DEVELOPMENT AND QUALITY EVALUATION OF OSMO-DRIED PLUM

By

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Thesis submitted to Faculty of Postgraduate Studies
in partial fulfillment of the requirements
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MASTER OF SCIENCE IN AGRICULTURE
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M.Sc.

DEVELOPMENT AND QUALITY EVALUATION OF OSMO-DRIED PLUM

Mandeep Kour

2020

CERTIFICATE-I

This is to certify that the thesis entitled **"Development and quality evaluation of osmo-dried plum"** submitted in partial fulfillment of the requirements for the degree of **Master of Science in Agriculture (Food Science and Technology)** to the Faculty of Post-Graduate Studies, Sher-e-Kashmir University of Agricultral Sciences and Technology of Jammu is a record of bonafide research carried out by **Ms. Mandeep Kour,** Registration No. **J-17-M-493,** under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma. It is further certified that such help and assistance received during the course of investigation have been duly acknowledged.

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CERTIFICATE-II

We, the members of the Advisory Committee of **Ms. Mandeep Kour,** Registration No. **J-17-M-493,** a candidate for the degree of **Master of Science in Agriculture (Food Science and Technology),** have gone through the manuscript of the thesis entitled **"Development and quality evaluation of osmo-dried plum"** and recommended that it may be submitted by the student in partial fulfillment of the requirements for the degree.

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Place: Jammu
Dated: 08-1-2020

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ABSTRACT

Title of Thesis	:	**Development and Quality Evaluation of Osmo-dried Plum**
Name of Student	:	**Mandeep Kour**
Admission No.	:	**J-17- M-493**
Major Subject	:	**Food Science and Technology**
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Abstract:

Plum (*Prunus salicina* L.) fruit is highly perishable in nature and has very short shelf life. Due to its high moisture content and acidic nature it is not palatable, hence processing is essential. Osmotic dehydration of the fruits by dipping in hypertonic solution thought to be a convenient alternate for utilizing them in some value added dried fruits which will be of high quality with respect to both sensory and nutritional aspects. In the present study, plum fruits were washed thoroughly with clean water and wiped properly. The fruits were pierced gently with the help of fork. Then the fruits were immersed in sugar and honey syrup of different concentrations (40, 50, 60, 70 ^{0}Brix) for 24 hours. After one day, the syrup was drained out and plums were dried in cabinet tray drier (60 ^{0}C) for 48 hours. After drying, the osmo-dried plums were packed in LDPE bags. Fresh fruits of plum had Moisture, TSS, titratable acidity, ascorbic acid, reducing sugar, total sugars, anthocyanin, total phenols, ash content and calcium content of 84.35 per cent, 13.60 ^{0}Brix, 1.63 per cent, 6.32 mg/100 g, 5.75 per cent, 7.06 per cent, 40.10 mg/100 g, 221 mg/100 g, 0.38 per cent and 20 mg/100 g, respectively. The processed product was stored at ambient conditions and subjected to physico-chemical, sensory and microbiological characteristics at an interval of one month for a period of three months.

The highest mean TSS (69.15 ^{0}Brix), reducing sugar (57.71 per cent), total sugar (66.65 per cent) and ascorbic acid (15.67 mg/100g) were recorded in treatment T_9 (70 ^{0}Brix honey syrup) and the lowest value of 35.06 ^{0}Brix, 15.01 per cent, 15.72 per cent and 11.51 per cent were recorded in control, respectively. The maximum value of total phenols (651.67 mg/100g) and calcium content (47.99 mg/100g) were recorded in T_9 (70 ^{0}Brix honey syrup) and minimum values (612.90 mg/100g) and (29.71 mg/100g) were recorded in T_2 (40 ^{0}Brix sugar syrup) and control, respectively. Maximum anthocyanin content (75.01 mg/100g) was recorded in T_5 (70 ^{0}Brix sugar syrup) and minimum (45.86 mg/100g) was recorded in T_6 (40 ^{0}Brix honey syrup). With the advancement of storage period, an increasing trend was observed in TSS, total sugar, reducing sugar and non-enzymatic browning however a decreasing trend in total phenols, ascorbic acid, anthocyanin, ash content, moisture, dehydration, rehydration ratio and calcium content was recorded during three months of storage. The osmo-dried plum prepared from the treatment T_9 (70 ^{0}Brix honey syrup) adjudged as the superior on the basis of sensory attributes by scoring 7.85, 7.75, 7.59 and 7.85 values for colour, texture, taste and overall acceptability, respectively.

Keywords: Honey, osmotic dehydration, osmo-dried plum, storage.

Signature of Major Advisor **Signature of Student**

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LIST OF ABBREVIATIONS USED IN THIS MANUSCRIPT

UT	**Union territory**
Mm	**millimeter**
Ml	**milliliter**
No	**number**
P=0.05	**Critical Difference at 5 per cent**
G	**gram**
Mg	**milligram**
%	**per cent**
TSS	**Total soluble solids**
KMS	**potassium metabisulfite**
pH	**power of hydrogen**
CRD	**completely randomized design**
Fig	**Figure**
i.e	**that is**
^{0}C	**Degree Celsius**
et al.	**and others**
viz.,	**namely**
h	**hour**
min	**minute**
cv	**cultivar**
LDPE	**Low density polyethene bags**
OD	**Optical density**
Nm	**nanometer**
@	**at the rate of**

Chapter-1

Introduction

CHAPTER-I

INTRODUCTION

Fruits and vegetables play an important role in human nutrition, preventing diseases and contribute to the nation's development and prosperity. They provide a valuable source of essential nutrients, minerals, vitamins, dietary fibre and antioxidants; as such they are also known as protective food. The energy (calorific value) produced by fruit crops is much higher than that by cereals. They are considered indispensable for the maintenance of health, it is therefore, necessary that fruit and vegetables should be included in our daily diet and consumed in fresh or preserved form throughout the year. Much quantity of these perishable commodities go waste as seasonal surpluses due to improper post harvest handling, transport, storage, distribution and marketing. It is estimated that 30 to 40 per cent of horticulture produce perish before reaching the consumer due to lack of proper post harvest techniques (Kaul *et al.,* 2007).

Plum (*Prunus salicina* L.) belonging to the family Rosaceae and sub-family Prunoideae is a member of genus *Prunus,* which has fifteen distinct species out of which European plum (*Prunus domestica* L), Japanese plum (*Prunus salicina* L) and Damsons plum (*Prunus insititia* L) are of commercial significance globally. Plum is one of the most important fruit crops of mid-hill areas of temperate regions, ranks next to peach fruit in economic importance and is native to china. In India, it is predominantly grown in Himachal Pradesh, Uttrakhand and also to some extent in Nilgiri hills of South India (Jindal and Chandel, 2002) and covers an area of 23,000 hectare (ha) with an annual production of 89,000 metric tons (MT) (Anonymous, 2018a). It is also one of the most important fruit crops of Jammu and Kashmir Union Territory (UT) where its cultivation is mainly concentrated in Kashmir due to the prevalence of favourable agro-climatic conditions and also in some districts of Jammu region. In Jammu and Kashmir Union Territory (UT), plum is cultivated over an area of 4,038 ha with an annual production of 11,860 metric tons with 'Santa Rosa plum' being cultivated on large commercial scale and other two varieties 'Silver plum' and 'Chogandhra' on small scale (Anonymous, 2018b).

Fresh plum fruits are delicious, nutritious and have wide variety of size, colour and they are excellent source of antioxidants, calcium, magnesium, iron, potassium and fibre; and besides this, fruit contain a substantial amount of vitamin C. Being a climacteric fruit, plum has a short shelf life of 3-4 days at ambient temperature and 1-2 weeks in the cold storage, resulting in market glut and thus increasing the post harvest losses. Therefore, need of the hour is to utilize this fruit in such ways so as to significantly reduce its post harvest losses. These losses can be minimised by developing techniques for the preparation of different value added products either in the form of whole fruit or pulp during the peak harvesting season. Plum fruits contain high moisture (85-90 per cent) in the form of free water molecules which is mainly responsible for spoilage of fruits. The rate of spoilage can be decreased by removing the free water molecules and hence, drying is considered as an important method of preservation for extended storage.

Drying of fruits is one of the oldest method or form of food preservation techniques known to man and is a complex process involving simultaneous heat and mass transfer resulting in significant changes in the chemical composition, structure and physical properties of food material. Loss of water and heating causes stresses in the cellular structure of the food leading to change in microstructure and shrinkage (Rahman, 2003). Thus, drying has the ability to extend the shelf life of food materials. Dried fruits can be used as an excellent nutritional snack or as additives in cakes, ice-creams, candies and cereals. The consumption of the dried plum may lower the risk of chronic diseases and relieve constipation and this effect is mainly associated with biologically active substances like phenolic compounds, carotenoids, vitamin C and dietary fiber that are naturally present in fruit (Stacewicz *et al.,* 2001). However, in the past, mainly food drying was performed to extend the shelf life without giving much importance to nutritional and organoleptic attributes (Wang *et al.,* 2011). With increased awareness of food nutrition and health, consumers have become more selective and challenge the researchers to develop ways for creating high quality dried commodities (Sagar and Suresh, 2010). Thus, to improve the quality of dried product, pre-treatments prior to drying are often employed. Osmotic dehydration, mainly as a pre-treatment have recently gained a renewed and increased interest.

Osmotic dehydration is the technique which is used for partial removal of free water molecules using a process of osmosis by immersing fruits or vegetables in aqueous solution of high osmotic pressure (Pandharipande *et al.*, 2012). The most commonly used osmotic agents are sucrose for fruits and sodium chloride for vegetables. Osmotic dehydration presents several beneficial effects such as reducing the damage of heat to the flavour, colour, inhibiting the browning of enzymes and prevents the loss of volatile compounds during dehydration (Alakali *et al.*, 2006; Torres *et al.*, 2006). It also results in increased shelf-life, little bit loss of aroma in dried and semi-dried food stuffs, lessening the load of freezing and to freeze the food without causing unnecessary changes in texture (Petrotos and Lazarides, 2001). A loss of water up to 50 per cent of the initial fruit weight is attainable but it mainly depends on several factors like concentration, temperature and type of the osmotic medium. While water diffuses out of the fruit tissue, there is a simultaneous movement of sugar from the solution into the fruit (Pointing, 1973).

Therefore, keeping in view the importance of plum fruits and the need to minimize their post-harvest losses, the present investigation entitled “Development and quality evaluation of osmo-dried plum” was undertaken with the following objectives:

1. To develop the technology for preparation of osmo dried plum.
2. To study the physio-chemical, microbial and organoleptic characteristics of developed product.
3. To study the shelf stability and economics of the finished product.

Chapter-2

Review of Literature

CHAPTER-II

REVIEW OF LITERATURE

Fresh plum fruits are palatable and highly nutritious with their qualitative characteristics being an eminently good source of antioxidants, inorganic minerals (calcium, magnesium, iron and potassium) and fibre. It is believed to be a natural remedy against various chronic diseases due to its various health benefits (Sabarez and Price, 1999). The highly perishable nature of the fruit makes its unsuitable for consumption within a period of 3-4 days (Sharma and Lal, 1999). Therefore drying is the best alternative. The dried plum can be widely used as an ingredient in bakery, as dried plum puree for incorporation in batters and dough and also as juice concentrates.

Traditional sun drying or mechanical drying of plum fruits have some limitations regarding the palatability due to hard texture and high acidity particularly the dried fruits of the juicy variety 'Santa Rosa'. Thus, to improve the product quality and reduce drying time, osmotic dehydration can be advantageous method for plum drying. The literature suggests that osmotic dehydration of fruits in hypertonic solution yield a product of light colour, acceptable taste, natural aroma and palatable texture of dehydrated fruits (Pinnavaia *et al.,* 1988).

The literature pertaining to present investigation entitled "Development and quality evaluation of osmo-dried plum" has been reviewed under the following headings and sub-headings:

2.1 Physio-chemical characteristics of fresh plum

Sharma *et al*. (2011) studied the fresh plum composition while working on instant value added products from dehydrated peach, plum and apricot recorded fresh plum fruit length, width, weight, moisture, TSS, acidity and ascorbic acid as 42.75 mm, 42.25 mm, 46.28 g, 85.30 per cent, 13.60 ^{0}Brix, 1.81 per cent and 6.59 mg/100 g, respectively. Raj *et al*. (2012) recorded moisture content, titratable acidity and TSS of 'Santa Rosa' plum as 84.10 per cent, 2.01 per cent and 14.17 ^{0}Brix, respectively.

Kaushal *et al*. (2017) studied the fresh plum composition and reported ash, ascorbic acid, total sugars, total soluble solids, moisture and acidity as 0.42 per cent, 18.30 mg/100 g, 9.26 per cent, 13.86 ^{0}Brix, 86.93 per cent and 2.94 per cent, respectively. Kumar *et al.* (2018) recorded the fresh plum weight, length and width as 56.61 g, 48.82 mm and 45.85 mm, respectively.

The main anthocyanin form in plums is cyanidine-3-gluco-side, cyanidine-3-rutinoside and peonidine-3-rutinoside. Total anthocyanin content ranged from 18 to 125 mg/100 g (Donovan *et al*., 1998; Łos *et al*., 2000; Kim *et al*., 2003; Cevallos-Casals *et al.*, 2006). Gill *et al.* (2002) reported vitamin C content in the range of 3-10 mg/100 g in fresh fruits of plum.

Total phenolic content of Japenese plum has been reported to range between 298 to 563 mg in fresh tissue (Scott and Chrisosto, 2002).

Netzel *et al*. (2012) and Stacewicz-sapuntzakis (2013) reported the calcium and ascorbic acid in fresh plum as 6 mg/100 g and 9.5 mg/100 g, respectively. Walkowiak -Tomczak (2008) studied fresh plum characteristics and reported ash content, vitamin C and calcium as 0.30 to 0.40 per cent, 4-11 mg/100 g and 6.0-45.0 mg/100 g, respectively.

Singh (2014) during his study recorded the fresh plum values for length, width, weight, anthocyanin and pulp stone ratio as 3.99 cm, 4.07 cm, 37.31 g, 15.33 mg/100 g and 19.18, respectively. Kumar (2013) during his studies recorded the values for fresh plum for total phenols, anthocyanin and reducing sugars as 228, 52.30 mg/100 g and 4.09 per cent, respectively.

Igwe and Charlton (2016) recorded total sugars, moisture content and ascorbic acid of fresh plum as 5.07 per cent, 87.23 per cent and 9.5 mg/100 g, respectively.

Moustafa *et al.* (2016) recorded the total ash, total sugar and reducing sugar of fresh plum fruit as 2.89, 10.26 and 6.65 per cent, respectively. Miljic *et al.* (2017) while studying phenolic compounds, chromatic characteristics and antiradical activity of plum wines reported the total anthocyanin content ranged from 18 to 25 mg/100 g of fresh plums.

2.2 Effect of syrup concentration on the physio-chemical characteristics of osmo-dried products

2.2.1 Moisture content

Rashmi *et al.* (2005) found that after osmo-air dehydration of pineapple, the moisture decreased with the values of 13.82, 12.72 and 12.75 % in 50, 60 and 70 ^{0}Brix sugar solution, respectively. The maximum moisture content was recorded in 50 ^{0}Brix solution while minimum at 60 ^{0}Brix.

Panda *et al.* (2005) observed that the tray drying after osmosis could remove nearly 35 per cent moisture from grapes, together osmosis + tray drying could remove around 85 per cent moisture from the sample when grapes immersed in sucrose syrup concentration of 50, 60 and 70 ^{0}Brix.

Rodrigues *et al.* (2006) investigated that when papaya pieces were osmotically dehydrated in 50 ^{0}Brix sucrose solutions, they had 82.35 per cent moisture, as compared to fresh papaya which had 88.99 per cent moisture.

Jalali *et al.* (2006) reported reduction in moisture content in banana slices increased with increase in temperature and osmotic syrup concentration which was due to increased diffusional changes and the osmotic pressure exerted on the fruit cell structure resulting in greater moisture reduction.

Anitha and Tiwari (2007) conducted an experiment to study the effect of different osmotic pre-treatments on moisture loss in osmotically dehydrated guava and observed that maximum effect on moisture loss of (53.24 per cent) was observed when guava slices were pre-treated with 70 ^{0}Brix syrup for 24 h.

Sagar and Kumar (2009) dipped mango fruit slices of 2 cm thickness in a solution containing potassium metabisulphite (0.05 per cent) and citric acid (0.1 per cent) with varying sugar syrup concentrations 40, 50, 60 and 70 ^{0}Brix. They reported that moisture content decreased linearly with increase in sugar syrup concentration from 40 to 70 ^{0}Brix.

Gani and Kumar (2013) carried out osmotic dehydration of carrot slices in sugar solutions 30-50 ^{0}Brix sugar concentration and temperature 30 and 40 ^{0}C and process duration of 120 min. and results revealed that moisture content decreased with increase of syrup concentration and temperature.

Hasanuzzaman *et al.* (2014) studied dehydration technique to prepare tomato candy and reported that initially the moisture content decreased with an increase in sugar solution from 40 to 60 per cent. Moisture content decreased from 7.42 to 7.01 per cent with increase in syrup concentration.

Singh (2014) studied storage of pulp and value added products of plum (*Prunus salicina* L.) and revealed that there was a decrease in the moisture content with an increase in syrup concentration from 50 to 60 per cent sugar syrup concentration.

Dhiman *et al*. (2016) processed wild pear halves using osmotic dehydration. Fully ripe wild fruits of pear were peeled and cut into halves and then the halves were soaked in 50, 60, 70 and 80 ^{0}Brix sugar solutions. The studies indicated that there was a significant decrease in moisture content with increased temperature and osmotic syrup concentration. The diffusional changes and the osmotic pressure exerted on the fruit cell structure results in greater moisture reduction.

Kushwaha *et al*. (2018) studied influence of osmotic agents on guava fruit and results revealed that an increase in syrup concentration increased weight and moisture loss. The moisture content in the sample reduced due to evaporation during storage (Kumar *et al.*, 2016)

2.2.2 Total Soluble Solids

Geetha *et al.* (2006) reported a study on osmotic concentration kinetics on aonla preserve and results revealed the rate constant kinetics of TSS increased with the increasing sugar syrup concentration and temperature**.**

Rai *et al.* (2007) reported that there was an increase in the total soluble solids of osmotically dehydrated pineapple slices when slices were treated with 70 ^{0}Brix sugar solution having final TSS of 79 ^{0}Brix at 50 ^{0}C.

Ghadge **(**2013) reported that the TSS of the osmotically dehydrated ripe banana exhibited an increasing trend with an increase in sugar syrup level. The TSS was highest in treatment T_4 (70 ^{0}Brix sugar syrup) and lowest was recorded in control.

Ahmad and Kumaran (2015) studied on the effects of honey incorporation on quality and shelf life of aonla preserve. The aonla preserve sample incorporated with 15% honey recorded highest TSS as compared to samples incorporated with 7.5% honey.

Kenghe (2016) studied the effect of machine pricked aonla and changes in chemical composition of aonla candy during storage. Osmotic solution of different concentrations *i.e* 50, 60 and 70 ^{0}Brix of sugar syrup were used. The data subjected to TSS revealed that an increase in TSS content of aonla candy was observed with an increase in syrup concentration.

Kumar and Vikram (2017) studied the effect of different treatments on osmotic dehydrated Allahabad safeda Guava slice (*Psidium guajava*) and reported that total soluble solids were found significantly increasing with an increase in the sucrose and honey concentration from 50 to 70 ^{0}Brix.

Kumari *et al.* (2018) studied effect of osmotic dehydration on shelf life of dehydrated guava slices and the results revealed that TSS significantly found increasing with an increase in the sucrose and honey per cent.

2.2.3 Titratable Acidity

Stojanovic and Silva (2007) reported the reduction in per cent titrable acidity with the increase in steeping period and concentration while developing osmotically dehydrated rabbit eye blue berries (*Vaccinium ashei Reade*).

Bhagyashree *et al.* (2008) studied the process of osmotic dehydration, followed by tray drying of grapes for raisin preparation. The grapes were dipped in sugar syrup of 60, 65 and 70 ^{0}Brix concentration and decrease in acidity was observed with an increase in syrup concentration.

Alam and Singh (2010) studied effect of sugar concentration 50 to 70 ^{0}Brix and they reported that minimum vitamin C loss 72.31 per cent was obtained at 70 ^{0}Brix of sugar concentration at 60 ^{0}C and 72 min of immersion time.

Khan (2013) observed that titratable acidity of osmotically dehydrated ripe sapota slices exhibited a decreasing trend with the increase in sugar level and its temperature. The minimum acidity was observed in slices steeped in 70 ^{0}Brix sugar solution.

Ghadge (2013) observed that titratable acidity of osmotically dehydrated ripe banana exhibited a decreasing trend with increase in the sugar syrup level. The acidity level was the highest (0.55 %) in T_5 *i.e.* control and the lowest acidity was observed in the treatment T_4 (70 ^{0}Brix sugar syrup).

Jadhav (2016) reported the decreasing trend in titratable acidity with the increase in sugar syrup from 40 to 70 per cent while the highest titratable acidity was recorded in untreated samples while studying osmotic dehydration of carambola slices.

2.2.4 Ascorbic acid

Sreehari (2006) found that ascorbic acid content of osmotically dehydrated sapota slices increases with an increase in syrup concentration from 50 to 80 ^{0}Brix sugar concentration while immersing for 24 h.

Singh *et al.* (2007) studied the nutritional quality of osmotically dehydrated aonla (*Emblica officinalis*) fruit segments. Steeping in 70 ^{0}Brix sugar syrup showed less Vitamin C loss in the preserve than in 60 ^{0}Brix syrup.

Thakor and Sawant (2008) found that ascorbic acid content of osmotically dehydrated pineapple slices at 40 ^{0}Brix sugar concentration and 30 ^{0}C temperature immersed for 24 h increased by 18.33 per cent as compared to fresh pineapple slices.

Panwar *et al.* (2013) reported that the intermediate moisture anola segments *cv.* Banarasi were prepared by using three types of osmotic agents, 60% sucrose, 60 % sucrose + glycerol (1:1) and 60 % glycerol. The 60 % sucrose + glycerol treatment was found to retain more ascorbic acid (399 mg /100 g) in the product.

Ghadge **(**2013) observed the increase in ascorbic acid of the osmotically dehydrated ripe banana with the increase in the sugar syrup level. The ascorbic acid content was highest in 70 ^{0}Brix sugar solution and lowest in control having the values of 66.82 and 19.93 mg/100 g, respectively.

Priya and Khatkar (2013) studied the effect of processing methods on keeping quality of aonla preserve and observed that with the increase in syrup concentration the ascorbic acid content also increased. The results revealed that 70 ^{0}Brix was found to be the most effective in retention of ascorbic acid followed by 60 and 50 ^{0}Brix sugar syrup.

Ahmad and Kumaran (2015) studied effect of honey incorporation on quality and shelf life of aonla preserve and observed that with an increase in honey concentration from 7.5 to 15 per cent the ascorbic acid content increased and lowest value was recorded in untreated sample.

2.2.5 Sugars

Sreehari (2006) studied the effect of osmotic dehydration on sapota slices and reported that an increasing trend observed in total and reducing sugars with the increase in osmotic syrup from 50 to 80 per cent while minimum were recorded in untreated slices (control).

Singh *et al.* (2007) evaluated the osmotically dehydrated aonla fruit segments for their physical, nutritional and organoleptic qualities. The osmotic dehydration was carried out in 60 and 70 ^{0}Brix sugar syrup with varying steeping time and results revealed that content of reducing and total sugars in the product increased with increasing sugar syrup concentration and steeping time.

Anitha and Tiwari (2007) studied the effect of osmotic dehydration on guava (*Psidium guajava* L.) and reported that increase in syrup concentration from 50 to 70 ^{0}Brix and duration of osmosis for 24 h resulted in increase in total sugar content in osmotically dehydrated guava.

El-Gendy (2014) reported that dipping figs in 40, 50 and 60 per cent date syrup concentration in presence of 1 per cent calcium chloride at 50 ^{0}C for 12 h resulted in an increase in total and reducing sugars from 64.20 to 70.90 and 49.93 to 56.50 per cent, respectively.

Suhasini (2014) studied osmotic dehydration of karonda slices and reported that total sugars increased with an increase in syrup concentration and time of immersion. The total sugars were recorded maximum in 70 ^{0}Brix syrup concentration and at 24 h of dipping time.

Singh (2014) studied storage of pulp and value added products of plum and the data showed a significant increase in the total sugars with the increase in osmotic treatment from 50 to 60 per cent sugar syrup concentration.

Jadhav (2016) studied osmotic dehydration of carambola (*Averrhoa carambola* L.) slices and observed with the increase in syrup concentration from 40 to 70 per cent sugar solution total and reducing sugars increased significantly while the lowest values were recorded in untreated samples.

Mondal *et al.* 2017 studied the effect of sucrose on physio-chemical, organoleptic qualities and shelf-stability of aonla candy. They reported that reducing and total sugars in aonla candy increased significantly with the increase in syrup concentration.

Munaza (2018) while studying on quince reported an increase in total and reducing sugars content with an increase in the syrup concentration from 45 to 65 ^{0}Brix.

2.2.6 Anthocyanin content (mg/100 g)

Tsai *et al*. (2004) studied the effect of sugar on anthocyanin with different sugar and honey concentration of 20, 40 and 60 per cent and results showed that sucrose was a good anthocyanin protector, especially at high concentration increasing the ability to bind with water molecules favored the stability of anthocyanin in sucrose solution.

Behir *et al.* (2012) observed that the anthocyanin content decreased from 82 to 68 mg/100 g during osmotic dehydration of pomegranate in sucrose solution (55 ^{0}Brix) for 20 min and during oven drying at 40, 50 and 60 ^{0}C, respectively. Similar trends were also observed for black carrot (Kirca *et al.*, 2007) during heating.

Singh (2014) reported anthocyanin content increased with an increase in syrup concentration from 50 to 60 per cent sugar syrup, while maximum retention of anthocyanin content was recorded in 60 per cent sugar syrup concentration in osmo-dried plum.

2.2.7 Rehydration and Dehydration ratio

Singh *et al.* (2015) reported that the rehydration characteristics of papaya slices were improved by immersing in different sucrose solution of 50, 55 and 60 ^{0}Brix at a temperature of 50 ^{0}C for 30 minutes.

Mamatha (2016) studied osmotically dehydrated banana slices and results revealed decrease in both dehydration and rehydration ratio with increase in syrup concentration. The maximum dehydration and rehydration ratio was recorded in control while minimum values were observed in dipping in 70 ^{0}Brix sugar solution for 24 h.

Fatima *et al.* (2016) studied the effect of concentration and temperature of osmotic agent on quality characteristic of chikoo slices and the physio-chemical analysis of dehydrated chikoo slices suggested that increasing concentration resulted in increased dehydration ratio.

Mondhe *et al*. (2017) studied osmotic dehydration of carrot slices and overall analysis of physical parameter of dehydrated carrot slices and the results revealed that dehydration ratio was found better in sugar solution of 60 ^{0}Brix, as concentration increased the dehydration ratio also increased.

Rahim *et al.* (2018) reported that the rehydration and dehydration characteristics of pineapple slices were improved by immersing in different concentrations of 35, 40, 45, 50, 55 and 60 ^{0}Brix at 60 ^{0}C for 29 h. Further they reported that with an increase in syrup concentrations the rehydration and dehydration ratio decreases, where as maximum rehydration and dehydration ratio was recorded in control.

2.2.8 Total phenols

Singh (2014) while working on value added products from plum reported that total phenols increased with an increase in syrup concentration from 50 to 60 per cent sugar solution and maximum phenol retention was recorded in 60 per cent sugar solution.

Dhiman *et al.* (2016) prepared wild pear halves using osmotic dehydration and reported that the total phenol content of osmotically dehydrated wild pear halves increase with an increase in syrup concentratrion from 50 to 80 ^{0}Brix sugar syrup.

Mondal *et al.* (2017) prepared aonla candy samples with varying syrup concentration (80, 70, 60, 50 and 40 per cent) using sucrose and fresh aonla candy as control. The study reported that the total phenol content increased with an increase in syrup concentration.

2.2.9 Non-enzymatic Browning

Selvakumar (2011) studied osmotic dehydration of carrot and reported initially least non-enzymatic browning was recorded in 60 ^{0}Brix sugar syrup where as untreated sample recorded the maximum non-enymatic browning.

Kumar (2013) studied method for the preparation of osmo-dried plum reported initially maximum value of non-enzymatic browning was recorded in simple mechanically dried plums while least was recorded in 70 ^{0}Brix sugar syrup.

Singh (2014) reported with an increase in sugar syrup concentration from 50 to 60 per cent the non-enzymatic browning kept on decreasing in osmo-dried plum.

2.2.10 Ash and Minerals

Idah and Obajemihi (2014) reported that the ash content of tomato treated with sugar solution of 50 and 60 ^{0}Brix for a time period of 1 and 2 h were higher than the untreated samples.

Tripura (2015) in ripe sapota slices osmotically dehydrated with invert sugar 60 ^{0}Brix for 8 h followed by solar drying showed significantly better results with respect to calcium and phosphorus when compared to all other treatments.

Singh *et al.* (2015) studied papaya slices with sucrose solution as osmotic agent at 50, 55 and 60 ^{0}Brix at 50 ^{0}C temperature showed that osmo-treated product at 60 ^{0}Brix at 50 ^{0}C temperature showed higher ash and mineral content than the untreated product.

Sharma *et al.* (2018) reported initially maximum ash content recorded in 70 ^{0}Brix honey syrup when compared to other treatments in osmo-dried apples, apple choco shots and apple pie.

Munaza (2018) studied optimization of drying conditions for development of value added products from quince and study revealed that the ash content decreased significantly, with an increase in syrup concentration from 45 to 65 ^{0}Brix but an increase in calcium content was recorded in quince with an increase in syrup concentration

2.3 Microbial Studies

Khandekar *et al.* (2005) carried out research on standard plate count of fig toffee after six months of preservation. The toffees, which were treated with sodium benzoate, reported lower microbial count ($11x10^3$/g) compared to untreated toffee ($23x10^3$/g).

Singh *et al.* (2010) reported optimum osmotic dehydration of carrot cubes process conditions for maximum retention of colour and sensory score were: 50 ^{0}Brix + 15 per cent sodium chloride solution, 54.8 ^{0}C solution temperature and 120 min process duration.

Hussain, *et al.* (2011) observed minimum growth of micro-organism in blended juice containing 75% apple juice + 25% apricot juice and preserved with 0.1% sodium benzoate and found most acceptable in respect of sensory and nutritive quality during 3 months of storage. Similarly, non-significant increase in total viable count of yeast and mould was observed in mango jam during a storage period of 150 days at ambient temperature (Safdar *et al.*, 2012).

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 ^{0}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 ^{0}Brix with one per cent citric acid.

Rahman *et al.* (2012) reported the preservation of Jack fruit (*Artocarpus heterophyllus*) by osmotic dehydration. Four treatments of sugar concentration *viz.* 35, 40, 45 and 50 ^{0}Brix were used for osmotic dehydration. Minimum microbial count was recorded for osmosis in 50 ^{0}Brix sugar solution followed by 45 ^{0}Brix sugar solution.

Gupta and Kaul (2013) studied the preparation of a candy like product (*chuhara)* from ber (*Zizyphus mauritiana*) by osmo-air drying process dipped in different sugar concentrations of 40, 50, 60 and 70 ^{0}Brix at 24, 48 and 72 h. They reported that with an increase in storage period, the moisture, ascorbic acid and tannin contents decreased, whereas, total sugars increased.

Priya and Khatkar (2013) conducted an experiment to study the processing methods on keeping quality of aonla (*Emblica officinalis* L.) preserve and found that the 'no-cooking method' at sugar syrup of 70 ^{0}Brix was found the most effective and showed low microbial-load.

Ravi *et al.* (2017) aimed to study the effect of syrup concentrations at 50, 60 and 70 ^{0}Brix with solution temperatures of 50, 60 and 70 ^{0}C maintained initially and later the segments were kept in the solutions for about 24 h of osmosis. They reported that no micro-organism was detected up to 120th day of storage period. However steeping of segments in 70 ^{0}Brix sugar syrup at 70 ^{0}C for 24 h recorded superior nutritional and organoleptic quality.

2.4 Organoleptic evaluation

Lakkond (2002) reported that sapota slices steeped in 50 ^{0}Brix sugar syrup containing 0.1 per cent KMS and 0.5 per cent citric acid for 12 h received higher organoleptic scores for colour and appearance (4.03), taste (3.64), texture (4.00), flavour (3.39) and overall acceptability (3.80) as compared to other treatments.

Gawade and Waskar (2003) observed that dried figs prepared from Poona and Dinkar varieties could be stored for more than 180 days at low temperature, which maintained high organoleptic scores for better market acceptability.

The sensory evaluation revealed that the highest overall acceptability was observed in the jackfruit osmosed in 70 per cent sugar with 2 per cent salt solution and oven dried at 50 ^{0}C. Based on the quality analyses, osmotic solution of 70 per cent sugar with 2 per cent salt and drying temperature of 50 ^{0}C were selected as the best combination for osmo-air drying of jackfruit (Prasannath and Mahendran, 2009).

Chavan *et al*. (2010) prepared osmotic dehydrated ripe banana slices and revealed that the osmo-dried banana slices prepared with sulphur fumigation @ 2 g/kg slices for 2 h followed by soaking in 60 ^{0}Brix sugar syrup containing 0.1 per cent KMS + 0.1 per cent citrate + 0.2 per cent ascorbic acid were found better with respect to colour and appearance, flavour, texture, taste and overall acceptability with non-stickiness of the product.

Divya *et al*. (2012) prepared sapota candy using sugar syrup concentration of 30, 40 and 50 ^{0}Brix and dried at 60 ^{0}C was judged to be better as the sample had obtained acceptable sensory scores for colour, flavour, taste and overall acceptability.

Chandan *et al*. (2012) carried out the work on osmotic dehydration of aonla fruits. The organoleptically acceptable dehydrated sweetened aonla slices with better quality was obtained by blanching for 5 min and sliced pieces steeped in 2 per cent salt for 2 h + steeping in 60 ^{0}Brix sugar syrup for 24 h.

Sneha *et al.* (2013) studied the value addition of pineapple slices through osmo-convective dehydration and they observed that pineapple slices treated with 40 per cent sucrose and 2 per cent CaCl was most accepted by the sensory panel and scored highest sensory points.

Priya and Khatkar (2013) while working on processing method on keeping quality of aonla preserve reported that maximum scores for overall acceptability was noticed in 70 ^{0}Brix sugar syrup followed by 60 ^{0}Brix sugar syrup concentration.

Swami *et al.* (2014) Developed osmo-tray dried ripe jackfruit bulb with varying treatments at 40 and 60 ^{0}Brix and one without osmosis treatment *i.e.* tray drying at 60 ^{0}C. From study it was revealed that treatment 60 ^{0}Brix was best and secured maximum sensory score colour 7.67, flavour 7.56, texture 7.89 and overall acceptability 7.78.

Singh *et al.* (2015) studied osmotic dehydration of papaya slices and concluded that the slices which were treated with 60 ^{0}Brix sucrose solution at 50 ^{0}C temperature and cabinet drying at 70 ^{0}C temperature showed the better organoleptic characteristic along with nutritional compounds retention.

Mini and Archana (2016) studied formulation of osmo-dehydrated cashew apple and sensory analysis of the developed product revealed that osmo-dehydrated cashew apples in honey had highest scores for appearance, flavour, colour, taste, texture and overall acceptability compared to other osmosed products.

Kumar and Vikram (2017) studied the effect of different treatments on osmotic dehydrated Allahabad Safeda guava slice (*Psidium guajava*) and the experimental results concluded that dipping of blanched guava slices in 60 ^{0}Brix glucose for 12 h followed by osmotic dehydration was found the most suitable in terms of quality and sensory scores.

Mahesh *et al.* (2017) studied standardization of honey and sugar solution of osmotic dehydration of pineapple (*Ananas comosus* L.) fruit slices and concluded that the treatment (steeping of 6 mm slices in honey syrup for 24 h) was found to be significantly superior with respect to moisture content (8.1 per cent), ascorbic acid (9.72 mg/100 g), acidity (1.8 per cent), total sugars (76.53 per cent), reducing sugars (38.82 per cent) and also excellent in sensory quality (colour, flavour, taste, texture and overall acceptability).

Kumari *et al.* (2018) while studying effect of osmotic dehydration on guava slices concluded that treatment T_6 (blanching in 0.5 % KMS followed by dipping in 70 ^{0}Brix sucrose) was found most suitable in terms of quality and sensory scores for 3 months of storage.

2.5 Effect of storage on osmo-dried products

Sharma *et al.* (2000) reported considerable increase in non-enzymatic browning of osmo-air dried apricot in all packaging materials (glass jars, laminated pouches and polyethylene packaging) was observed during the 6 months storage.

Nagaraju (2002) reported that ber slices steeped in 70 ^{0}Brix sugar syrup containing 0.5 per cent citric acid + 0.2 per cent KMS for 15 h and dried in an electric drier gave better quality of dehydrated products during storage.

Pragati and Dhawan (2003) conducted an experiment on the effect of drying methods on nutritional composition of dehydrated aonla fruit (*Emblica officinalis* Garten) during storage and they found that osmo-air drying method was found to be the best method for drying of aonla because of better retention of nutrients like ascorbic acid and sugars and also reported during storage they found the nutrient content in osmo-air dried aonla was satisfactory after 90 days of storage.

Rashmi *et al.* (2005) conducted studies to determine the optimum sugar syrup concentration for osmo-air dehydration of pineapple *cv. Giant Kew* and quality evaluation of osmotically dehydrated product. Significantly higher amount of moisture was removed by 70 ^{0}Brix sugar syrup followed by 60 ^{0}Brix syrup. At 60 ^{0}Brix, maximum dry fruit yield was obtained and showed lower moisture, higher ascorbic acid, carotenoids and also higher overall acceptability scores up to six months of storage at ambient conditions.

While working on Hawaiian papaya (*Carica papaya*) the results revealed that fruits subjected to osmotic dehydration using honey recorded the highest osmotic capacity while sucrose recorded the lowest (Rios-Perez *et al.*, 2005).

Sharma *et al.* (2006) subjected apricot fruit wholes and halves to osmotic treatment in sucrose syrups of varying concentration such as 50, 60 and 70 ^{0}Brix for 24 h followed by drying at 60 ^{0}C for 3 h. The products were subjected for organoleptic and chemical evaluation. A slight change in sensory quality and some of the chemical attributes occurred during 3 months of storage. Osmo-dehydrated apricot halves treated with 70 ^{0}Brix sucrose syrup concentration resulted in better quality products.

Rokhade *et al.* (2006) studied the changes in physico-chemical characteristics of sweetened dehydrated aonla slices during six months of storage involving 15 treatments and found that blanching followed by steeping in 2 per cent salt for 2 h and 60 ^{0}Brix sugar syrup for 24 h and then drying under sun gave best quality sweetened dehydrated aonla slices.

Singh *et al.* (2007) reported that blanched aonla segments immersed in 60 ^{0}Brix for 24 h was found to be the best in nutritional as well as organoleptic qualities and had a shelf life of three months.

Naikwadi *et al.* (2010) carried out the storage studies of osmo-dehydrated figs and reported a gradual decrease in moisture content, acidity and ascorbic acid but an increase in total and reducing sugar contents during storage period of six months.

Singh *et al.* (2011) found that dehydrated wild apricot fruits could be stored for more than 6 months under ambient storage conditions without much changes in different quality parameters.

Durrani *et al.* (2011) carried study 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 (T_1), 1,000 g honey + 1,000 g carrot (T_2) and 1,250 g honey + 1,000 g carrot (T_3). To establish the best product, sensory evaluation was done on 9-point Hedonic scale. T_1 was found to be most preferred candy and was further assessed for overall quality during storage at room temperature (25–30 ^{0}C) for 6 months. Candy can be preserved safely for 6 months in both glass and LDPE packaging materials.

Patel *et al.* (2013) observed that TSS and total sugars increased while ascorbic acid, titrable acidity and fiber content of the aonla murabba decreased during the storage period of six months.

Priya and Khatkar (2013) studied the effect of processing methods on keeping quality of aonla (*Emblica officinalis* Gaertn.) preserve and recorded decrease in moisture content, ascorbic acid, tannin and titratable acidity of the preserves during storage in all the samples.

Aggarwal and Michael (2014) studied the effect of substitution of sucrose with fructose on the physico-chemical composition and sensory characteristics of kinnow candy and observed decline in moisture, acidity and ascorbic acid content while total soluble solids, reducing and total sugars increased during four months of storage.

Patil *et al*. (2014) studied the sensory quality and economics of preparation of karonda candy. They found that 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.

Balaji *et al.* (2014) studied to assess the impact of varieties, honey coating and storage durations on aonla candy. The parameters like TSS, acidity, pH, ascorbic acid and optical density were analyzed there was increase in the level of total soluble solids, acidity and browning and decrease in pH, ascorbic acid, and organoleptic taste during storage. All the qualitative parameters were significantly superior with honey coated candy as compared to cane sugar prepared candy.

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. They reported decrease in ascorbic acid 5.50-5.00 mg/100 g and 5.12-4.84 mg/100 g, respectively in crystallized and Kashi petha where as, increasing trend in microbial population during storage period.

Attri *et al*. (2014) studied treatments for the preparation of toffee and bar/leather from papaya fruit. Out of various treatments papaya toffee prepared in combination with apricot (50:50) and papaya bar/leather prepared using 30 ^{0}Brix TSS, 0.5 per cent acidity and 0.02 per cent KMS were rated the best on the basis of sensory evaluation. The sensorial quality of the developed products was not affected during storage and these were rated 'liked very much' even after six months of storage at ambient temperature.

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 results revealed acidity and moisture content decreased with increase in storage days.

Mir *et al.* (2016) studied the effect of packaging and storage on the physico-chemical and antioxidant properties of quince candy. Candy was packaged in three different packaging materials viz. polyethylene pouch, laminate, and plastic jar and was analyzed at storage intervals of 0, 60 and 120 days. With laminate showing significantly higher acceptability among various packages, the overall acceptability of quince candy decreased significantly during storage. Total phenolic and flavonoid contents showed a significant decrease with increase in storage time.

Bhoite (2015) studied dehydration of plum using different sugar syrup treatments. The blanched fruits were dipped in sucrose, glucose, fructose and invert sugar syrups at 68, 72 and 75 ^{0}Brix for 24 h and were further dried to reach 20 per cent moisture in a tray dryer at 60 to 65 ^{0}C. The study revealed that on basis of sensory evaluation and chemical analysis sucrose syrup treatment at 75 ^{0}Brix was best for preparation of good quality dried plums and also maintained their market acceptability for 3 months.

Mahomud *et al.* (2015) studied to investigate the effect of solution on the shelf life and quality of banana slices and development of high quality dehydrated banana products. Solution effect was assessed using honey, sugar and mixed (honey plus sugar, 1:1) solution further osmosed samples were dried in a mechanical drier at 65 ^{0}C for 24 h to get desired moisture content up to 14.6 per cent. They reported dipping in honey solution plus 4 min steaming 20 min sulphyting (0.3% KMS) gave better colour and flavour of banana slices and showed highest degree of acceptability during storage.

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 and 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.

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

Surekha *et al.* (2016) studied standardization of pre-treatments for the development of intermediate moisture food products from papaya (*Carica papaya* L.) and results revealed developed products remained shelf-stable for 6 months at ambient temperature with minimum changes in their physico-chemical and sensory attributes.

Deepika *et al.* (2016) studied the evaluation of packaging materials to maintain quality of enriched fruit bars during storage. Bars were packed in different materials and evaluated for a storage period of 6 months. A declining trend in moisture, acidity and ascorbic acid was observed whereas Total soluble solids, total sugars, reducing sugars and non-enzymatic browning showed an upward trend.

Dhiman *et al.* (2016) reported storage studies indicated that there was significant decrease in moisture content, titratable acidity, ascorbic acid, total phenols, sensory quality scores and increase in TSS and of wild pear halves. The stored osmo-dried wild pear halves were found microbiologically safe and sensorily acceptable up to six months of storage at ambient conditions.

Dhakal and Pradhananga (2017) studied the utilization of watermelon rind in candy preparation using different pre-treatment and syrup. They reported honey incorporated candy in the ratio 25 per cent with sucrose (25 honey:75sucrose) in

1000 g watermelon rind was the best, based on sensory attributes and moreover the product can be safely preserved in polyethylene at room temperature.

Chapter-3

Material and Methods

CHAPTER-III

MATERIAL AND METHODS

The present investigation entitled "Development and quality evaluation of osmo-dried plum" was carried out in the Division of Food Science and Technology, Sher-e-Kashmir University of Agricultural Science and Technology of Jammu during 2018-2019. This chapter contains relevant information pertaining to research design and methodologies used for conducting the present study.

3.1 Raw Material

Plums (*cv*. *Santa rosa*) were purchased from fruit Mandi Narwal, Jammu. Fresh plums with uniform size and shape, free from transportation injuries, bruises, insect damages and diseases were selected for making the nutritionally rich osmo-dried plum.

3.2 Processing

Fully matured fruits of uniform size were washed thoroughly with clean water and wiped properly. The fruits were pierced gently with the help of fork. On the other hand, sugar and honey syrup of different concentrations *viz* 40, 50, 60 and 70 ^{0}Brix were prepared. Then the plums were dipped in different concentrations of sugar and honey for 24 h. After completion of dipping time, sugar and honey syrups were drained and the plums were spread on trays. The plums were dried for two days at 55-60 ^{0}C. After drying, the plums were collected and packed in LDPE bags and stored at room temperature for a period of 3 months. The osmo-dried plums were analysed at an interval of 0, 1, 2 and 3 months of storage for physio-chemical, microbiological and organoleptic parameters.

3.3 Treatment details

T_1	Control
T_2	Dipping in 40 ^{0}brix sugar syrup
T_3	Dipping in 50 ^{0}brix sugar syrup
T_4	Dipping in 60 ^{0}brix sugar syrup

T_5	Dipping in 70 ^{0}brix sugar syrup
T_6	Dipping in 40 ^{0}brix honey syrup
T_7	Dipping in 50 ^{0}brix honey syrup
T_8	Dipping in 60 ^{0}brix honey syrup
T_9	Dipping in 70 ^{0}brix honey syrup

Total treatments combinations : 9

Number of replications : 3

Storage duration : 3 months

Design : Factorial CRD

Fully mature fruits

⇩

Washing and wiping of fruits

⇩

Piercing of fruits with fork

⇩

Preparation of sugar/honey syrup (40, 50, 60 and 70 ^{0}Brix)

⇩

Immersion of pierced fruits in sugar/honey syrup (24 h)

⇩

Draining of syrup

⇩

Spreading of plums in tray (55-60 ^{0}C)

⇩

Packaging of osmo-dried fruits in LDPE bags

⇩

Storage (at room temperature)

Fig 1. Flow chart for osmo-dried plum

Plate 1. Fresh Fruit of plum

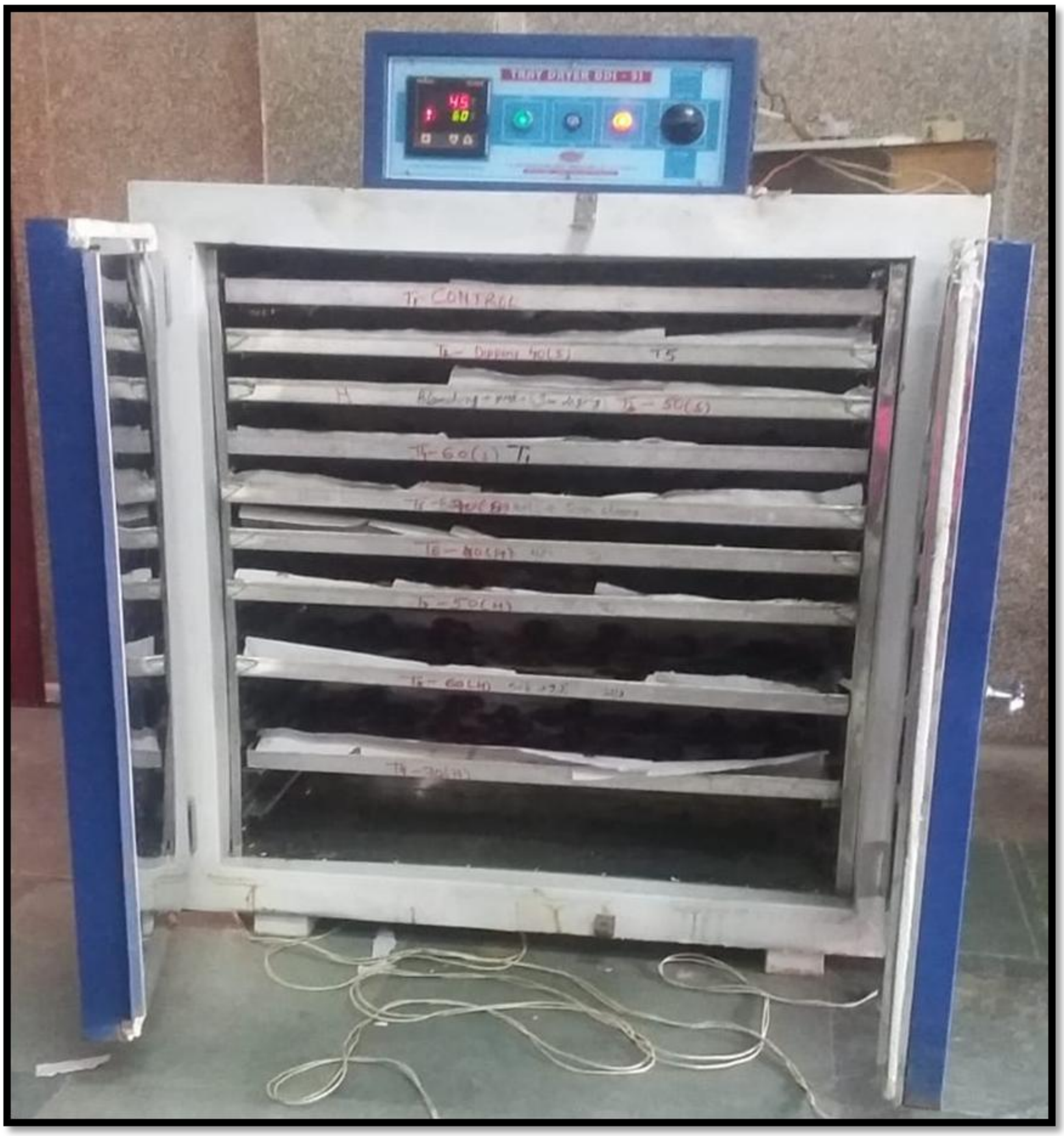

Plate 2. Drying of osmo-dried plum

Plate 3. Osmo-dried plums after drying

3.4 Observations

Osmo-dried plums were subjected to the following periodical observations.

3.4.1 Fruit weight

Weight of ten same fruits was taken on top pan electric balance and average weight of fruit was calculated and expressed in gram.

3.4.2 Fruit size

The length and width of ten randomly selected fruits were measured with the help of vernier calliper and their average value was calculated and expressed in centimetre.

3.4.3 Pulp-stone ratio

The ratio of pulp to stone of fruits was calculated by measuring the weight of whole fruit on top pan balance, then pulp was removed and stone was washed, dried and then weighed. By subtracting the weight of stone from whole fruit the pulp weight was calculated and finally the weight of the pulp was divided by weight of the stone to calculate the ratio.

3.4.4 Moisture content

The moisture content was determined by using an electronic moisture analyser at 105 ^{0}C by spreading a weighed sample (2 g) in an aluminium sample holder and evaporative moisture losses were automatically expressed as per cent moisture content.

3.4.5 Total soluble solids

TSS of the fruits was determined by crushing the fruits with pestle and mortar and then taking out the extract for observation with the help of muslin cloth. The TSS was observed by placing 1-2 drops of extract on the prism of a hand refractometer. The results were expressed as ^{0}B (Ranganna, 1986).

3.4.6 Titratable acidity

Titratable acidity was determined by titrating a known quantity of sample against standardized solution of 0.1 N sodium hydroxide to a faint pink colour using phenolphthalein as indicator. The results were expressed as per citric acid (Ranganna, 1986).

$$\text{Titrable acidity (\%)} = \frac{\text{Titre value} \times \text{Normality of NaOH} \times \text{Vol. made up} \times \text{Eq. wt. of acid}}{\text{Vol. of aliquot taken for estimation} \times 1000} \times 100$$

3.4.7 Ascorbic acid (mg/100 g)

The ascorbic acid was estimated as per method described by Ranganna (1986) using 2, 6, dichlorophenol indophenol dye. Initially the dye factor was determined by titrating a mixture of 5 ml of standard ascorbic acid plus 5 ml of 3 per cent metaphosphoric acid solution against 2, 6, dichlorophenol indophenol dye till faint pink colour appeared which persist for 15 seconds. The volume was noted and dye factor was determined as

$$\text{Dye factor} = \frac{0.5}{\text{Titre}}$$

The vitamin C was estimated by taking 10 ml of sample in a volumetric flask and volume made up to 100 ml with 3 per cent metaphosphoric acid. Sample was then filtered using filtrer paper. The aliquot of 10 ml was taken in a titration flask and titrated against dye 2, 6, dichlorophenol indophenol dye till light pink colour appeared (which persisted for 15 sec)

$$\text{Ascorbic acid (mg/100 g)} = \frac{\text{Titre value} \times \text{Dye factor} \times \text{Vol.made up}}{\text{ml of filtrate taken for estimation} \times \text{wt. of sample}} \times 100$$

3.4.8 Sugars

3.4.8.1 Reducing sugars

Lane and Eynon (1923) volumetric method as detailed by Ranganna (1986) was followed for determining reducing sugar. Measured quantity of sample (20 g) was taken in 250 ml volumetric flask to which 100 ml distilled water was added and neutralised with 40 per cent sodium hydroxide solution using phenolphthalein as indicator and clarified with 2 ml of 45 per cent natural lead acetate for about 30 minutes. Excess of lead acetate was removed by adding 5 ml of 22 per cent potassium oxalate. The volume was made to 250 ml and filtered through Whatman filter paper No. 4. The filtrate was titrated against 10 ml of standardised Fehling's solution, using methylene blue as an indicator, to a brick red precipitate for determination of reducing sugars.

3.4.8.2 Total sugars

A measured aliquot (100 ml) of the above filtrate was taken in 250 ml volumetric flask and was hydrolysed by adding 10 ml of 50 per cent hydrochloric acid, kept overnight for 24 h at room temperature followed by neutralization with 40 per cent sodium hydroxide solution using phenolphthalein as indicator. The volume was made to 250 ml and titrated against Fehling's solution, as above for total sugars and expressed in per cent total sugar.

Percentage of reducing and total sugars was calculated using the equation

$$\text{Reducing or total sugars (\%)} = \frac{0.5 \times \text{vol. made up}}{\text{Titre value} \times \text{wt. of sample}} \times 100$$

3.4.9 Anthocyanin (mg/100 g)

Anthocyanin content was estimated as per the method suggested by Harborne (1973). To estimate the anthocyanin content in osmo-dried fruit, 10 g sample was blended with 10 ml of ethanolic HCl (mixture of 95 per cent ethanol and 1.5 N HCl in the ratio of 85:15) and transferred to a 100 ml volumetric flask and final volume was made up to 50 ml and kept in refrigerator at 4 ^{0}C for overnight and then filtered through Whatman No. 1 paper using glass funnel. The residue and bottles were washed repeatedly with ethanolic HCl and extract was pooled and the final volume was made to 100 ml. The optical density of the aliquot was measured at 535 nm and the values were expressed as mg/100 g with the help of Spectrophotometer Spectronic-20.

3.4.10 Dehydration ratio

After taking the samples for analysis, the osmo dried plum were spread on aluminium trays which were kept in a tray dryer for dehydration. Then the osmo dried plum were thoroughly dried at 55-60 ^{0}C till the desired moisture content reached. The dehydration ratio was expressed as the ratio of the samples before drying to the dried weight of sample (Kalra, 1995).

$$\text{Dehydratrion ratio} = \frac{\text{Weight of fresh sample taken}}{}$$

Weight of dehydrated sample

3.4.11 Rehydration ratio

sample 5 g was taken in a beaker containing 100 ml distilled water covered with watch glass and boiled for few minutes. After boiling, water was drained and the sample was spreaded on filter paper for removing the adhering water and weighed gain. The rehydration ratio was expressed as ratio of the weight of rehydrated product to the weight of dried product (Ranganna, 1986).

$$\text{Rehydration ratio} = \frac{\text{Weight of product after rehydration}}{\text{Weight of dried sample taken}}$$

3.4.12 Total phenols content (mg/100 g)

Total phenols were estimated as per folin ciocalteu's procedure (Icier, 2012). 1 g of sample was taken in a screw caped vial and to this 10 ml of distilled boiled water was added, the contents were maintained at 100 ^{0}C for 5 min for proper extraction followed by cooling and filtering through a 0.45 mm filter paper. To filtrate, 0.5 ml of folin ciocalteau's reagent was added and mixed well and allowed to stand at room temperature for 7 minutes. After this 1.5 ml of 20 per cent (w/w) sodium carbonate solution was added and kept in dark for another 2 h, and the absorbance was measured at a wavelength of 765 nm using uv/vis spectrophotometer and was calculated against the standard curve already prepared.

3.4.13 Non-enzymatic browning

5 g of powdered sample was mixed with 100 ml of 80 per cent alcohol and kept over night. The absorbance of the filtrate at 440 nm was recorded in spectrophotometer (SPECTROCHEM) using 80 per cent alcohol as blank. The value of non-enzymatic browning was expressed as optical density (OD at 440 nm) (Srivastava and Kumar, 1998).

3.4.14 Ash

Ash content of sample was estimated by using standard method of AOAC (2007). 5 g of sample was transferred in pre-weighed crucible and ignited until no charred particles remained in the crucible. The crucible was then placed in muffle furnace (600 ^{0}C) for 3 h.

The crucible was cooled in a desiccator and weighed to a constant weight. The difference between the weights of silica crucible with ash and empty was the amount of total ash.

$$\text{Ash (\%)} = \frac{\text{Weight of ash (g)}}{\text{Weight of sample (g)}} \times 100$$

3.4.15 Mineral content

Measured quantity of sample (1 g) was taken in crucible to which 2 ml of sulphuric acid was added, and allowed to evaporate to dryness followed by ashing in muffale furnance at a temperature of 600 ^{0}C for 5 h. On cooling down the muffle furnance, the crucible was taken out and concentrated nitric acid was added in small proportions (1 to 2 ml) and heated until the ash fails to darken becomes white to ensure complete oxidation of organic matter and was allowed to cool to room temperature which was further washed 2 to 3 times with concentrated nitric acid and filtered through Whatman filter paper No. 4 into 25 ml volumetric flask and made up the volume with distilled water (Verma *et al.,* 2015). Suitable dilutions were made. Concentration of calcium were analysed by flame Atomic Absorption Spectroscopy (AAS).

3.5 Microbial content

Spread plate technique using dilution method as described by Pelczar and Chan (1997), was followed 1 g of sample was aseptically transferred into test tube containing 9 ml of sterile water and was mixed vigorously. After mixing, 1 ml of the mixture was again transferred to a test tube containing 9 ml sterile water for further dilution. The process was continued until 3rd dilution 10^{-3}. The petriplates containing potato dextrose agar PDA was inoculated with 0.1 ml of the diluted sample 10^{-3}, by spread plate technique and were incubated at 37 ^{0}C for 24 h by keeping the petri-plated upside down. The plates were computed and colonies counted after 24 and 36 h and multiplied by dilution factor.

$$\text{Microbial load} = N \times \frac{1}{V} \times D$$

Where,

N = no of colonies counted; V = volume of inoculum and D = dilution factor

3.6 Sensory evaluation

The osmo-dried samples were evaluated on the basis of colour, texture, taste and overall acceptability by semi-trained panel of 9-10 judges using 9 point hedonic scale assigning scores 9-like extremely to 1-dislike extremely. A score of 5.5 and above was considered acceptable (Amerine *et al.*, 1965).

3.7 Economics of the product

The cost of production of product was determined by taking into consideration the cost of raw materials, chemicals, packaging materials *etc*. used in the preparation of the product.

3.8 Statistical analysis

The data obtained was analysed statistically (Gomez and Gomez, 1984) using Factorial completely randomized design (CRD) for interpretation of results thrc alysis of variance at P= 0.05.

Chapter-4

Results

CHAPTER IV

EXPERIMENTAL RESULTS

The present investigation entitled "Development and quality evaluation of osmo-dried plum" was conducted in the Division of Food Science and Technology, Sher-e -Kashmir University of Agricultural Sciences and Technology of Jammu in the year 2018-2019. The results obtained from the present study are as under

4.1 Physio-chemical characteristics of fresh plum fruit

The data presented in Table 1 revealed that mean fruit weight, length, width and pulp stone ratio of fresh plum was found to be as 38.15 g, 40.05mm, 40.18mm and 16.18, respectively, where as moisture content, TSS, acidity, ascorbic acid, reducing and total sugars were recorded as 84.35 per cent, 13.60 ^{0}Brix, 1.63 per cent, 6.32 mg/100 g, 5.75 and 7.06 per cent, respectively. The anthocyanin content was recorded as 40.10 mg/100 g in plum fruit. The total phenols, ash and calcium content were recorded as 221 mg/100 g, 0.38 per cent and 20 mg/100 g, respectively in plum fruit.

Table1: Physico-chemical composition of fresh plum fruit

Attributes	Quantity
Physical parameters	
Weight of fruit (g)	38.15
Length of fruit (mm)	40.05
Width of fruit(mm)	40.18
Pulp stone ratio	16.18
Chemical parameters	
Moisture (%)	84.35
Total soluble solids (%)	13.60
Titratable acidity (%)	1.63
Ascorbic acid (mg/ 100 g)	6.32
Reducing sugar (%)	5.75
Total sugar (%)	7.06
Anthocyanin (mg/ 100 g)	40.10

Total phenols(mg / 100 g)	221
Ash content (%)	0.38
Mineral (Ca) (mg/ 100 g)	20

4.2 Physio-chemical characteristics of osmo-dried plum during storage

4.2.1 Moisture content

A perusal of data in Table 2 indicated that moisture content of osmo-dried plum decreased significantly during storage of three months. Initially the moisture content ranged from 12.60 to 15.09 per cent. The minimum moisture content of 12.60 per cent was observed in T_1 (Control) whereas, the maximum moisture content value 15.85 per cent was observed inT_2 (40 ^{0}Brix sugar syrup). After three months of storage, the maximum moisture content of 14.90 per cent was recorded in T_2 (40 ^{0}Brix sugar syrup) whereas, the minimum value of 12.30 per cent was recorded in T_1 (Control). The mean values of moisture content decreased from 15.19 to 14.23 per cent during the three months of storage period. The effect of interaction between treatment and storage period was also found significant at p=0.05

4.2.2 Total soluble solids (TSS)

The data revealed that with the advancement of storage period the TSS of osmo-dried plum increased significantly (Table 3). At the beginning, highest TSS of 67.23 ^{0}Brix was recorded in T_9 (70 ^{0}Brix honey syrup) and lowest value of 33.53 ^{0}Brix was recorded in control. After three months of storage T_9 (70 ^{0}Brix honey syrup) registered the maximum value of TSS (72.12 ^{0}Brix) which was followed by T_5, T_8 and T_4 treatments having the values 68.23, 58.65 and 56.25 ^{0}Brix, respectively, while the lowest value of 36.58 ^{0}Brix was recorded in control. In treatment mean values higher TSS was observed in T_9 (69.15 ^{0}Brix honey syrup) and lowest in control (35.06 ^{0}Brix). The mean values of TSS increased from 48.19 to 52.87 ^{0}Brix during the three months of storage period. The interaction between treatments and storage period was also found significant at p = 0.05

Table 2: Effect of treatments and storage period on moisture content (per cent) of osmo-dried plum

Treatments	Storage period (months)				
	0	1	2	3	Mean
T_1: Control	12.60	12.52	12.42	12.30	**12.46**
T_2: Dipping in 40 ^{0}Brix Sugar Syrup	15.85	15.72	15.05	14.90	**15.38**
T_3: Dipping in 50 ^{0}Brix Sugar Syrup	15.80	15.69	15.00	14.55	**15.26**
T_4: Dipping in 60 ^{0}Brix Sugar Syrup	15.75	15.25	14.93	14.78	**15.18**
T_5: Dipping in 70 ^{0}Brix Sugar Syrup	15.68	15.10	14.85	14.63	**15.06**
T_6: Dipping in 40 ^{0}Brix Honey Syrup	15.40	15.12	14.91	14.70	**15.03**
T_7: Dipping in 50 ^{0}Brix Honey Syrup	15.32	14.95	14.69	14.25	**14.80**
T_8: Dipping in 60 ^{0}Brix Honey Syrup	15.20	14.65	14.21	14.00	**14.51**
T_9: Dipping in 70 ^{0}Brix Honey Syrup	15.09	14.56	14.12	13.97	**14.43**
Mean	**15.19**	**14.85**	**14.46**	**14.23**	

Effect	**CD (P= 0.05)**
Treatments	0.04
Storage	0.02
Treatments× Storage	0.08

Table 3: Effect of treatments and storage period on TSS (^{0}Brix) of osmo-dried plum

Treatments	Storage period (months)				
	0	1	2	3	Mean
T_1: Control	33.53	34.38	35.74	36.58	**35.06**
T_2: Dipping in 40 ^{0}Brix Sugar Syrup	35.07	35.89	36.17	40.83	**36.99**
T_3: Dipping in 50 ^{0}Brix Sugar Syrup	43.72	43.95	44.11	47.87	**44.91**
T_4:Dipping in 60 ^{0}Brix Sugar Syrup	51.05	52.15	53.01	56.25	**53.11**
T_5:Dipping in 70 ^{0}Brix Sugar Syrup	64.00	64.85	65.20	68.23	**65.57**
T_6: Dipping in 40 ^{0}Brix Honey Syrup	38.18	38.95	39.20	42.93	**39.81**
T_7:Dipping in 50 ^{0}Brix Honey Syrup	46.80	47.25	48.10	52.33	**48.62**
T_8: Dipping in 60 ^{0}Brix Honey Syrup	54.10	55.00	56.23	58.65	**55.99**
T_9: Dipping in 70 ^{0}Brix Honey Syrup	67.23	68.25	69.00	72.12	**69.15**
Mean	**48.19**	**48.96**	**49.64**	**52.87**	

Effect	**CD (P= 0.05)**
Treatments	0.05
Storage	0.03
Treatments × Storage	0.10

4.2.3Titratable acidity

Perusal of data in indicated that the acidity content decreased significantly during storage of three months (Table 4). Initially the per cent titratable acidity ranged from 5.15 to 1.45 per cent. The highest titratable acidity of 5.15 per cent was recorded in control followed by 1.67 per cent in T_2 (40 ^{0}Brix sugar syrup) and 1.64per cent in T_3 (50 ^{0}Brix sugar syrup) whereas, the lowest titratable acidity value of 1.45 per cent was recorded in T_9 (70 ^{0}Brix honey syrup), followed by 1.48 per cent in T_8 (60 ^{0}Brix honey syrup) and 1.53 per cent in T_7 (50 ^{0}Brix honey syrup). After three months of storage, the highest titratable acidity of 4.65 per cent was recorded in control whereas, the lowest titratable acidity value of 1.27 per cent was recorded in T_9 (70 ^{0}Brix honey syrup). The mean values of titratable acidity content decreased from 1.96 to 1.73 per cent during three months of storage. The effect of interaction between treatment and storage period was also found significant at p= 0.05.

4.2.4 Ascorbic acid

The data pertaining to ascorbic acid depicted that at beginning, the highest ascorbic acid content of 16.32 mg/100 g was recorded in T_9 (70 ^{0}Brix honey syrup) and the lowest of 12.05 mg/100 g was recorded in T_1 (control) (Table 5). The ascorbic acid content decreased significantly during three months of storage. After three months of storage period, the maximum value of 14.73 mg/100 g was observed in T_9 (70 ^{0}Brix honey syrup) whereas, the lowest value of 10.85 mg/100 g was observed in T_1 (control). The highest value of ascorbic acid was recorded in treatment T_9 (70 ^{0}Brix honey syrup) and lowest in treatment T_1 (control) having values of 15.67 and 11.51 mg/100 g, respectively in treatment mean values. The mean values of ascorbic acid content significantly decreased from 14.75 to 12.34 mg/100 g during three months of storage. The interaction between the treatment and storage period was also found significant at p = 0.05.

4.2.5 Reducing sugar

The data depicted a significant increase in reducing sugar content during three months of storage (Table 6). Initially the lowest reducing sugar content of

14.18 per cent was recorded in T_1 (control) whereas, highest reducing sugar content of 56.42 per cent was recorded in T_9 (70 ^{0}Brix honey syrup). After one month of storage, the maximum value of reducing sugar content 57.10 per cent was recorded inT_9 (70 ^{0}Brix honey syrup) which was followed by treatments T_5 and T_8 with the values of 54.82 and 53.35 per cent, respectively whereas the minimum reducing sugar (14.75 per cent) was recorded in T_1 (control). Same pattern was followed after two and three months of storage. Under various treatment combinations maximum mean value of reducing sugar 57.71 per cent was recorded in T_9 (70 ^{0}Brix honey syrup) and lowest value of 15.01 per cent was recorded in T_1 (control).The mean values of reducing sugar content increased from 41.01 to 43.77 per cent during three months of storage period. Moreover, the interaction effects of treatment over storage period were found to be significant at p = 0.05.

4.2.6 Total sugars

The data in Table 7 revealed that total sugar content increased significantly during entire storage period. At beginning, the highest value of 65.15 per cent was observed in treatment T_9 (70 ^{0}Brix honey syrup) followed by treatment T_5 and T_8having values of 63.90 and 57.18 per cent, respectively. Where as lowest value of 15.10 was recorded in treatment T_1 (control). After three months of storage the maximum value of total sugar content in osmo-dried plum was 68.15 per cent recorded in T_9 (70 ^{0}Brix honey syrup) followed by T_5 and T_8 with values of 66.10and 60.20 per cent, respectively and minimum mean value of 16.32 per cent was recorded in treatment T_1 (control).The mean values of total sugar increased significantly from 47.66 to 50.34 per cent during three months of storage. The interaction between treatment and storage period was also found significant at p= 0.05.

4.2.7 Anthocyanin

It is evident from the data in Table 8 that the anthocyanin content of all the treatments decreased during three months of storage period. Initially, anthocyanin content in osmo-dried plums ranged from 56.85 to 73.05 mg/100 g. At the beginning, maximum anthocyanin content of 75.45 mg/100 g was recorded in treatment T_5 (70 ^{0}Brix sugar syrup) while minimum value of 46.16 mg/100 g

Table 4: Effect of treatments and storage period on titratable acidity (per cent) of osmo-dried plum

Treatments	Storage period (months)				
	0	**1**	**2**	**3**	**Mean**
T_1 :Control	5.15	5.09	4.85	4.65	**4.93**
T_2 : Dipping in 40 ^{0}Brix Sugar Syrup	1.67	1.60	1.52	1.46	**1.56**
T_3 : Dipping in 50 ^{0}Brix Sugar Syrup	1.64	1.56	1.49	1.41	**1.52**
T_4 : Dipping in 60 ^{0}Brix Sugar Syrup	1.60	1.52	1.45	1.36	**1.48**
T_5 : Dipping in 70 ^{0}Brix Sugar Syrup	1.57	1.50	1.44	1.38	**1.47**
T_6 : Dipping in 40 ^{0}Brix Honey Syrup	1.58	1.51	1.47	1.40	**1.49**
T_7: Dipping in 50 ^{0}Brix Honey Syrup	1.53	1.46	1.39	1.32	**1.42**
T_8: Dipping in 60 ^{0}Brix Honey Syrup	1.48	1.43	1.37	1.30	**1.39**
T_9: Dipping in 70 ^{0}Brix Honey Syrup	1.45	1.39	1.33	1.27	**1.36**
Mean	**1.96**	**1.89**	**1.81**	**1.73**	

Effect	**CD (P= 0.05)**
Treatments	0.02
Storage	0.01
Treatments × Storage	0.05

Table 5: Effect of treatments and storage period on ascorbic acid (mg/100 g) of osmo-dried plum

Treatments	Storage period (months)				
	0	1	2	3	Mean
T_1 :Control	12.05	11.90	11.23	10.85	**11.51**
T_2: Dipping in 40 ^{0}Brix Sugar Syrup	13.35	12.65	11.35	10.89	**12.06**
T_3 :Dipping in 50 ^{0}Brix Sugar Syrup	14.05	13.93	12.65	11.42	**13.01**
T_4:Dipping in 60 ^{0}Brix Sugar Syrup	15.20	14.85	13.45	12.15	**13.91**
T_5:Dipping in 70 ^{0}Brix Sugar Syrup	16.05	15.75	14.25	13.80	**14.96**
T_6:Dipping in 40 ^{0}Brix Honey Syrup	14.85	13.01	12.85	11.15	**12.96**
T_7: Dipping in 50 ^{0}Brix Honey Syrup	15.05	14.65	13.32	12.50	**13.88**
T_8: Dipping in 60 ^{0}Brix Honey Syrup	15.85	14.90	14.00	13.65	**14.60**
T_9: Dipping in 70 ^{0}Brix Honey Syrup	16.32	16.00	15.65	14.73	**15.67**
Mean	**14.75**	**14.18**	**13.17**	**12.34**	

Effect	CD (P= 0.05)
Treatments	0.05
Storage	0.03
Treatments × Storage	0.01

Table 6: Effect of treatments and storage period on reducing sugar (per cent) of osmo-dried plum

Treatments	Storage period (months)				
	0	**1**	**2**	**3**	**Mean**
T_1: Control	14.18	14.75	15.32	15.80	**15.01**
T_2: Dipping in 40 ^{0}Brix Sugar Syrup	30.25	31.12	32.36	33.15	**31.72**
T_3: Dipping in 50 ^{0}Brix Sugar Syrup	38.40	39.23	40.45	41.05	**39.78**
T_4:Dipping in 60 ^{0}Brix Sugar Syrup	51.32	52.08	53.12	54.32	**52.71**
T_5:Dipping in 70 ^{0}Brix Sugar Syrup	53.75	54.82	55.09	56.12	**54.94**
T_6:Dipping in 40 ^{0}Brix Honey Syrup	32.25	33.11	34.18	35.25	**33.69**
T_7: Dipping in 50 ^{0}Brix Honey Syrup	40.15	42.82	43.18	44.05	**42.55**
T_8: Dipping in 60 ^{0}Brix Honey Syrup	52.40	53.35	54.12	55.20	**53.76**
T_9:Dipping in 70 ^{0}Brix Honey Syrup	56.42	57.10	58.32	59.02	**57.71**
Mean	**41.01**	**42.04**	**42.90**	**43.77**	

Effect	**CD (P= 0.05)**
Treatments	0.05
Storage	0.03
Treatments × Storage	0.01

Table 7: Effect of treatments and storage period on total sugar (per cent) of osmo-dried plum

Treatments	Storage period (months)				
	0	1	2	3	Mean
T_1: Control	15.10	15.45	16.00	16.32	**15.72**
T_2: Dipping in 40 ^{0}Brix Sugar Syrup	38.92	39.65	40.32	41.65	**40.13**
T_3: Dipping in 50 ^{0}Brix Sugar Syrup	45.49	46.15	47.05	48.32	**46.75**
T_4:Dipping in 60 ^{0}Brix Sugar Syrup	55.05	56.10	57.15	58.75	**56.76**
T_5:Dipping in 70 ^{0}Brix Sugar Syrup	63.90	64.18	65.58	66.10	**64.94**
T_6:Dipping in 40 ^{0}Brix Honey Syrup	40.90	41.15	42.65	43.35	**42.01**
T_7: Dipping in 50 ^{0}Brix Honey Syrup	47.25	48.35	49.60	50.25	**48.86**
T_8: Dipping in 60 ^{0}Brix Honey Syrup	57.18	58.40	59.60	60.20	**58.84**
T_9: Dipping in 70 ^{0}Brix Honey Syrup	65.15	66.05	67.25	68.15	**66.65**
Mean	**47.66**	**48.39**	**49.47**	**50.34**	

Effect	**CD (P= 0.05)**
Treatments	0.04
Storage	0.02
Treatments× Storage	0.08

Table 8: Effect of treatments and storage period on anthocyanin content (mg/100 g) of osmo-dried plum

Treatments	Storage period (months)				
	0	1	2	3	Mean
T_1:Control	56.85	56.45	55.93	55.78	**56.25**
T_2: Dipping in 40 ^{0}Brix Sugar Syrup	48.16	48.00	47.90	47.82	**47.97**
T_3: Dipping in 50 ^{0}Brix Sugar Syrup	56.45	56.05	55.89	55.68	**56.02**
T_4:Dipping in 60 ^{0}Brix Sugar Syrup	65.53	65.10	64.90	64.88	**65.10**
T_5:Dipping in 70 ^{0}Brix Sugar Syrup	75.45	75.18	74.96	74.80	**75.01**
T_6:Dipping in 40 ^{0}Brix Honey Syrup	46.16	45.93	45.79	45.55	**45.86**
T_7 : Dipping in 50 ^{0}Brix Honey Syrup	54.20	53.79	53.45	52.01	**53.36**
T_8: Dipping in 60 ^{0}Brix Honey Syrup	63.32	63.00	62.89	62.72	**62.98**
T_9: Dipping in 70 ^{0}Brix Honey Syrup	73.05	72.90	72.78	72.64	**72.84**
Mean	**59.91**	**59.60**	**59.39**	**59.01**	

Effect	**CD (P= 0.05)**
Treatments	0.06
Storage	0.04
Treatments × Storage	0.01

recorded in treatment T_6 (40 ^{0}Brix honey syrup). During the three months of storage, values of anthocyanin decreased from its initial values in all the treatments under study. In treatment mean values, the maximum value of 75.01 mg/100 g was recorded in treatment T_5 (70 ^{0}Brix sugar syrup) which was followed by T_9 (70 ^{0}Brix honey syrup) with the value 72.84 mg/100 g, while as lowest value (45.86 mg/100 g) observed in treatment T_6 (40 ^{0}Brix honey syrup). The mean values of anthocyanin content decreased from 59.91 to 59.01 mg/100 g during three months of storage. The interaction between storage and treatment was also found to be significant at p=0.05.

4.2.8 Dehydration ratio

The data pertaining to the effect of treatment and storage on dehydration ratio has been presented in Table 9. During three months of storage, decrease in dehydration ratio was recorded in osmo-dried plums. Initially the maximum dehydration ratio of 7.94 was recorded in treatment T_1 (control) and minimum mean value of 2.18 recorded in treatment T_5 (70 ^{0}Brix sugar syrup) and after three months of storage treatment T_1 (control) registered the maximum dehydration ratio of 6.78 followed by treatment T_6, T_7 and T_2 having values of 3.93, 3.79 and 3.53, respectively. In treatment mean values, the maximum dehydration ratio of 7.31 was recorded in control whereas, minimum value of 2.24 recorded in T_5 (70 ^{0}Brix sugar syrup). The mean values of dehydration ratio during storage decreases from 4.14 to 3.54 . Moreover the interaction between the treatment and storage period was also found significant at p = 0.05.

4.2.9 Rehydration ratio

The data in Table 10 revealed that with the advancement of storage period the mean rehydration ratio decreased from initial level of 1.37 to 1.26.Initially the maximum value of 1.65 was recorded in treatment T_1 (control) and the minimum value of 1.21 recorded in treatment T_9 (70 ^{0}Brix honey syrup). After three months of storage, maximum rehydration ratio value of 1.55 was observed in T_1 (control) followed by T_2 and T_3 having values of 1.39 and 1.29, respectively whereas the lowest value of 1.10 was recorded in T_9 (70 ^{0}Brix honey syrup). The interaction between the treatment and storage period was found to be non-significant at p = 0.05.

4.2.10 Total phenols

The data in Table 11 depicted a significant decrease in total phenols during three months of storage and mean values of total phenols decreased from initial level of 638.39 to 624.05 mg/100 g after three months of storage. Initially among different treatments, the maximum total phenol content value of 660.15 and 654.30 mg/100 g was recorded in treatment T_9 (70 ^{0}Brix honey syrup) and T_5 (70 ^{0}Brix sugar syrup) which decreased to 643.25 and 643.15 mg/ 100 g whereas lowest value of 619.20 mg/100 g in treatment T_2 (40 ^{0}Brix sugar syrup) which decreased to 607.25 mg/100 g after three months of storage. In treatment mean values, maximum value of 651.67 mg/100 g was recorded in treatment T_9 (70 ^{0}Brix honey syrup) followed by 648.70 mg/100 gin T_5 (70 ^{0}Brix sugar syrup) while the lowest value of 612.90 and 618.67 mg/100 g were recorded in treatment T_2 (40^{0}Brix sugar syrup) and T_1 (control), respectively. As far as, the treatment means and storage means were concerned the total phenols of all the treatments, storage and their interactions were found significant at p =0.05.

4.2.11 Non enzymatic browning (OD at 440 nm)

The data pertaining to the effect of treatment and storage on non-enzymatic browning in osmo-dried plums have been presented in Table 12. During three months of storage period, increase in non-enzymatic browning was recorded in osmo-dried plums from the initial level of 0.17 to 0.28 (OD at 440 nm).At the beginning among different treatments, the maximum value of 0.25 (OD at 440 nm) was observed in control and minimum value 0.13 (OD at 440 nm) was observed in T_5 (70 ^{0}Brix sugar syrup). After three months of storage, maximum value of 0.40 (OD at 440 nm) was recorded in T_1 (control) whereas, the lowest value of 0.20 (OD at 440 nm) was recorded in T_5 (70 ^{0}Brix sugar syrup). The interaction between the treatment and storage period was also found to be non-significant at p=0.05.

4.2.12 Ash content

The perusal of data regarding the ash content of osmo-dried plum revealed that storage mean values decreased from the initial level of 1.35 to 1.15 during three

Table 9: Effect of treatments and storage periods on dehydration ratio of osmo-dried plum

Treatments	Storage period (months)				
	0	1	2	3	Mean
T_1: Control	7.94	7.41	7.10	6.78	**7.31**
T_2: Dipping in 40 ^{0}Brix Sugar Syrup	4.12	3.91	3.79	3.53	**3.84**
T_3: Dipping in 50 ^{0}Brix Sugar Syrup	3.96	3.77	3.57	3.31	**3.65**
T_4:Dipping in 60 ^{0}Brix Sugar Syrup	3.52	3.31	3.01	2.93	**3.19**
T_5:Dipping in 70 ^{0}Brix Sugar Syrup	2.18	2.51	2.23	2.05	**2.24**
T_6:Dipping in 40 ^{0}Brix Honey Syrup	4.70	4.52	4.05	3.93	**4.30**
T_7: Dipping in 50^{0}Brix Honey Syrup	4.25	4.02	3.90	3.79	**3.99**
T_8: Dipping in 60 ^{0}Brix Honey Syrup	3.55	3.33	3.10	2.97	**3.24**
T_9: Dipping in 70 ^{0}Brix Honey Syrup	3.04	2.93	2.79	2.56	**2.83**
Mean	**4.14**	**3.97**	**3.73**	**3.54**	

Effect	**CD (P= 0.05)**
Treatments	0.04
Storage	0.03
Storage × Treatment	0.08

Table 10: Effect of treatments and storage period on rehydration ratio of osmo-dried plum

Treatments	Storage period (months)				
	0	1	2	3	Mean
T_1: Control	1.65	1.61	1.58	1.55	**1.51**
T_2: Dipping in 40 ^{0}Brix Sugar Syrup	1.48	1.46	1.43	1.39	**1.44**
T_3: Dipping in 50 ^{0}Brix Sugar Syrup	1.41	1.37	1.33	1.29	**1.35**
T_4:Dipping in 60 ^{0}Brix Sugar Syrup	1.36	1.32	1.27	1.24	**1.29**
T_5:Dipping in 70 ^{0}Brix Sugar Syrup	1.30	1.26	1.20	1.16	**1.23**
T_6:Dipping in 40 ^{0}Brix Honey Syrup	1.37	1.34	1.29	1.25	**1.31**
T_7: Dipping in 50 ^{0}Brix Honey Syrup	1.30	1.26	1.21	1.17	**1.23**
T_8: Dipping in 60 ^{0}Brix Honey Syrup	1.27	1.22	1.19	1.15	**1.20**
T_9: Dipping in 70 ^{0}Brix Honey Syrup	1.21	1.17	1.14	1.10	**1.15**
Mean	**1.37**	**1.33**	**1.29**	**1.26**	

Effect	**CD (P= 0.05)**
Treatments	0.03
Storage	0.02
Treatments × Storage	N.S

Table 11: Effect of treatments and storage period on total phenols (mg/100 g) of osmo-dried plum

Treatments	Storage period (months)				
	0	1	2	3	Mean
T_1: Control	627.20	621.10	616.30	610.10	**618.67**
T_2: Dipping in 40 ^{0}Brix Sugar Syrup	619.20	614.10	611.05	607.25	**612.90**
T_3: Dipping in 50 ^{0}Brix Sugar Syrup	632.15	629.30	624.20	619.30	**626.24**
T_4:Dipping in 60 ^{0}Brix Sugar Syrup	641.10	636.02	631.50	628.10	**634.18**
T_5:Dipping in 70 ^{0}Brix Sugar Syrup	654.30	650.25	647.12	643.15	**648.70**
T_6:Dipping in 40 ^{0}Brix Honey Syrup	624.20	621.08	617.10	612.10	**618.62**
T_7: Dipping in 50 ^{0}Brix Honey Syrup	638.12	634.05	628.15	623.05	**630.84**
T_8: Dipping in 60 ^{0}Brix Honey Syrup	649.12	641.20	635.30	630.12	**638.93**
T_9: Dipping in 70 ^{0}Brix Honey Syrup	660.15	654.20	649.20	643.25	**651.67**
Mean	**638.39**	**633.45**	**628.88**	**624.05**	

Effect	**(P =0.05)**
Treatments	0.03
Storage	0.02
Treatments × Storage	0.06

Table 12: Effect of treatments and storage period on non-enzymatic browning (OD at 440 nm) of osmo-dried plum

Treatments	Storage period (months)				
	0	1	2	3	Mean
T_1: Control	0.25	0.30	0.36	0.40	**0.33**
T_2: Dipping in 40 ^{0}Brix Sugar Syrup	0.16	0.19	0.23	0.25	**0.21**
T_3: Dipping in 50 ^{0}Brix Sugar Syrup	0.15	0.18	0.22	0.24	**0.19**
T_4:Dipping in 60 ^{0}Brix Sugar Syrup	0.14	0.16	0.19	0.23	**0.18**
T_5-Dipping in 70 ^{0}Brix Sugar Syrup	0.13	0.15	0.17	0.20	**0.16**
T_6:Dipping in 40 ^{0}Brix Honey Syrup	0.20	0.24	0.29	0.33	**0.26**
T_7: Dipping in 50 ^{0}Brix Honey Syrup	0.18	0.22	0.26	0.30	**0.24**
T_8: Dipping in 60 ^{0}Brix Honey Syrup	0.16	0.21	0.25	0.28	**0.22**
T_9: Dipping in 70 ^{0}Brix Honey Syrup	0.14	0.20	0.24	0.26	**0.21**
Mean	**0.17**	**0.21**	**0.25**	**0.28**	

Effect	**CD (P= 0.05)**
Treatments	0.04
Storage	0.02
Treatments× Storage	N.S

Table 13: Effect of treatments and storage period on ash content (per cent) of osmo-dried plum

Treatments	Storage period (months)				
	0	1	2	3	Mean
T_1: Control	1.10	1.08	1.07	1.05	**1.07**
T_2: Dipping in 40 ^{0}Brix Sugar Syrup	1.40	1.34	1.28	1.24	**1.31**
T_3: Dipping in 50 ^{0}Brix Sugar Syrup	1.37	1.29	1.23	1.13	**1.25**
T_4 : Dipping in 60 ^{0}Brix Sugar Syrup	1.35	1.27	1.19	1.10	**1.23**
T_5: Dipping in 70 ^{0}Brix Sugar Syrup	1.32	1.25	1.17	1.10	**1.21**
T_6:Dipping in 40 ^{0}Brix Honey Syrup	1.45	1.36	1.30	1.26	**1.34**
T_7: Dipping in 50 ^{0}Brix Honey Syrup	1.42	1.33	1.25	1.18	**1.29**
T_8: Dipping in 60 ^{0}Brix Honey Syrup	1.39	1.32	1.24	1.16	**1.28**
T_9: Dipping in 70 ^{0}Brix Honey Syrup	1.35	1.27	1.20	1.13	**1.24**
Mean	**1.35**	**1.28**	**1.21**	**1.15**	

Effect	**CD (P= 0.05)**
Treatments	0.03
Storage	0.02
Treatments× Storage	0.06

months of storage (Table 13). Initially among different osmotic treatments, the maximum value of 1.45 per cent was recorded in treatment T_6 (40 ^{0}Brix honey syrup) whereas the minimum value of 1.10 per cent was recorded in control which decreased to 1.26 and 1.05 per cent, respectively after three months of storage. Maximum ash content value of 1.34 per cent was recorded in T_6 (40 ^{0}Brix honey syrup) while the lowest value of 1.07 per cent was recorded in control in treatment mean values. Moreover the interaction between the treatment and storage period was also found significant at p=0.05.

4.2.13 Calcium content (mg/100 g)

The data pertaining to the effect of treatment and storage on calcium content of osmo- dried plums have been presented in (Table 14). During three months of storage, the decrease in calcium content was recorded in osmo-dried plum from initial value of 40.80 to 40.24 mg/100 g. Initially maximum value of 48.15 mg/100 g was recorded in treatment T_9 (70 ^{0}Brix honey syrup) and minimum value of 30.16 mg/100 g recorded in control while as in storage period of three months, the maximum and minimum calcium content was recorded by T_9 (70 ^{0}Brix honey syrup) and T_1 (control) having values of 47.88 and 29.15 mg/100 g, respectively. Maximum calcium content (47.99 mg/100 g) was recorded in treatment T_9 (70 ^{0}Brix honey syrup) followed by T_5, T_8, T_4 and T_7 with the values 45.97, 45.06, 42.96 and 41.99 mg/100 g, respectively and lowest value of 29.71 mg/100 g was recorded in control in treatment mean values. The interaction between the treatment and storage period was also found significant at p = 0.05.

4.3 Microbial studies of osmo-dried plum

The data pertaining to microbial count is depicted in Table 15. Initially, no microbial growth was observed in osmo-dried plum initial, one or two month. After three months of storage, maximum growth of microbial count was observed in control while as minimum was found in treatment T_9 (70 ^{0}Brix honey syrup) having values of 3.45×10^4 and 1.50×10^4, respectively.

4.4 Sensory evaluation of osmo-dried plum

4.4.1 Colour

The scores for colour gradually decreased from the initial level of 7.37 to 6.99 during three months of storage (Table 16). At the beginning, maximum and the minimum colour scores were recorded in treatment T_9 (70 ^{0}Brix honey syrup) and T_1 (Control), having values of 8.00 and 6.00, respectively. After storage period of three months, the maximum colour score 7.69 was recorded in treatment T_9 (70 ^{0}Brix honey syrup) which was followed by T_8 and T_5 having values of 7.50 and lowest value of 5.50 was recorded in control. The maximum mean treatment value of colour score was observed in treatment T_9 (70 ^{0}Brix honey syrup) and minimum in control with the values of 7.85 and 5.80, respectively. The interaction between the treatments and storage period was found significant at $p = 0.05$.

4.4.2 Texture

Perusal of data revealed a decreasing trend in texture score of osmo-dried plum during storage period of three months (Table 17). Initially, lowest value for texture score was 6.00 recorded in control and highest value of 7.95 was recorded in T_9 (70 ^{0}Brix honey syrup) followed by 7.90 and 7.50 were in T_5 and $T_{8,}$ respectively where as same pattern was followed by three months of storage period. Highest mean treatment value for texture score was 7.83 recorded in T_9 (70 ^{0}Brix honey syrup), whereas the lowest mean treatment value of 5.84 was recorded in T_1 (control).The mean value of texture score decreased from 7.24 to 6.93 during the three months of storage period. The effect of interaction between treatment and storage period was found non- significant at $p = 0.05$.

4.4.3 Taste

The data related to changes in sensory score for taste of osmo-dried plum during storage have been depicted in (Table 18). During three months of storage, the scores for taste decreased with the advancement of storage period from initial value of 6.56 to 6.21. Initially in different osmotic treatments maximum taste score of 7.65 was recorded in treatment T_9 (70 ^{0}Brix honey syrup) whereas the lowest value of 5.45 was recorded in control which was decreased to 7.53 and 5.10 after three months of storage. The highest value for taste score7.59 was recorded in T_9

Table 14: Effect of treatments and storage period on calcium content (mg/100 g) of osmo-dried plum.

Treatments	Storage period (months)				
	0	1	2	3	Mean
T_1: Control	30.16	29.90	29.65	29.15	**29.71**
T_2: Dipping in 40 ^{0}Brix Sugar Syrup	35.65	35.40	35.12	34.85	**35.25**
T_3: Dipping in 50 ^{0}Brix Sugar Syrup	38.05	37.91	37.75	37.40	**37.78**
T_4:Dipping in 60 ^{0}Brix Sugar Syrup	43.15	43.00	42.90	42.78	**42.96**
T_5:Dipping in 70 ^{0}Brix Sugar Syrup	46.20	46.05	45.89	45.75	**45.97**
T_6:Dipping in 40 ^{0}Brix Honey Syrup	38.16	38.01	37.92	37.80	**37.97**
T_7 :Dipping in 50 ^{0}Brix Honey Syrup	42.30	42.00	41.89	41.76	**41.99**
T_8: Dipping in 60 ^{0}Brix Honey Syrup	45.38	45.13	44.93	44.80	**45.06**
T_9: Dipping in 70 ^{0}Brix Honey Syrup	48.15	48.00	47.92	47.88	**47.99**
Mean	**40.80**	**40.60**	**40.44**	**40.24**	

Effect	**CD (P= 0.05)**
Treatments	0.05
Storage	0.03
Treatments× Storage	0.11

Table 15: Effect of treatments and storage period on microbial count (cfu / g x 10^{-4}) of osmo-died plum

Treatments	Storage period (months)			
	0	1	2	3
T_1: Control	N.D	N.D	N.D	3.45
T_2: Dipping in 40 ^{0}Brix Sugar Syrup	N.D	N.D	N.D	2.65
T_3: Dipping in 50 ^{0}Brix Sugar Syrup	N.D	N.D	N.D	2.43
T_4:Dipping in 60 ^{0}Brix Sugar Syrup	N.D	N.D	N.D	2.33
T_5:Dipping in 70 ^{0}Brix Sugar Syrup	N.D	N.D	N.D	2.15
T_6:Dipping in 40 ^{0}Brix Honey Syrup	N.D	N.D	N.D	1.95
T_7 :Dipping in 50 ^{0}Brix Honey Syrup	N.D	N.D	N.D	1.84
T_8: Dipping in 60 ^{0}Brix Honey Syrup	N.D	N.D	N.D	1.65
T_9: Dipping in 70 ^{0}Brix Honey Syrup	N.D	N.D	N.D	1.50

Table 16: Effect of treatments storage period on colour of osmo-dried plum

Treatments	Storage period (months)				
	0	1	2	3	Mean
T_1: Control	6.00	5.90	5.80	5.50	**5.80**
T_2: Dipping in 40 ^{0}Brix Sugar Syrup	7.00	6.89	6.78	6.60	**6.82**
T_3: Dipping in 50 ^{0}Brix Sugar Syrup	7.30	7.20	7.10	6.90	**7.12**
T_4:Dipping in 60 ^{0}Brix Sugar Syrup	7.65	7.52	7.40	7.30	**7.47**
T_5:Dipping in 70 ^{0}Brix Sugar Syrup	7.85	7.75	7.63	7.50	**7.68**
T_6:Dipping in 40 ^{0}Brix Honey Syrup	7.10	7.00	6.90	6.80	**6.95**
T_7: Dipping in 50 ^{0}Brix Honey Syrup	7.50	7.30	7.20	7.10	**7.27**
T_8:Dipping in 60 ^{0}Brix Honey Syrup	7.90	7.82	7.60	7.50	**7.70**
T_9: Dipping in 70 ^{0}Brix Honey Syrup	8.00	7.90	7.80	7.69	**7.85**
Mean	**7.37**	**7.25**	**7.13**	**6.99**	

Effect	**CD (P= 0.05)**
Treatments	0.02
Storage	0.01
Treatments× Storage	0.05

Table 17: Effect of treatments and storage period on texture of osmo-dried plum.

Treatments	Storage period (months)				
	0	**1**	**2**	**3**	**Mean**
T_1: Control	6.00	5.90	5.80	5.68	**5.84**
T_2: Dipping in 40 ^{0}Brix Sugar Syrup	7.00	6.90	6.80	6.69	**6.85**
T_3: Dipping in 50 ^{0}Brix Sugar Syrup	7.15	7.05	6.91	6.80	**7.05**
T_4:Dipping in 60 ^{0}Brix Sugar Syrup	7.45	7.31	7.20	7.10	**7.35**
T_5:Dipping in 70 ^{0}Brix Sugar Syrup	7.90	7.80	7.70	7.59	**7.75**
T_6:Dipping in 40 ^{0}Brix Honey Syrup	7.00	6.90	6.80	6.70	**6.85**
T_7: Dipping in 50 ^{0}Brix Honey Syrup	7.20	7.10	7.00	6.91	**6.98**
T8: Dipping in 60 ^{0}Brix Honey Syrup	7.50	7.40	7.30	7.20	**7.26**
T_9: Dipping in 70 ^{0}Brix Honey Syrup	7.95	7.88	7.78	7.70	**7.83**
Mean	**7.24**	**7.14**	**7.03**	**6.93**	

Effect	**CD (P= 0.05)**
Treatments	0.02
Storage	0.01
Treatments× Storage	0.03

Table 18: Effect of treatments and storage period on taste of osmo-dried plum.

Treatments	Storage period (months)				
	0	1	2	3	Mean
T_1: Control	5.45	5.39	5.20	5.10	**5.28**
T_2: Dipping in 40 ^{0}Brix Sugar Syrup	5.85	5.70	5.49	5.40	**5.61**
T_3: Dipping in 50 ^{0}Brix Sugar Syrup	6.00	5.55	5.51	5.470	**5.63**
T_4:Dipping in 60 ^{0}Brix Sugar Syrup	6.65	6.60	6.56	6.50	**6.58**
T_5:Dipping in 70 ^{0}Brix Sugar Syrup	7.50	7.45	7.41	7.35	**7.43**
T_6:Dipping in 40 ^{0}Brix Honey Syrup	6.25	6.00	5.90	5.80	**5.99**
T_7-: Dipping in 50 ^{0}Brix Honey Syrup	6.65	6.55	6.41	6.38	**6.41**
T_8: Dipping in 60 ^{0}Brix Honey Syrup	7.00	6.53	6.45	6.38	**6.59**
T_9: Dipping in 70 ^{0}Brix Honey Syrup	7.65	7.61	7.57	7. 53	**7.59**
Mean	**6.56**	**6.38**	**6.28**	**6.21**	

Effect	**CD (P= 0.05)**
Treatments	0.04
Storage	0.02
Treatments× Storage	0.09

(70 ^{0}Brix honey syrup) which was followed by T_5, T_8 and T_4 having values of 7.43, 6.59 and 6.58, respectively while lowest value of 5.28 was observed in T_1 (control) in treatment mean values. The interaction between the treatments and storage period was found to significant at p = 0.05.

4.4.4 Overall acceptability

The effect of treatments and storage period on the mean score of overall acceptability of osmo-dried plum presented in (Table 19) which revealed that during three months of storage period overall acceptability score decreased significantly from initial value of 7.04 to 6.70. Initially maximum and minimum scores of 7.86and 5.81 were recorded in treatment T_9 (70 ^{0}Brix honey syrup) and T_1 (control). After three months of storage period, the highest value of sensory score for overall acceptability was 7.64 recorded in treatment T_9 (70 ^{0}Brix honey syrup) followed by T_5 and T_8 with the values of 7.48 and 7.02respectively, while the lowest value of 5.42 was observed in T_1 (Control). Maximum overall acceptability score was recorded in treatment T_9 (70 ^{0}Brix honey syrup) while as lowest in Control having the values of 7.74 and 5.64, respectively. The interaction between the treatment and storage period was found to be non-significant at p = 0.05.

4.5 Cost of production of osmo-dried plums

The cost of production of osmo-dried plum was comprises of fixed and variable cost of all the ingredients used and some other factors *viz.* processing charges, packaging materials etc. The cost of production of osmo-dried plums was arrived to ₹ 54.39/60 g (Table 20).

The present cost of production has been calculated on the laboratory scale basis, however the cost will definitely reduce if manufactured on large scale.

Table 19: Effect of treatments and storage period on overall acceptability of osmo-dried plum

Treatments	Storage period (months)				
	0	**1**	**2**	**3**	**Mean**
T_1: Control	5.81	5.73	5.60	5.42	**5.64**
T_2: Dipping in 40 ^{0}Brix Sugar Syrup	6.61	6.49	6.35	6.23	**6.42**
T_3: Dipping in 50 ^{0}Brix Sugar Syrup	6.81	6.60	6.50	6.39	**6.57**
T_4:Dipping in 60 ^{0}Brix Sugar Syrup	7.25	7.14	7.05	6.96	**7.10**
T_5:Dipping in 70 ^{0}Brix Sugar Syrup	7.75	7.66	7.58	7.48	**7.61**
T_6:Dipping in 40 ^{0}Brix Honey Syrup	6.78	6.63	6.53	6.43	**6.59**
T_7: Dipping in 50 ^{0}Brix Honey Syrup	7.11	6.98	6.87	6.79	**6.93**
T_8: Dipping in60 ^{0}Brix Honey Syrup	7.46	7.25	7.11	7.02	**7.21**
T_9: Dipping in70 ^{0}Brix Honey Syrup	7.86	7.79	7.70	7.64	**7.74**
Mean	**7.04**	**6.91**	**6.81**	**6.70**	

Effect	**CD (P= 0.05)**
Treatments	0.03
Storage	0.02
Treatments× Storage	0.07

Table 20: Cost of production of osmo-dried plum

Ingredients	Rate	Quantity	Amount (Rs)
Plum	120/kg	1 kg	120
Honey	240/kg	1.4 kg	336
Citric acid	120/kg	0.5 g	0.60
LDPE bags	1	12	12
Total ingredients			468.20
Over head charges including labour, fuel and machinery depreciation	@ 20 %		93.64
Profit	@ 15 %		71.16
GST	@ 12 %		19.77
Grand total			652.77
Cost/ pouches/(60 g)			54.39

Chapter-5

Discussion

CHAPTER-V

DISCUSSION

The results obtained are discussed under different heads:

5.1 Physico-chemical characteristics of fresh plum fruit

The data in (Table 1) revealed that the fresh plum having average fruit weight, length, width and pulp stone ratio 38.15 g, 40.05 mm, 40.18 mm and 16.18 respectively, where as moisture content, TSS, acidity, reducing and total sugars were found to be 84.35 per cent, 13.60 ^{0}Brix, 1.63 per cent, 5.75 and 7.06 per cent, respectively. These values are in accordance with findings of Singh (2014) and Kumar *et al*. (2018) while working on storage of pulp and value added products of plum (*Prunus salicina* L.) and studies to evaluate the morphological and horticultural diversity among 15 plum varieties under Kashmir conditions, respectively.

The ascorbic acid and ash content of the fresh plum were recorded as 6.32 mg/100 g and 0.38 per cent and the value for calcium was found to be 20 mg/100 g which coincides with the result of Sharma *et al*. (2011) while working on instant value added products from peach, plum and apricot fruits. Further the anthocyanin and total phenols values of fresh plum were recorded as 40.10 and 221 mg/100 g which were supported by the findings of Walkowaik- Tomczak (2008), Kumar (2013), Singh (2014) and Moustafa *et al*. (2016) while working on characteristics of plums as a raw material with valuable nutritive and dietry properties, the optimization of method for the preparation of osmo-dried plum (*Prunus salicina* L.), storage studies of pulp and value added products of plum *(Prunus salicina* L.*)* and osmotic dehydration of fig and plum, respectively.

5.2 Effect on physio-chemical changes during storage in osmo-dried plum

5.2.1 Moisture content

The data presented in the (Table 2) revealed that moisture content of osmo-dried plum decreased with the advancement in storage period. The moisture content decreased from initial mean value 15.19 to 14.23 per cent up to three months of storage.

A gradual decrease in the moisture content was observed with the increase in osmotic concentration this is may be due to increase in osmotic syrup concentration increases diffusional changes and the osmotic pressure exerted on the fruit cell structure resulted in greater moisture reduction in more concentrated solutions (Jalali *et al.,* 2006). Similar trend of decrease in moisture was also reported by Ahmad and Kumaran (2015) during their study on the effect of honey incorporation on quality and shelf life of anola preserve and Singh (2014) on storage of pulp and value added products of plum. Mondal *et al.* (2017) also reported decrease in moisture content of aonla candy which might be due to evaporation of moisture from the product.

5.2.2 Total soluble solids (TSS)

The TSS of osmo-dried plum increased with an increase in storage period. As it is evident from the Table 3, the TSS increased from the initial mean value of 48.19 to 52.87 ^{0}Brix. The possible reason for the increase in total soluble solids might be due to decrease in moisture content or due to the partial hydrolysis of the complex carbohydrates into simple carbohydrates.

These findings are in accordance with Chavan *et al*. (2010) in banana slices, Ravi (2015) while working on osmotic dehydration of aonla, Kumari *et al.* (2018) in dehydrated guava slices. Similar observations were also reported by Bishnoi *et al.* (2018) while working on development of low calorie aonla ladoo.

5.2.3 Acidity

With an increase in storage period, acidity of osmo-dried plum decrease significantly from initial mean levels of 1.96 to 1.73 per cent (Table 4). The loss of acid in the samples during storage might be due to utilization of acids for conversion of non-reducing sugars to reducing sugars and in non–enzymatic browning reactions.

Similar observations were also recorded by Suhasini (2014) who reported that percent acidity decrease from 3.79 to 2.43 per cent with increase in syrup concentration from 60 to 70 ^{0}Brix. Kenghe (2016) while working on preparation and storage of anola candy, Sharma *et al*. (2018) in development of novel products from osmo-dried apples, apple choco shots and apple pie. These results are also in line with Kushwaha *et al.* (2018) while working on influence of osmotic agents on drying behaviour and product quality of guava fruit.

5.2.4 Ascorbic acid

The results of present study revealed that ascorbic acid content decreased significantly in osmo-dried plum during three months of storage period. The data depicted in Table 5 revealed that the initial mean values decreased from 14.75 to 12.34 mg/100 g during entire three months of storage. This could be due to thermal degradation during dehydration process and subsequent oxidation in storage. Beside this, leaching of ascorbic acid in hypertonic solution also plays a little role in loss of ascorbic acid (Sagar and Kumar, 2009).

Similar results were also reported by Sreehari (2006) while working on sapota slices. Priya and Khatkar (2013) in keeping quality of anola preserve, Singh (2014) while carrying studies on storage of pulp and value added products of plum and Mini and Archana (2016) during formulation of osmo- dehydrated cashew apple (*Anacardium occidentale* L.)

5.2.5 Reducing sugar

The reducing sugar content was found to be significantly increased from initial mean value of 41.01 to 43.77 per cent after three months of storage presented in Table 6. This might be due to the osmosis which leads to decrease in moisture content and consequently increase in sugar content due to sugar uptake from the syrup or might be due to inversion of non-reducing sugars to reducing sugars.

The results are in accordance with those obtained by Rashmi *et al.* (2005) for osmo-air dehydration of pineapple. Naikwadi *et al.* (2010) also reported increasing trend in reducing sugars in dehydrated fig and Ahmed *et al.* (2016) in osmo-air drying of peach. Similar observations were also supported by Mondal *et al.* (2017) in aonla candy and Kumari *et al* (2018) in dehydrated guava slices.

5.2.6 Total sugars

A significant increase in total sugar had been observed during the three months of storage period. As it is evident from the Table 7, the total sugar increased from the initial mean value of 47.66 to 50.34 per cent with the advancement of storage period. The increased levels of total sugars were probably due to conversion of starch into simple sugars (Divya *et al.*, 2012) or might be due to the hydrolysis of polysacchrides resulting in conversion of soluble compounds like sugars.

The present findings are also in conformity with the reported works of Sreehari (2006) while working on sapota slices, Chavan *et al.* (2010) in dehydrated banana slices, Singh (2014) while carrying studies on storage of pulp and value added products of plum and Kumari *et al.* (2018) in dehydrated guava slices also confirms our findings.

5.2.7 Anthocyanin content

The data pertaining to changes in anthocyanin content in osmo-dried plum during storage have been depicted in (Table 8). As it is evident from the table the initial mean values of 59.91 to 59.01 mg/100 g with the advancement of storage period of three months. The decrease in anthocyanin content might due to the increase in browning due to lower activation energy of anthocyanin.

These results are in accordance with Tsai *et al.* (2004) while sudying effect of sugar on anthocyanin degradation and water mobility in Roselle anthocyanin, Kumar (2013) in osmo-dried plum and similar observations of decrease in anthocyanin content was also supported by Singh (2014) in value added products of plum.

5.2.8 Dehydration ratio

A significant decrease in dehydration ratio was observed during three months of storage period as shown in (Table 9). The significant decrease in dehydration ratio from the initial mean values of 4.14 to 3.54 during entire three months of storage. The reason for decrease in dehydration ratio during storage might be due to increased concentration of sugar syrup in which water transport from the fruit is high.

The results are in accordance with the findings of Thippanna (2005) in case of banana. Fatima *et al.* (2016) reported decrease in dehydration ratio while studying osmotic dehydration of chikoo slices and Kumari *et al.* (2018) also reported decrease in dehydration ratio in osmotic dehydrated guava slices.

5.2.9 Rehydration ratio

It is considered to be one of the important quality attribute for dried products. The rehydration indicates the physical and chemical changes occur during processing conditions. The rehydration ratio decreased significantly in osmo-dried plum during three months of storage period from initial mean values of 1.37 to 1.26 (Table 10).

Alkesh (2001) reported similar trend of decrease of rehydration ratio in dehydrated apple rings, Ahmed *et al*. (2016) also reported decrease in rehydration ratio in osmo-air dried peach and also supported by Munaza (2018) in value added products from quince.

5.2.10 Total phenols

The data presented in the (Table 11) shows the effect of treatment and storage on the total phenols of osmo-dried plum. A gradual decrease in the total phenol was observed with the increase in storage period. The means values of total phenols decreased from 638.39 to 624.05 mg/100 g up to the three months of storage. The decrease in total phenols during storage might be due to oxidation, degradation of phenolic compounds and the polymerization of phenolic compounds with proteins (Valera Santos *et al.,* 2012) or might be due to their condensation in brown pigments.

Kim and Zakour (2004) reported that the decrease in total phenolics could be due to distruption in cell structure during processing. Similar observations were also reported by Mishra *et al.* (2015) in mango candy, Mondal *et al.* (2017) in aonla candy and similar findings were also supported by Munaza (2018) while working on value added products from quince.

5.2.11 Non enzymatic browning (OD at 440 nm)

The data depicted in (Table 12) revealed that there was an increase in non-enzymatic browning from the initial value of 0.17 to 0.28.

The several factors such as temperature, moisture, carbonyl compounds, organic acids, oxygen and sugars have also been reported to be responsible for causing NEB in stored food as reported by Thippanna (2005) in banana. Similar findings of increase in non-enzymatic browning were also reported by Durrani *et al.*

(2011) in honey based carrot candy and also supported by Priya and Khatkar (2013) in aonla preserve, Tyagi and Dhawan (2017) in osmotic dehydrated aonla confirms our findings.

5.2.12 Ash content

As it is evident from the (Table 13) ash content decreased significantly from the initial mean value of 1.35 to 1.15 percent with advancement in storage period up to three months. The decrease in ash content due to microbial activities utilizing the minerals for growth. The rate of decrease of ash content was more pronounced at ambient temperatures. The findings are in confirmity with Muzaffar *et al.* (2016) in pumpkin candy, Hasanuzzaman *et al.* (2014) in tomato candy, Ahmed *et al.* (2016) in osmo-air dried peach and Munaza (2018) also reported decline in ash content during storage storage while working on value added products from quince.

5.2.13 Mineral

5.2.13.1 Calcium content

During the three month of storage there was significant decrease in calcium content from the initial mean value of 40.80 to 40.24 per cent in (Table 14). The decrease in calcium content may be due to leaching effects of osmotic dehydration and microbial activity. The highest calcium content was recorded in T_9 (70 ^{0}Brix honey syrup) and the lowest value was recorded in control. The present findings were also reported by Singh *et al.* (2015) in dehydrated papaya slices using osmotic dehydration, Tripura (2015) in ripe sapota slices and Munaza (2018) while studying value added products from quince.

5.3 Microbial quality of osmo-dried plum

As it is evident from the (Table 15), that no microbial count was observed with the advancement of storage period. However, at the end of storage, the highest microbial count of 3.45×10^4 was recorded in treatment T_1 (Control) and the lowest of 1.50×10^4 in T_9 (70 ^{0}Brix honey syrup) .Yet it remained below the range than the limits specified by FDA for such products. An acceptable count of microbes was also observed in aonla preserve by Priya and Khatkar (2013). Ravi (2015) did not observe any microbial growth in osmotic-dehydrated aonla.

5.4 Sensory evaluation of osmo-dried plum

Sensory evaluation of osmo-dried plum revealed that there was decline in all the parameters viz. colour, texture, taste and overall acceptability with the advancement of storage period up to three months.

5.4.1 Colour

The colour of the product is the key to the success of a processed product in the market. Colour mean score decreases from 7.37 to 6.99 in osmo-dried plum during three months of storage period as revealed in Table 16. Maximum colour mean score of 7.85 was observed in treatment T_9 (70 ^{0}Brix honey syrup). The colour mean scores decreases during three month of storage this might be due to enzymatic and oxidative browning.

Similar findings were also reported by Chavan *et al.* (2010) in osmotic dehydration of banana slices and Kumar (2013) in osmo-dried plum. The results are also in conformity with Dhiman *et al.* (2016) in osmotic dehydrated wild pear and Mahesh *et al.* (2017) in osmotic dehydration of pineapple slices.

5.4.2 Texture

Texture score was found to be non-significant in osmo- dried plum during three months of storage period. The maximum texture score was 7.75 noticed in treatment T_9 (70 ^{0}Brix honey syrup) as shown in (Table 17). This could be due to better solid gain and optimum water loss.

Texture mean score decreased during storage period of three months from 7.24 to 6.93 which might be due to the absorption of moisture and hygroscopic nature of osmo-dehydrated products which soften the tissue in pulp. These results are in accordance with those of findings of Durrani *et al.* (2011) in honey based carrot candy, Pritika (2015) in osmotically dried pumpkin cubes and Mahesh *et al.* (2017) in osmotic dehydration of pineapple slices.

5.4.3 Taste

Taste score was found to be significant in osmo- dried plum during three months of storage period. The maximum texture mean score was 7.59 noticed in treatment T_9 (70 ^{0}Brix honey syrup) depicted in (Table 18).

Taste mean score decreased with advancement of three months storage period from 6.56 to 6.21 because of dilution of sugars and change in acidity in product. The results also supported by Chavan *et al.* (2010) for osmotic dehydration of banana slices, Singh (2014) in value added products from plum and Mahesh *et al.* (2017) in osmotic dehydration of pineapple slices.

5.4.4 Overall acceptability

Overall acceptability of osmo-dried plum can be determined by considering the colour, texture and taste. Significantly highest overall acceptability mean value was 7.74 found in T_9 (70 ^{0}Brix honey syrup) shown in (Table 19). This could be due to presence of highest colour, taste, flavour and texture score.

The mean overall acceptability decreased significantly during three months of storage period from 7.04 to 6.70. This may be due to the physical characteristics of the product viz., colour, taste, flavour and texture score. The decrease in overall acceptability score may be due to absorption of atmospheric moisture, dilution of sugars and changes in acidity, oxidation of ascorbic acid, hygroscopic nature of osmo-dehydrated product as well as changes in biochemical constituents of product. The results are also in conformity with Chavan *et al.* (2010) for osmotic dehydration of banana slices, Dhiman *et al*. (2016) in osmotic dehydrated wild pear and Mahesh *et al.* (2017) in osmotic dehydration of pineapple.

5.5 Cost of production

Cost of production of osmo-dried plum is based upon the fixed and variable costs. The fixed cost includes the overall charges, machinery depreciation, labour, fuel and variable cost comprises of raw materials which includes fruits and all other ingredients, cost of packaging material, value added tax and a seasonable profit margin. The cost of production of osmo-dried plum comes to ₹ 54.39/ 60 g in (Table 20)

Since, the cost of production has been calculated on the laboratory scale basis, further reduction in cost of production on large scale can be expected.

Chapter-6

Summary and Conclusion

CHAPTER-VI

SUMMARY AND CONCLUSION

The present investigation entitled "Development and quality evaluation of osmo-dried plum" was carried out in the Division of Food Science and Technology, during the year 2018-2019. The developed product were analysed for physio-chemical, microbial and organoleptic characteristics at a regular interval of 30 days for a period of three months. The results achieved are being summarized as under:

- The mean fruit weight, length, breadth and pulp stone ratio of fresh plum were recorded as 38.15 g, 40.05 mm, 40.10 mm and, 16.18 respectively. Whereas, in the chemical analysis of fresh plum fruits, the moisture, total soluble solids, titratable acidity, ascorbic acid, reducing sugar, total sugar, anthocyanins, total phenols, ash and calcium content were 84.35 per cent, 13.60 ^{0}Brix, 1.63 per cent, 6.32 mg/100 g, 5.75 per cent, 7.06 per cent, 40.10 mg/100 g, 221 mg /100 g, 0.38 per cent and 20 mg/100 g, respectively.
- The moisture content decrease with the increase in storage period. Highest moisture content was observed in treatment T_2 (40 ^{0}Brix sugar syrup) while as lowest in control
- TSS content increased in all treatments with the advancement of storage period. Maximum TSS was found in treatment T_9 (70 ^{0}Brix sugar syrup) where as minimum TSS in treatment T_1 (Control).
- Maximum acidity was recorded in T_1 (Control) and where as minimum titratable acidity was recorded in T_9 (70 ^{0}Brix honey syrup).
- Ascorbic acid was maximum in T_9 (70 ^{0}Brix honey syrup) and minimum value was in T_1 (Control). Ascorbic acid declined in all treatments with the advancement of storage period
- Reducing and total sugars exhibited increasing trend in all treatments during storage upto three months of storage period. Maximum reducing and total sugars content were found in T_9 (70 ^{0}Brix honey syrup) where as minimum value was observed in control.
- The anthocyanin content of osmo-dried plum decreased with the advancement of storage period for entire three months. Maximum anthocyanin content value was recorded in T_5 (70 ^{0}Brix sugar syrup) while minimum value was observed in T_6.

- Both dehydration and rehydration ratio decrease with the increase in storage period in osmo-dried plum.Treatment T_1 (Control) recorded the maximum values.
- Among all the treatment there was decline in the total phenols and maximum retention was recorded in treatment T_9 (70 ^{0}Brix honey syrup) in osmo-dried plum during the entire storage period of three months.
- Non enzymatic browning showed increasing trend, the maximum value was observed in control and minimum value was recorded in treatment T_5 (70 ^{0}Brix sugar syrup) during the entire three months of storage.
- Ash content decreased with the increase in the storage period. Maximum ash content was observed in T_9 where as minimum value was recorded in control.
- Calcium content in osmo-dried plum showed a decreasing trend during entire three months of storage. Among different treatments the maximum value was recorded in T_9 (70 ^{0}Brix honey syrup) and lowest in control.
- On the basis of sensory evaluation (colour, texture, taste, and overall acceptability) treatment T_9 (70 ^{0}Brix honey syrup) was evaluate best among all the treatments with mean score of 7.85, 7.83, 7.59, and 7.74, respectively in osmo- dried plum.

Conclusion

Findings summarized above indicated that plum fruits grown under mid and high hills of Jammu and Kashmir UT can be used successfully for the preparation of osmo-dried plum to increase their nutritive and functional values. On the basis of the sensory evaluation (colour, texture, taste and over all acceptability), the treatment T_9 (70 ^{0}Brix honey syrup) was adjudged superior among all the other treatments. Thus, the developed technology can be commercially explored at industry level for the production of quality osmo-dried plum for efficient and profitable utilization of this fruit for ensuring better returns to the growers. Nutritionally enriched osmo-dried plum developed in this study are rich source of phenolics corresponding to high anthocyanins thus suggesting that such dehydrated fruits can be commercialized and therefore could be an important component of diet.

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OGPA % Marks	7.23
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Title of Master’s thesis	“Development and quality evaluation of osmo-dried plum”

Evaluation Card for Hedonic Rating of …………………………

Name: **Date:**

Evaluate these samples and check how much you like or dislike each one. Use appropriate scale to show your attitude by checking at the point that best describe about the sample.

Treatments	Colour	Texture	Taste	Overall Acceptability
T_1				
T_2				
T_3				
T_4				
T_5				
T_6				
T_7				
T_8				
T_9				

Scores:

9. Like extremely
8. Like very much
7. Like moderately
6. Like slightly
5. Neither like nor dislike
4. Dislike slightly
3. Dislike moderately
2. Dislike very much
1. Dislike extremely

Signature of Evaluator

CERTIFICATE-IV

Certified that all the necessary corrections as suggested by the external examiner and the advisory committee have been duly incorporated in the thesis entitled **"Development and quality evaluation of osmo-dried plum"** submitted by **Ms. Mandeep Kour,** Registration No. **J-17-M-493.**

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