Studies on Osmotic Dehydration of Nepali hog plum (Lapsi) *Choerospondias axillaris*

Dissertation Report

DEPARTMENT OF FOOD TECHNOLOGY AND NUTRITION

SCHOOL OF AGRICULTURE

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CERTIFICATE

This is to certify that Ojasweta Lama (Registration no. 11706573) has personally completed M.Sc. Dissertation-1 entitled "Studies on Osmotic Dehydration of Nepali hog plum (Lapsi) *Choerospondias axillaris*" under my guidance and supervision. To the best of my knowledge, the present work is the result of her original investigation and study. No part of pre-dissertation has ever been submitted for any other purpose at any University. The project report is appropriate for the submission and the partial fulfilment of the conditions for the evaluation leading to the award of Master of Food Technology.

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Chapter 1- Introduction

Lapsi (Choerospondias axillaris) is a giant, wild, broad leaf, edible indigenous local fruit tree of the family Anacardiacea with multiple benefits. Resident to Nepal hills (850-1900 m asl), the tree has also been surveyed from India, China, Thailand, Japan and Vietnam. Fruits are rich in essential amino acids, especially arginine (106mg/100gm), glutamic acid (36mg/100gm), glutamine (32mg/100gm); vitamin C and minerals such as potassium (355mg/100gm), calcium (57mg/100gm) and magnesium (34mg/100gm) Paudel et al., (2002) and are imbibed fresh, pickled and processed for preparing a kinds of sweet and sour, delicious food products locally called as “Mada” and “candy”. The candy products are generally made from the mesocarp of ripe fruits and are famous among women, children, trekkers and tourists in Nepal. Lapsi wood is utilized as light construction timber and fuel wood; seed stones are used as fuel in brick kilns and the bark has a medicinal value Nguyen et al., (1996). Fruit products are currently eaten usually inside the country but have prospective for international market advancement.

The tree has been considered as suitable crop for multiple use in mountain farms and the Nepalese government has emphasized the production and processing of such high value agroforestry products APP, (1995). The tree is dioecious but it is difficult to distinguish male and female plants at the seedling stage Agarwal et al., (1991, 1992).

TABLE 1: Classification of lapsi used by farmers Poudel, (2003)

Criteria	Type
Fruit size: small and large	Sano and thulo lapsi
Fruit maturity: early and late	Aghaute and pachaute lapsi
Taste of fruit: sweet and sour	Guliyo and amilo lapsi
Pulp content: high and low	Bose and hade lapsi

TABLE 2: Morphological differences between bearing and non-bearing tress Poudel, (2003)

Criteria	Female lapsi	Male lapsi
Lea emergence	Later	Earlier
New leaf colour	Yellowish	Purple/reddish
Leaf margin	Entire	Mostly serrated
Colour of latex	Milky, thick	Watery, thin

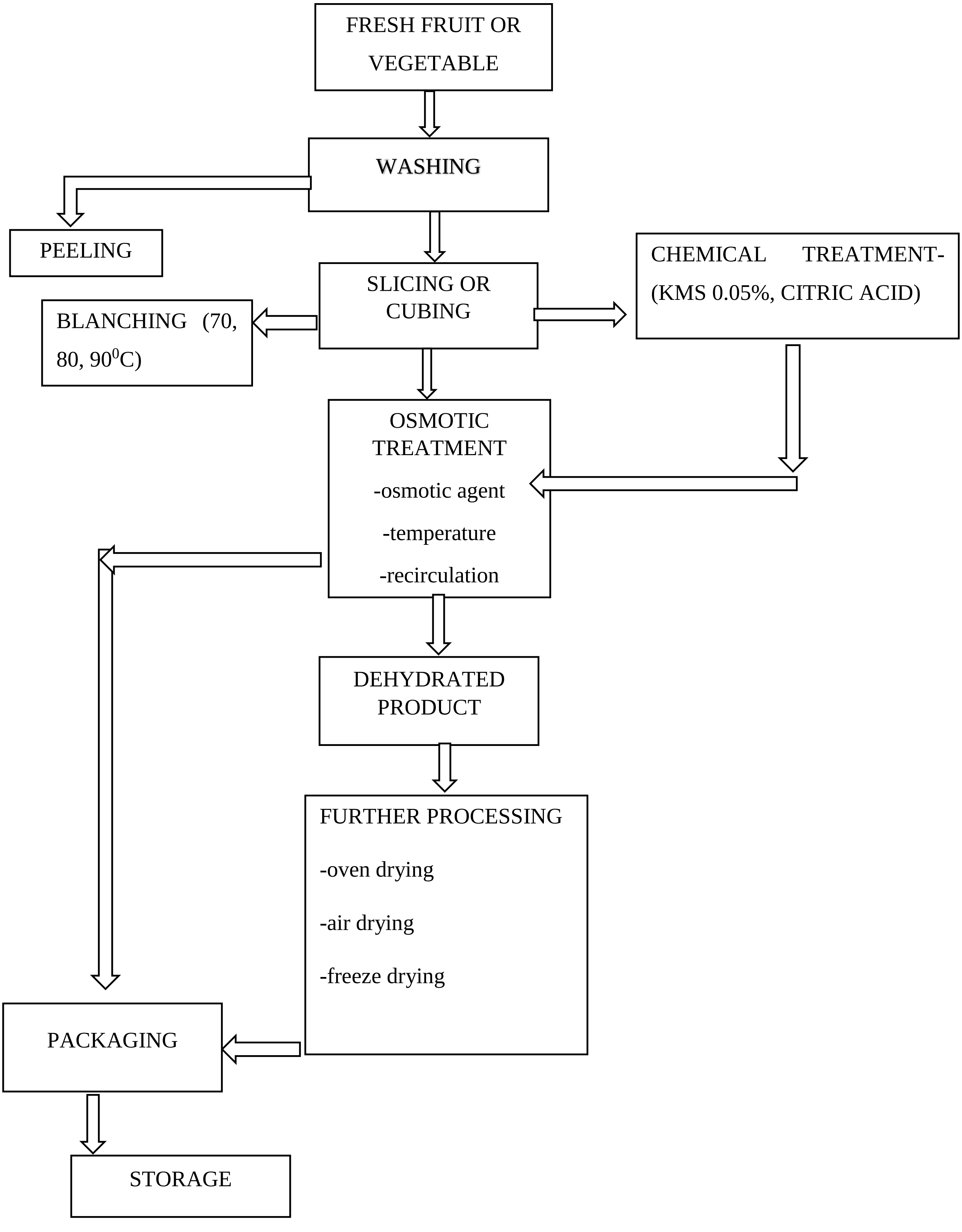
OSMOTIC DEHYDRATION

There is ever growing customer need for products with a comparatively long life span, which preserve the attributes of fresh products. In the case of fruit, to obtain a fresh like product implies certain operations such as peeling, cutting and packaging in a syrup or often, partial dehydration of the product. In this case osmotic dehydration has been the main effective method of dehydration Talens et al., (2000) with some advantages over other methods of drying but it also brings some problems.

Osmotic dehydration is the process of removal of water by immersion of water containing cellular solids (fruit/vegetables) in a concentrated aqueous solution of sugar/salt. This results in intermediate moisture product with lower water activity. At low water activity, most of the chemical reactions which deteriorate the food, the growth and toxins production by microorganisms are ceased. Besides, it improves the colour, flavour, texture and is less energy intensive process compared air or vacuum drying process as no phase change takes place during the moisture removal from the substrate Islam and Flink, 1982; Karthanos et al., 1995; Erketin et al., 1996; Pokharkar, (2001).

Osmotic dehydration can remove 30 to 40% moisture from the product. The amount of water loss taking place during initial period is high and as dehydration period increases, the rate of water loss decreases and rate of solute gain increases Erketin and Cakaloz, (1996). Also for removing 30-40% moisture, it takes a lot of time ranging from 3h to 3 days for osmotic dehydration of fruits and vegetables Islam and Flink, (1982); Grabowski et al., (1994); Welti et al., (1995); Erketin and Cakaloz, 1996; Sugar, (2001).

Osmotic dehydration has received considerable attention in recent years due to the use of moderate operating temperature, low energy process, reduced loss of volatile compounds and better quality of the final product.



FLOW CHART OF OSMOTIC DEHYDRATION IN FRUITS

Chapter 2- Review of Literature

2.1 METHODS-

Within the dehydration of osmosis, the fruit slices are dipped in a hypertonic liquid mixture involving a big quantity of osmotic force at a specific period of time and temperature. The power force for removing liquid is the concentration slope between the solution and the intracellular fluid. If the layer is finely semi-permeable, solid is not able to pass through the partition into the cells. Selective properties of cell membranes allow it to be possible for liquid and low-molecular cell sap compound to diffuse into the neighbouring solution of greater osmotic force.

Sugar syrup of 70 °Brix was found to be fruitful in carrying away moisture from giant kew, a diverse of pineapple. As stated by the sensory marks the extreme dry fruit yield, lower moisture, higher ascorbic citric acid and carotenoid content, the 60 °Brix sugar syrup with 0.2% critic acid and 700 ppm KMS (Potassium metabisulphite) was excellent for osmotic dehydration for the period of 24 h. The studies were conducted initial and following storage of about 6 month at optimum conditions Rashmi et al., (2005). Osmotic dehydration of pomegranate seed was moved out at various temperature (30, 40 and 50 °C) in 50 °Brix sucrose, glucose and mixture of two in 50:50. After 20 min of dewatering water loss was obtained as 46% in sucrose, 37% in glucose and 41% in mixture solution. Temperature increases the water loss. Ratio of frozen and unfrozen water decreased from 5 to 0.5%. It was also found that glass transition temperature was dependent on type of the sugar (Bchir et al., 2009).

2.2 TREATMENTS-

Different pretreatment procedures used for osmotic dehydration of fruits had been determined. Mechanical, chemical and osmotic dehydration were conducted. In mechanical pretreatment the fruits were cut into halves and quarters. In chemical pretreatment the only difference was in temperature of chemical agent and dipping time of fruits, while in osmotic dehydration varieties of osmotic agent in different concentration were used along with varying osmotic dehydration time. On the basis of results according to mass gain, solid gain and moisture, it was stated that quarter halves gave the best marks and time and concentration of osmotic agent remarkably promote the result but however different chemical treatment showed no difference in product quality Sunjka and Raghavan, (2004).

2.3 MATHEMATICAL MODELLING AND MASS TRANSFER-

In osmotic dehydration operation, there is an occurring counter current mass transfer of water from solution to hypertonic solution and of solid from solution into the specimen. Soluble solids of the specimen such as organic acids, minerals and vitamins also enter relatively in the small quantities from specimen to solution Chaudhari et al., (1993). Fundamental aspects of mass transfer in a cell and in aggregate cell has been given in detail by Le Maguer (1988).Mathematical modelling is required for describing mass transfer in the osmotic dehydration procedure.

a. Estimation of water loss and solid gain as a purpose of time, temperature and initial concentration of the medium.
b. Based on cellular structure according to non-reversible thermodynamics principles.
c. Prediction of balance moisture loss and solid gain on the basis of short period data.
d. Pressure gradient dependent modelling accounting the capillary and external pressure effects (Hydrodynamic mechanism).

Soluble solids of the specimen such as organic acids, minerals and vitamins also enter relatively in the small quantities from specimen to solution Chaudhary et al., (1993).In osmotic dehydration operation the most important parameter is dispersing coefficient of liquid and solid. Extent of water loss and solid gain was studied. In 60% (w/w) sucrose solution the equilibrium water amount ranged from 34 to 36% and it was not established to be dependent on temperature. As the temperature rose from 30 to 50 °C, the equilibrium sugar content increased from 45 to 54%, the shrinkage in the thickness was established independent on temperature and dependent only on water content Ramallo et al., (2004).

Ferrari and Hubinger, (2008) studied on the mass transfer kinetics and mechanical properties of osmodehydrated melon cubes. Samples were immersed in a hypertonic solution of sucrose or maltose up to 8 h under controlled temperature and agitation. Water loss, sugar gain and mechanical properties were analyzed throughout the procedure. Mass transfer kinetics was modelled as stated to the Peleg equation. Greater water removal, lower sugar imbibing and stress at rupture values more similar to fresh fruit were observed in specimen treated with maltose solutions. Peleg's model exhibit the excellent adjustment to all the experimental data.

Optimization process of osmosis of Banana followed by air drying was studied by (Oliveira et al., 2006). Since banana is a highly perishable fruit and cannot withstand at freezing also, so there must be some alternative to preserve banana. After optimization it was establish that moderate to high sucrose concentration (55–65 °B) osmotic reagent at reduced pressure could be used as osmotic treatment for banana that reduces processing time.

Pomegranate seeds were osmo dehydrated utilizing date juice with 55 °Brix sucrose. The kinetics of osmotic dehydration displayed that mass transfer occurred significantly at a particular course of first 20 min of the action. Throughout the action water loss and solid gain was developed around 39 and 6% respectively. Scanning electron microscopy revealed texture enhancement by the procedure. Pure sugar available in the date juice allows in replacing the 35% sucrose amount of the osmotic solution Bchir et al., (2010). The drying of pomegranate seeds was looked over at 40, 50 and 60 °C with air velocity 2 m/s. earlier to drying seeds were osmo dehydrated in 55 °Brix sucrose solution for 20 min at 50 °C. Drying kinetics, antioxidant, total phenolic, color and texture were fixed by Bchir et al., (2010). The outcomes presented that 40 °C is the best temperature on which less effect on the quality of seed was establish.

2.4 PROCESS OPTIMIZATION-

Fernandez et al., (2006) studied the optimization of osmotic dehydration of Papaya followed by air drying. They put the data of loss of papaya fruit ranges between 10% and 40% and could be reduced by drying. The process of osmotic dehydration followed by air drying was studied and modeled for papaya preservation. An optimization was done using the model in order to search for the excellent operating condition that would reduce the processing time.

Azoubel, (2003) worked on the optimization of sucrose and osmotic dehydration of cashew Apple in two various solution of corn syrup using response exterior methodology. Three different factors were temperature (30–50 °C), sugar syrup concentration (40–60%$^{w}/_{w}$) and dipping time (90–240 min) and responses were water loss (%) and solid gain (%) studied in polynomial equation with multiple correlation coefficient ranging between 0.92 and 0.99. It was tried to obtain maximum water loss and minimum incorporation of solid so that the fruit resemble fresh. The ascorbic acid was found almost same in both various osmotic reagent solutions. Optimization of osmotic of melons followed by air drying was done. Osmotic dehydration is the best alternative to reduce the post-harvest losses of fruit. Osmotic solution to fruit weight ratio were examined of the melon sample. Models were established and data were analyzed to search the best operating condition in less time (Teles et al., 2006).

2.5 OSMOTIC AGENTS-

A number of osmotic agent can be used in osmotic dehydration either singly or in combination. The osmotic agent should also reduce water activity of a solution substantially for increasing the driving force. It has to be effective, convenient, and non-toxic and have a good taste. It should be readily dissolved to form a high concentrated solution. It shall not react with the product and has to be cheap. The concentration of osmotic agent plays an important role in osmotic dehydration. In general, extra the concentration of syrup, additional the rate of osmosis took place Chaudhary et al., (1993).

Fuji variety of apples were treated in aqueous sucrose (50% w/w) and salt (NaCl, 10% w/w) solutions for 2, 4 and 8 h (27 °C). Concentration profiles were determined as a function of the distance more by osmotic solution considering unidirectional movement by Monnerat et al., (2010). The density, water, sugar and salt contents were determined for each piece of apple. Effective diffusion coefficients as a function of concentration were determined, using the material coordinate to consider tissue shrinkage. The coefficients were obtained by simultaneously integrating the three differential equations (for water, sucrose and salt). The sliced apples were also examined by light microscopy to learn the cellular behavior.

Alves et al., (2005), investigated the osmotic dehydration of frozen mature acerolas in an incubator at temperature 25–60 °C and constant agitation. They performed an experiment in which acerolas were blanched in water (80 °C for 3 min) and dehydrated using binary (water + sucrose) and triple (water + sucrose + salt) solutions. The concentration of sucrose were varied from 30% to 60% (w/w) in binary solution and from 20% to 50% (w/w) in triple solution with 10% (w/w) salt. Various variables viz. water loss, solid gain, solid gain/water loss ratio and water reduction were evaluated. The excellent marks were establish at 60 °C for two solutions but 60% (w/w) sucrose in binary solution and 50% (w/w) sucrose with 10% (w/w) salt in triple mixture provides optimum result.

2.6 EFFECTS ON THE PARAMETERS OF OSMOTIC DEHYDRATION

Process Temperature- Temperature of osmotic solution plays a major role in osmotic dehydration operation. The impact of temperature is more pronounced between 30 to 60^0 C for fruits and vegetables on the kinetic rate of moisture loss without affecting solid gain Pokharkar, (2001).

Agitation/Circulation- The osmotic dehydration is faster in fruits, when syrup is agitated/circulated. This is because of reduced mass transfer resistance at the surface, in other words, localized dilution which affects the water removal rate is avoided. However, agitation may be difficult and may cause damage to the sample. The circulation of syrup with centrifugal pump is simple and quite effective. It has also been discovered advantageous in case of apple that little sugar uptake took place when the syrup was circulated and pieces were kept stationary. Sugar uptake was rapid, reaching the maximum level after half an hour of treatment at which it remained constant Karel, (1976).

Solution to sample ratio- The sample weight to solution ratio is an important consideration during the osmosis. The change in ratio affects the mass transfer during osmosis up to a certain limit. Most of research workers used the sample to solution ratio ranging from 1:1 to 1:5 in order to study the mass transfer kinetics by subsequent changes in concentration of solution and other factors Pokharkar, (2001). According to Tiwari (2005), 1:2 or 1:3 is optimum for practical purposes.

Time Treatment- In general, as the time of treatment increases, the weight loss increases, but the rate at which it occurs decreases. Studies on the osmotic duration revealed that the mass exchange takes place within the first two hours of the osmotic treatment. Tiwari and Jalali (2004) reported that during osmotic dehydration of mango and pineapple increase in osmotic duration resulted in increased in weight loss but the rate at which it occurs decreases. The treatment time can be selected in such a way that the amount of water removal is maximum with no appreciable uptake of solids. At this point, the rate of moisture removal is much less as compared to the rate of solid uptake Chaudhary et al., (1993). Gaspartero et al., (2003) and Mauro et al., (2004) that when banana and apple slices dipped in 70 and 50^{0}Brix, osmotic solution temperature of 50^{0}C for 3 hours immersion time gave optimum water loss and sugar gain.

Size and shape of the sample- The kinetics of osmotic dehydration is affected by the size and shape of the samples, due to different specific surface area or surface to thickness ratio. Also different forms of samples are selected on the basis of end use of product after further processing Ghosh et al., (2004).

2.7 PACKAGING AND STORAGE

A storage experiment study using different kinds of packaging materials and determining which one is suitable in providing passive atmospheric modification.

Impact of modified atmosphere packaging on the osmodehydrated papaya stability were studied by Rodrigues et al., (2006). Papaya pieces were osmotically dehydrated in a 50°Brix sucrose solution containing calcium lactate (0.05 M) and lactic acid (0.02 M) as additives for 1 h at 25 C, packed in polyethylene terephthalate (PET) containers and stored at 5 C for 15 days. Fresh fruit pieces packed in PET containers and under atmosphere condition were used as control samples. Sensory acceptance, nutritional quality, microbial count and weight loss of the product were evaluated. There results showed that PET containers prevented weight loss during storage. The utilization of calcium lactate as additive was effective in maintaining fruit hardness during refrigerated storage.

Chapter 3- Problem Background of Lapsi

Current production and supply of lapsi fruit do not meet the market demand for quality products on the one hand and the production from remote areas has not been able to fill this gap on the other. Lapsi is a wild fruit but a perishable one, there are not many researches, experiments, techniques conducted for this fruit. One of the major problem is due to lack of knowledge about the benefits, importance in lapsi fruit. It is indigenous fruit of multiple benefits. Fruits of C. axillaries have been reported to possess several properties for treatment of myocardial ischemia, calming nerves, ameliorating blood circulation and improving microcirculation in Mongolia. Phenolic and flavonoid compounds, rich in antioxidants are responsible for the effect of fruit of C. axillaries. Epidemiological studies have shown that administration of antioxidants may decrease the probability of cardiovascular diseases. Some researchers have found that flavonoids content of C. axillaries could inhibit dexamethasone-induced thymocyte apoptosis Li et al., (1998). Recently, Ao et al., (2007) have reported that flavonoids content of C. axillaries could attenuate the serum levels of CK, CK-MB and LDH in isoproterenol-induced MI injury in rats. In light of the previous findings, Chunmei et al., (2013) hypothesized that TFC can inhibit oxidative damage and cardiomyocyte apoptosis associated with AMI.

Due to these beneficial properties of Lapsi we need to combine the knowledge with scientific methods for making a better opportunities of Lapsi products in market. Lapsi is rich in essential amino acids, minerals and vitamin C. It has a tart flavour and has nutritional benefits, therefore study and research methods to enhance the quality of lapsi, increase shelf-life and make better use of the fruit.

CHAPTER 4- PROPOSED RESEARCH METHODOLOGY

3.1 The present study is undertaken with following objectives:

1. To study the osmotic dehydration kinetics of Lapsi in osmolyte solution.
2. To study the convective dehydration kinetics of un-osmosed and osmosed Lapsi
3. To study the effect of packaging on quality and shelf life of osmo air dried Lapsi.

3.11 Osmotic dehydration kinetics Lapsi in sucrose solution.

Osmotic dehydration to be carried at different temperature, concentration of sucrose solution.

Temperature- 30, 40, 50^0 C.

Sugar Concentration- 30, 40, 50^0 Brix.

Syrup/fruit ratio- 5:1, 10:1, 15:1, 20:1 (v/v)

Time interval for every 15, 30, 45, 60, 75, 90, 120, 150, 180 and 240 min.

PROCEDURE OF OSMOTIC DEHYDRATION KINETICS OF LAPSI

- ✓ Washing, peeling, de-seeding, and cutting it i. Sample blotting with tissue paper to remove adhering surface water and weighing
- ✓ Preparing sugar solution by dissolving appropriate amount of 30, 40 and 50g of sugar per 100g of solution. Osmotic process to be carried out in different sucrose concentrations (30-50^0 C)
- ✓ Solution temperatures (30-50°C) with agitation of 90 rpm. Placing the sample in 250 ml beakers containing the osmotic solution and maintaining inside a temperature-controlled bath.
- ✓ Mass ratio of osmotic medium to fruit sample to be kept at (5:1, 10:1, 15:1, 20:1). Sample has to be removed from the solution at 15, 30, 45, 60, 75, 90, 120, 150, 240 min after immersion, draining the excess of solution on surface will be removed by absorbent tissue paper.
- ✓ Average moisture and dry matter content is determined by drying and dehydrating samples at 70 ^{0} C in a hot air oven. All the experiments to be done in triplicate and the average value taken or calculations.
- ✓ The resulting osmotic sample to be packed in different packaging materials and kept at ambient temperature for sensory analysis.

Water loss has been expressed as the net water loss from the freshly peeled lapsi samples after osmotic dehydration based on initial sample mass. Solid gain has been defined as the net solid uptake by the lapsi sample, based on the initial sample weight;

% Water loss (WL) = $[(W_o-W_\tau) + (S_\tau-S_o)/W_o]$ X100;

%Solute gain (SG) = $[S_\tau–S_o/W_o]$ X100

W_o is the initial weight (g) the sample, W_τ is the weight of the sample after osmotic dehydration for time in hours, S_o is the initial weight of solids (dry matter) in the sample (g) and S_τ is the weight of solids (dry matter) of sample after osmotic dehydration for t (h).

ANALYSIS- Curves of water loss and solid gain as a function of time were constructed using experimental data. Values and parameters like water loss and sugar gain weight estimated.

3.12 Convective dehydration kinetics of fresh and osmosed lapsi.

Convective dehydration of unosmosed and osmosed lapsi upto final moisture content to prepare shelf stable product at different drying temperature.

In convective dehydration the syrup should be manually stirred at regular intervals to maintain uniform temperature. The osmosed and fresh samples have to be dried in a drier at drying air temperature with air flow of velocity.

The samples to be weighed before performing the experiment and after the drying of the sample

% Water loss (WL) = $[(W_o-W_\tau) + (S_\tau-S_o)/W_o]$ X100;

%Solute gain (SG) = $[S_\tau–S_o/W_o]$ X100

W_o is the initial weight (g) the sample, W_τ is the weight of the sample after osmotic dehydration for time in hours, S_o is the initial weight of solids (dry matter) in the sample (g) and S_τ is the weight of solids (dry matter) of sample after osmotic dehydration for t (h).

Drying Rate is obtained by following procedure;

For example-

Container weight = 50 g

Container and sample weight before drying = 65 g

Wet sample weight = 15g (Calculation: 65g-50g = 15g)

Container and sample weight after drying = 62 g

Dry sample weight =12g (Calculation:62g-50 g = 12g)

Dry matter = 80% (Calculation: 12 g/15 g= 0.8 x 100 = 80%)

ANALYSIS-Moisture content %, drying rates at drying temperature.

3.13 To study the effect of packaging on quality and shelf life of osmo-air dried Lapsi

Method for osmo-air dehydration of lapsi and evaluating their quality retention in different packages during storage. Packing the osmo-air dried Lapsi in polythene pouches like high density polyethylene and low density polyethylene pouches, glass jars and laminated pouches.

ANALYSIS- Physiochemical characteristics like average fruit weight, moisture content, total sugars, titratable acidity, reducing sugars, total sugars, ascorbic acid c, estimating minerals like calcium magnesium; Microbial count. Overall appearance of the product.

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