EFFECT OF PRETREATMENTS ON QUALITY OF *AMLA* *(Phyllanthus emblica)* PRESERVE

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Effect of Pretreatments on Quality of *Amla (Phyllanthus emblica)* preserve

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Approval Letter

This *dissertation* entitled *Effect of Pretreatments on Quality of Amla (Phyllanthus emblica) preserve* presented by Samiksha Basnet has been accepted as the partial fulfillment of the requirements for the B.Tech. Degree in Food Technology.

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Abstract

The present study was carried out for the process optimization of *amla* preserve in respect of certain pretreatment (blanching and brining). The *amla* were purchased from local market of Dharan and were washed and pricked with stainless steel fork/knife. Then pricked *amla* were divided into 2 lots for pretreatment, one of them was blanched (98±1°C for 4 min) and second was not blanched. Both of the lots were dipped in 2% NaCl solution for varying periods of time i.e. 6, 12, 18 and 24 h respectively. From the sensory analysis changes in bitterness was analyzed by using one way ANOVA and the maximum bitterness was reduced in 12^{th} hour of dipping in blanched sample whereas it took a longtime for de-bittering (more than 24 h) in un-blanched sample. The losses of vitamin C were analyzed from one way ANOVA (no blockings) with respect to the dipping time in NaCl solution.

All the pre-treated samples were used for preparation of *amla* preserve by using sucrose. The *amla* preserve was subjected to sensory analysis. The sensory data were statistically analyzed using two way ANOVA (no blocking) at 5% level of significance which shows that there exists significant difference ($p<0.05$) in the overall acceptability among the samples. The sample blanched got the highest mean sensory score. The statistical analysis of sugar uptake characteristics (total sugar and reducing sugar) by sample blanched and un-blanched by one way ANOVA showed that there exists significant difference ($p<0.05$) in change in sugar content within the samples as well as with respect to time. The extent of vitamin C reduction in un-blanched sample during the syruping was higher (295.80 mg/100 g to 185.50 mg/100 g), whereas in blanched sample the reduction was from 264.50 to 193.60 mg/100 g. This losses were significantly difference with each other which was analyzed by one way ANOVA at 5% level of significance. The *amla* preserve was satisfactory made from the blanched sample followed by 12^{th} hour of brining and the composition was found 24.2%, 2.560%, 72.5%, 34.40%, 0.841% and 193.60 mg/100 g in terms of moisture content, pH, total sugar, reducing sugar, acidity (citric acid) and vitamin C respectively.

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List of Abbreviations

Abbreviations	Full form
ANOVA	Analysis of Variance
IMF	Intermediate Moisture Food
^{o}Bx	Degree Brix
RTS	Ready to Serve
TSS	Total Soluble Solid
LSD	Least Significant Different
FAO	Food and Agriculture Organization
USSR	Union of Soviet Socialist Organization
DHSS	Department of Health and Social Service

Part I

Introduction

1.1 General introduction

Amla (*Phyllanthus emblica*) is highly nutritious fruit that grows abundantly in Nepal. It is found plentifully during the winter season in Terai and middle low hilly region of Nepal (Gautam, 1991). It has been traditionally used in the Ayurvedic and Unani systems of medicine since time immemorial (Udupa, 2003). It has high medicinal as well as nutritional value due to its high vitamin C content of about 600 mg/100 g of fresh fruit (Gopalan *et al.*, 1993). It is a low cost easily available fruit than any other citrus fruits and vegetable. The fruit is extensively used in the preparation of Ayurvedic medicines. Owing to its nutritive and miraculous medicinal properties, this fruit has acquired wide popularity (Ranote, 2006).

Fresh *amla* is rich in vitamin C and very few people are aware of its therapeutic value in Nepal. As such the fresh fruit is not consumed much. It is sometimes used for making pickles and dry-candy in the homes. *Amla* preserve (*mada or murabba*) is a delicious product which is liked by many people. It is probably made from *amla* processed for commercial purpose (Singh and Kumar, 2000).

Fruit preserves are preparation of fruits, vegetables and sugar, often canned or sealed for long-term storage. The preparation of fruit preserves today often involves adding commercial or natural pectin as a gelling agent, although sugar or honey may be used, as well. Before World War II, fruit preserve recipes did not include pectin, and many artisan jams today are made without pectin (Lal *et al.*, 1998).

Freshly made preserves are wholesome and have an attractive appearance. When they are stored for a long period, their natural color and flavor deteriorates on account of oxidative changes. They should therefore be made only during the season, unless these are adequate facilities to keep the fruits so that they are available in the off season also. Preserves made from frozen fruits are generally superior in color and flavor to those made from fresh fruits stored at ordinary room temperature (Bharthakur *et al.*, 1999).

Amla fruits are astringent, carminative, digestive, stomachic, laxatic, altrant, aphordisac, diuretic, antipyretic and trichogenous. They are useful in curing many diseases like diabetes, cough, asthma, bronchitis, headache, ophthalmic disorders, dyspepsia, colic, flatulence, skin diseases, leprosy, jaundice, scurvy, diarrhea and greyness of hair (Naik *et al.*, 2005). The fruits have been used to prepare ready-to-serve (RTS) beverage, *murrabba*, candy, pickles, jam, squash, chavyanprash, toffees, fruit bar, powder, etc. (Singh, 2003).

1.2 Statement of the problem

Many fruits and vegetables are season oriented. Likewise, *amla* is also one of the winter season fruit. It contains higher percentage of ascorbic acid as compared to other fruits and vegetables (Dewan, 1994; Gopalan *et al.*, 1993). *Amla* fruit is highly nutritive with great medicinal values and rich source of Vitamin C. As *amla* fruit is highly perishable in nature, its storage is very limited. Due to its astringent nature, consumers are hesitant to eat it in raw form. Fresh *amla* is so sour that most people find it intolerable. The method of preparation of *amla* preserve is hygienic, consume lesser time and provide maximum retention of nutrient. Nowadays, the craze towards processed food has been greatly increased which is very low or either deficit in Vitamin C content and people go through many problems related to deficiency in Vitamin C. The deficiency of ascorbic acid results in the defective formation of the intercellular cement substances. Fleeting joints pains, irritability, retardation of growth in the child, anemia, shortness of breath, poor wound healing, and increased susceptibility to infection are among the signs of deficiency. Scurvy is the deficiency disease resulting from the lack of ascorbic acid in the diet (Scartezzini *et al.*, 2006). Hence present study was an effort to develop a suitable product which contains higher amount of vitamin C and other medical components. Thus, the present work is concerned with the study of effect of pretreatments on quality of *amla* preserve. So it is essential to improve the sensory quality to increase its acceptability among the community. The mandate of this study is to improve the sensory as well as nutritional quality of *amla* preserve so that it can be commercially marketed.

1.3 Objectives

1.3.1 General objective

The general objective of this work is to study the effect of pretreatments on quality of *amla (Phyllanthus emblica)* preserve.

1.3.2 Specific objectives

The specific objectives of this work are as follows:

1. To study the effect of dipping of *amla* in brine solution on vitamin C content and astringency.
2. To study the effect of blanching on retention of vitamin C, sugar uptake and sensory attributes of a*mla* preserve.
3. To study the cost evaluation of *amla* preserve.

1.4 Significance of the study

Generally *amla* is season oriented fruit and are highly perishable and hence they need to be preserved. Fresh *amla* is rich in vitamin C and very few people are aware of its therapeutic value. It has high medicinal as well as nutritional value due to its vitamin C content of about 600 mg/100 g of fresh fruit. Ascorbic acid is not synthesized by our body. It should be taken externally from plant source (Naik *et al.,* 2005). It is therefore ascorbic acid of *amla* could be a good dietary source for the fulfillment of our requirement. The vitamin C content in *amla* compared to other fruits (approximately 500 mg/100 g) is very high. Even though there is small loss in Vitamin C during the processing, the final value in the product is still enough to fulfill the daily requirement of vitamin C. Hence, the product is very helpful to reduce vitamin C deficiency disease. Fresh *amla* generally is not consumed due to its high astringency but a processed form has got great potential consumed. *Amla* itself is bitter in taste so the benefits of making this product are preferable for children as well as adult.

Amla preserve so prepared is aimed to contain sufficient vitamin C needed for human health. Although with health benefits, preserve would be an alternative solution for

enhancement of economic value of *amla* in our nation. This dissertation helps to increase the aesthetic value of the fruit by decreasing astringency through pretreatment. Besides, this work will help in prevention of loss of *amla* for farmers and promote its commercial farming.

1.5 Limitation of the study

1. Shelf life could not be studied due to lack of time.

Part II

Literature review

2.1 *Amla*

2.1.1 Historical background

Amla (*Phyllanthus emblica*) or Emblica officinalis tree belongs to the family euphorbiaceae. Its common name is Emblic myrebalan or Indian goose berry. It is also known as dhatiphal in *Sa*nskrit and "*Amla*" in Nepali and Hindi also. The term '*Amla*' has come from Sanskrit word'*Amla*'(Udupa, 2003).

Amla is native to Srilanka, India, Malaysia, China (Zhang *et al.*, 2003) and distributed in terai and subtropical valleys in Nepal. Several authors have reported that the distribution of this fruit tree is in terai, inner terai and central terai low hills throughout the country from 400-1800 meters altitude. The fruit of *amla* is round deeply ribbed, pale green and highly acidic and attractive. The fruit is nearly stalk less and smooth divided into six lobes through pale linear grooves. The surface is shiny, quite hard with a thin and translucent skin. The hexagonal stone containing six small seeds embedded tightly in the flesh (Singh and Kumar, 2000).

Amla (Emblica officinalis), is a small size, minor subtropical fruit and grows widely along the hillsides and sub-mountainous areas of Nepal. The fruit is acrid, cooling, refrigerant, diuretic and laxative, hence used for treating chronic dysentery, bronchitis, diabetes, fever, diarrhea, jaundice, & coughs etc. It is highly nutritive and one of the richest source of ascorbic acid. It contains 500-1500 mg of ascorbic acid per 100 g of pulp. The Gallic acid present in *amla* fruit has antioxidant properties. This fruit is extensively used in the preparation of Ayurbedic medicines. Owing to its nutritive and miraculous medicinal properties, this fruit has acquired wide popularity (Ranote, 2006).

2.2 Botanical profile

The plant is an annual herb attending a height of 8 to 18 m prominent groove of glands and white hairs are present on the stem and branches. Bluish purple flowers bloom from March to May and fruits on August to February and it is reported that one tree gives three muri fruits. The fruit of *amla* is round deeply ribbed, pale green and highly acidic and attractive.

The fruit is nearly stalkless and smooth divided into six lobes through pale linear grooves. The surface is shiny, quite hard with a thin and translucent skin. The hexagonal stone containing six small seeds embedded tightly in the flesh (Arora *et al.*, 2007). Fruit is minute, ovate, oblong, glabrous, rounded about 4 mm long, 2-3 mm broad; pericarp attached to seeds. Taste is bitter, acrid and unpleasant. Seeds are kidney shaped. 2-4 mm long, 2-3 mm broad, smooth exalbuminous with straw colored hard testa. A deciduous tree, small to medium in size, the average height being 5.5 meters; its bark is usually light brown to black, coming off in thin strips or flakes, exposing the fresh surface of a different color underneath the older bark; the average girth of the main stem is 70 cm; in most cases, the main trunk is divided into 2 to 7 scaffolds very near the base. Leaves, 10 to 13 mm long, 3 mm wide, closely set in pinnate fashion, making the branches feathery in general appearance. The leaves develop after the fruit-set (Zhang *et al.*, 2003).

2.3 Biochemical and nutritional composition of *amla*

2.3.1 Chemical composition

The fruit juice is reported to contain nearly 20 times as much Vitamin C as orange juice. Every 100 g edible fruit provides 470-680 mg of Vitamin C. Fruit contains moisture, protein, fat, minerals, fibers and carbohydrate. Its mineral and vitamin contents include calcium, phosphorous, iron carotene, carbohydrate, thiamine, riboflavin besides Vitamin C. A recent study on *amla* attributes its strong antioxidant properties to its small molecular weight tannoid complexes (Desouky *et al.*, 2000).

Detailed chemical composition of edible parts of *amla* is given in the Table 2.1, 2.2 and 2.3.

Table 2.1 Chemical composition of *amla*

Parameters	(Gopalan *et al.*, 1993)	(Shah, 1978)	(Bajpai and Shukla, 1998)	(Bhartakur and Arnold, 1990)
Moisture (%)	81.8	79.76	81.2	79.8
Protein (%)	0.5	0.46	0.5	0.69
Fat (%)	0.1	0.15	0.1	0.62
Ash (%)	0.5	0.63	0.7	-
Fiber (%)	3.4	19	3.4	-
Carbohydrates (%)	13.7	-	14	-
Ascorbic acid(mg)	600	-	600	588.9

All the values are per 100 g edible portion.

Table 2.2 Minerals and trace elements of *amla*.

Parameters	(Gopalan *et al.*, 1993)	(Bhartakur and Arnold, 1990)
Calcium (mg)	50	27.6
Phosphorus (mg)	20	28.2
Iron (mg)	1.2	3.3
Sodium (mg)	5.0	4.2
Potassium (mg)	225	282
Magnesium (mg)	-	11.8
Sulphur (mg)	-	16.6
Manganese (mg)	-	1.1

All values are per 100 g edible portion.

Table 2.3 Vitamin content of *amla*.

Vitamins	Amount (Gopalan *et al.*, 1993)
Carotene (µg)	9
Thiamin (mg)	0.03
Riboflavin (mg)	0.01
Niacin (mg)	0.2
Vitamin C (mg)	600

All the values are per 100 g edible portion.

2.3.2 *Amla* as a rich source of ascorbic acid

Many authors (Bhartakur and Arnold, 1990; Gopalan *et al.*, 1993; Majupuria, 1978; Shah, 1978) have reported the content of ascorbic acid in *amla* which indicates *amla* as a rich source of ascorbic acid compared to other fruits and vegetables. The ascorbic acid content of *amla* is reported to be the highest among fruits and vegetables. Compared to edible portions, it has 20 times vitamin C of grape fruit and 15 times that of lemon (Nisha *et al.*, 2004). Consumption of only 10 g (one average size fruit) will meet the recommended daily allowances (RDA) of vitamin C. The ascorbic acid contents of small and large size fruits of *amla* found to be 412 and 900 mg per 100 g edible portion, respectively (Bhartakur and Arnold, 1990). The ascorbic acid contents of some of fruits and vegetables are given in Table 2.4.

Table 2.4 Ascorbic acid contents of some fruits and vegetables.

Fruits	Ascorbic acid	Vegetables	Ascorbic acid
Rich source		Amaranath leaves	173
Amla	700	Brussels sprouts	72
Guava	300	Cabbage	124
Good source		Coriander leaves	135
Orange	68	Drumstick leaves	220
Pineapple	63	Ipomoea leaves	137
Mango(ripe)	24	Spinach leaves	48
Tomato (ripe)	32	Radish leaves	65
Fair source			
Apple	2-8		
Banana	2-6		
Grapes	2-6		

All values are mg per 100 g of edible portion Source: Swaminathan (1997)

2.4 Varieties of *amla*

The different varieties of *amla* which are categorized on the basis of color are given as (Singh, 2003):

1. ***Green tinged:*** fairly large, nearly green in color, best for pickles and *murabba*.
2. ***Red tinged:*** medium size fruit having white streaks.
3. ***Hathiful:*** commercial variety found in U.P fairly large tree, fruit size good, with shining, conspicuous glands.
4. ***Chakaiya:*** fruits are small, fibrous and flattened in appearance.
5. ***Banarasi:*** fairly large in size, shining, thin skinned, and transparent and of yellowish color, best used for preserves.

2.5 Uses of *amla*

2.5.1 Food use

Amla is used for making different products such as pickles and dry candy (salt and spiced titaura) in Nepal as well as preserve which is popular in Nepal and India. *Murabba* is preserved by boiling the fresh fruit and keeping it in concentrated boiled sugar solution. Also different *amla* jam, sauces can be prepared from *amla*. It is useful during summer and provides cool to the consumer (Bhattacharya *et al.*, 2003).

2.5.2 Therapeutic use

It has been traditionally used in the Ayurvedic system of medicine since the time immemorial. Dried *amla* is one of the constituents of "*trifala*", a renowned Ayurvedic medicine. The tender shoots with butter and milk are equally useful for indigestion and diarrhea. Green fresh leaves with curd or sour milk are equally useful for indigestion and diarrhea. Milky juice of the plant is used as a dressing for fresh ark mixed with honey and turmeric is a remedy for gonorrhea. The bark of stem is also useful in diarrhea. Fermented preparation from the root is prescribed in jaundice, dyspepsia and cough (Dasaroju and Gottumukkala, 2014).

The fresh fruit is refrigerant, tonic, antiscorbutic, diuretic and laxative. A Sherbet or sweet juice prepared from the juice is regarded to be antibilious, diuretic and cooling, fevers, hiccups, vomiting, indigestion, chronic, constipation and other complaints of indigestion. The juice of fruit with clarified butter is prescribed as a restorative tonic. A mixture of fresh fruit juice and sugar is useful for relieving itching or burning sensation of trachea. Infusion prepared by keeping dried fruit overnight in water in an earthen vessel is effective as an Eye wash in ophthalmia (Krishnaveni and Mirunalini, 2011). *Amla* preserve has a beneficial effect in reducing cholesterol content of blood (Kapoor, 2008).

2.5.3 Uses of seed

The seed of *amla* too has some benefits. Infusion of seed is recommended as a drink in fever and diabetes; seeds are also used as a remedy for bilious infections and nausea. An

ointment prepared by burning seeds with oil is prescribed for scabies and itch. The root leafs; bark and fruit are also for the cure of snake bite (Khan, 2009).

2.5.4 Pharmacological use of *amla*

The pharmacological properties of the *amla* are numerous. Not only is it a wonderful antioxidant, but it has proven anti-fungal, anti-bacterial, anti-viral, anti-mutagenic, yeast inhibiting, anti-inflammatory, hypolipidemic, and hypotensive relieving properties, it also acts as an antacid and anti-tumorganic agent. In addition, it increases protein synthesis and is thus useful in cases of hypoglycemia. Vitamin C in *amla* is powerful as it is a complex of ascorbate, tannins and polyphenols (Kapoor, 2008).

The antioxidant properties of *amla* extracts and their effects on the oxidative stress in streptozoticin-induced diabetes were examined in rats. *Amla* also showed strong inhibition of the production of advance glysosylated end products. The oral administration of *amla* extracts to the diabetic rats slightly improved body weight gain and also significantly alleviated various oxidative stress indices of the serum of the diabetic rats (Ghosal *et al.*, 2002). The elevated serum levels of 5-hydroxymehtylfurfural, which is a glycosylated protein that is an indicator of oxidative stress, were significantly reduced dose-dependently in the diabetic rats fed *amla* (Ghosal *et al.*, 2002).

2.5.5 Medicinal uses of *amla*

Amla or *Emblica Officinalis* is a natural, efficacious, an antioxidant with the richest natural source of Vitamin C. The fruit contains the highest amount of Vitamin C in natural form and cytokine like substances identified as zeatin, z. riboside, and z. nucleotide. Its fruit is acrid, cooling, refrigerant, diuretic and laxative. The dried fruit is useful in hemorrhage, diarrhea and dysentery. It is anti-bacterial and its astringent properties prevent infection and help in the healing of ulcers. It is used as a laxative to relieve constipation in piles. *Amla* protects cells against free radical damage and provides antioxidant protection (Krishnaveni and Mirunalini, 2010). Other novel functions are as follows:

(a) Fortifies the liver: *Amla* helps purify the *Rasa Dhatu* (nutrient fluid) and *Rakta Dhatu* (blood), thus supporting the functions of the liver. It also strengthens the

liver, helping it in eliminating toxins from the body. Research shows that *amla* helps lower cholesterol (Grover *et al.*, 2010).

(b) ***Amla*** **balances stomach acids:** Because it improves digestion but does not heat the body. *Amla*-Berry is ideal for calming mild to moderate hyperacidity and other gull bladder related digestive problems. It should always be taken with food in such case (Grover *et al.*, 2010).

(c) Nourishes the brain and mental functioning: *Amla*-Berry is good for the brain. It is nutritious- nurturing for the mind and enhancing coordination among memory, recall and retention. It helps sharpen the intellect and mental functioning. It supports the nervous system and strengthens the senses (Grover *et al.*, 2010).

(d) Supports the heart: It is *hridya*, which means it nurtures the heart, blood and circulation. It supports the cardiovascular system. On the other hand, it sometimes acts as a cardiac stimulant. For this reason, if you have a heart problem, you should check with a medical doctor before using *amla*-berry tablets (Thakur *et al.*, 2002).

(e) Strengthens the lungs: *Amla*-Berry is a wonderful tonic for strengthening and nourishing the lungs and the entire respiratory tract. It also helps to maintain moisture balance in the lungs (Nadkarni, 2007).

(f) Helps the urinary system: Since, it enhances all the digestive fibers, *amla*-berry is especially supportive to the urinary system and can be helpful in a mild burning sensation while urinating. It supports natural diuretic action, but does not force water from the body like diuretic pills. In other words, it helps eliminate waste form the body but does not over–stimulate the urinary system (Grover *et al.*, 2010).

(g) Good for the skin: Because *Amla*-Berry strengthens digestion, helps the live detoxify and is rich in Vitamin C and other minerals, it is very good for the complexion. *Amla* Berry moisturizes the skin, cleanses the tissues of toxins, and supports immunity of the skin against bacterial infection (Thakur *et al.*, 2002).

(h) Promotes healthier hair: *Amla*-Berry boosts absorption of calcium, thus creating healthier bones, teeth, nails and hair. It also helps maintain youthful hair color and retards premature graying, and supports the strength of the hair follicles, so there is less thinning with age (Thakur *et al.*, 2002).

(i) **Flushes out toxins:** Individual who has been eating "junk" food for a while tends to have accumulated deposits of preservatives and additive in the liver. *Amla*-Berry helps support the liver in flushing out chemical and additives from the physiology (Ghosal *et al.*, 2001).

(j) **Increases vitality:** Because it has five tastes, helps in many body functions and cleanses the blood and the micro-channels of the body, *amla*-berry increases energy and removes fatigue. It supports regeneration of cells-the process by which tired old cells are replaced by vital, new ones (Ghosal *et al.*, 2001).

(k) **Improves muscle tone:** *Amla*-Berry enhances protein synthesis, which is why it is good for strengthening muscles and building lean muscle mass. Its unique *Ayurvedic* action offers athletes and body-builders a natural way to tone muscles and build lean mass (Ghosal *et al.*, 2001).

(l) **Acts as an antioxidant:** *Amla*-berry tablets and other chemicals that contain *amla* are effective broad-spectrum antioxidants and free radical scavengers, helping to reduce disease and slow the aging process (Ghosal *et al.*, 2001).

(m) **Enhances immunity:** All of the benefits already mentioned make *amla*-berry a strong immunity booster. Polyphenols have been shown to have numerous health protective benefits, including lowering blood lipids and blood sugar, enhancing blood circulation, and blocking the actions of carcinogens, which together contribute to the anti-ageing effect (Suman, 2009).

(n) **Regulates elimination:** *Amla*-Berry tablets helps with the downward flow of energy in the body. They keep the function of elimination regular and ease constipation (Ghosal *et al.*, 2001).

2.6 *Amla* products

Different products can be made from *amla* in earlier time it was consumed as suds and lately following the development it was started being consumed as *amla* pickle, *amla* candy, indigenous *titaura* and *amla* sauce, *amla* squash. Recipe of some *amla* products developed by some experts have been given below.

2.6.1 Jam

Amla fruit pulp (50%) is taken and 67% sugar is added. Herbs like 5% asparagus and 2% ashwagandha extract will increase its medicinal properties. The mixture is cooked and citric acid is added (acidity 1.2%). After judging the end point (68° Brix), it is filled into clean sterilized glass jars, upon setting of jam, lids and jars are closed ensuring an air tight seal. Highly acceptable even after the storage period of more than 9 months (Ranote, 2006).

2.6.2 Sauce

Five kg of sauce containing 50% *amla* pulp and 50% tomato pulp with 75 g sugar, 10 g salt, 60 g onion, 6 g garlic, 12 g ginger, 5 red chilies, and 12 g hot spices was prepared. Acetic acid and sodium benzoate as preservatives were added at the rate of 1ml and 0.3 g/kg of final product, respectively. Finally the sauce was filled in glass bottles and crown corked followed by processing in boiling water for 30 minutes and air-cooled. The product was highly acceptable (Ranote, 2006).

2.6.3 Pickle

Amla pickles are also widely consumed and prepared with the intention of commercialization and household purposes. Pakistanis *amla* pickles are known to have good quality and acceptance in the international trade. *Amla* pickles are prepared. *Amla* is pretreated first in water to soften its tissues and it is worked with spices which is ultimately sun dried to obtain good quality of product (Ranote, 2006).

2.6.4 *Amla* candy

Amla candy is prepared by the process given by (Siddappa *et al.*, 1986). The fruits were dipped on 30° Bx sugar syrup. The Bx was then raised by 10° Bx per day up to 60° Bx and then by 5° Bx per 2days up to 75° Bx. 0.15% of citric acid was added on the basis of sugar syrup initially and then on sugar (which added in each step) to add inversion process. At 75° Bx it was left for 1 week to be equilibrium. The fruit is drained from the syrup and then dried placing at trays using electric cabinet drying 66°C for 9 hrs.

2.6.5 *Amla* juice

Amla fruits are preserved either in water or salt solution for a couple of weeks for the commercial preparation of products. Ina the quality of *amla* juice prepared from fruits steep preserved in water for 30 days was assessed during storage up to 9 months under ambient conditions. The juice was prepared from fruits withdrawn of steeping preservation in water, pasteurized at 90°C and preserved with 500 ppm SO_2 in glass bottles under ambient conditions (Jain and Khurdia, 2002).

2.6.6 *Amla* squash

(Srivastava and Kumar, 2007) standardized the recipe for preparation of herbal squash. Five different recipes with or without asparagus juice and ginger juice were developed. Asparagus and ginger juice were mixed with *amla* pulp and the remaining procedure is as such followed for simple squash. A recipe containing 25% *amla* pulp, 5% asparagus extract and 2% ginger juice with 50% TSS and 1.2% acidity is found most ideal for preparation of herbal squash.

2.7 Vitamin C

Vitamin-C is a white crystalline compound, relatively simple structure and closely related to the monosaccharide sugars, with sour taste but no smell its empirical formula is $C_6H_5O_6$ and molecular weight is 176. Vitamin C was given the name ascorbic acid by its discoverer (Mottram, 1974).

2.7.1 Chemistry of vitamin C

Ascorbic acid is highly soluble compound that has both acidic and strong reducing properties. It is the most unstable of all known vitamins. In solution it easily gets oxidized, especially on exposure to heat. Oxidation is accelerated in the presence of copper and alkaline pH.

On mild oxidation ascorbic acid is converted into dehydroascorbic acid. The oxidized form may be reduced back to ascorbic acid. Both ascorbic acid and dehydroascorbic acid have the vitamin C activity. When dehydroascorbic acid is treated with weak acid it is

converted into diketogulonic acid (DKG) with no vitamin C activity, it cannot be reduced to dehydroascorbic acid again (Manaya and Shadaksharaswamy, 2008).

2.7.1.1 Physicochemical properties of ascorbic acid

1. Ascorbic acid is very stable when dry, moderately stable in acid solution but unstable in alkali (Levine and Welch, 2009).
2. Vitamin C is a comparatively strong acid, a half percent solution of ascorbic acid in water has a pH of about 3 and its acidic property is caused by the presence of enediol group. It behaves as a monobasic acid and give salt when reacted upon with alkalis (Ginter *et al.*, 2003).
3. Ascorbic acid is precipitated by lead ion at pH 7.6 (Levine and Welch, 2009).
4. Ascorbic acid is rapidly lost due to oxidation by exposure to air at relative humidity. The oxidation is speeded up by heat and prevented during cold storage (Rajlakshmi, 2000).
5. The oxidation of Ascorbic acid is accelerated by heat, light alkalis, oxidative enaymes and traces of Cu and Fe (Sebrell and Harris, 2001).
6. Vitamin C is the least stable among other Vitamins and is most easily oxidized to form dehydroascorbic acid (Sebrell and Harris, 2001).

2.7.2 Function of ascorbic acid on the body

2.7.2.1 Biochemical function

- The principal function of ascorbic acid is the formation of collagenous intercellular substances. Ascorbic acid is essential for hydroxylation of two amino acids, proline and lysine to hydroxyproline and hydroxylysine which are important constituents of collagen. This helps in wound healing and increases the ability to withstand the stress of injury or infection (Ashwell *et al.*, 2001).
- For other hydroxylation reaction to the formation of corticosterone and 17 hydroxycorticosterone from deoxy-corticosterone, and for the conversion of tryptophan to 5 hydroxytryptophan (Buettner, 2003).

- For cell respiration and function of enzymes; it includes oxidation of phenylalanine to tyrosine, reduction of ferric iron to ferrous iron in the gastrointestinal track so that iron is more readily absorbed (Ashwell *et al.*, 2001).
- For synthesis of steroid hormones and decrease the cholesterol level (Haworth and Hirst, 2002).

2.7.2.2 Physiological function

For tissue oxidation as ascorbic acid identified as a reducing agent in living tissue, its function is in tissue oxidation though without much success, the oxidized form of vitamin i.e. dehydroascorbic acid can act as a hydrogen acceptor in the oxidation of phenolic amino acids, phenylalanine and tyrosine. Probably the ascorbic acid plays in the metabolism of active tissues which maintain the vitamin in the reduced state in living cells (Levin, 2008). Adrenal cortex function: Firstly (Ginter *et al.*, 2003) observed that ascorbic acid has a particular association with adrenal cortical hormones is of interest because both are concerned with the integrity of connective tissue (Levin, 2008). Blood formation: It is suggested that ascorbic acid is concerned with the formation of red blood corpuscles hemolytic state develop in scurvy and is responsible for the anemia (Levin, 2008).

2.7.3 Effect of deficiency

The deficiency of ascorbic acid results in the defective formation of the intercellular cement substances. Fleeting joints pains, irritability, retardation of growth in the child, anemia, shortness of breath, poor wound healing, and increased susceptibility to infection are among the signs of deficiency. Scurvy is the deficiency disease resulting from the lack of ascorbic acid in the diet (Levine *et al.*, 2002).

2.7.4 Side effect from over dosage

The reported side effects based on biochemical theory are gastro-intestinal disturbance, increase peristalsis, abdominal colic, gastro-enteritis and anal irritation, looseness of bowels, occasional diarrhea, abnormal uric acid metabolism, production of gout, oxaluria, and stone formation, bone demineralization and increased collagen catabolism, calcium resorption, allergic symptoms, occasional urticaria and erythema, transient urticaria,

haemolytic crisis, human infertility. These effects were observed taking daily dose in the range between 200 mg to 300 mg (Harper, 2000).

2.7.5 Recommended daily allowances of ascorbic acid

The recommended human dietary intake of vitamin C varies from 30 mg in the UK to 125 mg in the USSR (Harper, 2000).The recommended daily allowances purposed by food and nutrition board national academy of science, the nutrition expert group of the ICMR, India, FAO and DHSS report are given Table 2.5.

Table 2.5 Recommended daily allowances of ascorbic acid.

SOURCE/SUBJECT	FAO (1970)
Infants	20mg
Children	20mg
Males	30mg
Females	50mg
Pregnancy	50mg
Lactation	50mg

2.7.6 Occurrence of ascorbic acid on body

The normal human body when fully saturated contains about 5 g of vitamin of which perhaps 30 mg are in the adrenal glands, 200 mg in the extra cellular fluids and rest distributed in varying concentration throughout the cells of the body. Blood contains about 1 mg/100ml ascorbic acid (Levin, 2008).

2.7.7 Metabolism of ascorbic acid on body

In normal circumstances, the vitamin C is absorbed from the alimentary canal and passes into the plasma. It is absorbed by the leucocytes by active and passive mechanism where it is stored provided that tissues demands have been satisfied and vitamin utilization is stable. Absorption is impaired during the latter stages of vitamin C, deficiency possibly in consequence of damage to the lining membrane of the alimentary canal or as a result of pituitary disfunction (Ashwell *et al.*, 2001).

2.7.8 Synthesis and biosynthesis of ascorbic acid

Ascorbic acid is synthesized from glucose and other simple sugars by plants and by most animals species (Haworth and Hirst, 2002). But man, monkeys, guinea pigs, Indian fruit bat, the red vented bulbul bird and fish are unable to synthesize this vitamin (Seib and Tolbert, 2005). Ascorbic acid is not present in microorganisms nor does it seem to be required (Ginter *et al.*, 2003). Glucose and galactose are involved in the biosynthesis of ascorbic acid (Levine and Welch, 2009).

2.7.9 Therapeutic use of ascorbic acid

Ascorbic acid has specific effect in the treatment of scurvy. Even small doses (e.g. 10 mg/day) not only prevent scurvy but cure the clinical features of ascorbic acid deficiency by Sheffield experiment. Ascorbic acid corrects the hyper tyrosinaemia that sometimes occurs in new infants, especially the premature and acts as a reducing agent in correction the rare condition methaemoglobinaemia (Levin, 2008).

2.7.10 Industrial applications

Due to its multifunctional ability, ascorbic acid has been used by food processors in the following ways (Woods, 2001) as:

a. A vitamin
b. An acid
c. An curing aid
d. An antioxidant
e. Oxygen scavenger
f. A color stabilizer
g. A bread improver
h. A clarity improver in beer

The main fields of applications are as now follows (Klaui *et al.*, 2000)

a) Soft drinks: Especially beverages based on citrus fruits, where vitamin C functions as an antioxidant for the flavors as well as a nutrient.
b) Meat and meat containing products: In meat curing and pickling.
c) Flour/Bread: For improving the baking quality.
d) Beer: As a stabilizer.
e) Frozen fruits: As an antioxidant.

2.7.11 Losses of vitamin C

(a) Pre harvest factor: Variations in the vitamin content of raw material can affect the content of vitamins in the final food products to a considerable extent. Raw food may vary widely in the vitamin content because of climatic and soil condition, genetic variation and maturity at the time of harvest (Harris, 2008).

(b) Oxidation of ascorbic acid: Vitamin C may be oxidized both by air and by enzymes (Wills *et al.*, 2003). Enzymes containing copper or iron in their prosthetic groups are most efficient catalysts of ascorbic acid decomposition. The most important enzymes of this group are ascorbic acid oxidase, phenolase, cytochrome oxidase and peroxidase. Among them only ascorbic acid oxidase involves a direct reaction between enzymes, substrate and molecular oxygen. The other enzymes oxidize the vitamin indirectly. Phenolases catalyses the oxidation of mono and dihydroxy phenols to quinines and this reacts directly with ascorbic acid (Welch *et al.*, 2007). Cytochrome oxidase oxidizes cytochromes to the oxidized form and this react with L-ascorbic acid. Peroxidase in combination with phenolic compounds utilizes H_2O_2, to bring out oxidation (Wills *et al.*, 2003). The enzymes do not act in intact fruits because of the physical separation of enzymes from the substrates. When the fruit is damaged or cellular fragments occurred, reductase is more liable and therefore oxidases are free to react with ascorbic acid. The route and rate of oxidation is influenced by several factors, including pH, trace metals, enzymes, oxidation reduction potential, presence of oxygen as well as time and temperature (Stevens, 2008).

(c) Leaching of ascorbic acid: When fruits and vegetables are cooked, a large part of vitamin C can be washed out into the cooking water. Leaching in the prime cause of vitamin C loss when undamaged peels are blanched at 97°C (Ponne *et al.*, 2005).

(d) Drying or dehydration: Ascorbic acid is the most difficult of the vitamins to preserve during the dehydration of food; it is generally considered that the presence of vitamin C in processed food is highly correlated with overall quality of food products (Nagy, 2007).

(e) Anaerobic destruction: Anaerobic destruction of ascorbic acid following oxidative changes is also significance. The rate of this reaction is virtually independent of pH except in the range 3-4 where it is slightly increased. Accelerators of this reaction are fructose, Fructose 6-phosphate, fructose, 1,6diphosphate, sucrose and caramelized fructose. Furfural and carbon dioxide are appeared to be the major end products of decomposition (Welch *et al.*, 2007).

(f) Non enzymatic changes: Non enzymatic changes which are of the catalytic effects of Cu. which are enhanced by iron, resulting in the formation of dehydro ascorbic acid and hydrogen peroxide. The H_2O_2 produced in this reaction further changes and gives O_2 and water (Welch *et al.*, 2007).

(g) Loss during storage: The destruction rate of ascorbic acid during storage is affected by moisture content, enzyme, temperature and time. Significant losses begin to occur during storage and rate of loss is time and temperature dependent (Welch *et al.*, 2007).

2.7.12 Retention of vitamin C

1. Optimum harvest condition
2. Shortest possible processed time
3. Blanching
4. Construction and maintenance of equipment
5. Removing oxygen
6. Acidic condition
7. Uses of sulphites

8. Best storage condition
9. Packaging practices
10. Powder form of product
11. Quick freezing

2.8 Blanching

Heat treatment of food for a short period prior to canning, freezing and dehydration followed by cooling is called blanching. It is generally applied to fruit and vegetables, and primarily carried out to inactivate enzymes. Un-blanched frozen or dried foods undergo relatively rapid changes during storage, in food quality such as color, flavor, texture and nutritive value due to continuous enzymatic activity (Kharel, 2004). In plant tissues, enzymes such as lipoxygenase, polyphenoloxidase, polygalacturanase and chlorophyllase, cause loss of nutrition, flavor and texture. In addition, peroxidase and catalase are the two most heat resistant although they are not implicated as a cause of deterioration during storage, their activity is used to evaluate the effectiveness of blanching. If both of these enzymes are inactivated, then it can be safely assumed that other significant enzymes are also inactivated. Peroxidase is the more heat resistant of the two and the absence of residual peroxidase activity indicates that other less heat resistant enzymes are also destroyed (Kharel, 2004).

2.8.1 Effect on foods by blanching

The heat received by the food during blanching inevitably causes some changes to sensory and nutritional qualities. In, general, the time- temperature combination used for blanching is a compromise which ensures adequate inactivation but prevents excessive softening and loss of flavor in the food (Fellows, 2009). Foods are processed in various ways to lengthen the time they can be stored, e.g. by canning, freezing, drying, sterilization and irradiation, and ascorbic acid losses vary depending on the method used. Before canning or freezing, vegetables are exposed to boiling water or steam to inactivate enzymes that have a detrimental effect during storage. This is known as blanching. Blanching softens the tissues, pectic substances in cell wall and middle lamella. Loss of ascorbic acid due to

blanching is between 13–60%. Short exposure to high temperatures is less harmful than longer heating at lower temperatures. Blanching process involves heat and water, which are the key factors in loss of water-soluble nutrients and vitamins in foods and affect nutrient content in blanched foods as water-soluble vitamins and nutrients leach out and degrade in blanching water, and small pieces of vegetable lose more ascorbic acid than do large pieces (Rahman and Perera, 2000).

2.8.1.1 Effect on nutrients by blanching

Some minerals, water- soluble vitamins and other water-soluble components are lost during blanching. Losses of vitamins are mostly due to leaching, thermal destruction and, to a lesser extent, oxidation (Fellows, 2009). The extent of vitamin loss depends upon on a number of factors including:

- The maturity of food and variety
- Methods used in preparation of the food, particularly the extent of cutting, slicing or dicing
- The surface-area-to volume ratio of the pieces of food
- Method of blanching
- Time and temperature of blanching (lower vitamin losses at higher temperature for shorter times)
- Method of cooling

Blanching as a unit operation is a short time heating in water at temperatures of 100°C or below. In order to reduce losses of hydro soluble substances (mineral salts, vitamins, sugars, etc.) during water blanching, several methods have been developed (Heldman and Hartel, 1999):

1. Setting temperature at 85-95°C instead of 100° C
2. Adjusting blanching time, just sufficient to inactivate enzymes catalase and peroxidase.

2.8.1.2 Effect on color and flavor by blanching

Blanching brightens the color of some foods by removing air and dust on the surface and thus altering the wave length of reflected light. The green color of chlorophyll is protected by using alkaline blanching, although the increase in pH may increase losses of ascorbic acid. Blanching water is often added with sodium carbonate to neutralize the natural acidity of the products. When, correctly blanched, most foods have no significant changes to flavor or aroma, but under blanching can lead to the development of off- flavors during storage of dried or frozen foods (Fellows, 2009). Green tender peas when blanched with the use of blanching aids, 0.125% MgO and 0.1% $NaHCO_3$ retained maximum percentage of Chlorophyll (Muftugil, 2001).

2.8.1.3 Effect on texture by blanching

One of the purposes of blanching is to soften the texture of vegetables to facilitate filling into containers prior to canning. Calcium chloride (1-2%) is added to the blanched water to form insoluble calcium pectate complexes and thus to maintain firmness in the tissue (Fellows, 2009).

Blanching is essential where fruits and vegetables are to be frozen or dried because drying or freezing operations only slow down enzymatic action but do not completely stop it. If blanching is not done prior freezing or drying then the frozen or dried product, which is often held in frozen or dried state for many months, will slowly develop off flavors and off colors and also other kinds of enzymatic spoilage might result. Under blanching may cause more damage to food than the absence of blanching does. Heat, which is sufficient to disrupt tissue but not to inactivate enzymes, causes the mixing of enzymes and substrates. In addition, only some enzymes may be destroyed which causes increased activity of other enzymes and thus accelerates deterioration (Kharel, 2004).

2.9 Effect of different osmotic agents on fruits and vegetables

Lerici *et al.* (2002) reported that the addition of a small amount of NaCl (2% maximum on w/w basis) to different sucrose solutions during apple dehydration led to higher rates of water loss without significantly increasing the solids gain.

Mass transfer phenomena were investigated during osmotic dehydration of apple, banana and kiwi in glucose and sucrose osmotic solution. A complete set of experiments was performed for a wide range of temperature, sample size, speed of agitation, osmotic agent concentration and immersion time. The effect of solute molecular weight on mass transfer phenomena during osmotic treatment was evaluated.

Three mass transfer processes are established:

(1) Water diffusion from the food material to the surrounding osmotic medium due to the concentration gradient between them.
(2) Solute diffusion from the osmotic solution to the food, and
(3) Leaching of natural solutes from the food.

The difficulty with osmo-dehydration, however, is the inability to control leaching of soluble components and solute uptake as an overload of solutes adds on to the resistance to mass transfer from the inner to the outer surface of the product (Wang and Sastry, 2000).

2.10 Tannins

Tannins are astringent, bitter plant polyphenols that either bind and precipitate or shrink proteins. The astringency from the tannins is that which causes the dry and puckery feeling in the mouth following the consumption of red wine, strong tea, or an unripened fruit (McGee, 2004). The term tannin refers to the use of tannins in tanning animal hides into leather; however, the term is widely applied to any large polyphenolic compound containing sufficient hydroxyls and other suitable groups (such as carboxyls) to form strong complexes with proteins and other macromolecules. Tannins have molecular weights ranging from 500 to over 3000 (Bate-Smitch *et al.,* 1962). Tannins are found as shapeless yellowish or light brown masses like powder, flakes or sponge, tannins are found almost in all plants and in all climates all over the world. The name ‘tannin’ is derived from the French word ‘tanin’ (tanning substance) and is used for a range of natural polyphenols. Lower plants such as algae, fungi and mosses do not contain much tannin. The percentage of tannins present in the plants, however, varies. While they are present in significant proportions in some plants, many others have too little of them. Tannins are usually found in large quantities in the bark of trees where they act as a barrier for

microorganisms and protect the tree. Apart from tanning, tannins are also used in dyeing, photography, refining beer and wine as well as an astringent in medicines (Nonaka *et al.*, 2001). Significantly, tannins form a vital element of tea. While soluble, astringent materials are found in some plants like tea and coffee, tannins are supplemented to various processed foods, including ice-cream and caramel. They are used as refining materials to precipitate proteins in wines and beer. As tannins often lower the absorption of some materials into the body, tannins are also often known as anti-nutrients (Ashok and Upadhyaya, 2012).

2.11 Preserves

Fruit preserves are preparations of fruits, vegetables and sugar, often canned or sealed for long term storage. The preparation of fruit preserves today often involves adding commercial or natural pectin as a gelling agent, although sugar or honey may be used, as well. Before World War II, fruit preserve recipes did not include pectin, and many artisan jams today are made without pectin. The ingredients used and how they are prepared determine the type of preserves; jams; jellies and marmalades are all examples of different styles of fruit preserves that vary based upon the fruit used (Lal *et al.*, 1998).

Many varieties of fruit preserves are made globally, including sweet fruit preserves, such as strawberry, as well as savoury preserves of culinary vegetables, such as tomatoes or squash. In American English, the plural form preserves is used to describe all types of jams, with the singular preserve being applied to high fruit content jam, often for marketing purposes. Additionally, the name of the type of fruit preserves will also vary depending on the regional variant of English being use. *Amla* preserve is an extremely popular traditional product, which is also known as *amla murabba* in India. *Amla* preserve has the beneficial effect of purifying blood. This also helps in reducing the cholesterol levels in blood and in improving eyesight (Rakesh *et al.*, 2004).

A preserve is made from properly matured fruit by cooking it whole or in the form of large pieces in heavy sugar syrup, till it becomes tender and transparent. Freshly made preserves are wholesome and have an attractive appearance. Preserves made from frozen

fruits are generally superior in color and flavor to those made from fresh fruits stored at ordinary room temperature (Lal *et al.*, 1998).

2.11.1 Some fruit preserves

2.11.1.1 Apple preserve

Although varieties of apple are available, only two types, namely the sweet and the sour ones are important in the preparation of apple preserve. Peel the apples thinly, but do not remove the stem and core. Prick the peeled fruits. Place the sweet variety of apple in 2-3% common salt solution and sour variety in plain water to prevent browning. Next transfer them to dilute lime water and leave for 24 hours. Prepare 2-3% alum solution and bring it to boiling pan. Now transfer apples to boiling pan. Add a small quantity of sodium bisulphate to whiten color. Now, take sugar equal to half the weight of fruit in cooking pan. Warm the mixture to dissolve the sugar, skimming off skims in the process. Cook the syrup to a temperature of about 104˚C. Repeat this once again and raise strength of syrup to 70°Bx. The preserve is now ready (Lal *et al.*, 1998).

2.11.1.2 Bael (*Aegle marmelos*) preserve

The Bael fruit is very hard to cut and peel. The usual procedure is to make a slit at the bottom end of the fruit with a strong knife, insert the pointed end of the knife under the rind and remove the rind pieces. Slice the peeled fruits crosswise into slices 2.2 cm thick and wash with water. Prick them and steep pieces overnight in cold water. Blanch in boiling water, containing a suitable edible red color, until they become soft and absorb sufficient color. Now, take sugar equal to half the weight of fruit in cooking pan. Warm the mixture to dissolve the sugar, skimming off skims in the process. Cook the syrup to a temperature of about 104°C. Repeat this once again and raise strength of syrup to 70°Bx. The preserve is now ready (Lal *et al.*, 1998). Bael preserve is a highly important medicinal and therapeutic material in the indigenous systems of medicine (Lal *et al.*, 1998).

2.11.1.3 Ber (*Zizyphus jujube*) preserve

Wash Bers of large size and prick with wooden needles or forks. Place pricked fruits in 2% common salt solution and raise strength daily up to 8% containing 0.2% potassium

metabisulphite, and allow the mass stand for 1-3 months for curing. After this follow the syrup treatment process as same in apple preserve procedure (Lal *et al.*, 1998).

2.11.1.4 Carrot preserve

Take young and tender carrots having soft pith. Scrape off the thin peel. Prick peeled carrots and cut them into pieces of suitable size. Boil the pieces in water until they become soft. Use them for the preparation of carrot preserve following the procedure recommended for apples (Lal *et al.*, 1998).

2.11.2 General process of preparation of preserve

The brining and picking of fruits and vegetables have been practiced from ancient ages and it is remarkable that all these have the same principle of preservation. Preserved fruits also belong to a family of processed food. The Intermediate Moisture Food (IMF) after the innovation of scientific technology in the latter half of 20th century, modern methods were adopted. Jam, Jellies, (candied, crystallized, glazed fruits) all belong to this group. There are several methods of preparation of preserved fruits. Some use the short term process by boiling fruit pieces in a sugar solution to forces more sugar within the product while others gradually increase the sugar concentration by frequently dipping the product in progressively concentrated sugar syrup until the desired Brix is achieved (Goel, 2004). According to (Lal *et al.*, 1998), there are three methods of cooking the fruit in syrup:

2.11.2.1 Open kettle one period process

In this process the fruits are cooked in a low sugar with gentle heating till the syrup becomes sufficiently thick. The final concentration of sugar should not be less than 68°Brix, which corresponds to a boiling point of 106°C at sea level. The main drawback of this simple and cheap process is that the flavor and color of the product suffer considerably during boiling (Lal *et al.*, 1998).

2.11.2.2 Open kettle slow process

The fruit is cooked in water until it becomes tender. Then it is cooked in the sugar syrup of 35°Brix and gradually increased the syrup to 70°Brix by heating and allowing standing for

many days so that the fruit pieces could gradually absorb the sugar without shrinkage. Although it is tedious and time consuming process the flavor, color and texture in the product is high (Lal *et al.*, 1998).

2.11.2.3 Vacuum process

In this process the fruit is initially softened by boiling and then placed in the syrup, which should be 30-40°Brix. The boiling is done under reduced pressure. Hard fruits require slow boiling to facilitate penetration of sugar. If fruits are cooked in heavy syrup straight away, its juice will be drawn out rapidly due to osmosis with the result that it could shrink and there would consequently be very absorption of sugar subsequently. The process must not be hurried through because otherwise the fruit shrivel and sweat and become unfit for glazing and crystallizing (Lal *et al.*, 1998).

2.11.3 Preserve as intermediate moisture food (IMF)

The Intermediate Moisture Foods (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. In 1980s, the committee for IMF of France's National Center 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, nor freezing or refrigeration, but by an adequate adjustment of their formulation: composition, pH, additives and mainly a_w (activity of water) which must be approximately between 0.65 and 0.90 measured at 250C. Generally, they contain moderate levels of moisture of the order of 20 to 50 per cent. The IMF foods have an acceptable eating quality and reasonable storage stability under ambient conditions (Vora *et al.*, 2003).

The condition of IMF is accomplished by drying, salting, addition of sugar, or combination of these processes. The traditional foods have moisture contents between 10 and 40%. Most IMF foods formulated in the past have aw lying in the range of 0.80-0.86 and this a_w is considered safe enough to eliminate the growth of pathogenic microorganisms. The corresponding moisture content varies from 20 to 60% by weight

(Kharel and Hashinaga, 2004). According to (Iman *et al.*, 2011) IMFs have between a_w 0.6 and 0.90. IMF are among the oldest preserved foods based on lowering the water activity through the addition of humectants with the addition of mycostatic and bacteriostatic agents such that the addition of additional chemicals improve the microbial stability and increase the organoleptic properties (Kharel and Hashinaga, 2004). IMFs have recently been developed along the following technological principles:

1. Lowering of water activity by addition of polyhydric alcohols, sugar and or salts.
2. Retardation of microbial growth by addition of antimicrobial and primarily antimycotic agents such as propylene glycol or ascorbic acid.
3. Improvement of organoleptic properties such as texture and flavor through physical and chemical treatments.

2.11.4 Advantages of IMF

(Cook, 2006) defined an IMF as "one that can be eaten as is without rehydration and yet is shelf-stable without refrigeration or thermal processing". The principle food deterioration processes, which must be brought under control in devising an IMF, are as follows:

1. Microbial: Lower water activity will control most bacteria, many molds and yeasts.
2. Oxidation: The a_w range of IMF is probably the optimum for lipid oxidation.
3. Browning (non-enzymatic): This is at maximum at the end of range of IMF.
   The properties, which make IMF desirable, have been widely discussed and include:

1. Microbial stability
2. Storage stability without provisions
3. Compact product
4. Can be eaten as without dehydration

This definition clearly indicates the advantages of IMF products over those prepared by processes such as thermal processing, freezing, dehydration and refrigeration. An IMF does not require refrigeration for the stability; can be eaten with no preparation; texture is close to that of their normal counterpart; are plastic and can be compressed into cohesive

bars for the maximum packaging and packing efficiency. Since an IMF does not support the growth of microorganisms its wholesomeness or safety is not directly dependent upon the integrity of its package. It has calorie value and relief from the problem of packaging breakage and subsequent food spoilage associated with airdrops and other conditions of rough handling (Jayaraman, 2002).

2.11.5 Microbial stability and spoilage

The microbiological stability of IMF due to reduced water activity results from an interruption of vital processes essential of microbial growth or spore germination which is mediated by depressed availability on activity of water in food (Torres and Karel, 2007). At lower a_w the growth, which occurs at a_w above 0.99, the growth rate is reduced, spore germination is delayed, and the log phase is lengthened. The effect of a_w on microbial growth is also influenced by other factors affecting growth, such as temperature, nutrients, and other components of the medium, pH and oxygen supply (Danilo, 2004). It can be seen from the literature that yeasts and molds are the principal types of spoilage microorganisms, which can grow at the a_w of IMF. Besides these, halophilic bacteria will grow at a_w as low as 0.75. A maximum a_w of 0.90 is permissible if the pH of the food is below 5.0 (Torres and Karel, 2007).

2.12 Ingredients of preserve

Fruits and sugars are the main raw materials required for making preserve (Lal *et al.*, 1998).

2.12.1 Fruits

Slightly unripe fruits should be taken because fully ripe and overripe fruits develop jam like consistency in the syruping process (Lal *et al.*, 1998). Variety and maturity are important as well as freedom from defects and bruises. To avoid excessive softening and to preserve the fresh aroma and flavor, heating and freezing are avoided (Tressler and Woodroof, 2001). The most suitable fruits are those which possess pronounced flavor such as pineapple, peach, pear, peels of orange, lemon, grapefruit, cherry, and ginger etc (Lal *et al.*, 1998).

2.12.2 Sugars

2.12.2.1 Cane sugar or sucrose

The principle sweetener and crystal former for candy making is sucrose, the sugar from cane or beet. At room temperature about two parts of sucrose can be dissolved in one part of water giving a concentrated solution of approximately 67% (Potter and Norman, 2004). Cane sugar contains 99.8% sucrose and about 0.05% reducing sugar. It lowers the water activity, increases sweetness and also helps mask saltiness and bitterness. Another property is its ability to be hydrolyzed by acids or enzymes into its monosaccharide's, glucose and fructose according to the following equation:

$$C_{12}H_{22}O_{11} + H_2O \longrightarrow C_6H_{12}O_6 + C_6H_{12}O_6$$

(Sugar) (Water) (Glucose) (Glucose)

2.12.2.1.1 Solubility of sugar

In the preserve making process the concentration of the syrup has to be increased up to 70˚Brix. In this context, we should have to consider about the solubility of sugar. Solubility of sucrose at 20, 50, and 100°C are 67.1, 72.4 and 84.1% respectively. Hence increase in temperature, increases the solubility. The solubility of sucrose can also be increased by mixing invert sugar (Table 2.6 and Table 2.7). In preserving process, invert sugar is formed by inversion due to acid (either added or naturally present) and the specific TSS above the scope of sucrose can be met.

Table 2.6 Solid content of solution (% by weight) just standard with sucrose at 20°C.

Sucrose%	Invert sugar%	Solid content
100	-	67
78.6	21.4	70
68.6	32.4	72
57.6	42.4	74
48.8	51.4	70

Table 2.7 Solid content of solution (% by weight just saturated with invert sugar)

Sucrose %	Invert sugar %	Solid content%
47.5	52.5	76.1
40	60	73.6
30	70	70.5

Dextrose is less soluble than sucrose. Mixture of dextrose and sucrose has a greater total solubility than those of dextrose and sucrose alone, but individual solubility's are depressed. Solubility's of dextrose at 20, 30, and 40°C are 47.1, 51.2 and 61.8% respectively (Jackson, 2001).

2.12.2.2 Invert sugar

Dextrose and fructose are the components of invert sugar, which are produced from the hydrolysis of sucrose. It contains nearly equal proportions of two sugars (Budathoki, 2012). An important property of invert sugar is that it can prevent the degree of sucrose crystallization because addition of invert sugar increases the solubility of sucrose alone. Invert sugar may be obtained commercially as such and substituted for the part of the sucrose in the candy formula or it may formed directly from the sucrose during candy making by including a food acid such as citric acid and/or cream of tartar in the formula. The mixture of invert sugar and sucrose is sweeter than sucrose. Additional properties of invert sugar include hygroscopicity, which helps prevent more chewy candies from drying out and becoming overly brittle (Potter and Norman, 2004). Invert sugar not only limits the amount or sucrose crystallization but also encourages the formation of all small crystal essential to smoothness rather than grittiness in fondant creams, soft mint, and fudges (Tomotani and Vitolo, 2010).

2.12.2.3 Other sugars

Other sugars or sugar sources used in candy making include molasses, honey and maple sugar but these generally are used for their particular flavor properties rather than for special functional attributes.

2.13 Preservation of fruit preserves

The (a_w) water activity of food influences the multiplication and metabolic activity (including toxin production) of microorganisms, as also their survivals and resistance. In a_w range of IMF (0.90-0.60) some bacteria (*Pedicococcus, Streptococcus, Micrococcus, Lactobacillus),* yeasts (*Hansenula, Candida, Toruplosis, Saccharomyces, Hanseniaspora*), molds (*Cladosporium, Paecilomyces, Penicilium, Asperigillus*) may multiply. Most of these organisms cause spoilage; some produce toxins (*Penicillium, Asperigillus*). On the other hand, well-adapted strains of lactobacillus as well as selected molds might also be desirable in IMF as competitive microflora and thus be used as starter cultures. An inhibitor of microorganism in IMF cannot be solely dependent on a_w: it also depends on the pH, Eh, and temperature. Competitive micro flora and preservative might be of importance too. Where feasible the raw material should be heat processed. The preparation of IMF should be done under hygienic conditions and refrigeration to ensure a low initial count of aw tolerant organisms. If the palatability of the product permits, the law of IMF should be below 0.85 or the below 5.0, since either of these "hurdles" protects the product against staphylococcal enterotoxin production. If possible, IMF should be packaged in evacuated containers of pouches, which are impermeable to oxygen. The addition of toxicologically acceptable fungistatic substances in IMF will improve the stability of the product with respect to mold and yeasts. IMF shouldn't need refrigeration. However the shelf-life of these foods is prolonged if they are stored below room temperatures (Leistner, 1992).

2.14 Defects or spoilage in preserve

(Cordier, 2000), had stated bloom, microbiological and other spoilage problems in case of chocolate and confectionary. He stated bloom, especially fat bloom; and sugar bloom; microbiological spoilage or fermentation (By osmophilic yeasts zygosacharomyces, Torulopsis), rancidity (Oxidative and Hydrolytic), mould growth and graining or crystallization. According to (Lal *et al.*, 1998), there is likelihood of spoilage occurring due to fermentation especially in the initial stages of preparation of the preserves of candies under the concentration of sugar is low. If the preserves and crystallized fruits are stored under humid conditions, they throw off some of their sugar owing to absorption of moisture from the air.

2.15 Packaging of fruit preserve

Glass or plastic jars are an efficient method of storing and packaging. Though sugar can keep for exceedingly long times, containing it in a jar is far more useful than older methods. Other methods of packaging preserves, especially for industrially produced products, include cans and plastic packets, especially used in the food service industry for individual servings. Fruit preserves typically are of low water activity and can be stored at room temperature after opening, if used within a short period of time (Lopez *et al.*, 2004).

Part III

Materials and methods

3.1 Materials

3.1.1. Collection of *amla*

Fresh *amla* grown in Dhankuta district was purchased from Agriculture produce Market, Dharan. The fruit was brought from Hile, a hilly region north to Dharan. The collected samples were mature and fresh.

3.1.2 Sucrose

Pure, clean, white granular cane sugar was purchased from Dharan market.

3.1.3 Sodium chloride

Sodium chloride was brought from the local market of Dharan.

3.1.4 Citric acid

Citric acid was used for making candy by inversion process and also added at finishing stage for development of acidic taste, which was taken from college store.

3.2 Equipments

Electric balance, thermometer, hand refractometer, stainless steel knives, kettles, cooking arrangement, glassware's, hot air oven, pH meter, blotting paper, etc. needed for the work were all obtained from the college store.

3.3 Methods

3.3.1 Preparation of *amla*

3.3.1.1 Sorting/Grading

Damaged and bruised fruits were sorted out from undamaged fruits. Large and medium *amla* were selected.

3.3.1.2 Washing

The selected fruits were washed with tap water to remove dusts, adhered impurities, mud etc.

3.3.1.3 Pricking

The fruit was pricked with stainless steel knives.

3.3.2 Pretreatment process

Before going ahead with the actual preserving of *amla* a few works were done to optimize the pretreatment process of *amla* preserve. The pricked *amla* samples were divided into two part. One part is blanched and the next part is un-blanched. Then the both blanched and un-blanched *amla* were dipped in a 2% NaCl concentration separately for varying period of time. i.e. 6 h, 12 h, 18 h and 24 h respectively. These work were done with a view to minimize the losses of vitamin C during pretreatment as well as to remove the astringency of *amla* (Lal *et al.*, 1998). The various pretreatment used in present work are given in the table 3.1

Table 3.1 Pretreatment process of *amla*

Treatment code	NaCl concentration	Dipping time
A (Blanched)	2%	6 hours
B (Un-blanched)	2%	6 hours
C (Blanched)	2%	12 hours
D (Un-blanched)	2%	12 hours
E (Blanched)	2%	18 hours
F (Un-blanched)	2%	18 hours
G (Blanched)	2%	24 hours
H (Un-blanched)	2%	24 hours

3.3.3 Washing

After completion of different dipping time in 2% NaCl concentration, the *amla* samples were washed to remove the adhered salt. The *amla* were washed in tap water separately to remove adhered salt.

3.3.4 Pretreatment analysis

Vitamin C was analyzed in each steps. Such as in fresh condition, after blanching and after dipping in 2% NaCl concentration for various dipping time intervals. i.e. 6 h, 12 h, 18 h and 24 h respectively.

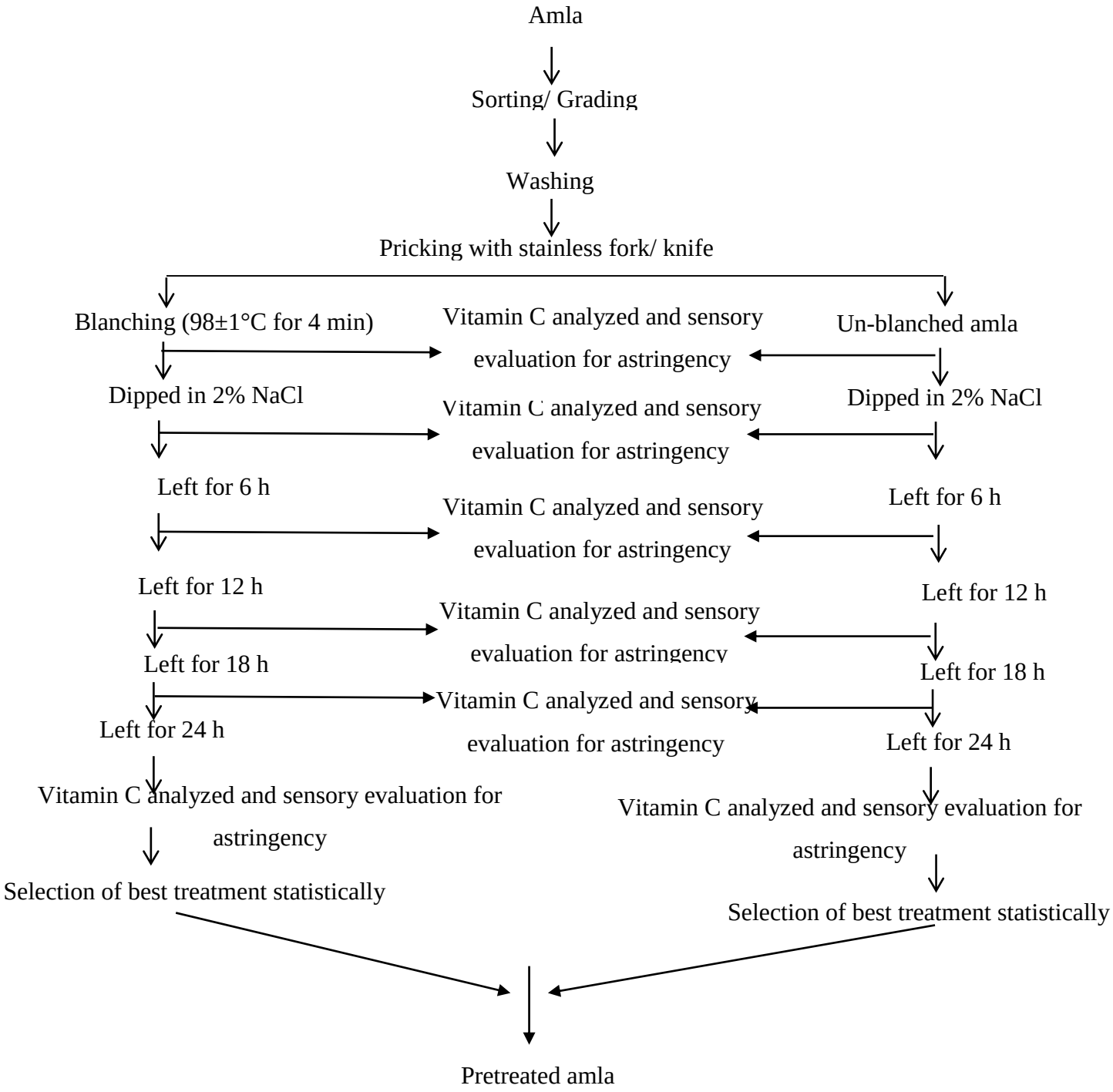

Fig 3.1 Flowchart for optimization of pretreatment process in *amla* preserve

3.4 Preparation of *amla* preserve

3.4.1 Preserve making

Preserve making process was followed as given by (Lal *et al.*, 1998). The pretreated *amla* were dipped in 50°Bx sugar syrup followed by boiling for 8 minutes and rest for 24 h. Next day °Bx was measured and dry sugar was added in syrup to raise the °Bx by 10°Bx per day and boiled for 8 minutes and rest for 24 h. In all the samples °Bx was raised by 10°Bx per day up to 60°Brix. 0.1% citric acid was also added on the basis of sugar amount. After each addition (sugar), the syrup was heated to dissolve the sugar. After reaching 60 °Bx, the strength of syrup was increased by 5°Bx in each day followed by boiling until the syrup strength reached to 75°Bx. When the TSS reached to 75°Bx the product was allowed to rest for 24 h. Vitamin C was analyzed every day for each samples. The TSS of the syrup was measures regularly. Increase of total sugar and reducing sugar was analyzed daily.

3.4.2 Packaging/ storage

After desired °brix achieved the *amla* preserve, the product was then packed in plastic bottles and closed tightly and stored at ambient temperature. The best treatment obtained from the sensory evaluation was the final product. A schematic flow diagram for the preparation of *amla* preserve is shown in Fig. 3.2

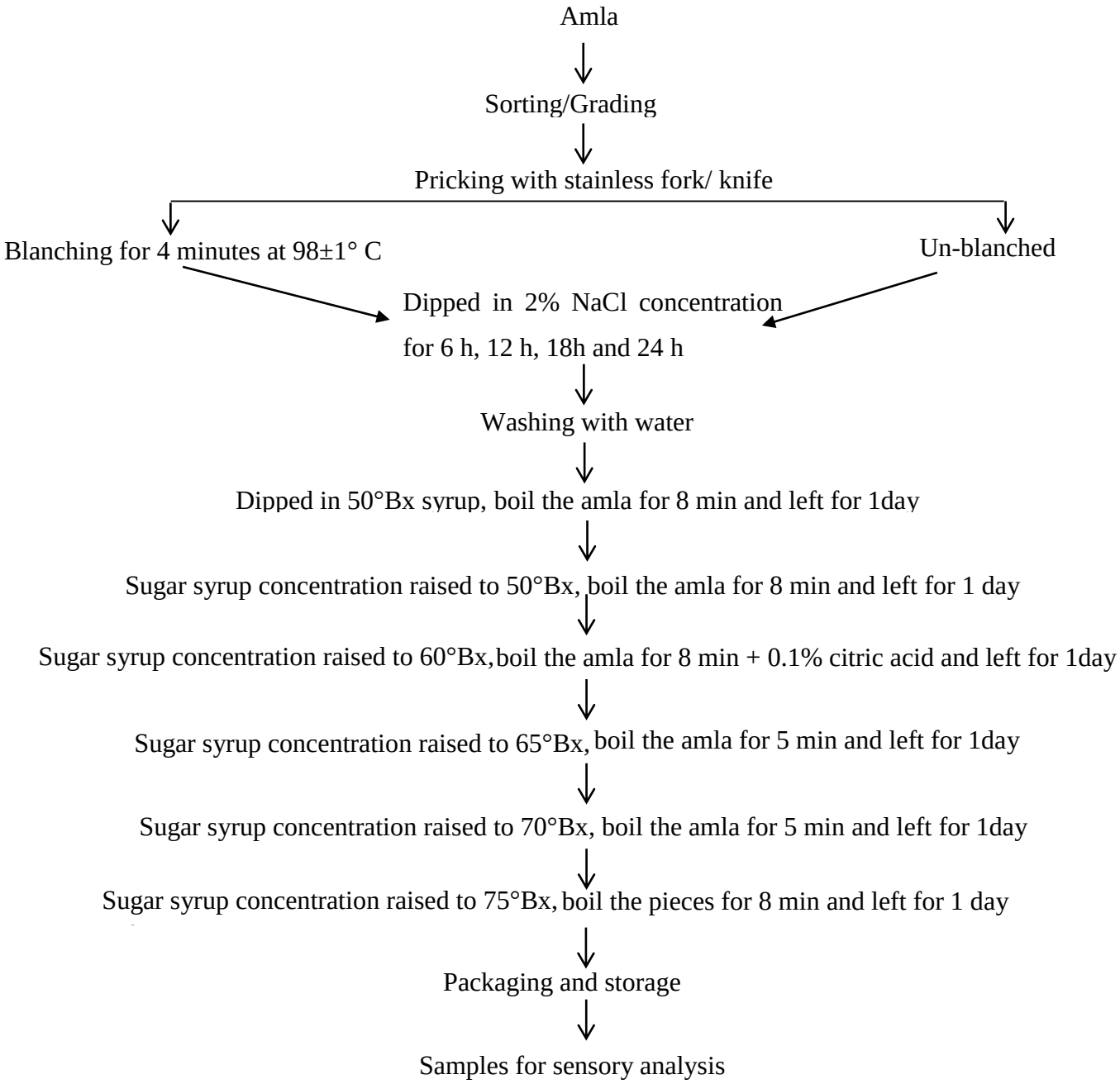

Fig 3.2 Preparation of *amla* preserve

3.5 Analytical method

3.5.1 Preparation of samples for analysis

The samples were taken every day after dipping into the syrup for 1 day (24 h). The samples were taken by spoons. The adhering sugar syrup was removed by washing lightly in running tap water and immediately the surface water was removed by tissue paper. They were placed in the corresponding coded petridishes. The samples were grinded properly

using distilled water in motor and pestle and were used for determination of total sugar, reducing sugar, and ascorbic acid content.

3.5.1.1 Determination of Total sugar and reducing sugar

Total sugar and reducing sugar was determined by Lane and Eynon's method from the process given by (Ranganna, 2010).

3.5.1.2 Determination of TSS of syrup

TSS of syrup was determined using hand refractometer and Abbe refractometer.

3.5.1.3 Determination of titrable acidity

Acidity was determined by (KC and Rai, 2007) titration with the standard sodium hydroxide (0.1N) solution and expressed as % citric acid.

3.5.1.4 Determination of Ascorbic acid

The ascorbic acid content was determined by 2-6 dichlorophenol indophenol titration method described by (Ranganna, 2010).

3.5.2 Determination of moisture content

The moisture content was determined by Hot air oven method as described by (Ranganna, 2010) by slight modification. At first sand was taken and washed several time to separate mud from it. The pure sand was dried and weight was recorded. The *amla* was taken out from the syrup and wiped thoroughly and grinded in mortar and pestle and paste was made. 10gm of paste was taken, mixed with dried sand and spread in the previously weighted clean porcelain dish. It was dried in hot air oven (98±3°C) up to the constant weight, and final moisture was determined as usual method.

3.6 Quality evaluation of prepared preserve

3.6.1 Sensory evaluation

The preserve prepared by varying the pretreatments and proportions of sugar was subjected to sensory evaluation for consumer's acceptability. Sensory attributes (such as color, taste, texture and overall acceptability) were evaluated using 9 points ranging from dislike extremely (1) to like extremely (9) as described by (Ranganna, 2010) by the help of 10 semi trained food technologists selected from those who were familiar with preserve from Central Campus of Technology, Dharan. The samples were served in clean, transparent and labeled petriplate. Sensory evaluation card and water for mouth rinsing between each testing were provided. The sample of sensory evaluation card is given in Appendix A.

3.6.2 Statistical analysis

The data obtained from the sensory analysis was analyzed by two ways ANOVA (no blockings) and sugar uptake was analyzed by one way ANOVA (no blockings) at 5% level of significance. The mean values were compared by using LSD method (Genstat 5 Release 7.1 software programme developed by Lawes Agricultural Trust, Rothamsted Experimental Station, 1985). Means of the data were separated whether they are significant or not by using Fisher's LSD (least significant difference) method at 5% level of significance.

Part IV

Results and discussion

The present study was carried out to optimize the preparation of *amla* preserve. *Amla* were pricked and blanched (98±1°C for 4 min). The pricked blanched and un-blanched *amla* were dipped in 2% NaCl solution for 24 hours. During dipping in salt solution, ascorbic acid retention and reduction in astringent taste of *amla* were determined at 6 h intervals (i.e. 6 h, 12 h, 18 h and 24 h respectively). Ascorbic acid was chemically analyzed and reduction in astringency was measured by sensory methods. As the dipping time increased the bitterness decreased and increased the sensory scores. Data obtained for ascorbic acid determination were statistically analyzed by one way ANOVA. And the best treatment was used for the preparation of *amla* preserve using sugar. Finally the best preserve was evaluated using sensory analysis. During the work the chemical composition of fresh *amla* and processed final products (preserve) were analyzed. The data were taken for changes of Vitamin C and sugar uptake (total sugar and reducing sugar) during syruping. The results of the study are given in Table 4.1 and discussion accordingly.

4.1 Chemical constituents of fresh *amla*

The chemical composition of *amla* is given below in Table 4.1

Table 4.1 Chemical composition of fresh *amla*

Constituents	Value
Acidity as citric acid %	2.70±(0.02)
Vitamin C as ascorbic acid (mg/100 g)	578.5±(0.73)
Moisture %	81.86± (0.03)
Total sugar %	6.52±(0.07)
TSS (°Bx)	11.3±(0.03)
Reducing sugar %	2.95±(0.02)
pH	3.4±(0.17)

*Values are means of triplicate. Figures in the parentheses are the standard deviations.

The result obtained from Table 4.1 showed positively with the result of (Jain *et al.*, 2001) and (Suman, 2009). The moisture content of *amla* was found to be 81.86% which was similar to the data given by (Suman, 2009) which is 83.08%. The total sugar, Vitamin C, TSS, pH, of *amla* was found to be 6.52%, 578.5 mg/100 g, 11.3°Bx, 3.4 respectively which was similar to that of (Jain *et al.*, 2001) i.e. 7.13%, 550 mg/100 g, 11.75°Bx, 3.6 for total sugar, vitamin C, TSS, pH respectively. The acidity of *amla* was 3.5% as (Suman, 2009) but the acidity was found to be 2.7% which was lower than the given data. The difference in result might be due to variation in species.

4.2 Effect of blanching on ascorbic acid content of *amla*

4.2.1 Effect of blanching on ascorbic acid retention of *amla* during dipping in NaCl solution

The effect of blanching on ascorbic acid retention of *amla* were studied and results were shown in Fig 4.1 (Appendix D)

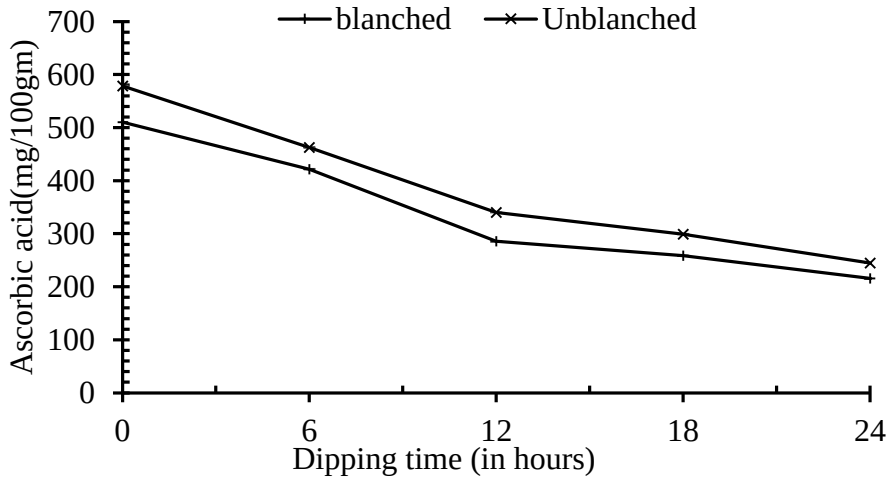

Fig. 4.1 Effect of blanching on ascorbic acid retention of *amla* during dipping in 2% NaCl solution.

The average value of ascorbic acid retention of the blanched *amla* during dipping in 2% NaCl concentration were found to be 510.2 mg/100 g, 421.6 mg/100 g, 285.6 mg/100 g, 258.4 mg/100 g and 215.7 mg/100 g in 0, 6, 12, 18 and 24 h respectively. Likewise, ascorbic acid retention in un-blanched *amla* were found to be 578.5 mg/100 g,

462.6 mg/100 g, 340 mg/100 g, 299.2 mg/100 g and 244.8 mg/100 g in 0, 6, 12, 18 and 24 h respectively.

The statistical analysis shows that pretreatment (blanching and salting) has significant effect ($p<0.05$) on ascorbic acid retention in *amla*. The ascorbic acid content was measured at different time intervals within 24 h of salt dipping i.e. 0, 6, 12, 18 and 24 h respectively. The data showed that the initial ascorbic acid content was found 510.2 mg/100 g for blanched and 578.5 mg/100 g for un-blanched. The extent of losses of ascorbic acid for blanched sample during salt dipping was at higher rate than the un-blanched sample. Ascorbic acid was lowest in the 24^{th} hour of salt dipping. The losses of ascorbic acid is due to leaching out of the vitamin-C from the *amla* into the NaCl solution and oxidation of ascorbic acid in the formation of dehydroascorbic acid (Wills *et al.*, 2003). The LSD shows that there exists significant difference ($p<0.05$) on ascorbic acid retention in both samples blanched and un-blanched. The data was statistically analyzed by one way ANOVA (without interactions) at 5% level of significance.

The changes in ascorbic acid during blanching and salting were studied. The result of ascorbic acid content in 0, 6, 12, 18 and 24 h is shown in Fig 4.1 (Appendix D). The one way analysis of variance (no blocking) showed that the ascorbic acid of samples blanched and un-blanched were significantly different with each other in varying period of time.

The retention of ascorbic acid during salting was found to be higher in un-blanched sample than blanched. The initial ascorbic acid content for blanched sample was found to be 510.20 mg/100 g. During dipping in salt solution for 24 h, it reached to 215.70 mg/100 g. In the case of un-blanched the initial ascorbic acid content of 578.50 mg/100 g was reduced to 244.80 mg/100 g at the end of the salting. The higher decreased of ascorbic acid in blanched sample may be due to the solubilization and heat degradation of the ascorbic acid. Blanching softens the tissues and mild heating in water result in the losses of ascorbic acid due to leaching out in blanched water (Desouky *et al.*, 2000). Similar result was obtained in the work done by Gebczynski and Lisiewska (2006), who reported that the loss of ascorbic acid range from 13-60 %. Brewer *et al.* (1995) reported that after blanching vitamin C was found lower than the un-blanched broccoli. The data shows that the ascorbic

acid content gradually decreased in both blanched and un-blanched sample. But the rate of reduction of ascorbic acid in blanched sample was higher than un-blanched.

4.2.2 Effect of pretreatment (blanching and salting) on sensory (bitterness) of blanched and un-blanched *amla*

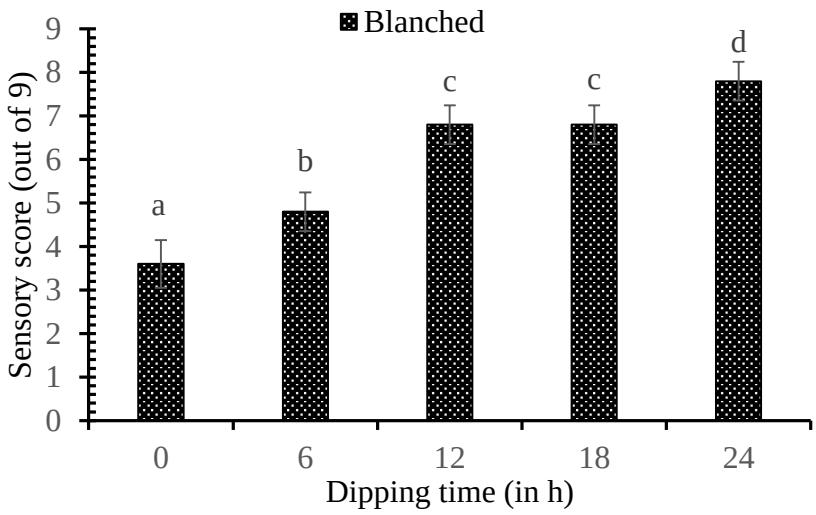

Fig.4.2 Sensory score for bitterness of blanched *amla* during dipping in 2% NaCl solution

The mean sensory scores (bitterness) of the blanched sample was taken in 6 hours of interval (0, 6, 12, 18 and 24 h). The bitterness gradually decreased over dipping time i.e. the lowest being at 24th hour. This might be due to mass transfer phenomena in which soluble components leach out in the salt water and solute (salt) uptake increase from outer to inner surface of the product (Wang and Sastry, 2000). And with increase in time the bitterness of *amla* decreases gradually. The LSD shows significant difference in decreasing bitterness in each time period. But there was no significant difference in 12th and 18th hour of dipping time which was statistically analyzed by one-way ANOVA (without interactions) at 5% level of significance (Appendix E).

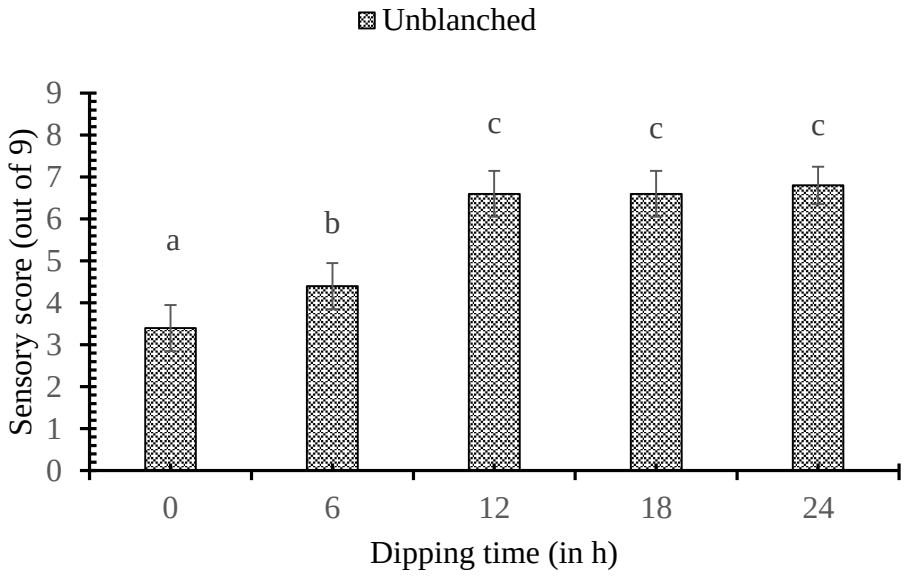

Fig.4.3 Sensory score for bitterness of un-blanched *amla* during in 2% NaCl solution

The mean sensory scores (bitterness) of the Un-blanched sample was taken in 6 hours of interval (0, 6, 12, 18 and 24 h). The bitterness gradually decreased over dipping time i.e. the lowest being at 24th hour. This might be due to mass transfer phenomena in which soluble components leach out in the salt water and solute (salt) uptake increase from outer to inner surface of the product (Wang and Sastry, 2000). The LSD shows significant difference between in each time period and not significant difference in 12th, 18th and 24th hour of dipping time. Similarly, there exists significant difference on sensory score in different time period which was statistically analyzed by one-way ANOVA (without interactions) at 5% level of significance (Appendix E).

From Fig. 4.2 and 4.3, during dipping in 2% NaCl solution, the astringency was continuously decreased in both blanched and un-blanched sample. In case of the blanched sample there was no significant difference in astringency between 12th and 18th hour of salt dipped samples. In case of the un-blanched sample there was no significant difference in bitterness of the sample dipped for 12th, 18th and 24th hour. In the sample of the 24 h dipping time the astringency was very low and the product was highly accepted regarding the bitterness. But in 24 h dipping of *amla* the ascorbic acid retention was minimum.

Therefore, regarding the retention of ascorbic acid and reduction of astringent taste, 12th hour of salt dipping time was taken as appropriate time for de-bittering of *amla.*

4.3 Sensory evaluation of pretreated *amla* preserve

Amla (blanched and un-blanched) dipped in 2% NaCl concentration for 12 h was used for preserve preparation. *Amla* preserve was prepared using the methods given in materials and methods section. During preserve making process the pretreated *amla* were dipped in sugar solution for 6 days. The °Bx of the syrup was increased at the rate of 10 and 5% during dipping time. During the dipping periods, the total sugar and reducing sugar content in the sample were analyzed. After achieving 75 °Bx the *amla* were taken as a final product (*amla* preserve). Thus prepared preserve were then sent for sensory test for evaluation of its color, taste, texture and overall acceptability. The samples were coded as A for blanched *amla* and B for un-blanched *amla*. The average sensory scores are shown in Appendix F and in the Fig. 4.4

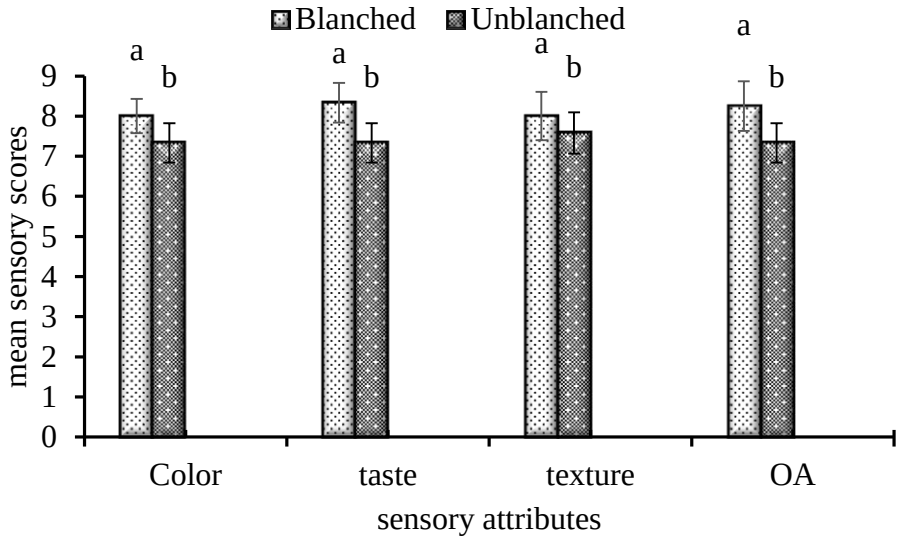

Fig. 4.4 Sensory evaluation of *amla* preserve

The values in the Fig. 4.4 are the means scores of panelists for different sensory attributes of *amla* preserve made by blanched and un-blanched samples.

The statistical analysis shows that the blanching has significant effect ($p<0.05$) on the sensory parameters of *amla* preserve. In terms of superiority ($p<0.05$) with respect to color, taste, texture and overall acceptance, following conclusion can be drawn:

From the Fig. 4.4, it shows that in terms of color blanched sample had highest mean score compared to un-blanched sample. Statistical test showed that blanching has significant effect ($p<0.05$) on color property. Color of blanched sample was superior than un-blanched. The better color of blanched sample might be due to inactivation of different color hydrolysis enzymes.

From the Fig. 4.4, it shows that in terms of taste, blanched sample had highest mean score compared to un-blanched. Statistical test showed that blanching has significant effect ($p<0.05$) on taste property. This might be due to higher sugar uptake in blanched sample where more sugar will penetrate through it which provides its own characteristics taste.

In terms of texture blanched sample had highest mean score compared to un-blanched. Statistical test showed that blanching treatment has significant effect ($p<0.05$) on texture property. The better texture of blanched sample might be due to higher total solids which maintain the body of the preserve. Sugar penetration in the blanched *amla* is more and texture becomes more chewy and rubbery which has got the high preference from the panelists.

From the Fig. 4.4, it has been observed that in terms of overall acceptances the blanched sample had highest mean compared to un-blanched. The higher score in overall acceptability of the blanched sample has got higher sensory score than the un-blanched. Statistical test showed that blanching has significant effect ($p<0.05$) on the overall acceptability. This may be due to better color, texture, taste and mouth-feel. Thus, based on the highest sensory scores with respect to all the parameters, blanched sample was superior and selected as the best *amla* preserve.

4.4 Effect of blanching on total sugar during preparation of *amla* preserve

The effect of blanching on total sugar of *amla* preserve during syruping is given in Fig. 4.5:

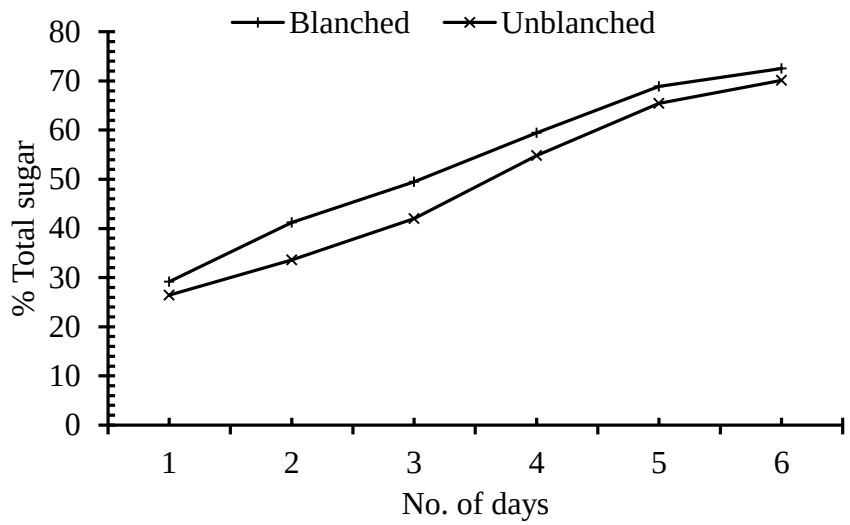

Fig 4.5 Change in total sugar during preserve making process

In blanched sample, it shows that the total sugar increases at a faster rate during the initial days of preserve making. In day 1st the total sugar increases to 29.16% and in day 2nd to 41.2%. This is mainly due to the high and increases in concentration gradient at the initial period which increases the driving force. On the subsequent days the level of total sugar tends to level up. i.e. the total sugar increases to 49.5%, 59.42%, 68.86% and 72.50% on 3rd, 4th, 5th and 6th days respectively. The increase in total sugar could be attributed to gradual inversion of non-reducing sugars (Jain *et al.*, 2004).

In un-blanched sample, it can be observed that the higher rate of increase in total sugar at the initial stages i.e. the total sugar increases to 26.43% and 33.62% on day 1st and day 2nd. This is might be due to the higher concentration gradient which increases the driving force. On subsequent days, the increasing level of total sugar increases to 42%, 54.84%, 65.43% and 70.13% on 3rd, 4th, 5th and 6th days respectively. The increase in total sugar could be attributed to gradual inversion of non - reducing sugars (Jain *et al.*, 2004).

The effect of blanching on total sugar of *amla* preserve were studied. The result of total sugar per day is given in Fig. 4.5 and shown in Appendix G. The one way analysis of variance (no blocking) showed that the total sugar level in blanched and un-blanched samples were significantly different with each other from day 1st to day 6th.

For blanched sample, the total sugar content after 1st syruping day was 29.16%. And in final 6th day the total sugar was 72.5%. On the other hand, for the un-blanched sample, the total sugar content after 1st day was 26.43% and at the final stage of preserve making the total sugar for un-blanched sample was 70.13%. In each day the total sugar was higher in blanched sample than un-blanched and were significantly different with each other from 1st day to 6th day, which states that the blanched sample have higher rate of sucrose uptake. The total sugar content of blanched sample is greater than un-blanched sample. In un-blanched sample the extent of total sugar increase is slightly lower than the blanched. The sugar increases by 29.16%, 41.2%, 49.5%, 59.42%, 68.86% and 72.50% from the 1st day to 6th day in blanched sample. This is because blanching increases the permeability of plant tissues i.e. the uptake of sugar is higher in the case of blanched sample. Therefore, more sugar will penetrate through it (Fellows, 2009). Similar results were obtained in the work by (Daisy and Gehlot, 2006).

4.5 Effect of blanching on reducing sugar during preparation of *amla* preserve

The change in reducing sugar of *amla* preserve during syruping is given in Fig. 4.6:

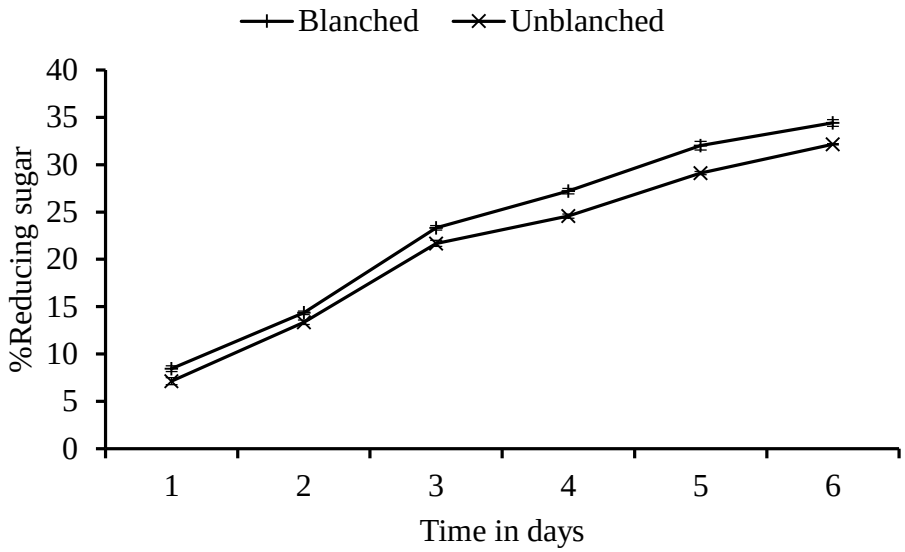

Fig 4.6 Change in reducing sugar during preserve making process

In the Fig. 4.6 blanched sample shows that the reducing sugar increases at a faster rate during the initial preserve making process. In day 1st the reducing sugar increases to 8.44% and in day 2nd to 14.36%. This is mainly due to the high and increases in concentration gradient at the initial period which increases the driving force. On the subsequent days the level of reducing sugar tends to level up i.e. the reducing sugar increases to 23.32%, 27.2%, 32% and 34.4% on 3rd, 4th, 5th and 6th days respectively. According to (Shakir *et al.*, 2008) increase in reducing sugars is due to hydrolysis of sucrose by low pH and heat treatment.

In the case of un-blanched sample, it can be observed that the higher rate of increase in reducing sugar at the initial stages i.e. the reducing sugar increases to 7.14% and 13.36% on day 1st and day 2nd. This is might be due to the higher concentration gradient which increases the driving force. On subsequent days, the increasing level of reducing sugar increases to 21.68%, 24.57%, 29.1% and 33.6% on 3rd, 4th, 5th and 6th days respectively. According to (Shakir *et al.*, 2008) increase in reducing sugars is due to hydrolysis of sucrose by low pH and heat treatment.

The one way analysis of variance (no blocking) showed that the reducing sugar level in blanched and un-blanched samples were significantly different with each other from day 1st to 6th day of preserve making process (Appendix H).

For sample blanched, the reducing sugar content after the 1st day was 8.44%. And at the 6th day it was 34.40%. In the case of un-blanched sample there was higher rate of increase in reducing sugar in the initial phase of preserve making process than at the final stage. The reducing sugar content was 7.14%, 13.36%, 21.68%, 24.57%, 29.1% and 33.6% in 1st, 2nd, 3rd, 4th, 5th and 6th day respectively in un-blanched sample. According to (Fellows, 2000) blanching softens the pieces, increase sugar uptake. According to (Shakir *et al.*, 2008) increase in reducing sugars is due to hydrolysis of sucrose by low pH and heat treatment. Similar results were obtained in the work by (Damame *et al.*, 2002) who reported that a marked increase in reducing sugar content of *amla* preserve.

4.6 Effect of blanching on Ascorbic acid during preparation of *amla* preserve

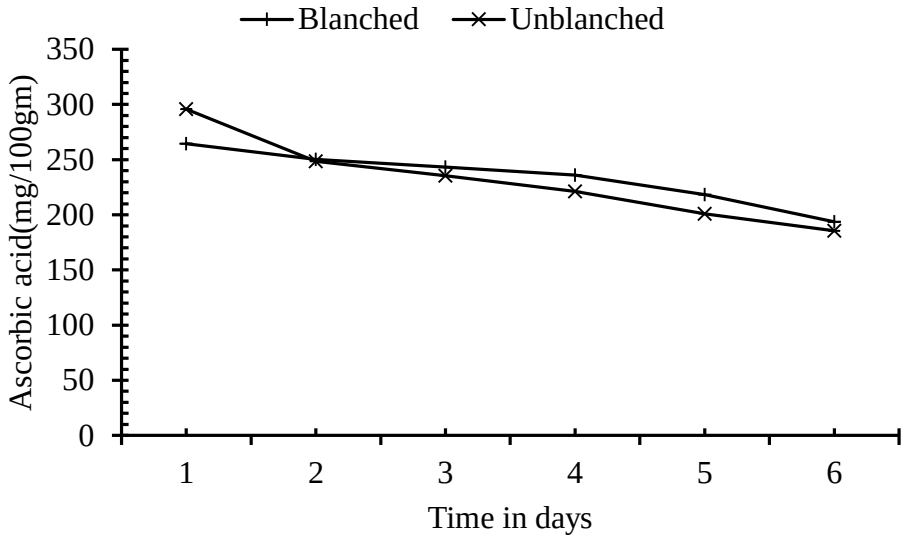

Fig. 4.7 Change in ascorbic acid during preserve making of *amla*

In the Fig. 4.7, blanched sample shows that the ascorbic acid decreases at a faster rate during the initial preserve making process. In day 1st the ascorbic acid decreases from 285.6 to 264.5 mg/100 g and in day 2nd decreases to 250.13 mg/100 g. Likewise on the subsequent days the level of ascorbic acid decreases i.e. the ascorbic acid decreases to

243.16 mg/100 g, 236.49 mg/100 g, 218.36 mg/100 g and 193.60 mg/100 g on 3rd, 4th, 5th and 6th days respectively. This is mainly due to the fact that ascorbic acid being sensitive to oxygen, light and heat was easily oxidized in presence of oxygen in the formation of dehydroascorbic acid (Welch *et al.*, 2007). The destruction of ascorbic acid increases with time and temperature and results in decrease of ascorbic acid in samples.

In the Fig. 4.7, sample un-blanched shows that the ascorbic acid decreases at a faster rate during the initial preserve making process. i.e. on day 1st the ascorbic acid decreases from 340 to 295.8 mg/100 g and in day 2nd decreases to 248.50 mg/100 g. Likewise on the subsequent days the level of ascorbic acid decreases more rapidly. i.e. the ascorbic acid decreases to 235.40 mg/100 g, 221.30 mg/100 g, 201 mg/100 g and 185.50 mg/100 g on 3rd, 4th, 5th and 6th days respectively. This is mainly due to the fact that ascorbic acid being sensitive to oxygen, light and heat was easily oxidized in presence of oxygen in the formation of dehydroascorbic acid (Welch *et al.*, 2007). The destruction of ascorbic acid increases with time and temperature and results in decrease of ascorbic acid in samples.

The one way analysis of variance (no blocking) showed that the ascorbic acid in blanched and un-blanched samples were significantly different with each other. In every blanched and un-blanched sample the ascorbic acid is significantly different with each other ($p<0.05$) from day 1st to 6th day during the study period (Appendix I).

In the blanched and un-blanched sample the destruction of ascorbic acid at faster rate in the initial stage. When the losses of ascorbic acid in the blanched and un-blanched *amla* during the preserve making process was compared the extent of losses of ascorbic acid was higher in the un-blanched sample than blanched. For sample blanched, the ascorbic acid content after 1st day was 264.50 mg/100 g and for un-blanched sample ascorbic acid content was 295.80 mg/100 g. During preserve making process, the boiling process in open kettle destroyed a very large portion of ascorbic acid due to leaching out from the *amla* into the syrup. Likewise on the subsequent days the ascorbic acid goes on decreasing. LSD shows that there exists significant different between the sample blanched and un-blanched after every processing days. After 24th hour of sugar dipping (syruping) the ascorbic acid was lower in blanched sample as compared to un-blanched which is due to previous blanching process. But on the subsequent days ascorbic acid of un-blanched sample goes

on decreasing in a faster way as compared to that of blanched sample. This might be due to inactivation of oxidative enzymes which degrade the ascorbic acid (Fellows, 2009). Gupta *et al.* (2008) reported that blanching inactivates enzymes and maximum ascorbic acid retention. Similar result was obtained by (Kumar *et al.*, 2012) in *amla* products.

4.7 Chemical composition of final product Sample blanched and un-blanched.

The chemical composition of final products sample blanched and sample un-blanched is shown in the Table 4.2

Table 4.2 Chemical composition of final products sample blanched and sample un-blanched.

Chemical composition/Samples	Blanched	Un-blanched
Moisture content (%)	24.2±(0.07)	25.29±(0.09)
pH	2.560±(0.14)	2.700±(0.06)
Total sugar (%)	72.500±(0.31)	70.130±(0.11)
Reducing sugar (%)	34.40±(0.34)	32.14±(0.07)
Acidity (%)	0.841±(0.06)	0.890±(0.04)
Vitamin C (mg/100 g)	193.60±(0.37)	185.50±(0.21)

*Values are means of triplicate. Figures in the parentheses are the standard deviations.

4.7.1 Moisture content

The moisture content of sample blanched and un-blanched were found to be 24.4% and 25.29% respectively. The moisture content of the *amla* preserve was found out to be in the range as determined by (Damame *et al.*, 2002) which is 24.14%. The moisture content is significantly different in blanched and un-blanched *amla* preserve. The lower moisture content in blanched *amla* preserve is due to the higher sugar diffusion and moisture release from the tissues. The moisture content of the blanched and un-blanched samples was significantly difference as determined by one-way ANOVA at 5% level of significance (Appendix J).

4.7.2 pH

The pH content of sample blanched and un-blanched were found to be 2.56 and 2.70 respectively. The pH content of the *amla* preserve was found out to be in the range as determined by (Daisy and Gehlot, 2006) which is 2.67. The pH content of sample un-blanched is higher than sample blanched. The pH content of the samples had no significant difference between the samples as determined by one-way ANOVA at 5% level of significance (Appendix J).

4.7.3 Total sugar content

The total sugar content of sample blanched and un-blanched were found to be 72.5% and 70.130% respectively. The total sugar content of the *amla* preserve was found out to be in the range as determined by (Daisy and Gehlot, 2006) which is 72.89%. The total sugar content of blanched sample is higher than sample un-blanched which is due to its better sugar uptake rate. The total sugar content of the preserve is nearly about the total soluble solids. The total sugar content of the blanched and un-blanched samples was significantly difference as determined by one-way ANOVA at 5% level of significance (Appendix J).

4.7.4 Reducing sugar content

The reducing sugar content of blanched and un-blanched sample were found to be 34.40% and 32.14% respectively. The reducing sugar content of the *amla* preserve was found out to be in the range as determined by (Damame *et al.*, 2002) which is 35.15%. The sample blanched has highest reducing which might be due to hydrolysis of sugar into invert sugar by heat and acid. The reducing sugar content of the blanched and un-blanched samples was significantly difference as determined by one-way ANOVA at 5% level of significance (Appendix J).

4.7.5 Acidity

The acidity of sample blanched and un-blanched were found to be 0.841% and 0.890% respectively. The acidity of the *amla* preserve was found out to be in the range as determined by (Daisy and Gehlot, 2006) which is 0.85%. The sample blanched has minimum acidity compared to sample un-blanched which is probably due to more leaching

losses of acid in sugar. The acidity of the samples had no significant difference between the samples as determined by one-way ANOVA at 5% level of significance (Appendix J).

4.7.6 Vitamin C content

The Vitamin C content of sample blanched and un-blanched were found to be 193.60 mg/ 100 g and 185.50 mg/100 g. The vitamin C of the *amla* preserve was found out to be in the range as determined by (Kumar and Singh, 2001) which is 191.250 mg/100 g. The sample un-blanched has minimum vitamin C content compared to sample blanched. The Vitamin C of the samples has significant difference between the samples as determined by one-way ANOVA at 5% level of significance (Appendix J).

Part V

Conclusions and recommendations

Based on the above results and discussions of this study, the following conclusions and recommendations were drawn:

5.1 Conclusions

1. Among two pre-treatment blanched and un-blanched *amla* which was dipped in 2% of NaCl solution, the maximum astringency (bitterness) was removed at 12 hours of dipping time. Compared to 18 h and 24 h, the minimum loss of vitamin C was occurred at 12 h compared to 18^{th} and 24^{th} hours. So 12 h was taken for preparation of *amla* preserve.

2. The *amla* preserve made from blanched and un-blanched samples using sucrose, the blanched sample absorbed more sugar, had soft texture and better appearance. In overall acceptability the blanched sample was found to be superior.

3. The increased of total sugar and reducing sugar was at a faster rate in the blanched *amla* than un-blanched during the preserve making process.

4. The retention of Vitamin C in the *amla* preserve made from blanched *amla* was found more than un-blanched.

5. Low cost *amla* preserve can be prepared from locally available raw materials. This type of preserve can be prepared in low scale, which requires simple equipment, simple technology and lower investment. The cost of per kg of product was 70/kg.

5.2 Recommendations

1. Shelf life of *amla* preserve can be studied by using different chemical preservatives.
2. Different storage condition for storage stability of product could be determined.
3. Different packaging materials can be carried out to increase the shelf life of product.

Part VI

Summary

Amla (*Phyllanthus emblica*) has been used in different *Ayurvedic* formulation since time immemorial. Though it has several nutritional, medicine and therapeutic values, it is not consumed much in raw state due to its astringency taste. Thus the preparation of preserve leads to the higher consumption of *amla*. *Amla* is a natural, efficacious, an antioxidant with the richest natural source of vitamin C. *Amla* has different food use for e.g. jam, pickle, and candy can be prepared. Similarly, it has been medicinal uses and therapeutic uses. It enhances food absorption, balances stomach acids, nourishes the brain and mental functioning, supports heart, strengthens the lungs, promotes healthier hair, and flushes toxins and so on.

Intermediate moisture foods (IMF) are advantageous in developing countries which may be due to its desirable properties such as long shelf-life, nutritive value, organoleptic acceptable (Vora *et al.*, 2003). *Amla* preserve is a sweet product with the addition of sugar and citric acid. The work was carried out to study on the optimization of pretreatment and product formation. The *amla* was pretreated with NaCl solution with time variation and was used to formulate a nutritious and Vitamin C enriched *amla* preserve.

Amla was washed, pricked with stainless steel fork/knife. Then the *amla* were divided into 2 lots for pretreatment. The first lot was blanched and second was not blanched and both were dipped in 2% NaCl solution and was left for 6, 12, 18 and 24 h respectively. The data were statistically analyzed and the treatment of 12 hours was found to be best in terms of bitterness and the minimum loss of vitamin C was found at 12 hours compared to others. So it was chosen for further preserve preparation. The samples were made by boiling the *amla* in sucrose syrup of 50˚Bx. The strength of syrup was raised by 10˚Bx each day up to 60˚Bx and 0.1% of citric was added to the amount of sugar used at 60˚Bx. Then the strength of syrup was increased by 5˚Bx each day up to 75˚Bx with continuous boiling. This prevents shrinkage and sweating of *amla* (Lal *et al.*, 1998). The products blanched sample and un-blanched sample was analyzed by sensory analysis. The statistical analysis of the sensory data shows significant difference in color, taste, texture and overall acceptance. Sample blanched got the highest mean sensory score.

The sugar uptake by the samples blanched and un-blanched were determined at each step. Among the samples, sugar uptake by sample blanched was higher this may be due to blanching softens the *amla* and increase sugar uptake (Fellows, 2009). The sugar uptake by the samples were statistically analyzed using one way ANOVA (no blocking) at 5% level of significance which showed that there exists significant difference in sugar content within the samples as well as the sugar content of samples were increasing significantly with respect to time. Likewise, vitamin C was analyzed in both samples blanched and un-blanched at each step. The losses of ascorbic acid is due to leach out of the vitamin-C from the *amla* into the syrup and oxidation of ascorbic acid in the formation of dehydroascorbic acid (Welch *et al.*, 2007). The vitamin C was higher in sample blanched. Satistical analysis shows significant difference between the sample blanched and un-blanched. And the satisfactory result was found in sample blanched. The statistical analysis of the chemical composition of final products shows there exists no significant difference except moisture content, ascorbic acid, reducing and total sugar which were significantly different between the samples.

The cost of the product was calculated on the basis of raw materials, ingredients used and 10% overhead cost of total ingredients. The actual cost of preserve may be reduced if produced in large scale.

References

Arora, S., Kaur, K. and Kaur, S. (2007). Traditional Herbal Medicine in India *J. Clin. Biochem. Nutr.* **40** (3), 163–173.

Ashok, P. K. and Upadhyaya, K. (2012). Tannins are astringent *Int. J. Pharma. Phytochem.* **1** (3), 45-48.

Ashwell, G., Kanfer, J., Smiley, J. D. and Burns, J. J. (2001). "Metabolism of ascorbic acid and related uronic acids, aldonic acids and pentoses". Vol. 11. Tata McGraw-Hill Publisher Co. London.

Bajpai, P. N. and Shukla, H. S. (1998). Tropical and sub tropical. *In:* "Anola Fruits". (T. K. Bose and S. K. Mitra, Eds.). pp. 512-514.

Bhartakur, K. and Arnold, S. (1990). [Cited in S. Dhital. (1999). Stability of Ascorbic Acid in *Amla*. B.Tech. (Food) Dissertation. Trivuwan Univ., Central Campus of Technology, Dharan, Nepal].

Bharthakur, N. N., Arnold, N. P. and Babu, P. S. (1999). Chemical analysis of the emblic *(Phyllanthus emblica L)* and its potential as a good sources. *Sci. Horti.* **47**, 99-105.

Bhattacharya, A., Chatterjee, A., Ghosal, S. and Bhattacharya, S. (2003). Antioxidant activity of active tannoid principles of *Emblica officinalis*. *Indian J. Expt. Biol.*, 676–680.

Brewer, M. S., Begum, S. and Bozeman, A. (1995). Microwave and conventional blanching effects on chemical, sensory and colour characteristics of frozen broccoli. *J. Food Qual.* **18**, 479-493.

Budathoki, R. (2012). Preparation and quality evaluation of pear candy and study on sugar uptake by using different sugar. B.Tech (Food) Dissertation. Trivuwan Univ., Central Campus of Technology, Dharan, Nepal.

Buettner, G. R. (2003). The pecking order of free radicals and antioxidants lipid peroxidation, alpha-tocopherol, and ascorbate. *Arch. Biochem. Biophys.* **300** (2), 535-543.

Cook, D. J. (2006). Intermediate moisture foods. *Nutri. Food Sci.* **75** (3), 20-21.

Cordier, J. L. (2000). Sugars, honey, cocoa, chocolate and confectionery products. *In:* "Microbiological Safety and Quality of Food ". (B. M. Lund, T. C. Parker and G. W. Gould, Eds.). pp. 941–959. Gaithersburg. Aspen Publishers.

Daisy and Gehlot, R. (2006). Physical and bio-chemical differences in fresh aonla fruits and preserve of cvs. Banarasi and Chakaiya. *Haryana J. Horti. Sci.* **35** (1), 56-59.

Damame, S. V., Gaikwad, R. S., Patil, S. R. and Masalkar, S. D. (2002). Vitamin-C content of various aonla products during storage. *Orissa J. Hort.* . **30** (1), 19-22.

Danilo, J. (2004). Handling and preservation of fruits and vegetables by combined methods *In:* "General Considerations for Preservation of Fruits and Vegetables". (M. Stella and S. Maria, Eds.). pp. 39-45. Agriculture and Consumer Protection.

Dasaroju, S. and Gottumukkala, K. M. (2014). Current trends in the research of *Emblica officinalis (Amla)*: a pharmacological perspective. *Cent. Pharma. Sci.* . **24** (2).

Desouky, S. K., Ryu, S. Y. and Kim, Y. K. L. (2000). Potential fruit for processing *National Sci. Council of Sri Lanka*. **22**, 91-95.

Dewan, A. D. (1994). "Food for Health". M.S A.C Specialist Publisher Pvt. Ltd. New Delhi.

Fellows, P. J. (2009). "Food Processing Technology" (3rd ed.). Wood Head Publ. Ltd. England.

Gautam, H. (1991). Amla candy preparation following different blanching time and determination of sugar and ascorbic content at each step. B. Tech Dissertation. Tribhuvan Univ., Nepal, Nepal.

Gebczynski, P. and Lisiewska, Z. (2006). Comparison of the level of selected antioxidative compounds in frozen broccoli produced using traditional and modified methods. *Innov. Food Sci. Emerg. Technol.* **7**, 239-245.

Ghosal, S., Sairam, K. and Bhattacharya, S. K. (2002). Effect of bioactive tannoid principles of *Emblica officinalis* on ischemiareperfusion induced oxidative stress in rat heart. *Indian J. Expt. Biol.* **9** (2), 171-178.

Ghosal, S., Triethi, V. K. and Chauhan, S. (2001). Active constituents of *Emblica officinalis*: The chemistry and antioxidative effects of two new hydrolysable tannins, Emblicanin A and B. *Indian J. Chem.*, 941-948.

Ginter, E., Seith, P. A. and Toblert, B. M. (2003). Role of ascorbic acid in lipid metabolism (ascorbic acid, chemistry, metabolism and uses). *American Chemi. Soci.* **200**, 381-393.

Goel, R. K. (2004). Technology of food Products. *Small Business Publication* 183-184.

Gopalan, C. I., Ramasastri, B. V. and Bal Subramanian, S. C. (1993). Nutritive value of Indian foods. *Indian J. Food Nutri.* **6**, 17-18.

Grover, H. S., Deswal, H., Singh, Y. and Bhardwaj, A. (2010). The ayurvedic wonder. *Ann. N. Y. Acad. Sci.* **7** (2), 65-68.

Gupta, S., lakshmi, A. A. and Prakash, J. (2008). Effect of different blanching treatments on ascorbic acid retention in green leafy vegetables. *Nat. Prod. Rad.* **7** (2), 111-116.

Harper, A. E. (2000). The recommended dietary allowances for ascorbic acid. *Ann. N. Y. Acad. Sci.* **258**, 491-497.

Harris, R. S. (2008). "Effects of Agricultural Practices on the Composition of Foods" (2nd ed.). Vol. 42. The AVI Publishing Company. Westport.

Haworth, W. N. and Hirst, E. L. (2002). Synthesis of ascorbic acid. *J. Chem. Soc.* **52** (3), 645-647.

Heldman, D. R. and Hartel, R. W. (1999). Pasteurization and blanching. *In:* "Principles of Food Processing". (R. Dennis, Ed.). pp. 34-55. Boston.

Iman, S., Bano, S., Shaukatullah, S. and Naz, H. (2011). Physico-chemical analysis and quality evaluation of intermediate moisture apple slices. *Biochem. Mol. Biol.* **44** (1), 27-31.

Jackson, R. (2001). Saturation relations in mixtures of sucrose, dextrose, and levulose. *J. Res. Natl. Bur. Stand.* **24**, 267-272.

Jain and Khurdia, D. S. (2002). Studies on juice extraction of aonla. *Food Sci. Technol.*, 515-516.

Jain , S. P., Tripathi, V. K., Ram, H. B. and Singh, S. (2001). Optimum stage of maturity of preparation of anola (*Emblica officinalis* Gaertn) preserve. *Indian Food Pack*. **37** (6), 85-88.

Jain , S. P., Tripathi, V. K., Ram, H. B. and Singh, S. (2004). Varietal suitability of litchi for squash making. *Indian Food Packer*. **43** (2), 235-239.

Jayaraman, K. S. (2002). Critical review on intermediate moisture fruits and vegetables. *In:* "Food Preservation by Moisture Control-Fundamental and Application ". (J. Barbosa and G. V. Cenovas, Eds.). pp. 411-442. Switzerland. Basel, Switzerland Technomic Publishing.

Kapoor, L. D. (2008). "Handbook of Ayurvedic Medicinal Plants". Lucknow and Publications and Information Directorate. New Delhi, India.

KC, J. B. and Rai, B. K. (2007). "Basic Food Analysis Handbook" (1st ed.). Prompt Printers Pvt.Ltd. Kathmandu, Nepal.

Khan, K. H. (2009). Roles of *Emblica officinalis* in medicine. *Bot. Res. Int.* **2** (4), 218-228.

Kharel, P. G. and Hashinaga, F. (2004). "Principles of Food Preservation". Shibundo Co. Ltd. Kagoshima, Japan.

Klaui, H., Birch, G. G. and Parker, K. J. (2000). "Technical uses of Vitamin C" (2nd ed.). Vol. 42. Applied Science Publisher Ltd. London.

Krishnaveni, M. and Mirunalini, S. (2010). Therapeutic potential of *Phyllanthus emblica (amla)* the ayurvedic wonder. *J. Basic Clin. Physiol. Pharmacol.*, 93-105.

Krishnaveni, M. and Mirunalini, S. (2011). The Role of ayurvedic therapeutic herbs in cancer. *J. Basic Clin. Physiol. Pharmacol.* **4** (3), 13-17.

Kumar, A., Singh, A. and Dora, J. (2012). Essential perspectives for *Emblica officinalis*. *Int. J. Pharm. Chem. Biol. Sci.* **1** (1).

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

Lal, G., Siddappa, G. S. and Tandon, G. L. (1998). In: "Preservation of Fruits and Vegetables." [Cited in C. M. Uprety. (1987). Study on dehydration of *amla* and losses of Vitamin-C during its dehydration & storage. B.Tech. (Food) Dissertation. Central Campus of Technology, Dharan].

Leistner, L. (1992). Food preservation by combined method. *Food Res. Int.* **25**, 151-158.

Lerici, C. R., Pinnavaia, G., Dalla, R. M. and Bartolucci, L. (2002). Osmotic dehydration of fruit: influence of osmotic agents on drying behavoiur and product quality. *J. Food Sci.* . **50** (5), 1217-1219.

Levin, M. (2008). New concepts in the biology and biochemistry of ascorbic acid. *J. Medi.* **31** (2), 892-902.

Levine, M., Dhariwal, K. R. and Welch, R. W. (2002). Determination of optimal vitamin C requirements in humans. *The American J. Clin. Nutri.* **62** (2), 418-423.

Levine, M. and Welch, R. W. (2009). New Concepts in the Biology and Biochemistry of vitamin C. *The New England J. Medi.* **314** (4), 892-902.

Lopez, A. R., Almener, E., Hernandez, P. A., Lagaron, J. M., Catala, R. and Gavara, R. (2004). Overview of active polymer-based packaging technologies for food application. *J. Food Rev. Int.* . **20** (4), 357-387.

Majupuria, T. C. (1978). [Cited in A. B. Suman. (2008). Study on kinetic thermal degradation of ascorbic acid in *amla (Phylanthus emblica L.)*. B.Tech. (Food) Dissertation. Tribhuvan Univ., Central Campus of Technology, Dharan, Nepal].

Manaya, M. S. and Shadaksharaswamy, M. (2008). "Food Facts and Principle" (3rd ed.). Vol. 3. New Age Interanational (P).Ltd. India.

McGee, H. (2004). "On Food and Cooking" (2nd ed.). Simon & Schuster. New York.

Mottram, V. H. (1974). "Human Nutrition". Printed at Britain by Staker Brothers Ltd. Whitestable

Muftugil, N. (2001). Effect of different types of blanching on the color and the ascorbic acid and chlorophyll contents of green beans. *J. Food Proc. Preserv.* **10**, 69-76.

Nadkarni, K. M. (2007). *Amla* traditional food and medicine. *Engl. J. Med.* **8** (15), 16-21.

Nagy, S. (2007). Vitamin C contents of citrus fruit and their products. *J. Agri. Food Chem.* **28**, 8-18.

Naik, G. H., Priyadarsini, K. I. and Bhagirathi, R. G. (2005). In vitro antioxidant studies and free radical reactions of triphala, an ayurvedic formulation and its constituents. *Phyto. Research*. **19** (7), 582-586.

Nisha, P., Singhal, R. S. and Pandit, A. B. (2004). A study on degradation kinetics of ascorbic acid in *amla (Phyllanthus emblica* L.) during cooking. *Int. J. Food Sci Nutr.* . **55** (5), 415-422.

Nonaka, G., Hsu, F. and Nishioka, I. (2001). Structure of dimeric, trimeric, and tetrameric procyanidins from areca catechu. *J. Chemi. Soci.* **32** (3), 781-783.

Ponne, C. T., Baysal, T. and Yuksel, D. (2005). Blanching leafy vegetables with electromagnetic energy. *Food Sci.* **59** (2), 1037-1045.

Potter and Norman, N. (2004). "Food Science". Vol. 2. CBI Publishers and Distributers, Inc. USA.

Rahman, M. S. and Perera, C. (2000). Drying and food preservation. *In:* "Handbook of Food Preservation" (Vol. 2nd). (M. S. Rahman, Ed.). pp. 192-194. New York. Marcel Dekker, Inc.

Rajlakshmi, R. (2000). "Applied Nutrition" (4th ed.). Oxford and IBH Publishing Company Pvt. Ltd.

Rakesh, Arya, S. S. and Moond, S. K. (2004). Processing products of aonla *Engl. J. Med.* . **7** (4), 20-23.

Ranganna, S. (2010). "Handbook of Analysis and Quality Control for Fruits and Vegetables Products" (2nd ed.). Tata McGraw-Hill Publisher Co. New Delhi.

Ranote, P. S. (2006). Value added Aonla Products. *J. Nutri.* **20** (2), 143-145.

Scartezzini, P., Antognoni, F., Raggi, M., Poli, F. and Sabbioni, C. (2006). Vitamin C content and antioxidant activity of the fruit *J. Ethnopharma.* **104**, 113–118.

Sebrell, W. H. and Harris, R. S. (2001). Normal and therapeutic nutrition. *Biochem. Med. Sci.* **46** (2), 167-173.

Seib, P. A. and Tolbert, B. M. (2005). Ascorbic Acid Chemistry, Metabolism, and Uses. *American Chemi. Soci.* **200**, 453-455.

Shah, D. H. (1978). "Chemical composition of Amla. ". Research Bulletin of FoodAgr. and irrigation Ministry food research section, HMG. kathmandu.

Shakir, I., Qazi, M. R., Zeb, A. and Hussain, I. (2008). Physio-chemical analysis of apple and pear mixed fruit jam *J. Nutri.* **17** (1), 177-180.

Siddappa, G. S., Giridharilal and Tandon, G. L. (1986). "Preservation of Fruits and Vegetables". Indian Council of Agricultural Research. New Delhi.

Singh, A. (2003). "Fruits Physiology and Production" (5th ed.). Kalyani Publisher. New Delhi, Ludhiyana.

Singh , A. and Kumar, P. S. (2000). "Fruits Physiology and Production". Kalyani Publisher. New Delhi.

Srivastava, R. P. and Kumar, S. (2007). "Friut and Vegetables Preservation" (3rd ed.). International Book Distributing Company. Lucknow.

Stevens, M. A. (2008). Varietal influence on nutritional value. *In:* "Nutritional Qualities of Fresh Fruits and Vegetables". (P. L. White and N. Selvey, Eds.). pp. 87-110. New York.

Suman, A. B. (2009). Study on kinetic thermal degradation of ascorbic acid *amla (Phylanthus emblica L.).* B.Tech. (Food) Dissertation. Tribhuvan Univ., Central Campus of Technology, Dharan, Nepal.

Swaminathan, M. (1997). "Essentials of Food and Nutrition". Vol. 1. Banglore Printing and Publishing Company Ltd. Banglore

Thakur, R. S., Puri, H. S. and Husain, A. (2002). Major herbs of ayurveda. *Cou. Sci. Ind. Res.* **42** (3), 162-167.

Tomotani, E. J. and Vitolo, M. (2010). Inverted sugar syrup attained from sucrose hydrolysis using a membrane reactor. *Brazilian J. Pharma. Sci.* **46** (3), 167-170.

Torres, A. and Karel, M. (2007). Microbial stabilization of intermediate moisture food surfaces. *J. Food Proc. Preserv.*

Tressler, D. K. and Woodroof, J. G. (2001). "Food Products Formulatory". Vol. 3. The AVI Publishing Company, INC Westport Connecticut.

Udupa, K. N. (2003). Ayurveda for promotion of health. *J. Ayurveda*. **32** (3), 123-127.

Vora, P., Senecal, A. and Schaffnar, D. W. (2003). Survival of Staphylococcus aureus in intermediate moisture food is highly variable *Biochem. Mol. Biol.* **23** (1), 229-236.

Wang, W. and Sastry, S. K. (2000). Effects of Thermal and Electro-thermal pre-treatments on Hot air drying rate of vegetable tissue. *J. Food Eng.* **50** (23), 299–319.

Welch, R. W., Wang, Y. H., Crossman, A., Park, J. B., Kirk, K. L. and Levine, M. (2007). Accumulation of vitamin C (ascorbate) and its oxidized metabolite dehydroascorbic acid occurs by sperate mechanisms. *J. Biochem. Mol. Biol.* **270**, 12584-12592.

Wills, R. B. H., Wimalasiri, P. and Greenfield, H. (2003). Dehydroascorbic acid levels in fresh fruit and vegetables in relation to total vitamin C activity. *J. Agric. Food Chem.* **32**, 836-838.

Woods, H. F. (2001). The Addition of micronutrients to food. *In:* "Food and Nutritional Supplements". (J. Ransley and J. Donnelly, Eds.). pp. 111-118. New York.

Zhang , L. Z., Zhao, W. H., Guo, Y. J., Tu, G. Z., Lin, S. and Xin, L. G. (2003). Studies on chemical constituents in fruits of tibetan medicine *Phyllanthus emblica*. *J. Nat. Pod.* **28** (10), 940-943.

Appendices

Appendix A

Sensory evaluation card

Name of Panelist: ……. Date: ……

Name of the product: *Amla* preserve

Dear Panelist, you are given two sample of *amla* preserve, please conduct the sensory analysis based on the following parameter using the table given

Like Extremely	9	Dislike Slightly	4
Like Very much	8	Dislike Moderately	3
Like Moderately	7	Dislike very much	2
Like Slightly	6	Dislike Extremely	1
Neither like nor dislike	5		

Sample	Color	taste	texture	Overall Acceptance
A				
B				

Comment (if any)

……..……

…….....

…….....

Signature

Appendix B

Change in TSS, Total sugar, reducing sugar and ascorbic acid content of *amla* preserve

Sample A

Day	˚Brix	˚Brix of syrup	Total Sugar%	Reducing Sugar%	Ascorbic acid (mg/100g)
			3.54	2.95	285.6
1	50	38	29.16	8.44	264.5
2	50	48	41.20	14.36	250.13
3	60	57.5	49.500	23.32	235.33
4	65	63.5	59.42	27.2	221.3
5	70	69	68.86	32	201
6	75	74	72.5	34.4	185.5

Sample B

Day	˚Brix	˚Bx of syrup	Total Sugar%	Reducing Sugar%	Ascorbic acid (mg/100g)
0			3.54	2.95	340
1	50	36.5	26.43	7.14	295.8
2	50	46	33.62	13.36	270.64
3	60	55.5	42.00	21.68	251.5
4	65	61	54.84	24.57	243.16
5	70	67.5	65.43	29	236.13
6	75	72	70.130	33.6	193.6

Appendix C

Cost calculation of *amla* preserve

Cost of the product was calculated with considering only the cost of preserve making ingredients with 10% overhead cost.

	Quantity	Rate(NRs.)	Quantity used	Rate (NRs.)
Amla	1kg	40	2kg	80
NaCl	1kg	25	0.12kg	3
Citric acid	0.5kg	375	0.003g	2.25
Sucrose	1kg	90	3kg	270
Subtotal				355.25
Overhead cost(10%)				35.525
Total cost				390.775
			5.123kg	69.34 ≈ 70/kg

Appendix D

One way ANOVA (no blocking) table for ascorbic acid of pretreatment process of *amla*.

Table D 1 One way ANOVA (no blocking) for ascorbic acid

Variate: Blanched

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Time	4	1.820E+05	4.551E+04	5.256E+05	<.001
Residual	10	8.658E-01	8.658E-02		
Total	14	1.820E+05			

Since F pr. <0.05, ascorbic acid is significantly different in each time period and LSD value was calculated to be 0.5353.

Table D 2 One way ANOVA (no blocking) for ascorbic acid

Variate: Unblanched

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Time	4	2.175E+05	5.438E+04	3.813E+05	<.001
Residual	10	1.426E+00	1.426E-01		
Total	14	2.175E+05			

Since F pr. <0.05, ascorbic acid is significantly different in each time period and LSD value was calculated to be 0.6870.

Table D 3 One way ANOVA (no blocking) for ascorbic acid in 0^{th} hour

Variate: 0^{th} hour

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Sample	1	6997.3350	6997.3350	23784.28	<.001
Residual	4	1.1768	0.2942		
Total	5	6998.5118			

Since F pr. <0.05, ascorbic acid is significantly different in 0^{th} hour. LSD at 0.05=1.230

Table D 4 One way ANOVA (no blocking) for ascorbic acid in 6^{th} hour

Variate: 6^{th} hour

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Sample	1	2519.0406	2519.0406	22116.25	<.001
Residual	4	0.4556	0.1139		
Total	5	2519.4962			

Since F pr. <0.05, ascorbic acid is significantly different in 6^{th} hour and LSD at 0.05=0.765

Table D 5 One way ANOVA (no blocking) for ascorbic acid in 12^{th} hour

Variate: 12^{th} hour

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Sample	1	4439.04000	4439.04000	2.882E+05	<.001
Residual	4	0.06160	0.01540		
Total	5	4439.10160			

Since F pr. <0.05, ascorbic acid is significantly different in 12^{th} hour and LSD at 0.05=0.2813.

Table D 6 One way ANOVA (no blocking) for ascorbic acid in 18th hour

Variate: 18th hour

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Sample	1	2496.96000	2496.96000	31627.11	<.001
Residual	4	0.31580	0.07895		
Total	5	2497.27580			

Since F pr. <0.05, ascorbic acid is significantly different in 18th hour at LSD at 0.05=0.637

Table D 7 One way ANOVA (no blocking) for ascorbic acid in 24th hour

Variate: 24th hour

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Sample	1	1270.21500	1270.21500	18004.46	<.001
Residual	4	0.28220	0.07055		
Total	5	1270.49720			

Since F pr. <0.05, ascorbic acid is significantly different in 24th hour at LSD at 0.05=0.602

Appendix E

Table E 1 One way ANOVA (no blocking) table for sensory analysis (bitterness) of pretreatment.

Variate: Blanched

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Time	4	58.5600	14.6400	61.00	<.001
Panelists	4	0.5600	0.1400	0.58	0.679
Residual	16	3.8400	0.2400		
Total	24	62.9600			

Since F pr. <0.05, sensory analysis (bitterness) is significantly different in each time period and LSD at 0.05= 0.6568

Table E 2 One way ANOVA (no blocking) table for sensory analysis (bitterness) of pretreatment.

Variate: Un-blanched

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Time	4	48.5600	12.1400	38.54	<.001
Panelists	4	0.5600	0.1400	0.44	0.775
Residual	16	5.0400	0.3150		
Total	24	54.1600			

Since F pr. <0.05, sensory analysis (bitterness) is significantly different in each time period and LSD value at 0.05=0.776.

Appendix F

Two way ANOVA (no blocking) table for different sensory attributes of *amla* preserve.

1. Color

Table F 1 Two way ANOVA (no blocking) for color

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Sample	1	2.6667	2.6667	12.57	0.005
Panelists	11	2.3333	0.2121	1.00	0.500
Residual	11	2.3333	0.2121		
Total	23	7.3333			

Since, Fpr<0.05, there is significant difference between the samples. LSD at 0.05=0.4138

2. Taste

Table F 2. Two way ANOVA (no blocking) for taste

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Sample	1	6.0000	6.0000	22.00	<.001
Panelists	11	2.3333	0.2121	0.78	0.658
Residual	11	3.0000	0.2727		
Total	23	11.3333			

Since, Fpr<0.05, there is significant difference between the samples. LSD at 0.05=0.469

3. Texture

Table F 3. Two way ANOVA (no blocking) for texture

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Sample	1	2.6667	2.6667	12.57	0.005
Panelists	11	2.8333	0.2576	1.21	0.377
Residual	11	2.3333	0.2121		
Total	23	7.8333			

Since, Fpr<0.05, there is significant difference between the samples. LSD at 0.05=0.4138

4. Overall acceptibility

Table F 4. Two way ANOVA (no blocking) for overall acceptability

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Sample	1	5.0417	5.0417	16.04	0.002
Panelists	11	3.4583	0.3144	1.00	0.500
Residual	11	3.4583	0.3144		
Total	23	11.9583			

Since, Fpr<0.05, there is significant difference between the samples. LSD at 0.05=0.504

Appendix G

One way ANOVA (no blocking) table for total sugar of *amla* preserve

Table G 1 One way ANOVA (no blocking) for total sugar

Variate: Blanched

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Days	5	4175.0400	835.0080	6772.17	<.001
Residual	12	1.4796	0.1233		
Total	17	4176.5196			

Since F pr. <0.05, total sugar is significantly different in each day. LSD at 0.05= 0.6247

Table G 2 One way ANOVA (no blocking) for total sugar

Variate: Un-Blanched

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Days	5	4635.2288	927.0458	4381.12	<.001
Residual	12	2.5392	0.2116		
Total	17	4637.7680			

Since F pr. <0.05, total sugar is significantly different in each day. LSD at 0.05= 0.818

Table G 3 One way ANOVA (no blocking) for total sugar in 1day

Variate: 1 day

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Sample	1	11.17935	11.17935	173.46	<.001
Residual	4	0.25780	0.06445		
Total	5	11.43715			

Since F pr. <0.05, total sugar is significantly different in 1day at LSD at 0.05=0.575

Table G 4 One way ANOVA (no blocking) for total sugar in 2days

Variate: 2 days

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Sample	1	86.1846	86.1846	572.46	<.001
Residual	4	0.6022	0.1505		
Total	5	86.7868			

Since F pr. <0.05, total sugar is significantly different in 2days at LSD at 0.05= 0.880

Table G 5 One way ANOVA (no blocking) for total sugar in 3days

Variate: 3 days

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Sample	1	84.37500	84.37500	6070.14	<.001
Residual	4	0.05560	0.01390		
Total	5	84.43060			

Since F pr. <0.05, total sugar is significantly different in 3days at LSD at 0.05= 0.2673

Table G 6 One way ANOVA (no blocking) for total sugar in 4days

Variate: 4 days

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Sample	1	31.4646	31.4646	67.76	0.001
Residual	4	1.8574	0.4644		
Total	5	33.3220			

Since F pr. <0.05, total sugar is significantly different in 4days at LSD at 0.05= 1.545

Table G 7 One way ANOVA (no blocking) for total sugar in 5days

Variate: 5days

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Sample	1	17.6473	17.6473	68.41	0.001
Residual	4	1.0318	0.2580		
Total	5	18.6791			

Since F pr. <0.05, total sugar is significantly different in 5days at LSD at 0.05= 1.151

Table G 8 One way ANOVA (no blocking) for total sugar in 6days

Variate: 6days

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Sample	1	8.42535	8.42535	157.48	<.001
Residual	4	0.21400	0.05350		
Total	5	8.63935			

Since F pr. <0.05, total sugar is significantly different in 6days at LSD at 0.05= 0.5243

Appendix H

One way ANOVA (no blocking) for reducing sugar of *amla* preserve

Table H 1 One way ANOVA (no blocking) for reducing sugar

Variate: Blanched

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Days	5	1544.5576	308.9115	3048.97	<.001
Residual	12	1.2158	0.1013		
Total	17	1545.7734			

Since F pr. <0.05, reducing sugar is significantly different in each day. LSD at 0.05=0.5663

Table H 2 One way ANOVA (no blocking) for reducing sugar

Variate: Un-Blanched

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Days	5	1358.17825	271.63565	4320.82	<.001
Residual	12	0.75440	0.06287		
Total	17	1358.93265			

Since F pr. <0.05, reducing sugar is significantly different in each day. LSD at 0.05= 0.4461

Table H 3 One way ANOVA (no blocking) for reducing sugar in 1day

Variate: 1 day

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Sample	1	2.5350	2.5350	22.16	0.009
Residual	4	0.4576	0.1144		
Total	5	2.9926			

Since F pr. <0.05, reducing sugar is significantly different in 1day at LSD at 0.05= 0.2673

Table H 4 One way ANOVA (no blocking) for reducing sugar in 2days

Variate: 2 days

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Sample	1	1.50000	1.50000	32.72	0.005
Residual	4	0.18340	0.04585		
Total	5	1.68340			

Since F pr. <0.05, reducing sugar is significantly different in 2days at LSD at 0.05=0.4854

Table H 5 One way ANOVA (no blocking) for reducing sugar in 3days

Variate: 3 days

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Sample	1	4.03440	4.03440	51.69	0.002
Residual	4	0.31220	0.07805		
Total	5	4.34660			

Since F pr. <0.05, reducing sugar is significantly different in 3days at LSD at 0.05=0.633

Table H 6 One way ANOVA (no blocking) for reducing sugar in 4days

Variate: 4 days

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Sample	1	10.37535	10.37535	154.40	<.001
Residual	4	0.26880	0.06720		
Total	5	10.64415			

Since F pr. <0.05, reducing sugar is significantly different in 4days at LSD at 0.05=0.

Table H 7 One way ANOVA (no blocking) for reducing sugar in 5days

Variate: 5 days

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Sample	1	12.6150	12.6150	101.24	<.001
Residual	4	0.4984	0.1246		
Total	5	13.1134			

Since F pr. <0.05, reducing sugar is significantly different in 5days at LSD at 0.05=0.800

Table H 8 One way ANOVA (no blocking) for reducing sugar in 6days

Variate: 6 days

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Sample	1	7.66140	7.66140	122.68	<.001
Residual	4	0.24980	0.06245		
Total	5	7.91120			

Since F pr. <0.05, reducing sugar is significantly different in 5days at LSD at 0.05=0.566

Appendix I

One way ANOVA (no blocking) table for ascorbic acid of *amla* preserve

Table I 1 One way ANOVA (no blocking) for ascorbic acid

Variate: Blanched

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Days	5	9465.14980	1893.02996	47623.40	<.001
Residual	12	0.47700	0.03975		
Total	17	9465.62680			

Since F pr. <0.05, ascorbic acid is significantly different in each day. LSD at 0.05= 0.3547,

Table I 2 One way ANOVA (no blocking) for ascorbic acid

Variate: Un-blanched

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Days	5	2.276E+04	4.553E+03	1.123E+05	<.001
Residual	12	4.867E-01	4.056E-02		
Total	17	2.277E+04			

Since F pr. <0.05, ascorbic acid is significantly different in each day. LSD at 0.05= 0.3583.

Table I 3 One way ANOVA (no blocking) for ascorbic acid in 1day

Variate: 1day

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Sample	1	1469.53500	1469.53500	17237.95	<.001
Residual	4	0.34100	0.08525		
Total	5	1469.87600			

Since F pr. <0.05, ascorbic acid is significantly different in 1day at LSD at 0.05=0.662

Table I 4 One way ANOVA (no blocking) for reducing sugar in 2days

Variate: 2days

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Sample	1	3.98535	3.98535	70.41	0.001
Residual	4	0.22640	0.05660		
Total	5	4.21175			

Since F pr. <0.05, ascorbic acid is significantly different in 2days at LSD 0.05=0.5393

Table I 5 One way ANOVA (no blocking) for reducing sugar in 3days

Variate: 3days

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Sample	1	90.326400	90.326400	29137.55	<.001
Residual	4	0.012400	0.003100		
Total	5	90.338800			

Since F pr. <0.05, ascorbic acid is significantly different in 3days at LSD 0.05=0.1262

Table I 6 One way ANOVA (no blocking) for reducing sugar in 4days

Variate: 4 days

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Sample	1	329.893350	329.893350	2.275E+05	<.001
Residual	4	0.005800	0.001450		
Total	5	329.899150			

Since F pr. <0.05, ascorbic acid is significantly different in 4days at LSD at 0.05=0.0863

Table I 7 One way ANOVA (no blocking) for reducing sugar in 5days

Variate: 5 days

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Sample	1	4.521E+02	4.521E+02	6.955E+05	<.001
Residual	4	2.600E-03	6.500E-04		
Total	5	4.521E+02			

Since F pr. <0.05, ascorbic acid is significantly different in 5days at LSD at 0.05= 0.0578

Table I 8 One way ANOVA (no blocking) for reducing sugar in 6days

Variate: 6 days

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Sample	1	98.33402	98.33402	1047.59	<.001
Residual	4	0.37547	0.09387		
Total	5	98.70948			

Since F pr. <0.05, ascorbic acid is significantly different in 6days at LSD at 0.05= 0.695

Appendix J

One way ANOVA (no blocking) of final *amla* preserve samples

Table J 1 One way ANOVA (no blocking) for moisture content

Variate: Moisture content

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Sample	1	1.804017	1.804017	268.59	<.001
Residual	4	0.026867	0.006717		
Total	5	1.830883			

Since F pr. <0.05, moisture content is significantly different in final samples at LSD at 0.05=0.1858

Table J 2 One way ANOVA (no blocking) for pH

Variate: pH

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Sample	1	0.02940	0.02940	2.46	0.192
Residual	4	0.04780	0.01195		
Total	5	0.07720			

Since F pr. <0.05, pH is not significantly different in final samples. So LSD testing is not necessary.

Table J 3 One way ANOVA (no blocking) for Total sugar

Variate: Total sugar

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Sample	1	8.42535	8.42535	157.48	<.001
Residual	4	0.21400	0.05350		
Total	5	8.63935			

Since F pr. <0.05 total sugar is significantly different in final samples at LSD at 0.05=0.5243

Table J 4 One way ANOVA (no blocking) for ascorbic acid

Variate: Ascorbic acid

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Sample	1	98.33402	98.33402	1047.59	<.001
Residual	4	0.37547	0.09387		
Total	5	98.70948			

Since F pr. <0.05 total sugar is significantly different in final samples at LSD at 0.05=0.695

Table J 5 One way ANOVA (no blocking) for reducing sugar

Variate: Reducing sugar

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Sample	1	7.66140	7.66140	122.68	<.001
Residual	4	0.24980	0.06245		
Total	5	7.91120			

Since, F pr<0.05 reducing sugar is significantly different in final samples at LSD at 0.05=0.566

Appendix K

Plate

Blanched sample

Un-blanched sample

Plate.1 Sensory analysis *amla* preserve