet orange peel candy, treatment combination T<sub>3</sub>S<sub>3</sub> (36 hrs in 70% concentration sugar solution) showed the maximum value (91.13%), while T<sub>1</sub>S<sub>1</sub> (12 hrs in 50% concentration sugar solution) showed minimum value (87.00%) at the end of storage period.
- ✓ A significant increase in pH was observed in different treatments and treatment combinations during storage of candy. In sweet orange peel candy, treatment combination T<sub>3</sub>S<sub>3</sub> (36 hrs in 70% concentration sugar solution) showed the maximum value (3.15), while T<sub>1</sub>S<sub>1</sub> (12 hrs in 50% concentration sugar solution) showed minimum value (2.22) at the end of storage period.
- ✓ The TSS of candy increased significantly with the advancement of storage period. T<sub>3</sub>S<sub>3</sub> (36 hrs in 70% concentration sugar solution) showed maximum

TSS (84.66%), while T<sub>1</sub>S<sub>1</sub> (12 hrs in 50% concentration sugar solution) showed minimum TSS (60.33%) at the end of storage period.

- ✓ During storage period (120 days) candy showed significant decrease in titrable acidity content. Treatment combination T<sub>1</sub>S<sub>1</sub> (12 hrs in 50% concentration sugar solution) showed maximum value (0.61%), while T<sub>3</sub>S<sub>3</sub> (36 hrs in 70% concentration sugar solution) showed minimum value (0.48%) at the end of storage period.
- ✓ The ascorbic acid of sweet orange peel candy showed significant differences with dipping time and sugar concentration. Non significant differences were observed among various treatment combinations. Sweet orange peel candy showed significant decrease in ascorbic acid content during storage (120 days). In treatment combinations, maximum value (2.05 mg/100g) was observed in T<sub>1</sub>S<sub>3</sub> (12 hrs in 70% concentration sugar solution) and minimum value (0.21 mg/100g) in T<sub>3</sub>S<sub>1</sub> (36 hrs in 50% concentration sugar solution) at the end of storage period.
- ✓ Candy showed significant increase in reducing sugar during storage period. Non-significant differences were observed among various treatment combinations. T<sub>3</sub>S<sub>3</sub> (36 hrs in 70% concentration sugar solution) showed maximum value (22.40%), while T<sub>1</sub>S<sub>1</sub> (12 hrs in 50% concentration sugar solution) showed minimum value (18.08 %) at the end of storage period.
- ✓ A significant increase of total sugars was observed in treatments (T and S) and treatment combinations (TxS) during storage period (120 days) at 5% level of significance. T<sub>3</sub>S<sub>3</sub> (36 hrs in 70% concentration sugar solution) showed maximum value (68.54%), while T<sub>1</sub>S<sub>1</sub> (12 hrs in 50% concentration sugar solution) showed minimum value (44.55 %) at the end of storage period.
- ✓ The data reveals that the treatments (T and S) and treatment combinations (TxS) showed significant decrease in pectin during storage period (120 days) at 5% level of significance. For treatment combinations T<sub>1</sub>S<sub>3</sub> showed maximum value (1.54% calpectate), while T<sub>3</sub>S<sub>2</sub> showed minimum value (0.90 % cal pectate).
- ✓ A significant difference was observed in tannin content for dipping time, sugar concentration and their various combinations. In treatment combinations, T<sub>1</sub>S<sub>3</sub> (12 hrs in 70% concentration sugar solution) showed maximum value (74.99

mg/100g), while T<sub>3</sub>S<sub>1</sub> (36 hrs in 50% concentration sugar solution) showed minimum value (53.06 mg/100g).

- ✓ A significant decrease in mean score for treatments (T and S) and treatment combinations (TxS) was observed in colour of sweet orange peel candy during storage period at 5% level of significance. Maximum score (7) was observed in T<sub>3</sub>S<sub>3</sub> (36 hrs in 70% concentration sugar solution) with minimum score (3.96) in T<sub>1</sub>S<sub>1</sub> (12 hrs in 50% concentration sugar solution) at the end of storage period.
- ✓ The data reveal that treatments (T and S) and treatment combinations (TxS) had significant effect on texture of sweet orange peel candy during storage period (120 days) at 5% level of significance. T<sub>3</sub>S<sub>3</sub> (36 hrs in 70% concentration sugar solution) showed the maximum value (7.83), while T<sub>2</sub>S<sub>1</sub> (24 hrs in 50% conc. sugar solution) showed the minimum value (4.86) at the end of storage period.
- ✓ A significant decrease in mean score for treatments and treatment combination was observed in flavour of sweet orange peel candy during storage at 5% level of significance. In sweet orange peel candy, maximum score (7.00) was observed in T<sub>3</sub>S<sub>3</sub> (36 hrs in 70% concentration sugar solution) with minimum score (4.00) in T<sub>1</sub>S<sub>1</sub> and T<sub>2</sub>S<sub>1</sub> at the end of storage period.
- ✓ The data reveal that treatments and treatment combinations had significant decrease on overall acceptability of sweet orange peel candy during storage period at 5% level of significance. T<sub>3</sub>S<sub>3</sub> (36 hrs in 70% concentration sugar solution) showed the maximum value (7.3), while T<sub>1</sub>S<sub>1</sub> (12 hrs in 50% concentration sugar solution) showed the minimum value (3.83).

## CONCLUSION

The sweet orange peel candy was made up by using different treatment combinations i.e. dipping time and concentration of sugar solution. There are three dipping times i.e. 12 hrs, 24 hrs and 36 hrs and three levels of concentrations i.e. 50%, 60% and 70%. Candy was prepared by combining these treatments. Firstly the physico-chemical analysis of sweet orange peel was done. Sweet orange peel candy was stored for 120 days and the physico-chemical and organoleptic changes were recorded. During storage period there in significant decrease was observed in moisture, titrable acidity, ascorbic acid, pectin and tannins of sweet orange peel candy. Decrease in moisture is due to the evaporation of moisture from sample during storage period. Decrease in acids of candy may be due to the effect of salt treatment and reaction acid with basic minerals or interaction binding of acid with peel component with time and formation of dehydroascorbic acid during storage. Gradual decline in pectin and tannin is may be due to degradation of pectin into pectic acid and oxidation of tannins from candy during storage period. A significant increase in total solids, pH, TSS, reducing sugar and total sugar was observed during storage period. Increase in pH may be due to the decreasing acidity of candy and increase in total solids may be due to the decreasing moisture content of candy during storage period. Organoleptic quality of candy was decreases significantly during the storage period. Colour, texture, flavour and overall acceptability of candy gradually decreases with the advancement of storage period. Treatment combination, 36 hrs dipping time in 70% sugar solution showed maximum values during storage period for all organoleptic qualities. T<sub>3</sub>S<sub>3</sub> treatment combination reported highly acceptable at the time of preparation and during storage period, this is due to the high concentration of sugar solution and longer dipping time in comparison to other treatments. High sugar concentration imparted good colour, flavour and texture to sweet orange peel candy sensory basis. After completion of storage period of 120 days treatment combination T<sub>3</sub>S<sub>3</sub>, T<sub>3</sub>S<sub>2</sub> and T<sub>2</sub>S<sub>3</sub> was remained acceptable in organoleptic quality on the the basis of sensory evaluation.

## LITERATURE CITED

- Anon, 2006, Food and Agriculture Organization of the United Nations (2006). (FAO Statistics), <http://faostat.fao.org/default.aspx>.
- A.O.A.C. 1990. *Official Methods of Analysis. Association of Official Analytical Chemists*. Washington, D.C. 15th edition.
- Acibia, Zaragoza, Montgomery, R. 2004. Development of biobased products. *Bioresource Technology*, **91**, 1–29.
- Aggarwal, P. and Michael, M., 2014. Effect of Replacing Sucrose with Fructose on the Physico-chemical Sensory Characteristics of Kinnow Candy. *Czech J. Food Sci.* **32** (2): 158–163.
- Aggarwal, P. and Sandhu, K. S., 2003. Effect of harvesting time on physico-chemical properties of juice components of Kinnow. *J Food Sci Technol* **40**: 66-68.
- Ahemed, J. & Choudhary, D. R., 1995. Osmotic dehydration of papaya. *Indian Food Pack*, **49**, 5-11.
- Ahmad, S. and Kumaran, N., 2015. Studies on the effects of honey incorporation on quality and shelf life of aonla preserve. *Cogent Food & Agriculture* **1**: 1009334 1-8.
- Angew, O. N. 2007. Functional foods, *Trends in Food Science and Technology*, **30**: 19-21.
- Aronika, J. and Manimehalai, N., 2014. Studies on the Effect of Process Parameter on the Textural Characteristics of Osmotically Dehydrates Papaya (Var. Red lady) Cubes. *International Journal of Agriculture and Food Science Technology*. **5**: 75-80.
- Avis C. B., John O. A. and Gail S. H. B. T., 2007. Effect of drying and storage on flavour quality of orange (*Citrus cinensis* (Linn) Osbeck) peel for cupcakes . *Journal of Food, Agriculture & Environment*. **5** (2): 78-82.
- Ayub, M., Zeb, A. and Ullah, J. 2005. Effect of various sweeteners on chemical composition of guava slices. *Sarhad Journal of Agriculture*, **21**(1): 131-134.

- Babariya, V.J., Makwana, A.N., Hadwani, M. and Panjair, N., 2014. Standardization of a recipe for the preparation of candy (tuti fruiti) from unripe papaya. *The Asian Journal of Horticulture*, **9** (1): 94-99.
- Bajpai, R., Yadav, M., Mure, S. and Kushwah, R. S., 2015. Browning analysis of different Karonda processed products during storage. *Plant Archives*, **15** (1): 339-342.
- Balaji, V., Prasad, V.M. and Saroj, P.L., 2014. Comparative study of varieties, honey coating and storage durations on aonla candy. *Indian J. Hort.* **71** (1): 104-108.
- Benjamin, A. C., Akingbala J. O., and Baccus-Taylor G. S. H., 2007. Effect of drying and storage on flavour quality of orange (*Citrus cinensis* (Linn) Osbeck) peel for cupcakes. *Journal: Food, Agriculture and Environment (JFAE)* Vol. **5**, (2): 78-82.
- Bernardi, J., Licciardello, C., Russo, M.P., Chiusano, M. L., Carletti, G., Recupero, G. R., Marocco, A., 2010. Use of a custom array to study differentially expressed genes during blood orange (*Citrus sinensis* L. Osbeck) ripening, *Journal of Plant Physiology*, vol. **167**: 301–310.
- Bhatlu, L. D., Yadav A. K., and Singh, S. V., 2014. Preparation of Candy from Kinnow (*Citrus*) Peel, *Global Sustainability Transitions: Impacts and Innovation*. ISBN: 978-93-83083-77-0: 152-154.
- Bongirwar, D. R., & Sreenivasan, A., 1977. Osmotic dehydration of banana. *J. Food Sci. Technol*, **14** (3): 104-112.
- Braddock, R.J. 1999. *Handbook of Citrus By-Products and Processing Technology*. New York: John Wiley & Sons, Inc.: 117-133.
- Cha, J. Y., Cho, Y. S., Kim, I., Anno, T., Rahman, S. M., Yanagita, T., 2001. Effect of hesperetin, a citrus flavonoid on the liver triacylglycerol content and phosphatidate phosphohydrolase activity in orotic acid-fed rats, *Plant Foods for Human Nutrition*, **56**: 349–358.
- Chauhan, N., Singh, S., Singh, P., Singh B.R., Sweta, 2014. Effect of Different Citric Acids Levels on Quality Papaya Candy Prepared by Various Methods. *Indian Journal of Research*, **3** (9): 1-4.
- Choudhary, M.L., Verma, I.M., Singh J. and Godara, S.L., (2012) Studies on aonla (*Emblca officinalis* Gaertn) nectar and biochemical changes with

- advancement of storage period. *The Asian Journal of Horticulture*. **7** (1):128-132.
- Cohn, R., Cohn, A. L., 1997. Subproductos del procesado de las frutas. In: Arthey, D., Ashurst, P. R. (Ed.), *Procesado de frutas* (288).
- Crowell, P. L ., 1999. Prevention and therapy of cancer by dietary monoterpenes. *The Journal of Nutrition* **129** (3): 775S–778S.
- Dar, B. N., Ahsan, H., Wani, S. M. and Dalal, M. R., 2011. Effect of CaCl<sub>2</sub>, Citric Acid and Storage Period on Physico-Chemical Characteristics of Cherry Candy. *Journal of Food Science and Engineering*. **1**:154-160
- Deepika, Panja, P., Dombewarisa, S., Marak and Thakur, P.K., 2016. Effect of packaging on quality of enriched fruit bars from aonla (*Emblica officinalis* G.) during storage. *International Journal of Agriculture, Environment and Biotechnology*. **9**(3): 411-419.
- Durrani, A. M., Srivastava, P. K. & Verma, S., 2011. Development and quality evaluation of honey based carrot candy. *J Food Sci Technol*, **48**(4):502–505.
- Ehler, S. A., 2011. Citrus and its benefits, *Journal of Botany*, **5**: 201-207.
- Ejaz, S., Ejaz, A., Matsuda, K., Chae, W. L., 2006. Limonoids as cancer chemopreventive agents, *Journal of the Science of Food and Agriculture*, **86**: 339–345.
- Elangovan, V., Sekar, N., Govindasamy, S., 1994. Chemopreventive potential of dietary bioflavonoids against 20-methylcholanthreneinduced tumorigenesis, *Cancer Letters*, **87**: 107–113.
- Gupta, N. and Kaul, R.K., 2013. Effect of sugar concentration and time interval on quality and storability of ber chuhara. *Indian J. Hort.* **70**(4): 566-570.
- Hamapitour, M.S., Majidi, S.M., Abdi, M., Farbodnia 2004. Potentials for industrial utilization of citrus byproducts.16th International Congress of Chemical and Process Engineering, 22-26 APrague, Czech Republic: 9263.
- Hirano, T., Gotoh, M., Oka, K., 1994. Natural flavonoids and lignans are potent cytostatic agents against human leukemia HL-60 cells. *Life Science*, **55**: 1061–1069.
- Hiremath, J.B and Rokhade, A.K., 2012. Preparation of Sapota Candy. *International Journal of Food, Agriculture and Veterinary Science*. **2** (1): 107-112.

- Hussain, I., Iqbal, M., Shakir, I. and Ayub, M., 2004. Effect of sucrose and glucose mixture on the quality characteristics of osmotically dehydrated banana slices. *Pakistan Journal of Nutrition*, **3**(5): 282-284.
- Izquierdo, L. and J.M. Sendra., 2003. Citrus Fruit composition and characterization. In Encyclopedia of food sciences and nutrition, edited by B. Caballero, L. Trugo, and P. Finglas, 6000. Oxford Academic Press.
- Jain, K.S.P., Tripathi, V.K., Ram, H.B. and Singh, S., 1983. Optimum stage of maturity for preparation of aonla (*Emblica Officinalis* Gaertn.) preserve part II. *Indian Food Packer*, **37**(6):85-90.
- Jain, N., Bahadur, V., Singh, D. and Prasad, V.M., 2016. Physical and bio-chemical composition of value-added pomegranate toffee during storage. *Indian Journal Hort.* **73**(2): 312-313.
- Jesulin, A. R. and Manimehalai, N., 2014. Studies on the Effect of Process Parameter on the Textural Characteristics of Osmotically Dehydrated Papaya (Var. Red lady) Cubes. *International Journal of Agriculture and Food Science Technology*, **5** (2): 75-80.
- Jothi, J.S., Islam, M., Islam, M.S., Rahman, M.R.D. and Akther, S., 2014. Development and Shelf-Life Prediction of Pineapple (*Ananas comosus*) Preserve and Candy. *International Journal of Innovation and Scientific Research*. ISSN 2351-8014, **10** (1): 77-82.
- Kaiser, Y., Rayees Ul I., Kausar J., Basharat Y. and Ray, A., 2015. Effect of addition of mosambi (*Citrus limetta*) peel powder on textural and sensory properties of papaya jam. *Cogent Food & Agriculture*. **1**: 1023675.
- Kamble, A. K. and Lavande N. S., 2014. Solar Drying of Osmosed Aonla Flakes for Preparation of Aonla Candy. *Journal of Ready to Eat Food*. **1** (3): 120-126.
- Katzer, G., 1999. Orange (*Citrus sinensis* L. Osbeck). University of Graz. Retrieved 2009-10-16.
- Kaushik, R.A., Yamdagni, R. and Dhawan, S.S., 2002. Biochemical changes during storage of Bael preserve. *Haryana Journal of Horticultural Sciences* **31** (3 and 4): 194-196.
- Kumar, R., Bala, K.L., Kumar A., 2015. Study on development of value added product from citrus peel. *The Allahabad Farmer ( LXX)*, **2**: 39-44.

- Kumar, S., Kumar, K. and Prakash, C., 2015. Effect of sugar and jaggery on the quality characteristics of papaya leather and shelf life stability at room temperature. *South Asian J. Food Technol. Environ.* **1**(1): 79-85.
- Kumar, S. and Singh, I.S., 2001. Storage studies of aonla fruit products at ambient temperature. *Progressive Horticulturae*, **33**(2): 169-173.
- Laufenberg, G., K. Kunz, and M. Nystroem., 2003. Transformation of vegetable waste into value added products: (A) the upgrading concept; (B) practical implementations. *Bioresource Technology*, **87**: 167-198.
- Laxmi, D. B. M., Ashok, K. Y., Satya, V. S., 2014. Preparation of candy from kinnow (citrus) peel. *Global Sustainability Transitions: impact and innovation.* **7**(1) 151-155.
- Mamma, D., E. Kourtoglou, P. Christakopoulos., 2008. Fungal multienzyme production on industrial by-products of the citrus-processing industry. *Bioresource Technology.* **99**: 2373-2383.
- Martin, A.M. (ed.) 1998. Bioconversion of waste materials to industrial products. Second ed. Blackie Academic and Professional, London.
- Mehta, A., Ranote, P.S. and Bawa, A.S., 2005. Processing of kandi lemon (Galgal) peel waste for candy making. *Ind. Fd. Pack.*, **54**: 67-74.
- Miller, G. L. 1972. Use of DNSA reagent for determination of reducing and non reducing sugar. *Anal chem.*, **31**: 426-428.
- Mir, S. A., Wani, S. M., Ahmad, M., Wani, T. A., Gani, A., Masoodi, F. A., 2016. Effect of packaging and storage on the physicochemical and antioxidant properties of quince candy. *Journal Food Science Technology*, **52**(11): 7313–7320.
- Mishra, S., Verma, A., Prasad, V.M. and Sheikh, S., 2011. Development of value added amla candy with rose extract. *The Allahabad Farmer.* **66**(2): 134-136.
- Morton, J. F., 1987. Fruits of Warm Climates, First edition, Miami Florida, Publications: 482.
- Muzzaffar, S., Waqas, N. B., Nazir, N., Masoodi, F.A., Bhat, M.M. and Bazaz, R., 2016. Effect of storage on physicochemical, microbial and antioxidant properties of pumpkin (*Cucurbita moschata*) candy. *Cogent Food & Agriculture*, **2**: 1163650.

- Nath, A., Bidyut, C. Deka, Jha, A., Paul K., D., and Misra, L. K., 2013. Effect of slice thickness and blanching time on different quality attributes of instant ginger candy. *J Food Sci Technol*, **50**(1):197–202.
- Nayak, P., Tandon, D.K. and Bhatt, D.K., 2012. Study on changes of nutritional and organoleptic quality of flavored candy prepared from aonla (*Emblica officinalis* G.) during storage. *International Journal of Nutrition Metabolism*, **4**(7):100-106.
- Nicolosi, E., Deng, Z. N., Gentile, A., La Malfa, S., Continella, G. Tribulato, E., 2000. Citrus phylogeny and genetic origin of important species as investigated by molecular markers, *Theoretical and Applied Genetics*, **100** (8):1155–1166.
- Nowakunda, K., Andrés, A., Fito, P., 2004. Osmotic dehydration of banana slices as a pretreatment for drying processes. In: *Proceeding of the 14th International Drying Symposium (IDS 2004)*. Sao Paulo, Brazil, vol. C: 2077–2083.
- Pandey, S., Jha, A., Khemariya, P., Kumar, S., and Rai, M., 2014. Shelf-life and microbiological safety studies of refrigerated petha sweet. *J Food Sci Technol*, **51**(11):3452–3457.
- Patil, R., Raut, V. U. and Wankhade R.S., 2014. Sensory quality and economics of preparation of karonda Candy. *International Journal of Processing and Post Harvest Technology*, **5**(2):169-172.
- Pawar, M.B. and Patil, D.R., 2013. Sensory attributes changes in aonla (*Emblica officinalis* Gaertn) candy during the storage. *Internat. J. Proc. & Post Harvest Technol.* **4** (2):118-121.
- Pedapati, A. and Tiwari R. B., 2014. Effect of Different Osmotic Pretreatments on Weight Loss, Yield and Moisture Loss in Osmotically Dehydrated Guava. *Journal of AgriSearch*, **1**(1):49-54.
- Phattanapa, K. and Therdthai, N., 2009. Effect of osmotic agents on qualities of osmotically dehydrated mandarin cv. (Sai-Namphaung). *Proceedings of 47th Kasetsart University Annual Conference*, pp. 688-695.
- Premi, L. B. B. and Joshi, V. K., 1994. Distribution pattern of bittering principles in kinnow fruit. *J Food Sci Technol*, **31**: 140-41.

- Priya, M. D. and Khatkar, B.S., 2013. Effect of processing methods on keeping quality of aonla (*Emblica officinalis* Gaertn.) preserve. *International Food Research Journal*, **20**(2): 617-622.
- Priyadarshini, 2013. Effect of Pretreatment on Organoleptic Attributes of Apple Candy During Storage. *International Journal of Food, Agriculture and Veterinary Sciences*, **3** (2):139-148.
- Rahman, M. S., & Lamb, J., 1990. Air-drying behaviour of fresh and osmotically dehydrated pineapples. *J. Food Process Engi.* **14**:163-171.
- Ramamurthy, M. S., Bongiwari, D.R. and D. R. and Bondyapadhayay, D., 1970. Osmotic dehydration of fruits, possible alternative to freeze drying. *Indian Food Packer*, **32**(1): 108-111.
- Ranganna S., 1997. Handbook of analysis and quality control for fruit and vegetable products. IInd Ed. Tata McGraw Hill Pub. Co. Ltd., New Delhi :81-82.
- Ranganna, S., 2000. Handbook of Analysis of Quality control for Fruit and Vegetables Products. 2nd ed. Tata McGraw- Hill Pub. Co. New Delhi, :84-88
- Rani, U. and Bhatia, B.S. 1986. Studies on bagugosha and pear for preserves and a ready to eat product. *Indian Food Packer*, **40**(3): 25-31.
- Rao, N. S., Sharma, M. and Sharma, A., 2016. A High Dietary Fiber and Antioxidant Rich Product Developed from Lemon Peel. *Indian Journal of Research*, **5** (5):531-533.
- Sachin R. A., Ashwini N., Bellary, H.B., Sowbhagya, R., Baskaran, Navin, K. R., 2016. Osmotic treatment for the impregnation of anthocyanin in candies from Indian gooseberry (*Emblica officinalis*). *Journal of Food Engineering*, **175** :24-32.
- Sethi, V. and Anand, J. C., 1983. Retention of nutrients in carrot and amla preserve. *Indian Food Packer*, **37**(6): 64-67.
- Shamrez, B., Aftab S., Junaid, M., Ahmed, N. and Ahmed, S., 2013. Preparation and Evaluation of Candies from Citron Peel. *IOSR Journal of Environmental Science, Toxicology and Food Technology*, **7**: 21-24.
- Sharma, S., Dhaliwal, Y. S., Kalia, M., 1998. Candied apple: a new perspective, *Journal of Food Science and Technology*, **35**: 79-82.

- Siddiqi, N.A. 2005. Debittering of sweet orange by resin. M. Tech. Thesis, College of Food Technology. Marathwada Krishi Vidyapeeth, Parbhani, M.S. (INDIA).
- Sidhu, N., Arora, M., Mohammed, S. A., 2015. Biochemical, Microbial Stability and Sensory Evaluation of Osmotically Dehydrated Kinnow Peel Candy and Peel Powder. *International Journal of Science and Research (IJSR)*, **5**(9): 1428-1437.
- Singh, B. and Pathak, S., 2016. Evaluation of cultivars and packing materials during preparation and storage of ber candy. *Journal of Applied and Natural Science*, **8**(2): 630 – 633.
- Surekha, A., Anju, K D., Sharma, R. and Kaushal, M., 2016. Standardization of Pre-treatments for the Development of Intermediate Moisture Food Products from Papaya (*Carica papaya L.*). *Intl. J. Food. Ferment. Technol*, **6**(1): 143-149.
- Syed, H.M, Ghatge, P.U., Machewad, G., Pawar, S., 2012. Studies on Preparation of Squash from Sweet Orange. 1:311. doi:10.4172/scientificreports.311.
- Torreggiani, D. 1993. Osmotic dehydration in fruit and vegetable processing. *Food Res. Intl*, 26:59-68. [http://dx.doi.org/10.1016/0963-9969\(93\)90106-S](http://dx.doi.org/10.1016/0963-9969(93)90106-S).
- Tripathi, V.K., Singh, M.B. and Singh, S. 1988. Studies on comparative compositional changes in different preserved products of Aonla (*Emblca Officinalis Gaertn.*) var. Banarasi. *Indian Food Packer*, **42** (4): 60-66.
- Tsuda, H., Ohshima, Y., Nomoto, H. et al. (2004). Cancer prevention by natural compounds, *Drug Metabolism and Pharmacokinetics* **19** (44), pp. 245–263.
- Verma, S., Srivastava, P. K., Durrani, A., 2006. Organoleptic characteristics of honey based amla murabba. 40th ISAE Annual Convention, Tamilnadu Agricultural University, Coimbatore.
- Verma, R., Kalia, M. and Sharma, H.R. 2006. Effect of method of preparation and storage on the chemical characteristics of peel candy of Darunj (*Citrus medica*). *Journal of Dairying Foods*, **25**(2): 113-116.
- Wawan, B., Okid, P. A., Edwi, M., 2010. Effect of various sugar solution concentrations on characteristics of dried candy tomato (*Lycopersicum esculentum*). *Nusantara biosciences*, 2 (2):55-61.

- Webber, J., 1989. The Citrus Industry, University of California Division of Agricultural Sciences, (<http://lib.ucr.edu/agric/webber/>).
- Widmer, W.W. and Montanari, A.M., 1994. Citrus waste steams as a source for phytochemical. *Proceeding of the Florida State Horticultural Society*. :284-288.
- Xu, Q., Chen, L. L., Ruan, X., Chen, D., Zhu, A., Chen, C., Bertrand et al, D. (2013). The draft genome of sweet orange (*Citrus sinensis*), *Nature Genetics* **45**(1): 59-68.
- Younis, K., , Islam, R., Jahan, K., , Yousuf B., and Ray, A., 2015. Effect of addition of mosambi (*Citrus limetta*) peel powder on textural and sensory properties of papaya jam. *Cogent Food & Agriculture*. 1 (1): 1023675