EFFECT OF HUMECTANTS ON STORAGE STABILITY OF INTERMEDIATE MOISTURE BEETROOT CUBES

By

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(Registration No. J-14-M-383)

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M.Sc.
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Anil Kumar Chhibber

2016

CERTIFICATE–I

This is certify that the thesis entitled **"Effect of humectants on storage stability of intermediate moisture beetroot cubes"** 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 Agricultural Sciences and Technology of Jammu is a record of bonafide research carried out by **Mr. Anil Kumar Chhibber,** Regestration No. **J-14-M-383,** 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.

(Dr. Jagmohan Singh)
Major Advisor

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CERTIFICATE–II

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ACKNOWLEDGEMENT

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Date: 29-07-2016

Anil Kumar Chhibber

ABSTRACT

Title of the thesis	:	**Effect of humectants on storage stability of intermediate moisture beetroot cubes**
Name of the student	:	**Anil Kumar Chhibber**
RegistrationNo.	:	**J-14-M-383**
Major subject	:	**Food Science and Technology**
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ABSTRACT

Beetroot (*Beta vulgaris* L.) is rich in valuable, active compounds such as carotenoids, glycine betaine, saponins, betacyanines, betaxanthins, folates, betanin, polyphenols, flavonoids and vitamins. Consuming beetroot helps in curing many diseases such as anemia, blood pressure, cancer, kidney ailments and liver toxicity. Therefore there is a need of proper processing and preservation techniques so as to get maximum benefits from beetroot. In the present study, intermediate moisture beetroot cubes were prepared by soaking the beetroot cubes in the soaking solution containing sugar: glycerol/ sorbitol in the ratio of 100:00, 90:10, 80:20, 70:30, 60:40, 50:50 and 40:60. Fresh beetroot had moisture, total soluble solids, acidity, reducing sugar, total sugars, ash, calcium, phosphorous, and ascorbic acid as 86.12% 6.50^0 Brix, 0.02%, 0.96 %, 4.16 %, 1.20 %, 15 mg/100g, 36 mg/100g and 3.61 mg/100g respectively. The processed product was stored at ambient conditions and subjected to chemical, microbial and sensory evaluations at an interval of one month for a period of three months.

The highest value of reducing sugar (2.71%), total sugars (28.30%), acidity (0.10%), calcium (19.72mg/100g), phosphorous(24.48mg/100g) were recorded in treatment T_1(Sugar:Glycerol::100:00) and lowest values of reducing sugar (1.88%), calcium(17.91mg/100g) and phosphorous(22.41mg/100g) in T_7(Sugar:Glycerol::40:60), total sugars (23.34%) in T_{13}(Sugar:Sorbitol::40:60), titratable acidity (0.05%) in T_{13}(Sugar:Sorbitol::40:60) were recorded. The highest moisture content (27.14%) was recorded in treatment T_7(Sugar:Glycerol::40:60) and lowest values of 23.12%, was recorded in T_1(Sugar: Glycerol::100:00) The highest pH (7.25) was recorded in T_{13} (Sugar:Sorbitol::40:60)and lowest (6.98) was recorded in T_1(Sugar:Glycerol::100:00)Highest value of ascorbic acid (3.80 mg/100 gms) was recorded in T_6 (Sugar:Glycerol::50:50) and lowest(3.06 mg/100 gms) in treatment T_8(Sugar: Glycerol:: 90:10) However with the advancement of storage an increasing trend was observed in total sugars and reducing sugars. The decreasing trend was observed in moisture, pH, calcium, phosphorous and ascorbic acid during three months of storage. No microbial count was observed in all the treatments during first two months of storage. In the third month of storage the lowest microbial count was observed in treatment T_6(Sugar:Glycerol::50:50)and highest in treatment T_1(Sugar:Glycerol :: 100:00) The intermediate moisture beetroot cubes prepared from treatment T_6(Sugar:Glycerol::50:50)was adjudged the best on the basis of sensory attributes by scoring 7.88, 7.80,7.70 and 7.40 for taste, texture, flavor and overall acceptability respectively followed by treatment T_1(Sugar:Glycerol::100:00) Storability studies revealed that all the treatments could be kept for at least 90 days without affecting the quality attributes.

Key words : beetroot, intermediate moisture foods, humectants, additives.

Signature of Major Advisor **Signature of Student**

LIST OF ABBERVATIONS

et al.	et al (and others)
^{0}C	Degree celsius
g	gram
mg	milligram
ml	milliliter
%	per cent
pp	pages
min.	minutes
L	liter
N	Normality
No.	Number
TSS	Total soluble solids
Fig.	Figure
C.D.	Critical difference
@	at the rate of
Kg	Kilogram
^{o}B	Degree Brix
I M F	Intermediate Moisture Food

Chapter-1

Introduction

CHAPTER -I

INTRODUCTION

Fruits and vegetables are an important supplement to the human diet as they provide the essential minerals, vitamins and fibre (roughage) required for maintaining health. India is the second largest producer of fruits and vegetables. As per Indian Horticulture Database published by Ministry of Agriculture Govt. of India, during 2013-14, India produced 88.977 million metric tonnes of fruits and 162.897 million metric tonnes of vegetables. The area under cultivation of fruits stood at 7.21 million hectares while vegetables were cultivated at 9.39 million hectares (I.H.D.B). Fruits and vegetable losses in the developing countries are considerably high. In India, post harvest losses of fruits and vegetables are estimated as more than 25 percent. Daily consumption of fruits and vegetables reduce the risk of cancer, heart disease, premature aging, stress, and fatigue primarily due to the integrated action of oxygen radical scavengers such as β-carotene and ascorbic acid plus calcium and dietary fibre.

Beetroot (*Beta Vulgaris* L.) is botanically classified as a herbaceous biennial from Chenopodiaceae family and has several varieties with bulb colours ranging from yellow to red.. There are nine other species in Beta genus and all have the common name Beet .Beetroot grows plentiful throughout India from the hills of south India to the chilly areas of north. Beet root is mainly cultivated in Haryana, Uttar Pradesh, Himachal Pradesh, West Bengal and Maharashtra (anonymous, 2010). In India, this highly nutritious and medicinal valued crop is sown during months of September-November in northern plains while it can be sown from first week of March to July only in hilly areas having cool weather. Deep red-coloured beet roots are the most popular for human consumption, both cooked and raw as salad or juice. The purple- red colour is due to the presence of betalin pigment. Betanins, obtained from the roots, are used industrially as red food colourants, e.g to improve the colour of tomato paste, sauces, desserts, jams, jellies, ice creams, sweets and cereals.Beetroots are rich in valuable, active compounds such as carotenoids (Dias *et al*., 2009), glycine betaine, (De-Zwart *et al*., 2003), saponins (Atamanova *et al*., 2005), betacyanines and betaxanthins (Gandia-Herrero *et al*.,2010) , folates (Jastribova *et al.,* 2003), betanin, polyphenols and flavonoids (Vali *et al*., 2007). Therefore, beetroot ingestion can be considered a factor in cancer prevention (Kapadia *et al*., 1996). They have antimicrobial and antiviral effects (Strack *et al*., 2003) and also can inhibit the cell proliferation of human tumour cells (Reddy *et al*.,2005).Consumption of red beet which are rich source of antioxidants can contribute to protection from age related diseases. According toVinson(1998), Zitnanova *et al.*(2006) red beet is one of the most potent vegetable with respect to antioxidant activity. Significant amount of vitamin C ,Vitamin B_1, B_2, niacin, B_6, B_{12} are found in beetroot, while the leaves are an excellent source of vitamin A. Consuming beetroot helps in curing many diseases such as anemia, blood pressure, cancer, dandruff, gastric ulcers, kidney ailments, liver toxicity or bile ailments like jaundice, hepatitis, food poisoning, diarrhea or vomiting. (Kumar, 2015) Dried beetroots can be consumed directly in the form of chips as a substitute of traditional snacks, that are rich in trans fatty acids (Aro *et al.*, 1998) or after easy preparations as a component of instant food (Krejcova *et al*.,2007) Due to the beneficial effects, the crop should be consumed regularly in one or the other form. Therefore, there is a need of proper processing and preservation technique so as to get the maximum benefits from beetroot. Nowadays, the people are more health conscious and they want to know the pros and cons of the food which they are consuming. In recent years increased attention has been focused on utilization of healthy foods.

Intermediate moisture foods can be classified as partially dehydrated foods with suitable concentrations of dissolved solids to inhibit the growth of bacteria, molds, and yeasts and to control undesirable enzymatic activity The IMF are semi-moist foods that have some of their water bound by sucrose, glycerol, sorbitol, salt or certain organic acids for a short period of time, thus, preventing the growth of many microorganisms (Panwar *et al*. 2013) The committee for IMF of France's National Centre for Coordination of Research on Food and Nutrition proposed the definition for intermediate moisture foods: "Food products of soft texture, subjected to one or more technological treatments, consumable without further preparation and with a shelf stability of several months, assured without thermal sterilization, freezing and refrigeration, but by an adequate adjustment of their formulation, composition, pH, additives and mainly water activity(a_w) which must be approximately between 0.65 and 0.90 measured at 25^0C. Generally they contains moderate levels of moisture of the order of 20 to 50 per cent (Vora *et al.*, 2003)

The intermediate moisture foods have an acceptable eating quality i.e better colour, texture and flavour as compared to conventional hot air dried foods and have reasonable storage stability under ambient conditions (Iman *et al*., 2011).

Keeping in view the commercial potential for IMF the present study has been undertaken for preparation of intermediate moisture beetroot cubes with the following objectives.

1. To study the effect of humectants on quality characteristics of intermediate moisture beetroot cubes.

2. To assess the shelf stability and economics of the developed product.

Chapter-2

Review of Literature

CHAPTER -II

REVIEW OF LITERATURE

The beetroot is the taproot portion of the beet plant. It is an excellent food which impart very important role for the development and growth of human body. It also act as fruit as well as vegetable. Fresh form of beet root is generally consumed as a salad. Other than as a food, it plays another role as natural colorant in textile industry and as a medicinal plant to cure the various illness. Lots of work has been done on production, storage of beetroot but literature available with regard to preparation of various processed products of beetroot and their storage life is scanty. This study for the preparation of IMF beetroots would give value addition to this vegetable which could be consumed by indigenous population. Therefore the available literature on the product preparation and storage especially related to IMF of other fruits and vegetables has been reviewed in this chapter under the following headings.

2.1 Chemical characteristics of fresh beetroot.

Beetroot (*Beta vulgaris* L.) has several varieties with bulb colour ranging from yellow to red.They are biennials although usually grown as annuals. Medium sized tubers are of great demand and tubers are harvested after attaining a diameter of 3 to 5 cm.Beetroots main benefits are that it contains no fat,very few calories and is a great source of fibre. The best quality and root colour are obtained when the air temperature ranges between 10^0C to 18^0C. Betalain is a water soluble pigment which is responsible for the providing purple red colour to beetroot (Vitti et al., 2005). Betalains are combination of betaxanthin and betacyanin. Both betacyanin and betaxanthin are heat labile and degraded by light. Fresh beet root contained 100mg/100g and dried beet contained 16-38mg/100g betanine 0.5-1% betalain after centrifugation, pasteurization and concentration.

Nutritional composition of beetroot contained 9.6g carbohydrates, 1.6g proteins, 0.2g fat, 2μg vitamin A, 20μg β-carotene, 0.03mg Thiamine, 0.04mg riboflavin, 0.33mg niacin, 5mg vitamin C, 16mg calcium, 0.80mg iron (Sturziou *et al.,* 2011). Koul *et al*. (2002) reported that Beet root juice contained 7.0% sugar &, 0.35mg sodium, 325mg potassium and 40mg phosphorus in 100g beet root. Thakur and Das Gupta (2005) reported total soluble solids of beetroot as 6.5^0Brix, pH as 6.5, titratable acidity as 0.1

percent, reducing sugar as 0.21 percent and total sugar as 4.09 percent respectively. Beet root contained very high amount of nitrates that is 2500mg/40 mmol (Anon, 2011)

Singh and Hathan (2013) reported that beetroot is an alkaline food of pH 7.5 to 8.0 and contains higher antioxidant compounds. Juszczak *et al* .(2010)reported that the muddy flavor of beetroot is due to the presence of geosmin. Bhoyar and Chappalwar (2014) reported that beetroot contains 87.2per cent moisture, 0.83 per cent ash, 2.7 per cent crude fibre, 0.58 per cent fat, 1.47 per cent proteins, 7.74 per cent carbohydrates, 6.05 per cent reducing sugars.

2.2 Intermediate moisture foods.

The intermediate moisture foods (IMF) are the semimoist foods in which water content is lowered to a level that prevents microbial damage, but most of the bound water is retained in the food so that the texture of the original food is essentially preserved. The newly developed IMF are characterized by lower water activity (a_w) values and it is achieved by withdrawal of moisture by desorption, adsorption or concentration by addition of permissible additives which acts as humectants. IMF is a heterogenous group of foods that look dry but contain too much moisture to regarded as dry. Several foods like dry figs and dates had been used by man before the dawn of recorded history. Intermediate Moisture Foods are plastic, easily masticated and do not produce an oral sensation of dryness (Labuza *et at*., 1970). Intermediate Moisture Foods offer several potential advantages for special military situations in which re-supply is unreliable and the soldier must add to his already immoderate load whatever food he will consume on missions lasting for as long as 8 days and IMFs are suitable for direct consumption with no preparative effort. Such foods can be used in stress situations in which diversion of time or attention to the preparation of food is hazardous.

Brockman (1970) highlighted the potential advantage of IMF during special war like situations and considered these more suitable as combat rations. Thereafter, Labuza *et al*. (1970) had done pioneering work on standardizing intermediate moisture foods. They have discussed the basis for the presumed chemical stability of these foods as a function of water activity (a_w), which was later confirmed by a number of other scientists.

Jayaraman *et al*. (1974) prepared intermediate moisture guava preserve by employing immersion- equilibration procedure using a soak solution containing glycerol, sucrose, water and potassium sorbate at 38.45, 16.1, 0.196 per cent respectively. They found the products to be of a high calorific value (235 Kcals/100g). They further observed that the products when packed in cans, remained stable upto 6 months at 0°C, when stored at ambient temperature, with slight browning/darkening and weakening of flavour beyond 4 months, whereas upto 3 months it was acceptable at 37^{0}C. They further found that the product, was resistant to microbial growth. Even reuse of soak-solution did not affect the quality of the product.

Jayaraman *et al.* 1975 developed IM pineapple chunks and rings again by the immersion-equilibration procedures. The product was nutritionally analyzed for varying parameters and the a_w was found to be 0.79. They also estimated the storage stability of the product. Samples packed in cans and paper-foil polythene laminated pouches maintained their acceptability for more than 6 months at 0°C,upto 6 months at room temperature with slight browning and weakening of flavour beyond 4 months. Then again, the soak solution could be economically reused without affecting the quality of the product.

Jayaraman *et al.* (1976) carried their work further on the studies of the development of IMF mango slices from different varieties of mangoes, employing the same immersion equilibration procedure using the same ingredients. They concluded that the product had excellent flavour, colour and texture comparable to fresh fruits and could be eaten as such without any rehydration and therefore, could also serve as a suitable substitute for mango slices canned in sugar syrup.

Bongirwar and Sreenvasan (1977) have reported a method of partial dehydration of banana fruits by osmosis in sugar syrup of 70 per cent concentration. The flavour, colour, appearance and texture attributes were maximally retained. These could be preserved upto one year or more, depending upon the packaging material used and the storage conditions.

Jayaraman and Gupta (1978) reported about the development and storage of IMF vegetable (carrot). They prepared intermediate moisture carrot slices by soaking the blanched slices for 12-16 hrs in 6 per cent brine, followed by partial hot-air dehydration to 50 per cent moisture level. Presence of sucrose and glycerol at 10.0 per cent and 5.0 per cent levels respectively in the soak solution improved their texture on rehydration significantly. The concentration of additives used were sufficient to ensure microbiological stability at the intermediate moisture level but reached tolerable levels to taste on rehydration

Ramanuja and Jayaraman (1980) standardized IMF Banana slices by using a soak solution containing glycerol and sugar or sugar syrup and with or without partially hot air drying. In the event when the latter was used, the banana slices had good flavour and texture and could be eaten as such. They observed that the IMF slices prepared by using glycerol and sugar yielded product much better than that prepared using sugar alone. The IMF banana slices which when treated with 0.2 per cent potassium sorbate, were microbiologically safe at a water activity (aw) of 0.8. Even reuse of the spent solution did not affect the quality and the shelf-life of the product.

Sethi and Anand (1982) worked on the preparation of intermediate moisture carrot preserve. The soak solution used by them contained sugar, glycerol, water, acid, preservatives and the product got excellent sensory evaluation and could be consumed as such without any further rehydration or cooking. They further reported that the product remained acceptable for 6 months in glass containers with 40.0 per cent retention of beta-carotene.

Rani and Bhatia (1986) developed a similar product from Bagugosha pear by using sugar and glycerol alongwith preservatives as well as sugar alone. The product packed in polyethylene bags was found to be stable microbiologically for about 40 weeks under ambient conditions.

Giangiacomo *et al*. (1987) studied the osmotic dehydration of different fruits viz. cherry, apricot and peaches with the osmotic syrup. They explained that the sugar exchange dynamics between the syrup and the fruits was related not only to the flux of sugar from the syrup into the fruit, but was also affected by the individual sugars originally present in the fruit. The exchange was stated to be dependent on the species of fruits, the relative diffusibility of the sugars and enzymatic activity within the fruit.

Later on, an investigation was carried out by Thorat *et al*. (1988) for the preparation of IM Okra (*Abelmoschus esculentus*) and its storage performance at room temperature. The samples were estimated for chemical, nutritional, microbiological and packaging evaluation for 40 days. The samples treated with 7.5 per cent brine were superior for chlorophyll retention. The samples treated with 5.0 and 7.5 per cent were organoleptically acceptable as compared to 10.0 per cent.

Sahoo *et al.* (1994) referred to these foods as 'semi-moist foods' with 15-50 per cent moisture and a_w ranging between 0.60 - 0.85

Khan *et al* (1996) developed a sweetened intermediate moisture (IM) dehydrated pear product known as pear glace and it was prepared using six different solutions of corn syrup and crystalline sucrose and found that corn syrup and sucrose mixture (30 & 70 percent) was the most desirable product in terms of colour , texture and sweetness.

Barmany *et al.* (1998) prepared the IMF from sandpear by using glycerol and sugar and found the product to be more nutritious with shelf-life for 6 months.

Singh *et al.* (2005) developed intermediate moisture shelf stable product of ber by osmo- mechanical dehydration process.They found that drying of ber at 55^0 C treated and pricked, harvested at stage II resulted in a good quality intermediate moisture and shelf stable dried product.

Saxena *et al* .(2009) prepared shelf stable ready to eat intermediate moisture pineapple slices using hurdle technology. The combination of hurdles including osmotic dehydration, infrared drying and gamma radiation dose of 1 kGy, successfully reduced the microbial load to below detectable limit. The intermediate moisture pineapple slices were found to have good texture, colour and sensory acceptability during 40 days of storage.

Chavan and Amarowicz (2012) worked on the osmotic dehydration process for preservation of fruits and vegetables and standardized the osmotic dehydration process and concluded that osmotic dehydration process being a simple process facilitated processing of tropical fruits and vegetables such as banana, sapota, pineapple, mango, guava, carrot, pumpkin, papaya, etc. with retention of initial fruits characteristics viz., colour, aroma and nutritional compounds.

Panwar *et al.*(2013) studied the effect of osmotic agents on intermediate moisture aonla segments during storage. The intermediate moisture aonla segments cv. Banarasi were prepared by using 3 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 in the product and also developed more acceptable IMF aonla segments on sensorial basis.

Mondhe *et al.* (2013) studied the effect of osmotic solution and drying temperature on organoleptic evaluation of Papaya cubes. Papaya cubes treated in 60^0 Brix syrup concentration and air dried at 60^0 C were found to be more acceptable then those with 55, 75^0 Brix and air dried at 60^0 C. The process is economical, simple and non-destructive with least wastage of fruit during processing.

2.3 Storage studies

2.3.1 Moisture

Barmanray (1998) recorded decrease in moisture content during 90 days of storage in intermediate moisture sand pear in the processing technology of sand pear.

Pooja (1999) reported decrease in moisture content of intermediate moisture apricot during 90 days of storage. Whereas Sood (2000) reported that the moisture content in IMF of papaya, apple and white guard decreased during 90 days of storage when packed in cans, glass jars or polyethylene pouches. Ergun *et al.* (2010) reported a decrease in moisture content in candies during storage in the study on moisture and shelf life in sugar confectionaries. Panwar *et al*. (2013) reported decrease in moisture content during 90 days of storage in intermediate moisture aonla segments. Akhtar and Javed (2013) observed an increase in moisture content of intermediate moisture apple slices while performing physico-chemical analysis and quality evaluation of intermediate moisture apple slices.

A significant decrease in moisture content was observed during storage period of 90 days by Priya and Khatkar (2013) while studying the effect of processing methods on keeping quality of Aonla preserve. Chaturvedi *et al.* (2013) recorded a decrease in moisture content of intermediate moisture carrot shreds during storage of three months.

Muzzafar *et al.*(2016) reported a non-significant decreasing trend in moisture content of pumpkin candy during storage of one month. Moisture content decreased significantly for another two months storage.

2.3.2 Ascorbic acid

Chander (1982) reported reduction in ascorbic acid content during storage of intermediate moisture food prepared from the different mango varieties. Rani and Bhatia (1986) reported that the ascorbic acid values tended to decrease continuously in pear candy with duration of 40 weeks of storage. Singh (1988) observed that the ascorbic acid content of aonla intermediate moisture food reduced during six months of storage.

Barmanray (1998) recorded that the ascorbic acid content reduced significantly throughout the storage period of intermediate moisture pear products. IMF with sugar had higher initial ascorbic acid content. After 90 days of storage IMF with glycerol and sugar showed maximum retention of ascorbic acid.

Sood (2000) recorded the decrease in ascorbic acid content of intermediate moisture papaya cubes, apple slices, white guard cubes, carrot slices and yam cubes during 90 days of storage. Kumar and Singh (2001) also showed a decreasing trend in the ascorbic acid content during three months storage in aonla products. Panwar *et al*. (2013) reported that ascorbic acid content in intermediate moisture aonla segments decreased significantly during six months of storage

Priya and Khatkar (2013) observed a decreasing trend of ascorbic acid content in all the treatments and storage period of 90 days in aonla preserve.

2.3.3 Sugars

Adsule and Roy (1974) reported an increase in total sugars in canned mango slices during six months of storage. Whereas a decrease in non-reducing sugars and increase in reducing and total sugar content in various bael products were observed by Roy and Singh (1979).Thereafter (Sandhu,1994) and Sharma *et al.* (1998) revealed that the reducing sugars and total sugars of apple candy were found to increase significantly with the increase in storage time. Sood (2000) reported slight increase in total sugars and reducing sugars in apple, papaya and white guard intermediate moisture food.

2.3.4 pH

Siddique *et al.* (1990) observed that an increase in pH of blanched fruits was due to treatment with lime water whereas, fall in the pH of the candy samples was observed by same scientists. The fall in pH was probably due to an increase in HFS content of the samples.

Yousif *et al.* (1990) also reported a significant decrease in the pH of date jelly after 4 and 6 month of storage. Whereas Das and Jayaraman (1995) found a decrease in pH in semi-concentrates prepared from orange, pineapple and tomatoes during storage when packed in aluminium foil laminates. Thereafter Hassan and Ahmed (1998) were of the opinion that the decrease in pH could be attributed to certain chemical reactions such as Mallard's reaction taking place during storage leading to the production of organic acids. Chawla and Ghai (2012) recorded a decrease in pH of carrot preserve during storage of four months.

2.3.5 Titratable acidity

Sethi (1980) observed that acidity values gradually increased with storage time in I.M. aonla preserve. Similarly decrease in acidity during storage of ber preserve was also reported by Dhawan (1980). Whereas Sethi and Anand (1982) while studying the quality and storage stability of IMF carrot preserve, observed a decrease in acidity during storage of the product. Mehta and Bajaj (1984) also reported a similar decline in the acidity in candied peel during storage.

Rani and Bhatia (1986) studied the pear candy making and reported decrease in acidity of pear candy during storage. Singh *et al.* (1985) were also in consonance to the opinion of Rani and Bhatia (1986) in guava preserve. Similar results were also reported by Sharma (1993) who found decreasing trend in the acidity of apple candy during storage.

Pathak (1988) observed an increase in acidity of aonla candy during storage. Whereas Barmanray(1998) recorded a decrease in acidity during storage of intermediate moisture sand pear slices.

Sood (2000) reported an increase in acidity of intermediate moisture white guard, yam, apple and papaya during storage of three months. Similarly Chawla and Ghai (2012) recorded an increase of acidity in carrot preserve during storage of four months.

Muzzaffar *et al*. (2016) also reported that the titratable acidity of pumpking candies increased during storage at ambient temperature. A non significant increase during first month was followed by a significant increase with further storage of two months at ambient temperature.

2.3.6 Minerals

Yamaguchi and Wu (1982) reported that the water soluble components including minerals were lost during vegetable processing. Whereas Gupta (2007) reported that minerals viz. calcium and phosphorous decreased in osmodehydrated ber during storage of six months.

2.4 Microbial growth

Brockman (1970) reported that no microbial growth was observed in intermediate moisture food during 4 months of storage in sealed containers at 38^0 C.Then Jayaraman *et al.* (1974) observed that the I.M guava when prepared by immersion-equilibration procedure using a soak solution containing glycerol, sucrose, water and potassium sorbate, made it resistant to bacterial, yeast and mold growth and was microbiologically sound for consumption up to three months of storage.

Jayaraman *et al.* (1975) again revealed that in IMF pineapple chunks, the total plate count in general decreased to negligible level during 9 months of storage. Staphylococci and molds were reduced to nil and coliform was negative. Yeast showed a slight increase after 4 months but again became nil after 9 months. Probably this was due to the low a_w which was unfavorable to microbial growth.

Ramanuja and Jayaraman (1980) again found that during 9 months of storge in I.M. banana at room temperature the plate count was negligible (100 colonies/g), also the Staphylococcus, coliforms, yeasts and moulds were negligible. Gupta *et al.* (1980) stated that during microbiological examination of ber candy there was no harmful microbes present in candies and the count was very low. Further, they also reported that the most predominant microbes were yeast followed by fungi whereas, the bacteria were completely absent.

Sethi and Anand (1982) stated that IMF carrot preserve, was microbiologically sound up to six months of storage. Thereafer Siddique *et al.* (1990) stated that the blanched samples of fruits prepared with 60^0 Brix sugars got moldy within a week while the ones with 75^0 Brix stayed well.

Sandhu (1994) reported mold growth within a week when IMF products are stored in glass jars. Whereas Barmanray (1998) reported that I.M. pear showed gradual but little increase in microbial counts from 0 to 90 days of storage. IMF with glycerol (low temperature) showed least count. Then Saxena *et al.* (2009) reported that a combination of gamma irradiations at 1KGy, potassium metabisulphite treatment, osmotic dehydration and infrared drying was found to be effective in eliminating microbial load below the detection limit in I.M. Pineapple slices.

Muzzafar *et al.* (2016) reported that a significant increase in total plate count (1.74-3.4 log cfu/g) content in pumpkin candy. Pumpkin candy was found to be safe for human consumption during three months of storage.

2.5 Sensory evaluation

Jayaraman *et al.* (1974) organoleptically evaluated the I.M. guava samples which were found to be acceptable upto 6 months of storage although, there was slight browning and weakening of flavour beyond 4 months. Similar observations were made by the same group one year later in case of I.M. pineapple chunks (Jayaraman *et al.* 1975).

Roy and Singh (1979) observed an increase in sensory scores of the bael preserve during storage and attributed it to be because of an increase in TSS-acid ratio and softening of fruit pieces. Sensory quality of desorbed I.M. meats deteriorated during storage at high ambient temperatures showed buttery or diacetyl odour and to caprylic odour; and even a change in taste and colour (Webster, 1980). Among various factors which influence the quality of products, sensory attributes may be considered as a major factor and these are liable to change during storage (Rao and Roy 1980).

Rani and Bhatia (1986) made a mention about a decrease in organoleptic quality of pear jam and IMF and the acceptability only up to six months of storage was ascertained for both the products. The sensory score for I.M. okra treated with and 5 and 7.5 per cent brine were statistically superior to 10.0 per cent brine treated samples as reported by Thorat *et al*. (1988).

Kumar (1990) reported that the sensory score of papaya jam decreased gradually with storage and the jam was acceptable up to 8 months and papaya candy up to 9 months of storage. Thereafter Mir and Nath (1993) observed that sensory attributes as well as textural characteristics for fortified mango bars decreased during storage. But comparatively, less deteriorative changes were observed at low temperature storage.

Gowda *et al.* (1995) observed that mango fruit bar prepared by the addition of sugar, citric acid and potassium metabisulphite in combination was found best in organoleptic qualities. Chouhan *et al*. (1997) prepared protein enriched mango soy fruit bar in different combinations of mango pulp and soy slurry, and observed that product having 70% mango pulp, 30% soy slurry with 14.5% moisture, 11.35% protein and 50mg/100g ascorbic acid contents were best in sensory quality like flavour, texture and taste.

Saxena *et al*. (2009) reported that the penalists gave overall scores ranging between 4 and 5 for IM pineapple slices,with no statistical significant differences due to storage days or radiation doses. The scores for the colour were better than texture, aroma,taste and overall acceptability and decrease in average scores was observed during storage.

Akhtar and Javed (2013) investigated the physiochemical analysis and quality evaluation of intermediate moisture apple slices. On the basis of sensory evaluation sample prepared by sucrose:glucose (7:3) potassium metabisulphite and ascorbic acid retained best colour, texture and obtained maximum score for overall acceptability during storage. Henceforth Monde *et al*. (2013) reported that in papaya the overall acceptability scores of osmotically treated (65^0B) and air dried at 60^0C were higher as compared to samples treated with 55^0B and 75^0B as well as air dried at 55^0C and 60^0C respectively.

Panwar *et al.* (2013) observed that 60 percent glycerol treated intermediate moisture aonla segments were found to have least score of 8.0, which decreased to 5.7 after six months of storage. Adding sucrose solution, the osmotic agent improved the overall acceptability of intermediate moisture aonla segments.

Muzzafar *et al*. (2016) reported that all sensory parameters of pumpkin candy showed a decrease in three months of storage. Colour of candies showed a non significant decrease in first month of storage followed by a significant decrease. Texture and flavour changed after one month of storage. Overall acceptability decreased with storage, however pumpkin candy was acceptable even after three months of storage.

Chapter-3

Material and Methods

CHAPTER-III

MATERIALS AND METHODS

The present investigation entitled “Effect of humectants on storage stability of intermediate moisture beetroot cubes” was carried out in the Division of Food Science and Technology, Faculty of Agriculture, Sher-e-Kashmir University of Agricultural Sciences and Technology, Jammu during 2015-2016. This chapter contains relevant information pertaining to research design and methodologies used for conducting the present study.

3.1 Raw material

Good quality medium size beetroots were purchased from Narwal Mandi, Jammu and transported to Division of Food Science and Technology, S K U A S T- J for further processing.

3.2 Processing

Intermediate moisture beetroot cubes were prepared by standard method (Jayaraman, 1993).

Fresh beetroots were washed, cleaned, peeled and cut into cubes of 1cm×1cm×1cm The cubes were blanched and soaked for 12-16 hours in the soaking solution and kept in the refrigerator at (4^{o}C). The soaking solution was prepared by dissolving glycerol/sorbitol, sugar, water, potassium sorbate and sodium benzoate in different proportions as per treatment ratios. Permissible additives such as sugar, glycerol and sorbitol as humectants, potassium sorbate as fungistat and sodium benzoate as preservative were mixed in the soaking solution for increasing the concentration and lowering the water activity (a_w) values. The soaking solution was drained from the beetroot cubes which were then dried at 60-65^{0}c in cabinet drier for 2 hours. The processed product was packed in air tight polythene jars and stored at room temperature.

3.3 Experiment details

Preparation of Intermediate Moisture Beetroot cubes

Treatments	Sugar (%)	Glycerol (%)	Sorbitol (%)
T_1	100	00	-
T_2	90	10	-
T_3	80	20	-
T_4	70	30	-
T_5	60	40	-
T_6	50	50	-
T_7	40	60	-
T_8	90	-	10
T_9	80	-	20
T_{10}	70	-	30
T_{11}	60	-	40
T_{12}	50	-	50
T_{13}	40	-	60

.

Beetroots

Washing

Peeling

Cutting of beetroot into cubes

Blanching

Soaking cubes in solution :-
Sugar +glycerol /sorbitol (85%, as per treatment combinations), Water (14.5%) ,Potassium sorbate (0.45%), Sodium benzoate (200 ppm) for 12-16 hours at 4^{0}C

Draining

Drying cubes for two hours at $60\text{-}65^{0}$C

Cooling at room temperature

Packing in plastic jars (air tight)

Storing at room temperature

.

Fig 1. Flow chart for the preparation of Intermediate Moisture Beetroot Cubes.

The samples were evaluated for chemical, microbial and sensory parameters during 90 days of storage at an interval of 30 days.

3.4 Chemical parameters

3.4.1 Moisture content

The moisture content was determined on the basis of (A.O.A.C,1995) method. Weighed sample (5g) in triplicate were dried for eight hours in a hot –air oven at 105^{o}C in pre-weighed crucibles. The crucibles were transferred immediately to desiccators, cooled, weighed and moisture content present was calculated from loss of weight.

$$\text{Moisture content (\%)} = \frac{\text{Loss in weight of the sample}}{\text{weight of the sample}} \text{X100}$$

3.4.2 Total soluble solids

Total soluble solids (TSS) were measured by using hand refractometer (Erma, Japan) and the results were expressed as degree Brix (^{o}B) according to standard procedure as given in (Ranganna, 2006).The refractometer was calibrated with distilled water before use.

3.4.3 Titratable acidity

Titratableacidity was determined by titrating a known quantity of sample (10ml) against standard solution of 0.1 N Sodium hydroxide to a faint pink colour using phenolphthalein as an indicator. The results were expressed using per cent citric acid (A.O.A.C. 2005).

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

3.4.4 pH

The pH was estimated with the help of Elico pH-meter. The equipment was switched on to warm-up atleast 15 minutes before use. The temperature of the solution to be tested was accurately measured and the temperature control at this temperature was set. The instrument was standardised with a buffer solution of pH 7. A sample (5 g) was crushed properly and mixed with 50 ml of distilled water. Samples were properly mixed with the help of a magnetic stirrer. The electrode was dipped in a beaker containing tested solution and the readings were recorded.

3.4.5 Sugars

Sugars were estimated by Lane and Eynon method as detailed by Ranganna (2006) was followed. Measured quantity of sample (10g) was taken in 250ml volumetric flask to which 100 ml distilled water was added and neutralized with 40 per cent Sodium hydroxide solution using phenolphthaline as an indicator and clarified with 2 ml neutral lead acetate (45 per cent) for about 30 minutes. Excess of lead was removed with 5 ml potassium oxalate (22 per cent). The volume was made to 250 ml and filtered through Whatman filter paper No. 4 filter. The filtrate was titrated against 10 ml of standardized Fehling's solution using methylene blue as an indicator to a brick red precipitate for determination of reducing sugars.

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

3.4.6 Ascorbic acid

Ascorbic acid was determined using 2, 6-Dichlorophenol-indophenol visual titration method (A.O.A.C, 1995).

(A) Reagents

1. 4% oxalic acid.

2. Ascorbic acid standard

One hundred mg of L-ascrobic acid was weighted accurately and made up to hundred ml with 4% Oxalic acid. 10ml of this solution was diluted to hundred ml with 4% Oxalic acid (1ml = 0.1mg of Ascorbic acid).

3. Dye Solution

Fifty two milligrams of sodium salt of 2, 6-Dichlorophenol-indophenol was dissolve in approx.150 ml of hot glass distilled water containing 42mg of sodium bicarbonate. Volume was made up to 200 ml with distilled water and stored in refrigerator and standardized every day.

4. Standardization of Dye

Five ml of standard ascorbic acid solution was taken in a titration flask and 5ml of oxalic acid (4%) was added to it. A microburette was filled with a dye and titrated against standard ascorbic acid to a pink colour, which persisted for 15 seconds. Dye factor was determined i.e mg of ascorbic acid needed for titration per ml of the dye using the formula

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

(B) Preparation of sample

Ten gm of sample was taken and blended with 4% oxalic acid and volume was made up to 100 ml with oxalic acid and filtered.

(C) Procedure

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

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

3.4.7 Ash content

Ash content of the sample was estimated by using standard method (A.O.A.C,1995). Five gram sample was weighed and transferred in the pre-weighed crucible and ignited it until no charred particles remained in the crucible. The crucible was then placed in the muffle furnace (600^{o}C) for 3 hrs. The crucible was cooled in desiccators and weighed to a constant weight. The difference between the weight of crucible with ash and as empty was the amount of total ash.

$$\text{Ash (\%)} = \frac{\text{weight of the ash}}{\text{weight of the sample}} \text{ X } 100$$

3.4.8 Minerals

The estimation of Calcium was done as per the protocol described in (A.O.A.C.1995).

3.4.8.1 Calcium

10 ml of Hydrochloric acid extract was taken in a 100 ml beaker and 2-3 drops of methyl red indicator were added to it. It was heated to boiling, cooled and then 10 ml of saturated ammonium oxalate solution was added with constant stirring until the precipitate was coarsely granular. Again, the contents were heated till boiling cooled and dilute ammonium hydroxide (1:4) was added till the colour changed into faint pink. It was allowed to stand overnight to settle the precipitate. Then filtered through whatman filter paper no.40 and the precipitate was washed with hot water till it was free from soluble oxalates. The point of the filter paper was broken with glass rod and the precipitate was washed into the beaker in which calcium was precipitated. It was dissolved in about 10 ml of dilute sulphuric acid (1:9). Heated to about 60^{o}C and titrated against N/10 $KMnO_4$. Finally, the filter paper was also added and the titration finished. Faint pink colour persisting for at least 30 seconds indicates that the titration is complete.

$$\text{Calcium (\%)} = \frac{\text{ml of} \frac{N}{10} \text{KMnO 4 x volume of HCl extract made x 0.002}}{\text{weight of the sample taken for ashing x Aliquot taken}} \text{ x 100}$$

3.4.8.2 Phosphorus

Phosphorus content was estimated with the help of U V-Visible Spectrophotometer (UV-1601) by using Vandate-molybedete reagent (Singh *et al.* 1999). A known quantity (5 ml) of pre-digested aliquot was taken in 25 ml volumetric flasks to which 5 ml of Vandate-molybedete reagent was added and volume was made to 25 ml with double distilled water. After 30 minutes, the absorbance was recorded at 420nm wave length on UV-spectrophotometer. The phosphorus content was calculated by plotting against the standard curve obtained by taking known amount of potassium di-hydrogen phosphate (KH_2PO_4) salt. Results were expressed as mg/100g.

3.5 Microbial examination

Total plate count (TPC) was made as per the standard method (Ranganna, 2006) using nutrient agar medium. Serially diluted sample (0.1g) of appropriate dilution was used for inoculation of medium in Petri plates followed by pouring of total plate count agar (10-15 ml) under sterilized conditions of laminar air flow. The plates were then incubated at 25$\pm$2 ^{o}C for 48 hrs prior to counting. The results of total plate count (TPC) were expressed as log colony forming units (log cfu) of sample.

3.6 Sensory evaluation

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

3.7 Economics of the products

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

3.8 Statistical analysis

The results obtained were statistically analyzed using factorial completely randomized design (F.C.R.D.) for interpretation of results through analysis of variance (Gomez and Gomez,1984).

Chapter-4

Results

CHAPTER-IV

EXPERIMENTAL RESULTS

The present investigation entitled "Effect of humectants on storage stability of intermediate moisture beetroot cubes" was carried out in the Division of Food Science and Technology, SKUAST, Jammu, FOA Chatha. The results obtained from the present study are as under:-

4.1 Chemical Characteristics of Fresh Beetroot

Table-1 revealed that the moisture content, total soluble solids and titratable acidity of 86.12 per cent, 6.50^{O}Brix and 0.02 per cent were recorded in fresh beetroot respectively. Total and reducing sugars were found to be 4.16 and 0.96 per cent respectively. Ascorbic acid content in fresh beetroot was recorded as 3.61 mg/ 100 g, Ash as 1.20 per cent while as calcium and phosphorus content were observed to be 15 mg/ 100 g and 36 mg/ 100 g respectively.

4.2 Chemical Characteristics of Intermediate Moisture Beetroot Cubes

4.2.1 Moisture

The data pertaining to moisture content of different treatments in Table- 2 depicted a significant decrease in moisture content during storage. At the beginning of the storage period, the highest moisture content of 28.28 per cent was recorded in treatment T_7(Sugar:Glycrol::40:60) and lowest of 26.04 per cent in T_1 (Sugar:Glycerol::100:00) After 90 days of storage the highest moisture content of 27.14 per cent was recorded in treatment T_7 (Sugar:Glycrol::40:60) and the lowest moisture content (23.12 per cent) in treatment T_1(Sugar:Glycerol::100:00). The mean value of storage period showed a significant decrease from initial value of 27.07 to 25.63 per cent during 90 days of storage.

4.2.2 Titratable Acidity

Table - 3 illustrates the effect of various treatments and storage periods on the titratable acidity of intermediate moisture beetroot cubes. The data revealed that there was a slight increase in titratable acidity upto 90 days of storage in all treatments. However, the difference was non-significant. The maximum titratable acidity was 0.09 per cent in treatment T_1 (Sugar:Glycerol::100:00) and minimum of 0.04 per cent in

Table 1: Chemical characteristics of fresh beetroot

Moisture(%)	86.12
T S S(^{0}Brix)	6.50
Titratable acidity(%)	0.02
Reducing Sugars(%)	0.96
Total Sugars(%)	4.16
Ash(%)	1.20
Calcium(mg/100g)	15
Phosphorous(mg/100g)	36
Ascorbic acid(mg/100g)	3.61

Table 2 : Effect of treatments and storage period on moisture content (%) of intermediate moisture beetroot cubes.

Treatments	Storage period(days)				
	0	**30**	**60**	**90**	**Mean**
T_1 (Sugar:Glycerol::100:00)	26.04	25.55	24.32	23.12	24.76
T_2 (Sugar:Glycerol:: 90:10)	26.18	26.02	25.30	24.26	25.44
T_3 (Sugar:Glycerol:: 80:20)	27.32	26.91	26.18	25.80	26.55
T_4 (Sugar:Glycerol:: 70:30)	27.66	27.24	26.82	26.18	26.97
T_5 (Sugar:Glycerol:: 60:40)	27.97	27.29	26.96	26.75	27.24
T_6 (Sugar:Glycerol:: 50:50)	28.20	27.86	27.44	27.08	27.64
T_7 (Sugar:Glycerol:: 40:60)	28.28	28.03	27.85	27.14	27.82
T_8 (Sugar:Sorbitol:: 90:10)	26.15	25.83	25.20	24.31	25.37
T_9 (Sugar:Sorbitol:: 80:20)	26.60	25.86	25.31	25.10	25.72
T_{10} (Sugar:Sorbitol:: 70:30)	27.07	26.40	25.85	25.52	26.21
T_{11} (Sugar:Sorbitol:: 60:40)	27.10	26.72	26.40	25.64	26.46
T_{12} (Sugar:Sorbitol:: 50:50)	27.16	26.85	26.66	26.09	26.69
T_{13} (Sugar:Sorbitol:: 40:60)	27.21	26.91	26.71	26.20	26.76
Mean	27.07	26.72	26.23	25.63	

Factors	C.D.(P=0.05)
Treatments	0.02
Storage	0.01
Treatments x Storage	0.03

Table 3 : Effect of treatments and storage period on titratable acidity (%) of intermediate moisture beetroot cubes

Treatments	Storage period(days)				
	0	**30**	**60**	**90**	**Mean**
T_1 (Sugar:Glycerol::100:00)	0.09	0.09	0.09	0.10	0.09
T_2 (Sugar:Glycerol:: 90:10)	0.07	0.07	0.08	0.09	0.08
T_3 (Sugar:Glycerol:: 80:20)	0.07	0.07	0.08	0.09	0.08
T_4 (Sugar:Glycerol:: 70:30)	0.06	0.07	0.08	0.08	0.08
T_5 (Sugar:Glycerol:: 60:40)	0.06	0.07	0.08	0.08	0.07
T_6 (Sugar:Glycerol:: 50:50)	0.05	0.06	0.06	0.07	0.06
T_7 (Sugar:Glycerol:: 40:60)	0.05	0.06	0.07	0.08	0.06
T_8 (Sugar:Sorbitol:: 90:10)	0.06	0.06	0.06	0.06	0.06
T_9 (Sugar:Sorbitol:: 80:20)	0.05	0.05	0.06	0.06	0.05
T_{10} (Sugar:Sorbitol:: 70:30)	0.05	0.05	0.06	0.07	0.06
T_{11} (Sugar:Sorbitol:: 60:40)	0.05	0.06	0.06	0.07	0.06
T_{12} (Sugar:Sorbitol:: 50:50)	0.04	0.05	0.05	0.06	0.05
T_{13} (Sugar:Sorbitol:: 40:60)	0.04	0.04	0.05	0.05	0.05
Mean	0.06	0.06	0.06	0.07	

Factors	C.D.(P=0.05)
Treatments	N.S.
Storage	0.01
Treatments x Storage	N.S

treatment T_{13}(Sugar:Sorbitol::40:60). After 90 days of storage the highest titratable acidity of 0.10 per cent was observed in treatment T_1(Sugar:Glycerol::100:00) and the lowest of 0.05 per cent in T_{13} (Sugar:Sorbitol::40:60). The mean value of storage period showed an increase from initial value of 0.06 to 0.07 per cent during 90 days of storage.

4.2.3 pH

It is evident from Table-4 that treatments significantly influenced pH values of intermediate moisture beetroot cubes. The date on the pH at different intervals showed that at initial day of storage the maximum value of 7.35 was recorded in treatment T_{13}(Sugar:Sorbitol::40:60) and minimum value of 7.12 was recorded in treatment T_1 (Sugar:Glycerol::100:00). pH slightly decreased with the advancement of storage period. After 90 days of storage the maximum pH of 7.25 was recorded in treatment T_{13}(Sugar:Sorbitol::40:60) whereas minimum value of 6.98 in treatment T_1(Sugar:Glycerol::100:00). The mean value of pH decreased from 7.28 at initial day of storage to 7.07 after 90 days of storage.

4.2.4 Total Sugars

The data pertaining to total sugar content of different treatments in Table - 5 depicted a significant increase in total sugar content during storage in intermediate moisture beetroots cubes. At initial day the highest value 27. 65 per cent was recorded in treatment T_1 (Sugar : Glycerol::100:00) followed by 26.18 per cent in treatment T_2 (Sugar:Glycerol::90:10). After 90 days of storage period treatment T_1 (Sugar:Glycerol:: 100:00) recorded highest value of 28.30 per cent followed by treatment T_2 (Sugar:Glycerol::90:10) with total sugar content of 27.32 per cent. The minimum value of total sugars i,e 23.34 per cent was recorded in treatment T_{13} (Sugar:Sorbitol::40:60) The total sugar content of intermediate moisture beetroot cubes increased significantly during storage. The mean values of total sugars showed an increase from initial value of 24.28 to 25.69 per cent during 90 days of storage.

4.2.5 Reducing Sugars

It is evident from Table- 6 that treatments significantly influenced the reducing sugar content of intermediate moisture beetroot cubes. Among the treatments, treatment T_1(Sugar:Glycerol::100:00) recorded the highest value of 2.28 per cent followed by treatment T_2(Sugar:Glycerol::90:10) with reducing sugar content of 2.06 per cent at

Table 4 : Effect of treatments and storage period on pH of intermediate moisture beetroot cubes.

Treatments	Storage period(days)				
	0	**30**	**60**	**90**	**Mean**
T_1 (Sugar:Glycerol::100:00)	7.12	7.09	7.04	6.98	7.05
T_2 (Sugar:Glycerol:: 90:10)	7.18	7.14	7.09	7.02	7.10
T_3 (Sugar:Glycerol:: 80:20)	7.22	7.20	7.15	7.11	7.17
T_4 (Sugar:Glycerol:: 70:30)	7.26	7.24	7.19	7.16	7.21
T_5 (Sugar:Glycerol:: 60:40)	7.31	7.26	7.22	7.18	7.24
T_6 (Sugar:Glycerol:: 50:50)	7.32	7.29	7.25	7.22	7.27
T_7 (Sugar:Glycerol:: 40:60)	7.33	7.30	7.26	7.24	7.28
T_8 (Sugar:Sorbitol:: 90:10)	7.31	7.26	7.18	7.14	7.22
T_9 (Sugar:Sorbitol:: 80:20)	7.31	7.26	7.19	7.14	7.22
T_{10} (Sugar:Sorbitol:: 70:30)	7.32	7.27	7.19	7.15	7.22
T_{11} (Sugar:Sorbitol:: 60:40)	7.32	7.28	7.20	7.15	7.24
T_{12} (Sugar:Sorbitol:: 50:50)	7.33	7.28	7.22	7.16	7.25
T_{13} (Sugar:Sorbitol:: 40:60)	7.35	7.28	7.25	7.25	7.29
Mean	7.28	7.22	7.17	7.07	

Factors	C.D.(P=0.05)
Treatments	0.01
Storage	0.01
Treatments x Storage	0.03

Table 5 : Effect of treatments and storage period on total sugars (%) of intermediate moisture beetroot cubes.

Treatments	Storage period(days)				
	0	**30**	**60**	**90**	**Mean**
T_1 (Sugar:Glycerol::100:00)	27.65	27.82	27.98	28.30	27.93
T_2 (Sugar:Glycerol:: 90:10)	26.18	26.58	27.10	27.32	26.79
T_3 (Sugar:Glycerol:: 80:20)	25.75	26.15	26.56	27.04	26.37
T^4 (Sugar:Glycerol:: 70:30)	25.42	25.88	26.24	26.90	26.11
T_5 (Sugar:Glycerol:: 60:40)	24.91	25.36	25.86	26.51	25.66
T_6 (Sugar:Glycerol:: 50:50)	24.36	25.02	25.84	26.48	25.42
T_7 (Sugar:Glycerol:: 40:60)	23.90	24.22	24.91	25.31	24.58
T_8 (Sugar:Sorbitol:: 90:10)	24.81	24.98	25.26	25.46	25.12
T_9 (Sugar:Sorbitol:: 80:20)	23.96	24.41	24.98	25.28	24.65
T_{10} (Sugar:Sorbitol:: 70:30)	22.84	23.22	23.71	24.27	23.51
T_{11} (Sugar:Sorbitol:: 60:40)	22.33	22.84	23.41	23.90	23.12
T_{12} (Sugar:Sorbitol:: 50:50)	21.92	22.41	23.26	23.88	22.87
T_{13} (Sugar:Sorbitol:: 40:60)	21.68	22.28	22.76	23.34	22.66
Mean	24.28	24.70	25.22	25.69	

Factors	C.D.(P=0.05)
Treatments	0.02
Storage	0.01
Treatments x Storage	0.04

Table 6 : Effect of Treatments and storage period on reducing sugars (%) of intermediate moisture beetroot cubes.

Treatments	Storage period(days)				
	0	**30**	**60**	**90**	**Mean**
T_1 (Sugar:Glycerol::100:00)	2.28	2.35	2.54	2.71	2.47
T_2 (Sugar:Glycerol:: 90:10)	2.06	2.19	2.26	2.41	2.23
T_3 (Sugar:Glycerol:: 80:20)	1.95	2.18	2.24	2.36	2.18
T_4 (Sugar:Glycerol:: 70:30)	1.78	1.92	2.12	2.28	2.02
T_5 (Sugar:Glycerol:: 60:40)	1.66	1.80	1.93	2.15	1.88
T_6 (Sugar:Glycerol:: 50:50)	1.52	1.77	1.89	2.09	1.82
T^7 (Sugar:Glycerol:: 40:60)	1.47	1.60	1.62	1.88	1.64
T_8 (Sugar:Sorbitol:: 90:10)	2.12	2.26	2.48	2.64	2.38
T_9 (Sugar:Sorbitol:: 80:20)	2.03	2.21	2.35	2.55	2.28
T_{10} (Sugar:Sorbitol:: 70:30)	1.85	1.98	2.22	2.40	2.11
T_{11} (Sugar:Sorbitol:: 60:40)	1.81	1.90	2.06	2.24	2.00
T_{12} (Sugar:Sorbitol:: 50:50)	1.76	1.84	1.98	2.16	1.93
T_{13} (Sugar:Sorbitol:: 40:60)	1.62	1.75	1.90	2.04	1.83
Mean	1.84	1.98	2.12	2.30	

Factors	C.D.(P=0.05)
Treatments	0.02
Storage	0.01
Treatments x Storage	0.04

initial day. After 90 days of storage, the treatment T1(Sugar:Glycerol::100:00) recorded the highest value of 2.71 per cent followed by treatment T_2(Sugar:Glycerol::90:10) having the reducing sugar content of 2.41 per cent. The minimum value of 2.04 per cent of reducing sugar was recorded in treatment T_{13}(Sugar : Sorbitol::40:60) during 90 days of storage. There was a significant increase in reducing sugar content with the progress in storage period. The mean values of storage period showed an increase from initial value of 1.84 to 2.30 per cent during 90 days of storage.

4.2.6 Ascorbic Acid

The data presented in Table - 7 showed the effect of various treatments and storage periods on ascorbic acid content of intermediate moisture beetroot cubes. The data revealed that the treatments significantly influenced the ascorbic acid content of intermediate moisture beetroot cubes. At initial day of storage, the highest ascorbic acid content of 4.40 mg/100 g was recorded in treatment T_1(Sugar:Glycerol::100:00) and lowest value of 3.61 mg/100 g was recorded in treatment T_{13}(Sugar:Sorbitol:: 40:60). After 90 days of storage the highest ascorbic content 3.80 mg/ 100 g was observed in treatment T_6(Sugar:Glycerol:: 50:50) and lowest 3.06 mg/100 g in treatment T_8(Sugar: Sorbitol:: 90:10) Overall highest mean ascorbic acid content of 3.95 mg/100 g. was recorded in T_6(Sugar:Glycerol:: 50:50) and the lowest of 3.51 mg/100 g. was recorded in treatment T_{13}(Sugar:Sorbitol:: 40:60) Mean values during 90 days storage period decreased from 4.06 to 3.43 mg /100 g.

4.2.7 Minerals

4.2.7.1 Calcium

The data presented in Table- 8 showed the effect of various treatments and storage period on calcium content of intermediate moisture beetroot cubes. The data revealed that the treatments significantly influenced the calcium content of intermediate moisture beetroot cubes. At initial day of storage the highest calcium content of 19.88 mg/100g was recorded in treatment T_1(Sugar:Glycerol::100:00) and lowest 18.10mg/100 g in treatment T_7(Sugar:Glycerol::40:60). After 90 days of storage the value decreased to 19.72mg/100g in treatment T_1(Sugar:Glycerol::100:00) and 17.91 mg/100 g in treatment T_7(Sugar:Glycerol::40:60) Calcium content was significantly affected by storage period. There was significant decrease in calcium content of intermediate moisture beetroot

Table 7 : Effect of treatments and storage period on ascorbic acid(mg/100g) of intermediate moisture beetroot cubes.

Treatments	**Storage period(days)**				
	0	**30**	**60**	**90**	**Mean**
T_1 (Sugar:Glycerol::100:00)	4.40	4.21	3.78	3.32	3.93
T_2 (Sugar:Glycerol:: 90:10)	4.32	4.14	3.80	3.41	3.92
T_3 (Sugar:Glycerol:: 80:20)	4.29	4.11	3.82	3.46	3.92
T_4 (Sugar:Glycerol:: 70:30)	4.26	4.06	3.86	3.58	3.94
T_5 (Sugar:Glycerol:: 60:40)	4.12	4.02	3.90	3.77	3.95
T_6 (Sugar:Glycerol:: 50:50)	4.08	3.98	3.92	3.80	3.95
T_7 (Sugar:Glycerol:: 40:60)	3.95	3.92	3.89	3.76	3.88
T_8 (Sugar:Sorbitol:: 90:10)	4.10	3.82	3.51	3.06	3.62
T_9 (Sugar:Sorbitol:: 80:20)	4.06	3.81	3.53	3.12	3.63
T_{10} (Sugar:Sorbitol:: 70:30)	4.02	3.72	3.40	3.18	3.58
T_{11} (Sugar:Sorbitol:: 60:40)	3.93	3.72	3.41	3.36	3.60
T_{12} (Sugar:Sorbitol:: 50:50)	3.76	3.68	3.54	3.40	3.60
T_{13} (Sugar:Sorbitol:: 40:60)	3.61	3.56	3.52	3.37	3.51
Mean	4.06	3.98	3.68	3.43	

Factors	C.D.(P=0.05)
Treatments	0.02
Storage	0.01
Treatments x Storage	0.04

Table 8 : Effect of treatments and storage period on calcium(mg/100g) of intermediate moisture beetroot cubes.

Treatments	Storage period(days)				
	0	**30**	**60**	**90**	**Mean**
T_1 (Sugar:Glycerol::100:00)	19.88	19.86	19.86	19.72	19.83
T_2 (Sugar:Glycerol:: 90:10)	19.74	19.74	19.72	19.68	19.72
T_3 (Sugar:Glycerol:: 80:20)	19.34	19.31	19.30	19.22	19.29
T_4 (Sugar:Glycerol:: 70:30)	19.08	19.05	19.05	18.88	19.01
T_5 (Sugar:Glycerol:: 60:40)	18.91	18.90	18.87	18.78	18.86
T_6 (Sugar:Glycerol:: 50:50)	18.78	18.78	18.75	18.64	18.74
T_7 (Sugar:Glycerol:: 40:60)	18.10	18.06	18.04	17.91	18.03
T_8 (Sugar:Sorbitol:: 90:10)	19.42	19.40	19.36	19.30	19.37
T_9 (Sugar:Sorbitol:: 80:20)	19.23	19.21	19.21	19.14	19.20
T_{10} (Sugar:Sorbitol:: 70:30)	19.04	19.04	19.01	18.86	18.98
T_{11} (Sugar:Sorbitol:: 60:40)	18.76	18.75	18.72	18.61	18.71
T_{12} (Sugar:Sorbitol:: 50:50)	18.60	18.59	18.57	18.42	18.54
T_{13} (Sugar:Sorbitol:: 40:60)	18.48	18.48	18.45	18.38	18.45
Mean	19.02	19.01	18.99	18.88	

Factors	C.D.(P=0.05)
Treatments	0.02
Storage	0.01
Treatments x Storage	0.03

cubes from 0 to 90 days of storage. Mean values decreased from 19.02 to 18.88 mg/100 g. after 90 days of storage.

4.2.7.2 Phosphorous

The data presented in Table - 9 showed the effects of various treatments and storage period on phosphorous content of intermediate moisture beetroots cubes. At initial day of storage the highest phosphorus content of 24.60 mg/100 g. was recorded in treatment T_1(Sugar:Glycerol::100:00)and lowest 22.56 mg/100 g. in treatment T_7(Sugar:Glycerol::40:60). After 90 days of storage the value decreased to 24.48 mg/100 g in treatment T_1(Sugar:Glycerol::100:00) and 22.41 mg/100 g in treatment T_7(Sugar:Glycerol::40:60) Phosphorus content was significantly affected by storage period. There was significant decrease in phosphorus content of intermediate moisture beetroot cubes from 0 to 90 days of storage. The mean values of storage period showed a decrease from initial value of 23.61 to 23.48 mg/100 g. during 90 days of storage.

4.3 Microbial Count

It is clear from the in Table -10 that up to 60 days of storage there was no microbial growth. During 90 days of storage the maximum microbial count of $1.55x10^2$ cfu/g was recorded in treatments T_1(Sugar:Glycerol::100:00) and minimum of $1.33x10^2$ cfu/g in treatment T_6(Sugar: Glycerol::50:50) There was an increase in mean value of microbial count from 0.00 to $1.37x10^2$ cfu/g during 90 days of storage period, which is considered as significantly low and safe for consumption.

4.4 Sensory evaluation of intermediate moisture beetroot cubes.

4.4.1 Colour

It is evident from Table- 11 that colour score of intermediate moisture beetroot cubes decreased significantly during entire storage period. At initial day the maximum score of 7.60 was observed in treatment T_7(Sugar:Glycerol::40:60) followed by 7.50 in treatmentT_6(Sugar: Glycerol::50:50) and in treatment T_1(Sugar:Glycerol::100:00) . After 90 days of the storage period, scores decreased 7.10 in T_7(Sugar:Glycerol::40:60) and 7.05 in T6(Sugar: Glycerol::50:50) respectively. The highest overall mean colour score of 7.35 was recorded in T_7(Sugar:Glycerol::40:60) followed by 7.27 in treatment T_6(Sugar: Glycerol::50:50). During storage period, there was significant decrease in the mean score from 6.97 at initial day to 6.49 during 90 days of storage period.

Table 9 : Effect of treatments and storage period on phosphorous (mg/100g) of intermediate moisture beetroot cubes.

Treatments	**Storage period(days)**				
	0	**30**	**60**	**90**	**Mean**
T_1 (Sugar:Glycerol::100:00)	24.60	24.59	24.59	24.48	24.56
T_2 (Sugar:Glycerol:: 90:10)	24.10	24.10	24.07	23.94	24.05
T_3 (Sugar:Glycerol:: 80:20)	23.92	23.90	23.87	23.74	23.85
T_4 (Sugar:Glycerol:: 70:30)	23.61	23.61	23.60	23.48	23.57
T_5 (Sugar:Glycerol:: 60:40)	23.43	23.43	23.41	23.31	23.39
T_6 (Sugar:Glycerol:: 50:50)	23.28	23.26	23.25	23.18	23.24
T_7 (Sugar:Glycerol:: 40:60)	22.56	22.53	22.54	22.41	22.51
T_8 (Sugar:Sorbitol:: 90:10)	24.02	24.00	24.00	23.86	23.97
T_9 (Sugar:Sorbitol:: 80:20)	23.93	23.92	23.91	23.80	23.89
T_{10} (Sugar:Sorbitol:: 70:30)	23.76	23.76	23.75	23.65	23.73
T_{11} (Sugar:Sorbitol:: 60:40)	23.52	23.50	23.50	23.37	23.47
T_{12} (Sugar:Sorbitol:: 50:50)	23.21	23.20	23.20	23.12	23.18
T_{13} (Sugar:Sorbitol:: 40:60)	23.06	23.06	23.03	22.85	23.00
Mean	23.61	23.60	23.59	23.48	

Factors	C.D.(P=0.05)
Treatments	0.02
Storage	0.01
Treatments x Storage	0.03

Table 11 : Effect of treatments and storage period on colour of intermediate moisture beetroot cubes.

Treatments	Storage period(days)				
	0	**30**	**60**	**90**	**Mean**
T_1 (Sugar:Glycerol::100:00)	7.50	7.40	7.24	7.00	7.28
T_2 (Sugar:Glycerol:: 90:10)	7.05	6.90	6.72	6.53	6.80
T_3 (Sugar:Glycerol:: 80:20)	7.15	7.00	6.86	6.68	6.92
T_4 (Sugar:Glycerol:: 70:30)	7.20	6.95	6.78	6.70	6.91
T_5 (Sugar:Glycerol:: 60:40)	7.25	7.06	6.80	6.75	6.96
T_6 (Sugar:Glycerol:: 50:50)	7.50	7.35	7.20	7.05	7.27
T_7 (Sugar:Glycerol:: 40:60)	7.60	7.40	7.30	7.10	7.35
T_8 (Sugar:Sorbitol:: 90:10)	6.22	6.05	5.88	5.78	5.98
T_9 (Sugar:Sorbitol:: 80:20)	6.50	6.32	6.20	6.10	6.28
T_{10} (Sugar:Sorbitol:: 70:30)	6.52	5.39	5.28	6.15	5.83
T_{11} (Sugar:Sorbitol:: 60:40)	6.66	6.50	6.30	6.18	6.41
T_{12} (Sugar:Sorbitol:: 50:50)	6.72	6.45	6.34	6.25	6.44
T_{13} (Sugar:Sorbitol:: 40:60)	6.70	6.40	6.30	6.20	6.40
Mean	6.97	6.70	6.55	6.49	

Factors	C.D.(P=0.05)
Treatments	0.02
Storage	0.01
Treatments x Storage	0.03

Table 11 : Effect of treatments and storage period on colour of intermediate moisture beetroot cubes.

Treatments	Storage period(days)				
	0	**30**	**60**	**90**	**Mean**
T_1 (Sugar:Glycerol::100:00)	7.50	7.40	7.24	7.00	7.28
T_2 (Sugar:Glycerol:: 90:10)	7.05	6.90	6.72	6.53	6.80
T_3 (Sugar:Glycerol:: 80:20)	7.15	7.00	6.86	6.68	6.92
T_4 (Sugar:Glycerol:: 70:30)	7.20	6.95	6.78	6.70	6.91
T_5 (Sugar:Glycerol:: 60:40)	7.25	7.06	6.80	6.75	6.96
T_6 (Sugar:Glycerol:: 50:50)	7.50	7.35	7.20	7.05	7.27
T_7 (Sugar:Glycerol:: 40:60)	7.60	7.40	7.30	7.10	7.35
T_8 (Sugar:Sorbitol:: 90:10)	6.22	6.05	5.88	5.78	5.98
T_9 (Sugar:Sorbitol:: 80:20)	6.50	6.32	6.20	6.10	6.28
T_{10} (Sugar:Sorbitol:: 70:30)	6.52	5.39	5.28	6.15	5.83
T_{11} (Sugar:Sorbitol:: 60:40)	6.66	6.50	6.30	6.18	6.41
T_{12} (Sugar:Sorbitol:: 50:50)	6.72	6.45	6.34	6.25	6.44
T_{13} (Sugar:Sorbitol:: 40:60)	6.70	6.40	6.30	6.20	6.40
Mean	6.97	6.70	6.55	6.49	

Factors	C.D.(P=0.05)
Treatments	0.02
Storage	0.01
Treatments x Storage	0.03

4.4.2 Texture

Table -12 illustrates the average score for texture in intermediate moisture beetroot cubes at different intervals during the storage period. The data revealed that the maximum score of 7.90 was recorded in treatment T_6(Sugar: Glycerol::50:50) followed by 7.80 in treatment T_1(Sugar:Glycerol::100:00). During storage period, highest score 7.80 was recorded in treatment T_6 (Sugar: Glycerol::50:50)followed by 7.70 in treatment T_1(Sugar:Glycerol::100:00). Mean value of treatments varied significantly and the highest mean score of 7.85 was registered in treatment T_6(Sugar: Glycerol::50:50) and lowest of 6.06 in treatment treatment T_8 (Sugar:Sorbitol:: 90:10). During storage period, there was a significant decrease in the mean score from 7.06 at initial day to 6.74 during 90 days of storage period.

4.4.3 Taste

From Table- 13, it was found that the sensory scores for taste of intermediate moisture beetroot cubes showed a significant gradual decrease up to end of 90 days storage period. At initial day, the maximum score of 7.95 recorded in treatment T_6 (Sugar:Glycerol::50:50) followed by 7.90 in T_1(Sugar:Glycerol::100:00). After 90 days of storage, the values decreased to 7.80 in T_6(Sugar: Glycerol::50:50) followed by 7.70 in T_1(Sugar:Glycerol::100:00) The highest mean score of 7.87 was assigned to treatment T_6(Sugar:Glycerol::50:50) followed by 7.79 in T_1(Sugar:Glycerol::100:00). During storage period, there was significant decrease in mean score from 7.32 to 6.98 after 90 days of storage period.

4.4.4 Flavour

Table-14 shows that at initial day, the maximum flavour score of 7.95 was recorded in treatment T_6(Sugar:Glycerol::50:50) followed by 7.90 in T_1(Sugar:Glycerol::100:00) After 90 days of storage, the values decreased to 7.70 in treatment $T_{6(}$Sugar:Glycerol::50:50) followed by 7.50 in Treatment T_1(Sugar:Glycerol::100:00). During storage period, there was significant decrease in mean score from 7.15 to 6.70 after 90 days of storage.

4.4.5 Overall acceptability

Table-15 pertaining to score of overall acceptability revealed that at initial day, the highest score of 7.90 was recorded in treatment T_6(Sugar: Glycerol::50:50) followed

Table 14 : Effect of treatments and storage period on flavour of intermediate moisture beetroot cubes.

Treatments	**Storage period(days)**				
	0	**30**	**60**	**90**	**Mean**
T_1 (Sugar:Glycerol::100:00)	7.90	7.88	7.65	7.50	7.76
T_2 (Sugar:Glycerol:: 90:10)	7.15	7.30	7.20	6.40	7.01
T_3 (Sugar:Glycerol:: 80:20)	7.50	7.40	7.25	7.10	7.31
T_4 (Sugar:Glycerol:: 70:30)	7.55	7.42	7.30	7.12	7.35
T_5 (Sugar:Glycerol:: 60:40)	7.61	7.50	7.30	7.15	7.39
T_6 (Sugar:Glycerol:: 50:50)	7.95	7.90	7.85	7.70	7.85
T_7 (Sugar:Glycerol:: 40:60)	7.80	7.60	7.55	7.40	7.59
T_8 (Sugar:Sorbitol:: 90:10)	6.22	6.05	5.90	5.80	5.99
T_9 (Sugar:Sorbitol:: 80:20)	6.40	6.20	6.16	6.00	6.19
T_{10} (Sugar:Sorbitol:: 70:30)	6.50	6.30	6.18	6.05	6.26
T_{11} (Sugar:Sorbitol:: 60:40)	6.59	6.40	6.20	6.10	6.32
T_{12} (Sugar:Sorbitol:: 50:50)	7.06	6.80	6.65	6.58	6.77
T_{13} (Sugar:Sorbitol:: 40:60)	6.82	6.60	6.40	6.30	6.53
Mean	7.15	7.02	6.89	6.70	

Factors	C.D.(P=0.05)
Treatments	0.02
Storage	0.01
Treatments x Storage	0.04

Table 12 : Effect of treatment and storage period on texture of intermediate moisture beetroot cubes

Treatments	**Storage period(days)**				
	0	30	60	90	Mean
T_1 (Sugar:Glycerol::100:00)	7.80	7.76	7.74	7.70	7.75
T_2 (Sugar:Glycerol:: 90:10)	7.01	6.92	6.84	6.65	6.85
T_3 (Sugar:Glycerol:: 80:20)	7.06	6.90	6.78	6.71	6.86
T_4 (Sugar:Glycerol:: 70:30)	7.40	6.95	6.80	6.75	6.97
T_5 (Sugar:Glycerol:: 60:40)	7.52	7.30	7.25	7.10	7.29
T_6 (Sugar:Glycerol:: 50:50)	7.90	7.88	7.82	7.80	7.85
T_7 (Sugar:Glycerol:: 40:60)	7.70	7.65	7.60	7.55	7.62
T_8 (Sugar:Sorbitol:: 90:10)	6.30	6.12	6.04	5.80	6.06
T_9 (Sugar:Sorbitol:: 80:20)	6.32	6.30	6.25	6.10	6.24
T_{10} (Sugar:Sorbitol:: 70:30)	6.40	6.31	6.25	6.18	6.28
T_{11} (Sugar:Sorbitol:: 60:40)	6.46	6.28	6.25	6.20	6.30
T_{12} (Sugar:Sorbitol:: 50:50)	7.00	6.80	6.75	6.55	6.77
T_{13} (Sugar:Sorbitol:: 40:60)	7.00	6.75	6.62	6.50	6.72
Mean	7.06	6.91	6.84	6.74	

Factors	C.D.(P=0.05)
Treatments	0.02
Storage	0.01
Treatments x Storage	0.03

Table 13 : Effect of treatments and storage period on taste of intermediate moisture beetroot cubes.

Treatments	Storage period(days)				
	0	**30**	**60**	**90**	**Mean**
T_1 (Sugar:Glycerol::100:00)	7.90	7.80	7.76	7.70	7.79
T_2 (Sugar:Glycerol:: 90:10)	7.34	7.25	7.10	6.95	7.16
T_3 (Sugar:Glycerol:: 80:20)	7.72	7.50	7.48	7.34	7.51
T_4 (Sugar:Glycerol:: 70:30)	7.78	7.60	7.50	7.35	7.56
T_5 (Sugar:Glycerol:: 60:40)	7.80	7.65	7.54	7.40	7.60
T_6 (Sugar:Glycerol:: 50:50)	7.95	7.90	7.84	7.80	7.87
T_7 (Sugar:Glycerol:: 40:60)	7.85	7.84	7.60	7.50	7.70
T_8 (Sugar:Sorbitol:: 90:10)	6.40	6.35	6.20	6.00	6.24
T_9 (Sugar:Sorbitol:: 80:20)	6.67	6.50	6.40	6.35	6.28
T_{10} (Sugar:Sorbitol:: 70:30)	6.74	6.50	6.45	6.38	6.48
T_{11} (Sugar:Sorbitol:: 60:40)	6.79	6.60	6.50	6.40	6.57
T_{12} (Sugar:Sorbitol:: 50:50)	7.26	7.14	7.12	7.05	7.14
T_{13} (Sugar:Sorbitol:: 40:60)	7.00	6.80	6.65	6.60	6.76
Mean	7.32	7.18	7.08	6.98	

Factors	C.D.(P=0.05)
Treatments	0.02
Storage	0.01
Treatments x Storage	0.03

Table 15 : Effect of treatments and storage period on overall acceptability of intermediate moisture beetroot cubes.

Treatments	**Storage period(days)**				
	0	**30**	**60**	**90**	**Mean**
T_1 (Sugar:Glycerol::100:00)	7.60	7.55	7.40	7.30	7.46
T_2 (Sugar:Glycerol:: 90:10)	6.82	6.76	6.64	6.52	6.68
T_3 (Sugar:Glycerol:: 80:20)	7.26	7.11	7.08	6.92	7.27
T_4 (Sugar:Glycerol:: 70:30)	7.30	7.25	7.16	7.02	7.28
T_5 (Sugar:Glycerol:: 60:40)	7.32	7.26	7.20	7.04	7.30
T_6 (Sugar:Glycerol:: 50:50)	7.90	7.74	7.65	7.40	7.67
T_7 (Sugar:Glycerol:: 40:60)	7.40	7.35	7.18	7.00	7.24
T_8 (Sugar:Sorbitol:: 90:10)	6.48	6.36	6.24	6.06	6.28
T_9 (Sugar:Sorbitol:: 80:20)	6.75	6.64	6.48	6.32	6.54
T_{10} (Sugar:Sorbitol:: 70:30)	6.90	6.70	6.65	6.58	6.70
T_{11} (Sugar:Sorbitol:: 60:40)	6.90	6.71	6.60	6.59	6.71
T_{12} (Sugar:Sorbitol:: 50:50)	7.35	7.28	7.15	7.02	7.20
T_{13} (Sugar:Sorbitol:: 40:60)	7.10	6.96	6.82	6.76	6.91
Mean	7.16	7.05	6.94	6.81	

Factors	C.D.(P=0.05)
Treatments	0.02
Storage	0.01
Treatments x Storage	0.04

by 7.60 in treatment T_1(Sugar:Glycerol::100:00). During 90 days of storage the values decreased to 7.40 in T_6 (Sugar: Glycerol::50:50) and 7.30 in T_1(Sugar:Glycerol::100:00). The mean value of treatments varied significantly and the highest mean score of 7.67 assigned to T_6(Sugar:Glycerol::50:50) followed by 7.46 in treatment T_1(Sugar:Glycerol::100:00). During storage period, there was significant decrease in mean score from 7.16 at initial day to 6.81 at the end of 90 days of storage period.

4.5 Cost of production

Table-16 depicted that 50 g pack of intermediate moisture beetroot cubes cost an amount of Rs 36/-

Table 10 : Effect of treatments and storage period on microbial population (x10^2 cfu/g) of intermediate moisture beetroot cubes.

Treatments	**Storage period(days)**			
	0	**30**	**60**	**90**
T_1 (Sugar:Glycerol::100:00)	N. D.	N. D.	N. D.	1.55
T_2 (Sugar:Glycerol:: 90:10)	N. D.	N. D.	N. D.	1.40
T_3 (Sugar:Glycerol:: 80:20)	N. D.	N. D.	N. D.	1.40
T_4 (Sugar:Glycerol:: 70:30)	N. D.	N. D.	N. D.	1.35
T_5 (Sugar:Glycerol:: 60:40)	N. D.	N. D	N. D.	1.40
T_6 (Sugar:Glycerol:: 50:50)	N. D.	N. D.	N. D.	1.33
T_7 (Sugar:Glycerol:: 40:60)	N. D.	N. D.	N. D.	1.40
T_8 (Sugar:Sorbitol:: 90:10)	N. D.	N. D.	N. D.	1.40
T_9 (Sugar:Sorbitol:: 80:20)	N. D.	N. D.	N. D.	1.36
T_{10} (Sugar:Sorbitol:: 70:30)	N. D.	N. D.	N. D.	1.50
T_{11} (Sugar:Sorbitol:: 60:40)	N. D.	N. D.	N. D.	1.35
T_{12} (Sugar:Sorbitol:: 50:50)	N. D.	N. D.	N. D.	1.40
T_{13} (Sugar:Sorbitol:: 40:60)	N. D.	N. D.	N. D.	1.40
Mean	0	0	0	1.37

Table 16 -Cost of production of intermediate moisture beetroot cubes of treatment T_6 (Sugar : Glycerol : : 50 : 50)

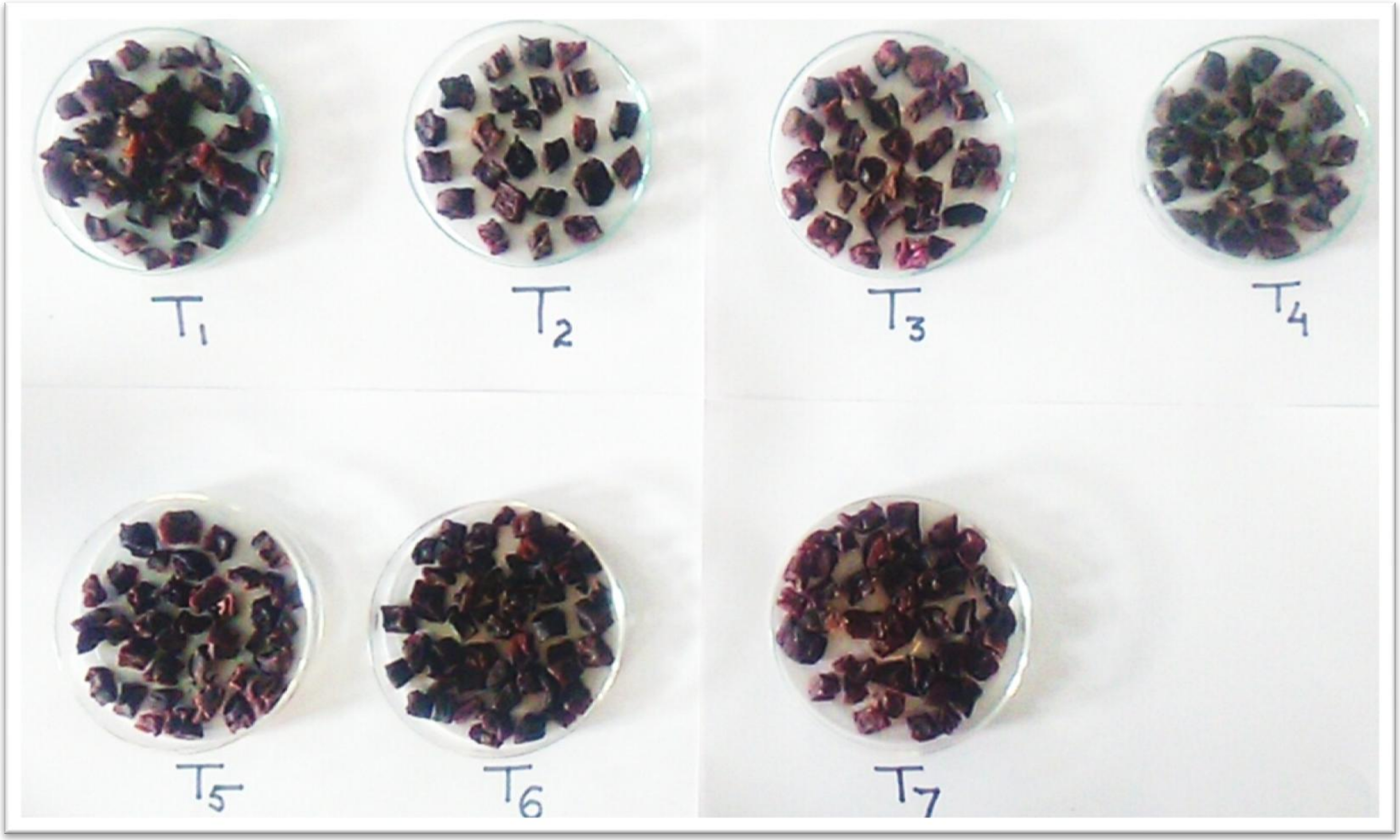
Ingredients	**Rate (Rs.)**	**Quantity**	**Amount**
Beetroots	30/kg	3 kgs	Rs.90/-
Soaking solution (reusing 2 times)			
Sugar	40/kg	500gms	Rs.20/-
Glycerol	826/kg	500gms	Rs.413/-
Potassium sorbate		4.5gms	Rs.5/-
Sodium benzoate	240/kg	0.8gms	Rs.1/-
Muslin cloth	20/mt	1 mt	Rs. 20/-
Plastic containers	Rs.3/-	24 nos.	Rs. 72/-
Labels	0.25	24nos.	Rs.6/-
Total			Rs.627/-
Processing charges@20%			Rs.125/-
Gross Total			Rs.752/-
Profit@10%			Rs.75/-
Vat@5%			Rs.37/-
Grand Total			Rs.864/-
Sale price/box of 50gms			Rs.36/-

Plate-1

Fresh Beetroot

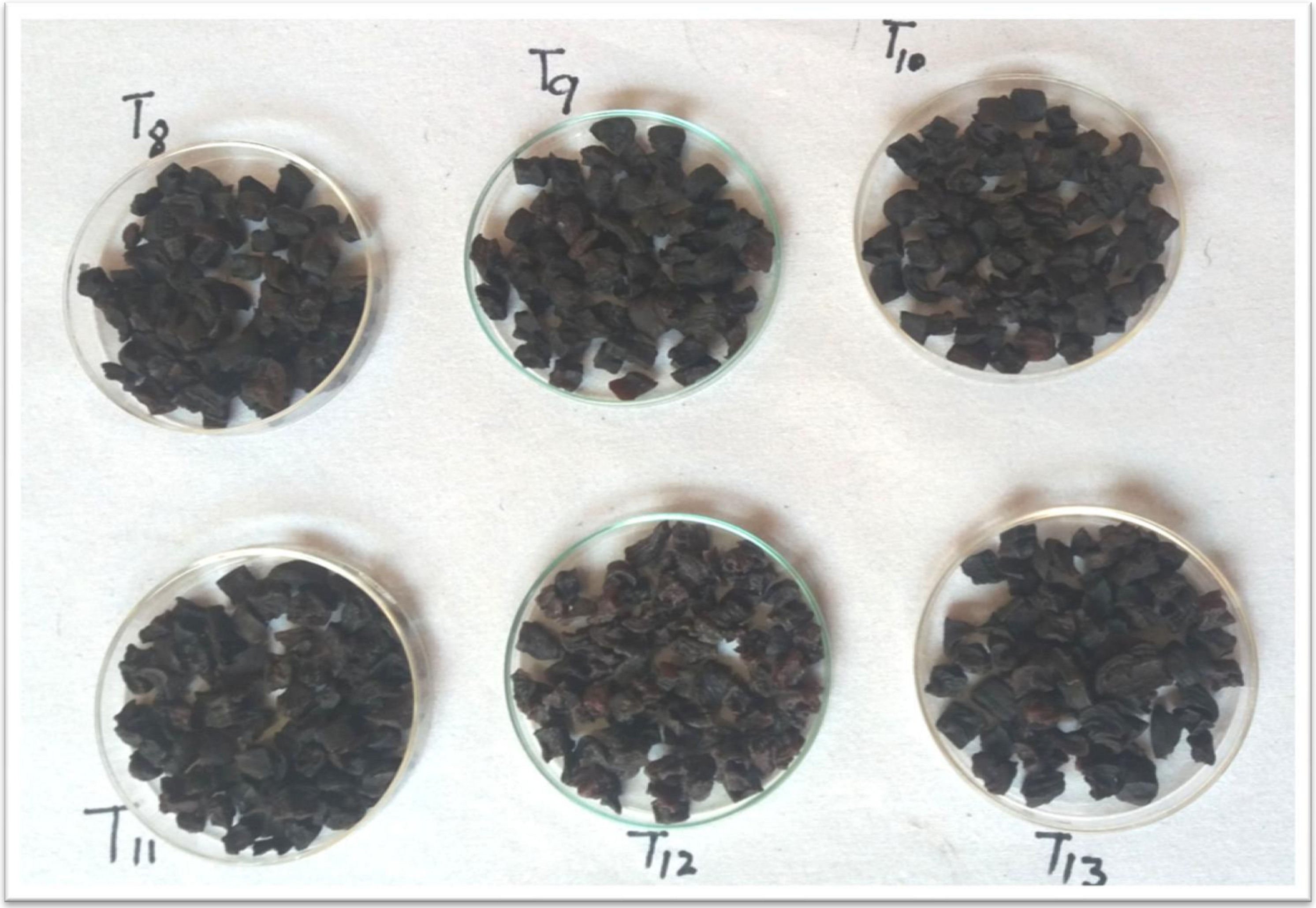
Fresh Beetroot Cubes

Plate-2



Intermediate Moisture Beetroot Cubes prepared by using Sugar : Glycerol in different ratios

Plate-3



Intermediate Moisture Beetroot Cubes prepared by using Sugar : Sorbitol in different ratios

Plate-4

Intermediate Moisture Beetroot Cubes
Treatment T_6 (Sugar : Glycerol :: 50 : 50)

Chapter-5

Discussion

CHAPTER-V

DISCUSSION

In the present investigation, an effort was made to develop intermediate moisture food product from beetroot using humectants glycerol/sorbitol with the main objectives of developing palatable, economical and nutritious product for human consumption. The quality with respect to chemical composition of developed product was monitored by drawing the periodic samples during ambient storage period of three months. The quality of the product was further ascertained by sensory evaluation. viz, colour, flavor, texture, taste and overall acceptability. The results obtained are discussed in this chapter under the following headings.

5.1 Chemical composition of fresh beetroot.

The data pertaining to Table-1 showed that the total soluble solids, titratable, acidity, ascorbic acid of beetroot was found to be 6.50^0 B, 0.02 per cent and 3.60 mg/100 g respectively which were in close compliance to the findings of Thakur and Das Gupta (2005).

Total Sugars and reducing sugars of 7.50 per cent and 0.76 per cent were recorded in beetroot which were also in accordance with the findings of Rodriguez-Sevilla *et al*.(1998), Thakur and Das Gupta (2005) and Wruss *et al.* (2015), and Calcium and phosphorus were found to be 15 mg/100g and 36mg/100g respectively which were in accordance with the finding of Kumar (2015).

5.2 Quality attributes of intermediate Moisture beetroot cubes

5.2.1 Moisture content.

Intermediate moisture beetroot cubes with sugar showed comparatively lower moisture content in comparison to IMF with glycerol or sorbitol. Initially the highest moisture content of 28.28 per cent was recorded in treatment T_7(Sugar:Glycerol:: 40:60) and lowest of 26.04 per cent treatment in T_1 (Sugar:Glycerol:: 100:00) as shown in Table-2. At the end of storage period the highest moisture content of 27.14 per cent was recorded in treatment T_7 (Sugar:Glycerol:: 40:60) and lowest 23.12 per cent in treatment T_1((Sugar:Glycerol:: 100:00). Increasing the amount of humectants retained more moisture in all intermediate moisture beetroot cubes. The mean value of storage period decreased from initial value of 27.07 to 25.63 per cent after 90 days of storage. The decrease in the moisture content could be due to loss of residual moisture from the surface by evaporation and also due to the change in the form from the crystalline to the amorphous which permit the binding of the water. Ahmed and Choudhary (1995) reported that during osmotic dehydration of papaya, the moisture content was reduced from 86.12 per cent to 12.06 per cent after drying.Similar findings were reported by Barmanray (1998) in the intermediate moisture pear which showed decrease in moisture content during preparation and storage at room temperature. Pattanapa *et al.* (2010) reported simil ar results in osmotically dehydratd mandarin. Sood(2000) reported a decrease in moisture content during storage of intermediate moisture foods of papaya, apple white guard. Panwar (2013) observed a decrease in moisture content of intermediate moisture aonla segments during six months of storage. Muzzaffar *et al.*(2016) reported a decrease in the moisture content of pumpkin candy during three months of storage.

5.2.2 Titratable acidity

Table-3 revealed that the titratable acidity increased slightly with the advancement of storage After 90 days of storage the highest titratable acidity of 0.10 per cent was observed in treatment T_1(Sugar:Glycerol::100:00) and lowest of 0.05 per cent in treatment T_{13}(Sugar:Sorbitol:: 40:60). The lowest value of titratable acidity might be due to - OH groups in humectants. The titratable acidity mean value increased slightly from 0.06 to 0.07 per cent during 90 days of storage. The increase in titratable acidity might be due to loss of moisture during storage period. It might be due to certain TCA activities still going on and also because a part of the sugars might have been utilized to yield various organic acids. Increases in acidity can also be attributed to the degradation of cell wall components to produce organic acids. Sethi(1980) observed a gradual increase in acidity during storage in IMF aonla preserve.

Sandhu (1994) observed an increasing trend in acidity of papaya candy stored at ambient temperature. Akhtar and Javed (2013) reported an increase in acidity of intermediate moisture Apple slices during two months of storage. Muzzaffar *et al*. (2016) also observed an increase in titratable acidity of pumpkin candy during three month of storage.

5.2.3 pH

The pH of intermediate moisture beetroot cubes decreased significantly in all the treatments during storage of 90 days (Table-4) It was observed that the samples prepared with Sugar:Sorbitol in the ratios of 90:10, 80:20, 70:30, 60:40, 50:50, 40:60 obtained a higher range of pH i,e 7.31, 7.31 7.32, 7.32, 7.33, 7.35 respectively followed by samples prepared using Sugar :Glycerol.

The maximum pH of 7.25 was observed in treatment T_{13}(Sugar: Sorbitol:: 40:60) after 90 days of storage and the minimum value 6.98 was found in T_1(Sugar:Glycerol:: 100:00) pH decreased from mean value of 7.28 to 7.07 during 90 days of storage. The decrease in pH might be due to the breakdown of ascorbic acid into dehydro ascorbic acid. Similar finding have been reported by Sood (2000) in intermediate moisture papaya cubes, apple slices, and white guard cubes. Akhtar and Javed (2013) also observed decrease in pH in intermediate moisture apple slice, during two months of storage.

5.2.4 Total Sugar

An increasing trend in total Sugars was observed with the progression of storage period. In intermediate moisture beetroot cubes, total sugars increased significantly from the initial mean value of 24.28 per cent to 25.69 per cent during 90 days of storage period. The highest total sugars of 28.30 per cent was recorded in treatment T_1 (Sugar:Glycerol::100:00) and lowest value of 23.34 per cent in treatment T_{13} (Sugar:Sorbitol::40:60).

The increase in total sugars supports the explaination that this could be due to hydrolysis of polysaccharides and inversion of non-reducing sugars. Similar trend was observed in pear candy by Rani and Bhatia (1986). Sandhu(1994) found an increase in total sugars during storage of papaya candy. Pathak (1998) reported an increase in total sugars during storage of Aonla Candy. Barmanray (1998) observed an increase in total sugars of intermediate moisture pear during 90 days of storage . Muzzaffar *et al*. (2016) observed that the total sugars increased significantly during three months of storage in pumpkin candy.

5.2.5 Reducing Sugars.

The data in Table-6 revealed that the reducing sugars content in intermediate moisture beetroot cubes increased significantly from the initial mean levels of 1.84 to

2.30 per cent during 90 days of storage. Highest reducing sugar (2.71per cent) was observed in treatment T_1 (Sugar:Glycerol::100:00) during 90 days of storage.

The increase in reducing sugars might be due to the inversion of non-reducing sugars into reducing sugars. These findings are well supported by the findings of Rani and Bhatia (1986) who observed that the reducing sugars in pear candy increased and non-reducing sugars decreased with storage because of increased inversion of sucrose. These results are also in confirmation with those reported by Kumar (1990) who reported that the reducing sugars of Papaya candy increased continuously during storage. Sharma *et.al.* (1998) revealed that the reducing sugars of apple candy under both room and refrigerated temperatures increased significantly with increase in storage time. Muzzaffar *et al*. (2016) observed that the reducing sugars increased significantly during three months of storage in pumpkin candy.

5.2.6 Ascorbic Acid.

The ascorbic acid in intermediate moisture beetroot cubes decreased significantly during 90 days of storage. The data in Table-7 revealed that the highest ascorbic acid content 3.80mg/100g was observed in treatment T_6 (Sugar:Glycerol :: 50:50) and while the minimum ascorbic acid content of 3.06 mg/100g was observed in treatment T_8 (Sugar:Sorbitol :: 90:10)

Reduction in ascorbic acid could be due to the oxidation by oxygen which resulted in the formation of dehydro ascorbic acid. Sandhu (1994) also observed a decreasing trend in ascorbic acid content of papaya candy during storage at both ambient and refrigerated temperatures. Sood (2000) reported a decrease in ascorbic acid content in intermediate moisture papaya cubes, apple slices and white guard cubes during three months storage. Similar observations were reported in intermediate moisture aonla segments Panwar *et al.* (2013). Muzzaffar *et al*. (2016) reported that the ascorbic acid decreased significantly during three months of storage in pumpkin candy stored at ambient temperature.

5.2.7 Minerals

5.2.7.1 Calcium

At initial day of storage the highest calcium content of 19.88 mg/100 g was recorded in treatment T_1(Sugar:Glycerol::100:00) and lowest 18.10mg/100 g in treatment

T_7(Sugar:Glycerol::40:60). After 90 days of storage the value decreased to 19.72mg/100 g in treatment T_1(Sugar:Glycerol::100:00) and 17.91 mg/100 g in treatment T_7(Sugar:Glycerol::40:60) There was significant decrease in calcium content of intermediate moisture beetroot cubes from 0 to 90 days of storage. The mean values decreased from 19.02 to 18.88 mg/100g after 90 days of storage. The decrease may be due to the microbial activity. Similar findings were given by Yamaguchi and Wu (1982) who reported that the water soluble components including minerals were lost during vegetable processing. Gupta (2007) also reported that minerals viz. calcium and phosphorous contents decreased in osmo dehydrated ber during storage of six months

5.2.7.2 Phosphorous

The data presented in Table - 9 showed the effects of various treatments and storage period on phosphorous content of intermediate moisture beetroots cubes. At initial day of storage the highest phosphorus content of 24.60 mg/100 g. was recorded in treatment T_1(Sugar:Glycerol::100:00)and lowest 22.56 mg/100 g. in treatment T_7(Sugar:Glycerol::40:60). After 90 days of storage the value decreased to 24.48 mg/100 g in treatment T_1(Sugar:Glycerol::100:00) and 22.41mg/100g in treatment T_7(Sugar:Glycerol::40:60) There was significant decrease in phosphorus content of intermediate moisture beetroot cubes from 0 to 90 days of storage. The mean values of storage period showed a decrease from initial value of 23.61 to 23.48 mg/100g during 90 days of storage. .The decrease may be due to the leaching effects of osmo dehydration and microbial activity. Similar findings were given by Yamaguchi and Wu (1982) who reported that the water soluble components including minerals were lost during vegetable processing. Gupta (2007) also reported that minerals viz. calcium and phosphorous decreased in osmo dehydrated ber during storage of six months in the study on processing and preservation of ber.

5.3 Microbial analysis

Table -10 revealed that after 90 days of storage the maximum microbial count of $1.55x10^2$ cfu/g was recorded in treatments T_1(Sugar: Glycerol::100:00) and minimum of $1.33x10^2$ cfu/g in treatment T_6(Sugar: Glycerol::50:50) There was an increase in mean value of microbial count from 0.00 to $1.37x10^2$ cfu/g during 90 days of storage period, which is considered as significantly low and safe for consumption. Similar findings have been given by Brockman (1970) who reported that no microbiological development have been seen in intermediate moisture foods during four months of storage in sealed containers at 38^0C. Barmanray (1998) reported that IMF pear prepared with glycerol (low temperature) showed least microbial growth initially and after 90 days of storage. Chaturvedi (2013) reported a least microbial count and low rate of growth throughout the storage period of six months in intermediate moisture carrot shreds.

5.4 Sensory Evalution

5.4.1 Colour

Table-11 revealed that the sensory scores of colour decreased in all treatments during 90 days of storage. Initially the maximum score of 7.60 was observed in T_7 (Sugar: Glycerol:: 40:60) and minimum of 6.22 in T_8 (Sugar: Sorbitol:: 90:10). During storage period of 90 days colour scores decreased form mean levels of 6.97 to 6.49. The decrease in colour scores during storage may be attributed to the presence of residual activity of the polyphenolase and oxidative type of deterioration resulting from chemical reactions. The same result was given by Sharma *et al* (2006) while studying the organoleptic and chemical evaluation of osmotically processed apricot wholes and halves. Similar findings have also been observed by Mondhe *et al.* (2013) in osmodehydrated papaya cubes. A decrease in colour score was observed in intermediate moisture apple slices during 49 days of storage by Akhtar and Javed (2013). Muzzaffar *et al.* (2016) observed a decrease in colour score in pumpkin candy during three months of storage.

5.4.2 Texture

A gradual decrease in texture scores in all the treatment was observed during 90 days of storage as shown in Table-12.Initially the maximum score of 7.90 was recorded in treatment T_6 (Sugar:Glycerol::50:50) which decreased to 7.80 after 90 days of storage which might be due to enzymatic breakdown of middle lamella and cell wall by pectin methlesterase, polygalacturanase, ß- galactosidase and cellulose (Ketsa and Daengkanit, 1999) Similar trend was observed by Sood (2000) in intermediate moisture papaya cubes, apple slices and white guard cubes during storage.

Similar decreasing texture score trend was observed by Muzzaffar *et al.* (2016) in pumpkin candy during three months of storage.

5.4.3 Taste

Table-13 revealed that a decreasing trend of taste scores was observed with the advancement of storage period. Highest taste score of 7.80 was observed in treatment T6 (Sugar:Glycerol :: 50:50) and lowest 6.00 in T8(Sugar:Sorbitol :: 90:10). Mean scores for taste of intermediate moisture beetroot cubes decreased significantly from 7.32 to 6.98 during 90 days of storage. Similar findings have been reported by Abe *et al.* (1980) in apple jam. Sood (2000) reported the decreasing trend of Taste score with increase in storage time of intermediate moisture papaya, apple and white guard cubes.

5.4.4 Flavour

Table-14 shows that flavour scores decreased from initial value of 7.95 in treatment T_6 (Sugar:Glycerol::50:50) to 7.70 after 90 days of storage. The mean flavour score decreased from 7.15 to 6.70 during storage of 90 days. The decrease in flavour on storage may be due to the volatile nature of flavouring components and the chemical interactions taking place between various constituents. Similar observation were reported by Jayaraman *et al.* (1976) in intermediate moisture mango slices.

Pooja (1999) reported loss of flavour in intermediate moisture food of apricots during 90 days of storage. Mondhe *et al.* (2013) observed reduction of flavour in intermediate moisture papaya cubes.

5.4.5 Overall acceptability

A significant decrease in overall acceptability was observed in all the treatments with the progression of storage period (Table-15). However intermediate moisture beetroot cubes were acceptable even after three months of storage..The highest initial overall acceptability score of 7.90 in treatment T_6 (Sugar:Glycerol::50:50) decreased to 7.40 after 90 days of storage. The mean overall acceptability score decreased from 7.16 to 6.81 during 90 days of storage. The decrease in overall acceptability scores in IMF products may be due to change in chemical composition of the product and loss of colour and flavor during storage period of 90 days.

Kumar and Sagar (2010) observed a decreasing trend in overall acceptability sensory score of osmodehydrated guava slices with increase in storage period of six months.

Panwar *et al.* (2013) reported a decrease in overall acceptability of intermediate moisture aonla segments during six months of storage.

Muzzaffar *et al*. (2016) observed that the overall acceptability of pumpkin candy decreased during three months of storage. However it was acceptable even after three months of storage

5.5 Cost of production

A 50g. pack of intermediate moisture beetroot cubes cost Rs. 36/- which is quiet low in cost as compared to Rs.50/- of the IMF products available in the market.

Chapter-6

Summary and Conclusion

CHAPTER-VI

SUMMARY AND CONCLUSION

The present investigation entitled "Effect of humectants on storage stability of intermediate moisture beetroot cubes" was carried out in the Division of Food Science and Technology, Faculty of Agriculture, S K U A S T, Jammu.

The intermediate moisture beetroot cubes were prepared by soaking the beetroot cubes in the soaking solution containing sugar: glycerol/sorbitol in the ratio of 100:00, 90:10, 80:20, 70:30, 60:40, 50:50 and 40:60. The cubes were then dried at 60-65^0 C in cabinet drier for 2 hours. The processed product was packed in air tight plastic jars and stored at room temperature.

The intermediate moisture beetroot cubes were subjected to chemical, microbial and organoleptic quality at 0, 30, 60 and 90 days of storage. The results are summarized as under:

- The analysis of intermediate moisture beetroot cubes revealed that the highest moisture content of 27.14 per cent was observed in treatment T_7 (Sugar: Glycerol ::40:60) and lowest 23.12 per cent in treatment. T_1 (Sugar:Glycerol::100:00). The moisture content decreased significantly during 90 days of storage.
- Titratable acidity exhibited a slight increasing trend during storage. Highest titratable acidity of 0.10 per cent was observed in Treatment T_1(Sugar:Glycerol:: 100:00) and lowest 0.05 per cent in treatment T_{13}(Sugar:Sorbitol::40:60)
- Maximum pH (7.25) was observed in treatment T_{13}(Sugar:Sorbitol::40:60) and minimum (6.98) in treatment T_1(Sugar:Glycerol::100:00) A decreasing trend was observed during 90 days of storage.
- Highest total Sugar content of 28.30 per cent was recorded in treatment T_1(Sugar: Glycerol::100:00) and lowest of 23.34 per cent was recorded in treatment T_{13}(Sugar:Sorbitol::40:60) An increasing trend was observed during storage.
- Reducing sugars also increased during storage with highest value of 2.71 per cent in treatment T_1(Sugar:Glycerol::100:00) and lowest of 1.88 per cent in treatment T_7(Sugar:Sorbitol:: 40:60)

- A decreasing trend was observed in ascorbic acid content during 90 days of storage. Highest 3.80 mg/100 g was found in treatment T_6 (Sugar:Glycerol:: 50:50) and lowest of 3.06 mg/100g in treatment T_8 (Sugar:Sorbitol :: 90:10).
- Both calcium and phosphorous content decreased with the increase in storage period. Treatment T_1 (Sugar:Glycerol::100:00) recorded the maximum values of 19.72 and 24.48 mg/100g of calcium and phosphorus respectively followed by treatment T_2 (Sugar:Glycerol::90:10)
- Microbial evaluation revealed that treatment T_6 (Sugar:Glycerol:: 50:50) showed minimum total plate count of $1.33x10^2$ cfu/mg.

On the basis of sensory evaluation treatment T_6(Sugar:Glycerol::50:50) was judged best with highest sensory scores of 7.80, 7.80, 7.70 and 7.40 for taste, texture, flavour and overall acceptability respectively.

Conclusion

It is concluded from the present study that increasing the amount of humectants enhances stability, maintains texture and reduces the microbial activities.

Treatment T_6 (Sugar:Glycerol::50:50) was considered to be the best treatment as it retained the maximum ascorbic acid. On the basis of sensory evaluation (taste, texture, flavour and overall acceptability) treatment T_6 (Sugar:Glycerol::50:50) was found to be the best treatment followed by treatment T_1(Sugar:Glycerol::100:00). The cost of production of intermediate moisture beetroot cubes is economically feasible.

It can be safely presumed that in future, the food industry shall give due consideration to the intermediate moisture foods, which not only add new dimension to our dietary habits but also retain the nutritive and quality parameters very close to the natural counterparts.

References

REFERENCES

Abe, E., Ho, T. and Odagri, S. 1980. Flavour of apple jam. *Nippon Mogeikagaku Kavishi,* **54** : 761

Adsule, P. G. and Roy ,S. K. 1974. Canned mango slices . *Journal of Food Science and Technology***, 11** : 269

Ahmed, J. and Choudhary, D. R . 1995. Osmotic dehydration of Papaya. *Indian Food Packer*, **49** : 5-11

Akhtar, S. and Javed, B. 2013 .Physicochemical analysis and quality evaluation of intermediate moisture apple slices. *Journal of Biological Sciences***, 1**(3) : 15-19

Anon (2011) www.ausport.gov.au/ais/nutrition/supplements.

Anonymous, 2010. nhb. gov. in/statistics/commodity-bulletin vegetables.html.

AOAC. 1995. Official Methods of Analysis. The association of official analytical chemists, USA,Ed : 15

AOAC. 2005. Official Methods of Analysis. The association of official analytical chemists, USA, Ed : 18

Aro, A., Amaral, E., Kesteloot, H., Rimestad, A., Thamm, M., Van Poppel, G., 1998. Trans fatty acids in French fries, soups and snacks from 14 European Countries: the transfair study. *Journal of Food Composition and Analysis,* **11** : 170-177

Atamanova, A., Brezhneva, T. A., Slivkin, A. I., Nikolaevskii, V. A., Selemenev,V. F., Mironenko, N. V. 2005. Isolation of saponins from table beetroot and primary evaluation of their pharmacological activity. *Pharmaceutical Chemistry Journal*, **39(**12) : 650-652

Azoubell, P. M. and Murr, F. E. X. 2003. Optimisation of Osmotic Dehydration of Cashew Apple in sugar solutions. *Food Science Technolgy International*, **9**(6) : 427-33

Barmanray, A. 1998. Studies on the processing technology of sand pear (*Pyrus serotina Rehd var. culta*) Patharnak. Ph.D, Thesis, C.C.S. Haryana Agricultural University, Hisar.

Bhoyar, A. F. and Chappalwar, V. M. 2014. Effects of osmotic treatments on beetroot cubes at different processing conditions with sucrose solution as an osmotic medium. *Beverage and Food World*, **41**(8) : 36-41

Bongirwar, D.R. and Sreenivasan, A.1977. Studies on osmotic dehydration of banana. *Journal of Food Science and Technology*, **14** : 104-111

Brockman, M.C. 1970. Development of intermediate moisture foods for military use. *Food Technology*, **24** : 896

Chander, B. 1982. Studies on the evaluation of certain mango varieties for the preparation of intermediate moisture mango slices. M.Sc. Thesis, Punjab Agriculture University, Ludhiana.

Chaturvedi, A., Sujatha,V., Ramesh, C, and Dilip, B. J. 2013. Development of shelf stable intermediate moisture carrot (*Daucus carota*) shreds using radiation as hurdle technology. *International Food Research Journal*, **20**(2) : 775-781

Chauhan, S. K. Lal, B. B. and Joshi, V. K. 1997. Preparation and evaluation of protein enriched mango fruit bar. *Indian Food Packer*, **51**(5) : 5-9

Chavan, U.D. and Amavowicz, R. 2012. Osmotic dehydration process of preservation of fruits and vegetables. *Journal of Food Research*, **1** (2) : 202-209

Chawla, P. and Ghai, S. 2012. Effect of storage on the nutritional, physico-chemical and organoleptic characteristics of carrot preserve. *Journal of Research of Punjab Agriculture University*, **42**(1) : 104-108

Dass,D. K. and Jayaraman. 1995. Preparation of fruit juice semi concentrate from orange pineapple and tomato by reverse osmosis and there storage evaluation .*Indian Food Packer*, **49 :** 13-28

De Zwart, F.J., Slow, S., Payne, R. J., Lever, M., George, P. M., Gerrard, J.A. and Chambers, S.T. 2003. Glycine betaine analogues in common foods. *Food Chemistry*, **83** : 197-204

Dhawan, S. S. 1980. Studies on post harvest technology of ber (*Zizyphus malintianali*). Ph.D. Thesis, C. C. S. Harayana Agricultural University, Hissar.

Dias, M. G., Camoes, M. F. G. F. C. and Oliveira, L. 2009. Carotenoids in traditional fruits and vegetables. *Food Chemistry*, **113** : 808-815.

Ergun, R., Lietha, R. and Hartel, R.W. 2010. Moisture and shelf life in sugar confections. *Food Science and Nutrition*, **50(**2) : 162-192

Gandia –Herrero, F., Escribano, J., Garcia-Carmona, F. 2010. Sturucturak implications on colour, florescence and antiradical activity in betalains. *Planta*, **232**(2) : 449-460

Giangiacomo, R., Torreggiani, D. and Abbo, E.1987. Osmotic dehydration of fruits : Part -1sugars exchange between fruit and extracting syrups. *Journal of Food Processing and Preservation*, **11** : 183-195.

Gomez,K. A. and Gomez, A.A. 1984. Statistical procedures for agricultural research (2nd Ed.) A Wiley–Interscience Publication, John Wiley and Sons, New York : 680

Gowda, D. Dan, A. and Ramanjaneya, K. H. 1995. Studies on mango fruit bar preparation *Indian Food Packer*, **49**(2) : 17-24

Gupta, N. 2007. Studies on processing and preservation of ber. Ph.D. Thesis, Sher-e-Kashmir University of Agricultural Sciences and Technology of Jammu, (J & K)

Gupta,O. P., Kainsa, R.L., Chauhan, K. S. and Dhavan, S.S. 1980. Post harvest studies in ber fruit, candy preparation. *Haryana Agriculture University Research Journal*, **10** : 163-165

Hassan, M. and Ahmed, J.1998. Physico-chemical and sensory characteristics of mango milk beverage. *Indian Food Packer,* **52** : 32-38

I.H.B.T. 2014. Indian Horticulture Data Base,Ministry of Agriculture,Govt.of India.

Iman, S., Bano, S., Shaukatullah, S. and Naz,H. 2011. Physico-chemical analysis and quality evaluation of intermediate moisture apple slices. *Pakistan Journal of Biochemistry and Molecular Biology*, **44**(1) : 27-31

Jastribova, J., Witthoft, C., Grahn, A., Svensson, U. and Jagerstad, M. 2003. HPLC determination of folates in raw and processed beet roots. *Food Chemistry,* **80** : 579-588

Jayaraman, K.S., Ramanuja, M.M., Bhatia, B.S. and Nath, H. 1974. Some studies on the preparation of intermediate moisture guava, *Journal of Food Science and Technology*, **11**:162-165.

Jayaraman ,K.S., Ramanuja, M.M., Venugopal, M.K., Lella, R.K. and Bhatia, B.S. 1975. Studies on the preparation of I.M. Pineapple, *Journal of Food Science and Technology*, **12** : 309-312.

Jayaraman, K.S., Ramanuja, M.M., Goverdhanan, T., Bhatia , B.S. and Nath, H. 1976. Technological aspects of use of ripe mangoes in the preparation of some convenience foods for defence services. *Indian Food Packer*, **30** : 76-82.

Jayaraman, K.S. and Gupta, D.K. 1978. Development and storage stability of intermediate moisture carrot, *Journal of Food Science*, **43** : 1880-1881.

Jayaraman, K. S. 1993. Some process technologies for the preparation of convenience food from fruits and vegetables for defence services. *Indian Food Industry*, **12**: 162-165

Juszczak, L., Witczak, M., Fortuna, T. and Solarz, B. 2010. Effect of temperature and soluble solids content on the viscosity of beetroot juice concentrate. *International Journal of Food Properties*, **13** : 1364-1372

Kapadia, G. J., Tokuda, H., Konoshima,T. and Nishino,H.,1996.Chemoprevention of lung and skin cancer by Beta vulgaris (beet root) extract, *Cancer Letters*, **100** : 211-24.

Ketsa, S. and Daengkanit, T. 1999. Firmness and activities of polygalacturonase, pectinesterase, β-galactosidase and cellulose in ripening durian harvested at different stages of maturity *Scientia Horticulturae,* **80 :** 181-188

Khan, A., Alam, Z., Khan, R., Fazali, K. and Noor, M. 1996. Development of new processing techniques for the preparation of glazed pear. *Sarhad Journal of Agriculture*, **12**(2) : 197

Koul, V.K., Jain, M.P., Koul,S., Sharma, V.K., Tikoo, C.L. and Jain, S.M. 2002. Spray drying of beetroot juice using different carriers. *Indian Journal of Chemical Technology*, **9**(5): 442-445.

Krejcova, A., Cernohorsky, T. and Meixner, D. 2007. Elemental analysis of instant soups and seasoning mixtures by ICP-OES. *Food Chemistry*, **105** : 242-247

Kumar, S. 1990. Studies on post harvest technology of papaya (*Carica papaya* L.) fruits Ph.D Thesis, N. D. University of Agriculture and Technology, Faizabad (U.P.)

Kumar, S. and Singh, I. S. 2001. Storage studies of aonla fruit products at ambient temperature. *Progressive Horticulture*, **33**(2) : 169-173

Kumar, S. and Sagar,V. R. 2010. Quality characteristics of osmo-dehydrated guava slices influenced by packaging material and storage period. *Beverage and Food World*, **37**(12) : 40-43

Kumar,Y.2015. Beetroot: A Super Food, *International Journal of Engineering Studies and Technical Approach*, **3**(1) : 20-26

Labuza, T.P. Tannenbaum, S. R. and Karel, M. 1970. Water content and stability of low moisture and intermediate moisture foods. *Food Science Technology*, **24** : 35-45

Mehta, U. and Bajaj, S. 1984. Changes in the chemical composition and organoleptic quality of citrus peel candy during preparation and storage. *Journal of Food Science and Technology*, **21**: 422-424

Mir, M. A. and Nath, N. 1993. Storage changes in fortified mango bars. *Journal of Food Science and Technology*, **30**(4) : 279-282

Mondhe, D.S., Gupta, S. K., Chand, T. and Sharma, S. R. 2013. Effect of osmotic solution and drying temperature on organoleptic evaluation of papaya cubes. *Journal Research Punjab Agricultural University*, **50**(22) : 48-51

Muzzaffar, S., Baba, W. N., Nazir, N., Masoodi, F. A., Bhat, M. M. and Bazaz, R. 2016. Effect of storage on physicochemical, microbial and antioxidant properties of pumpkin (*Cucurbita moschata*) candy. *Food and Agriculture*, **2** : 1-13

Panwar, S., Gehlot, R. and Siddiqui, S. 2013. Effect of osmotic agents on intermediate moisture Aonla segments during storage. *International Journal of Agricultural and Food* Technology**, 4**(6) : 537-542

Pathak, S. 1988. Post harvest technology of aonla. Ph.D. Thesis N D University of Agriculture and Technology, Faizabad .(U.P.)

Pattanapa, K., Therdthai, N., Chantrapornchai, W. and Zhou, W. 2010. Effect of sucrose and glycerol mixtures in the osmotic solution on characteristics of osmotically dehydrated mandarin. *International Journal of Food Science Technology*, **45** : 1918-1924

Pooja. 1999. Processing of apricot for intermediate moisture product and juice beverage by osmotic dehydration, MSc. Thesis, Himachal Pardesh Krishi Vishvavidyalaya, Palampur

Priya, M.D. and Khatkar, B. S. 2013. Effect of processing methods on keeping quality of Aonla (*Emblica officinalis* Gaertn.) preserve. *International Food Research Journal*, **20**(2) : 617-622

Ramanajua, M. N. and Jayaraman, K. S. 1980. Studies on the preparation and storage stability of intermediate moisture banana. *Journal of Food Science and Technology*, **17** : 183-185.

Ranganna, S. 1986. Handbook of analysis and quality control of fruit and vegetable products, 2nd ed. Tata McGraw-Hill, New Delhi, India

Ranganna, S.2006. Manual analysis of fruit and vegetable products. Tata McGraw-Hill, New Delhi, India

Rani, U. and Bhatia, B.S. 1986. Studies on the Baggugosha pear for the preserve and a ready to eat products. *Indian Food Packer,* **40** : 24-31

Rao, V. S. and Roy, K. S. 1980 Studies on dehydration of mango pulp, standardisation for making mango sheet/leather. *Indian Food Packer*, **34 :** 64-71

Reddy, K., Ruby, L., Lindo,A. and Nair,G.M.2005 Reative inhibition of lipid peroxidation, cycloxygenase enzymes and human tumor cells profiration by natural food colour. *Journal of Agricultural and Food Chemistry*, **53** : 968-97.

Rodriguez-Sevilla, M.D., Villanueva-Suarez, M. J., Redondo-Cuenca, A. 1998. Effects of processing conditions on soluble sugars content of carrot, beetroot and turnip. *Food Chemistry*, **66**(1) : 81-85

Roy, S. K. and Singh, R. N. 1979. Studies on utilisation of ber fruit for processing, preparation and preservation of ber fruit products. *Indian Food Packer***,** **33** : 3-9

Sahoo, J., Kumar , S.and Yadav, P.L. 1994. Development in technology of IMF with special reference to Indian meat industry. *Indian Food Industry*, **13**:35-45.

Sandhu, G. S. 1994. Development of sugar coated candied products, M.Sc. Thesis, Punjab Agriculture University, Ludhiana.

Saxena, S., Mishra, B. B., Chander, R. and Sharma, A. 2009. Shelf stable intermediate moisture Pineapple (*Ananas cosmoses*) slices. *Convention of food scientists and technologists in health foods*, **309** : 302-307.

Sethi, V. and Anand, J. C. 1982. Studies on the preparation, quality and storage of intermediate moisture carrot preserve. *Journal of Food Science and Technology*, **19 :** 168-171

Sethi, V. and Anand, J. C. 1983. Retention of nutrients in carrots and aonla preserves, *Indian Food Packer,* **37** : 64-67

Sethi, V. 1980 .Studies on the preparation and storage of semi dried preserve Ph.D. Thesis. Indian Agricultural Research Institute, New Delhi.

Sharma, H. R., Pooja and Verma, R. 2006. Organoleptic and chemical evaluation of osmotically processed apricot wholes and halves. *Natural Product Radiance* ,**5** : 350-56

Sharma, S., Dhaliwal, Y. S. and Kalia, M. 1998. Candied apples, a new perspective. *Journal of Food Science and Technology*, **35 :** 79-82

Sharma, S. 1993. Preparation of fruit candy with effect on storage stability and nutritional quality M.Sc. Thesis, H.P.K.V, Palampur (H. P.)

Siddique, M.,Ahmed, M.,Awan, J. A., Rahman, S. U. and Ahmed, A. 1990. Production of wax gourd candy by using high fructose syrup. *Journal of Food Science and Techology*, **27 :** 205-208

Singh, A. K.1985. Studies on preparation and storage of Guava preserve M.Sc. Thesis, N. D. University of Agriculture and Technology, Faizabad (U.P.)

Singh,B. and Hathan, B. S. 2013. Optimazation of osmotically dehydrated beetroot candy using response surface methodology. *International Journal Of Food And Nutritional Sciences*, **2**(1) : 15-21

Singh, D., Chhonkar, P. K. and Pandey, R. N. 1999. *Soil Plant Water Analysis: A Methods Manual*, IARI, New Delhi : 57-71

Singh, I.S. 1988. Changes during storage of aonla intermediate food. Paper presented at national workshop on Post- Harvest Technology of horticulture crops, held at Dapoli.

Singh, M., Kumar, S. and Arora, S. 2005. Influence of osmo- mechanical dehydration on the quality of ber. *Journal Research Punjab Agricultural University*, **42**(4) : 486-96

Sood, S. 2000. Development of intermediate moisture foods with an intent to enhance the shelf life and bioavailability, Ph.D. Thesis, Himachal Pardesh Krishi Vishvavidyalaya, Palampur.(H.P.)

Strack, D., Vogt, T. and Schliema,V. 2003. Recent advances in betalin research. *Phytochemistry*, **62** : 247-256

Sturzoiu, A., Stoica,A. and Dobre, T. 2011. Betanine extraction from *Beta vulgaris*-Experimental research and statistical modelling. University Politehnica of Bucharest-ScientificBulletin, **73** : 145-156

Thakur,V. and Das Gupta, D.K. 2005. Studies on the clarification and concentration of beetroot juice. *Journal of Food Processing and Preservation*, **30**: 194-207.

Thorat, S.S., Kadadi, A.M., Kulkarni, D.N. and Ingle, U.M. 1988. Preparation and storage studies on intermediate moisture okra. *Indian Food Packer*, **42** : 47-51

Vali,L., Stefanovits Banyai, E., Szentmihalyi, K., Febel, H., Sardi, E., Lugasi, A., Kocsis, I., Blazovics, A.,2007. Liver-protecting effects of table beet (*Beta vulgaris* var. Rubra) during ischemia-reperfusion. *Nutrition*, **23** : 172-178

Vinson, J. A. , Hao, Y. ,Su, X. and Zubik, L. 1998. Phenol antioxidant quantity and quality in foods, Vegetables. *Journal of Agricultural and Food Chemistry*, **46** : 3630-3634

Vitti, M. C. D., Yamamoto, L. K., Sasaki, F., Aguila, S. D., Kluge, R. A. and Jacomino, A.P., 2005. Quality of minimally processed beetroots stored in different temperatures. *Brazilian Archives of Biology and Technology*, **48**(4) : 503-510

Vora, P., Senecal ,A. and Schaffnar, D. W. 2003. Survival of Staphylococcus aureus ATCC 13565 in intermediate moisture food is highly variable. *Risk analysis*, **23**(1) : 229-236

Webster, C.E.M. 1980. Nottingham of Ledward, D. A., In: Development of meat science,2 Ed. Lawrie RA, Applied Science Publication : 193

Wruss, J., Waldenberger, G., Huemer, S., Uygun, P., Lanzerstorfer, P., Muller, U., Hoglinger, O., Weghuber, J. 2015. Compositional characteristics of commercial beetroot products and beetroot juice prepared from seven beetroot varieties grown in upper Austria. *Journal of Food Composition and Analysis,* **42** : 46-55

Yamaguchi, M. and Wu, C. M. 1982. Composition and nutritive value of vegetable processing. AVI Publication company., Inc. Westport Connecticut : 640-641

Yousif, A. K., Ali, M. A. and Idrease, A. B. 1990. Processing, evaluation and storability of date jelly. *Journal of Food Sciences and Technology***, 27** : 264-267

Zitnanova, I., Ranostajova,S., Sobotovo, H., Demelova, D., Pechan, I. and Durackova, Z. 2006. Antioxidant activity of selected fruits and vegetables. *Biologia,* **61** : 279-284

Appendix

Evaluation card for Hedonic rating of ______________________________

Name: **Date:**

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

Treatments	Colour	Texture	Flavour	Taste	Overall Acceptability
T_1					
T_2					
T_3					
T_4					
T_5					
T_6					
T_7					
T_8					
T_9					
T_{10}					
T_{11}					
T_{12}					
T_{13}					

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

Vita

VITA

Name of the student	:	Anil Kumar Chhibber
Father's name	:	Sh. S. P. Chhibber
Mother's name	:	Smt. Sudesh Chhibber
Nationality	:	Indian
Date of Birth	:	28-05-1970
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Educational Qualification		
Bachelor degree	:	B. Sc. Agriculture
University and year of award	:	Choudhary Charan Singh University Meerut (1992)
Percentage of Marks	:	70.00 %
P.G. degree	:	M. Sc.(Ag) Horticulture
University and year of award	:	Choudhary Charan Singh University Meerut (1995)
Percentage of Marks	:	74.00 %

CERTIFICATE – IV

Certified that all the necessary corrections as suggested by the external examiner/ evaluator and the advisory committee have been duly incorporated in the thesis entitled **"Effect of humectants on storage stability of intermediate moisture beetroot cubes"** submitted by **Mr. Anil Kumar Chhibber** Registration No. **J-14-M-383.**

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Place: Jammu

Date: 4. 10. 16

Head 5/10/16

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