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Study Review on Drying of Pineapple and Papaya Through Osmosis Dehydration Process

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ABSTRACT

In recent years, osmotic dehydration has emerged as a prominent technique for preserving fruits and vegetables, garnering increased attention due to its efficacy. This simple process is particularly beneficial for maintaining the original characteristics of fruits such as papaya and pineapple, including color, aroma, texture, and nutritional profile.

To prolong the shelf life of pineapples, various preservation methods have been employed. However, there's a growing demand for a cost-effective solution that preserves quality while being simple and inexpensive.

Osmo-air dehydration has emerged as a viable option, offering reduced drying costs and minimized quality losses. Moreover, it yields high reconstitution ratios upon rehydration.

For pineapple preservation, sugar syrup concentrations of 400 B resulted in a 3.54% water loss, while 300 B yielded a 2.52% water loss during osmosis. Similarly, for papaya, 400 B sugar syrup saw a 4.72% water loss, while 300 B had a 0.5% water loss during osmosis. Additionally, as sugar syrup concentration increased, there was a corresponding increase in weight reduction, from 179.88 to 182.6 g for pineapple and from 182 to 183 g for papaya.

Key words: papaya, pineapple, osmotic dehydration

CHAPTER 1 INTRODUCTION

Fruits and vegetables contribute a crucial source of nutrients in daily human diet. The world fruit production is estimated to be 434.7 million metric tons and vegetables 90.0 million metric tons. India is the second largest fruits and vegetable producer and its annual production is44 million metric tons from an area of 3,949,000 ha during 2000-2002 (**Srivastava & Kumar, 2002**). Fruits and vegetables losses in the developing countries are considerably high. In India, post-harvest losses of fruits and vegetables are estimated as more than 25 percent. Manyprocessing techniques can be employed to preserve fruits and vegetables by drying and dehydration is one of the most important operations that are widely practiced because ofconsiderable saving in packaging, storage etc. Osmotic dehydration has received greater attention in recent years as an effective method for preservation of fruits and vegetables. Being asimple process, it facilitates processing of tropical fruits and vegetables such as banana, sapota, pineapple, mango, and leafy vegetables etc. with retention of initial fruit and vegetables characteristics viz., colour, aroma and nutritional compounds (**Pokharkar & Prasad, 1998**). It is less energy intensive than air or vacuum drying processes because it can be conducted at low or ambient temperature. It has potential advantages for the processing industry to maintain the food quality and to preserve the wholesomeness of the food. It involves dehydration of fruit slices in two stages, removal of water using as an osmotic agent (osmotic concentration) and subsequent dehydration in a dryer where moisture content is further reduced to make the productshelf stable (**Ponting, 1973**). Osmotic concentration is the process of water removal from fruits and vegetables, because the cell membranes are semi-permeable and allow water to pass throughthem more rapidly than sugar. During osmosis small quantity of fruit acid is removed along withwater. It is a dynamic process, in which water and acid are removed at first and then move slowly, while sugar penetration is very slight at first but increases with the time. Therefore, the characteristics of the product can be varied by controlling temperature, sugar syrupconcentration, concentration of osmosis solution, time of osmosis etc. to make osmotic concentration process faster.

Fruits and vegetables are highly perishable, spoiled primarily due to biochemical changes (enzymatic and/or by the activity of bacteria, yeast and moulds). Microbial activities are controlled or destroyed in order to preserve the fruits and vegetables. In the tropical countries, post-harvest losses in fruits and vegetables are one of the most processing problems.

The pineapple (*Ananas comosus*) is a tropical plant with an edible multiple fruit consisting of coalesced berries, also called pineapples, and the most economically significant plant in the Bromeliaceae family. Pineapples may be cultivated from a crown cutting of the fruit, possibly flowering in 5–10 months and fruiting in the following six months. Pineapples do not ripen significantly after harvest. They are found in a wide array of cuisines.

Pineapple is the second harvest of importance after bananas, contributing to over 20 % of the world production of tropical fruits **(Coveca, 2002).** Nearly 70% of the pineapple is consumed as fresh fruit in producing countries. Its origin has been traced to Brazil and Paraguayin the Amazonic basin where the fruit was domesticated. Pineapple (Ananas comosus) is one of the commercially important fruit crops of tropical world. It is one of the choicest fruit all over the world because of its pleasant taste and flavor. Total pineapple production worldwide is around 16 to 18 million tons (**Carvalho et al., 2008; Fernandes et al., 2008**). Nearly 70% of the pineapple is consumed as fresh fruit in producing countries. Pineapple is also known as Pina,Nanas, Abacaxi and Ananas. Cultivation of pineapple originated in Brazil and gradually spread to other tropical parts of the world. Pineapple cultivation was introduced to India ON Portuguese in 1548 AD. Other leading producers are Thailand, Philippines, Brazil, China,Nigeria, Mexico, Indonesia, Colombia and USA. Today, almost a third of the world‟s production and sixty percent of canned pineapple comes from Hawaii.

The world production of pineapple shows a steady increase over the years much of the expansion of pineapple industry in the developing countries of Far East, Africa and Latin America (Burkill, 1997). India is the fifth largest producer of pineapple with an annual output of about 1.2 million tones. The major states producing pineapple are Assam, West Bengal, Kerala, Meghalaya and Karnataka. In India, Tripura is one of the largest pineapple growing states in the country and there are more than 100 pineapple orchards spread through the state. The state grows mainly two varieties of pineapples, queen and queue that are renowned world over for their flavor, aroma and sweetness with the increase in production of processed fruit products, theamount of fruit wastes generated is increasing enormously. Large amount of these wastes poses the problem of disposal without causing environmental pollution. These wastes can be effectively disposed by manufacturing useful byproducts from them. A valuable byproduct that can be obtained from pineapple peel is pectin. A research reported that postharvest losses in pineapple are 40 percent due to poor handling and indiscriminate use of growth promoting and ripening agents (Hassan, 2010). Pineapple‟s nutrients include calcium, potassium, fibred and vitamin C it is low in fat and cholesterol. Vitamin C is the body‟s primary water soluble antioxidant, against free radicals that attack and damage normal cell. It is also a good source of vitamin B1, vitamin B6, copper and dietary fiber. Ascorbic acid content in pineapple is 27.0 to 165.2 mg per 100g.

Papaya (*carica papaya*) is one of the commercially important fruit crop of tropical world. It is one of the choicest fruit all over the world because of its pleasant taste and flavour. Total papaya production worldwide is around 73.01million tonnes. The pawpaw is believed to be native to southern Mexico and neighbouring Central America. It is currently cultivated in Florida, Hawaii,Eastern British Africa, South Africa, Sri-Lanka, India, Canary Islands, Malaysia and Australia. Itis now present in every tropical and subtropical country. India is the first place in production of papaya with 54 lakh tonnes. The major states producing papaya are Andhra Pradesh, Gujarat, Karnataka, West Bengal, Madhya Pradesh and Maharashtra. In India, Andhra Pradesh is one of the largest papaya growing state in the country. Papaya, botanical name Carica papaya, is an lozenge tropical fruit, often seen in orange-red, yellow-green and yellow-orange hues, with a richorange pulp. The fruit is not just delicious and healthy, but whole plant parts, fruit, roots, bark, peel, seeds and pulp are also known to have medicinal properties. The many benefits of papaya owed due to high content of Vitamins A, B and C, proteolytic enzymes like papain and chymopapain which have antiviral, antifungal and antibacterial properties. Carica papaya can be used for treatment of a numerous diseases like warts, corns, sinuses, eczema, cutaneous tubercles, glandular tumors, blood pressure, dyspepsia, constipation, amenorrhoea, general debility, expel worms and stimulate reproductive organs and many, as a result Carica papaya can be regarded as a Neutraceutical.

To increase the shelf life of potatoes and papaya, different preservation techniques are being employed that comprise of manipulation of storage temperature and relative humidity, addition of chemical preservatives, protection against air / germ pollution through waxing, dehydration and processing into other products. However, the success of these methods depends on how it meets certain requirements of the product quality for consumption. Therefore, it is essential to preserve the tomatoes by using any of the food preservation techniques and to be made available in an acceptable form throughout the year at relatively minimum cost **(Rajkumar Perumal 2007)**.

To increase the shelf life of pineapples and papaya, different preservation techniques are beingemployed that comprise of manipulation of storage temperature and relative humidity, addition of chemical preservatives, protection against air / germ pollution through waxing, dehydration and processing into other products. However, the success of these methods depends on how it meets certain requirements of the product quality for consumption. Therefore, it is essential to preserve the pineapples on using any of the food preservation

techniques and to be made available in an acceptance form throughout the year at relatively minimum cost. The goal of food preservation is to increase the time for keeping food safe while retaining quality and nutrients. Osmo-air dehydration is a useful preservation technique for the production of safe, stable, nutritious, tasty, economical and concentrated food obtained on placing the solid food, whole or in pieces in sugar or salt aqueous solution of high osmo-airpressure. Osmo-air dehydration is a process that entails the partial removal of water of food items such as vegetables and fruits. Osmo-air dehydration works on soaking food in a higher osmo-air pressure solution sometimes referred to as a hypertonic or concentrated solution. Thewater then passes through the food into the concentrated solution under the osmo-air pressure gradient influence. This process is done because fruits and vegetables are generally 75 percent water, and as a result spoil rapidly. Osmo-air dehydration enables fruits and vegetables to be stored for a longer period of time.

1.1 Objectives of experiment

1. Evaluate the dehydration process of pineapple and papaya slices.
2. Assess the characteristics of drying for pineapple and papaya slices using osmo air dehydration compared to hot air oven drying.
3. Study the attributes of two different concentrations of syrup for the diffusion process of pineapple and

papaya.

4. CHAPTER II REVIEW OF LITERATURE

Some of the research findings of scientists on different concentrations of osmo-airsolution of different fruits and vegetables and also on drying characteristics using different drying methods and their observed values on quality analysis are presented in this chapter.

Shahab Uddin , M. et al. (1990) studied the drying behavior of osmosed and fresh pineapple, and the development of pineapple powder for use as dry food ingredient were investigated in this study. It was found that ON osmo-air dehydration alone 30-40% of the water content of pineapple could be removed in a day. The observed valuess of temperature and sample thicknesswere evaluated when drying was carried out with air under controlled conditions. A mass transfer model, based on Fick"s law of diffusion as applied to thin slab, was used to determine the observed valuesive diffusivity ON using the experimental data where the shrinkage in sample thickness due to loss of water was taken into account. A power law equation was used to correlate the shrinkage in thickness with the moisture content of the sample. The observed valuesive diffusivity was found to be in the order of 10 m^2/s. the activation energy for pineapple,which is estimated ON using Arrhenius equation, was found to be 35.5 kJ/mol. For the production of pineapple powder, hygroscopicity and caking are considered to be the main problems. Chemical treatment with magnesium stearate was found useful at a concentration of 1% ON weight.

Choudari et al. (1993) studied the osmo-air dehydration of fruits and vegetables. The principle used in this process is that water diffuses from dilute solution to concentrated solution through semi-permeable membrane until equilibrium is reached. The driving force is the water activity gradient caused due to osmo-air pressure. This technique can be used to remove water from cellular materials such as fruits and vegetables. The cell membrane of these fruits is semi- permeable in nature and is more selective for water and acid than solute.

xpedito, **T.F. et al. (1996)** was studied the osmo-air dehydration as an intermediate step in air orvacuum drying of pineapple. Osmo-air dehydration kinetics indicated that both water loss and solids gain increased with increase of syrup temperatures and concentration, the former having much more observed values for the range of values tested. Equilibrium kinetics was modeledON defining equilibrium constants and in non-equilibrium period water loss and solid gain followed the penetration theory of mass transfer. The color, flavor and texture of osmo-air dried pineapple indicated that the product was organoleptically acceptable.

Kara *et.al* (2001) studied osmotic dehydration of banana slices at five levels of temperature (25,35, 55 and 65°C) and concentration of sugar gain solution at 40, 50, 60, 70, and 80°B. The moisture loss and sugar gain were characterized at one hour integral for 4 hours. The study indicated that about 16% of moisture could be removed from slices after 1 h of osmosis at a sugar concentration of 70°C B and temperature of 50°C with 5% initial solids as sugar gain.

Kar et al. (2001) studied on osmo-air dehydration of banana pieces. It was studied at five levels each of temperatures 25□C, 35□C, 45□C, 55□C and 65□C solution to sample ratio 1, 3, 5, 7and 9; concentration of sugar solution 40, 50, 60, 70 and 80□ B. Response surface methodology was used to optimize the osmo-air dehydration with special reference to maximum moisture removal and minimum solid gain. The study indicated that about 16% of initial moisture could be removed from the banana pieces after one hour of osmosis at a sugar concentration 70□ B, solution to sample ratio of 1.5 and a temperature of 50□C with only 5% of initial solids as sugar gain. The second order response surface model could estimate the moisture losses as well as solids gain within 5% of the observed value.

Giraldo et al (2003) studied on the influence of sucrose concentration on kinetics and yield during osmotic dehydration of mango and reported that the water transfer rate increased whenthe concentration of sucrose increased upto 45□B, whereas this effect didn"t appear between55□ B and 65□B, the rate constant being slightly greater for the treatment at 55□B.A case hardening effect could be responsible for the mass transfer reduction at the highest sucrose concentration.

Sharma et al., (2003) studied the effect of sucrose syrup concentration and fruit to syrup ratioon weight loss, solid gain and mass loss of sliced pears after osmotic dehydration, change in syrup concentration from 35-45°B with a fruit to syrup ratio of 1:2 resulted in more significant percent changes.

Abadio, F.D.B. et al. (2004) was studied the observed values of malt dextrin concentration (10- 15%) and atomization speed (25000-35000 rpm) on the physical properties of spray dried pineapple juice using response surface methodology. Spray drying was undertaken at inlet and outlet temperature of 190 and 90□C, respectively, blower velocity of 25000 rpm and feed rateof 0.18 kg/min. The pineapple powder was evaluated with respect to color parameters, moisture content, solubility and density (apparent and true). Apart from true density, the liner models obtained for responses to changes in atomization speed and malt dextrin concentration were not significant. The powder had low density and the use of lower atomization speed and 10% malt dextrin was recommended. This level of malt dextrin was sufficient to obtain free flowing products with good solubility.

Graziella et al (2004) studied on the osmotic dehydration of carica papaya L Influence of process variables and reported that increase of variables (temperature concentration and geometry of sample) leads to an increase in water and weight loss.

Kephas et al., (2004) studied osmotic dehydration of banana slices as a pre-treatment for dryingprocesses and results obtained suggest that a product for further drying could be obtained ON treating the slices at temperatures not more than 30^{o}C and using osmotic solution at 55 or 65 B.

Laura, A. et al. (2004) studied pineapple fruits have an important concentration of vitamin C in their composition, but it degrades quickly during fresh fruit storage due to its high moisture content. The reduction of water content ON air dehydration process would reduce the deterioration rate of ascorbic acid, if dehydration were carried under mild temperature regimes. The change of l- ascorbic acid content in pineapple half pieces through the drying under different conditions (45,060 and 75□C) was determined. The quantification of ascorbic acid was made ON liquid chromatography. The retention of L- ascorbic acid was found to be maximal when the drying temperature was fixed in 45□C. With the objective to find a prediction method of L-ascorbic acid content during pineapple drying under different conditions, a kinetic model ofAA loss in equilibrium condition (data taken from literature) was combined with the experimental variation of water content throughout the drying process (non-equilibrium conditions). The results of the prediction had an excellent agreement to own experimental data of AA destruction during hot air drying.

Laura *et.al* (2005) studied the objective of present work were to analyze the effect of temperature on water loss ,solute gain & glucose & fructose leakage during the osmotic dehydration of pineapple and to study the concentration profiles developed during this process, approximately 1mm thickness.

Phanidra kumar *et.al* (2005) were studied the observed values of addition of organic acids and sugar prior to pasteurization on the thermal behavior and hydroscopicity freeze-dried pineapple juice powder. Pasteurization of pineapple juice at 80□C for 5 min in the presence of added acids (citric, malic and fumaric) and cane sugar was found to increase its reducing sugar content from 3.5to6.5%, which in turn decreases the glass transition temperature (Tg) and increased the hygroscopicity of juice powder. Inversion of sucrose could be avoided ON adding sugar and acid to pasteurized cooled juice. Among the acids, citric acid caused 30% more hygroscopicity than malic and fumaric acids. Incorporation of other additives to the juice prior to freeze-drying helped to reduce the tendency towards hygroscopicity. Among the additives tried, trehaloese, beta-cyclodextrin and sorbitol were found to be beneficial, because they both increased Tg and reduced the tendency towards hygroscopicity.

Ramesh babu et.al (2005) was developed a ready to reconstitute spray dried pineapple- milk and lassi powder blend and its physicochemical and sensory properties and shelf stability were investigated. Products were prepared ON mixing extracted pineapple juice with concentration (ON thermal evaporation) milk as well as curds and they spray drying. The products were evaluated for bulk density, tapped density, compressibility and sorption isotherm as well as chemical parameters. Shelf life of the powders in polypropylene pouches stored at 5, 20-33 (room temperature) and 37□C was evaluated. Bulk properties of both the powders were quite high indicating less flow ability. Water activity was 0.12 and 0.10 while the monolayer values were 4.45 and 6.14, respectively, for milk and lassi powders. Both the powders were high in protein (29.11, 25.04%), fat (7.83, 9.97%) and sugar (35.35, 26.74%) contents. Storage studies showed that the initial peroxide value and free fatty acid values increased progressively during storage of 6 months; however, sensory analysis (with addition of sugar) on the basis of color, aroma, flavor and overall acceptability indicated that pineapple-milk and lassi powders were acceptable up to 6 months of storage at room temperatures as well as at 37^{o}C.

Rashmi , HB et al. (2005) studied that the determination of optimum sugar syrup concentration for osmo-air dehydration of „Giant Kew" variety of pineapple and quality evaluation of osmotically dehydrated product. Pineapple fruits were washed, peeled, cored and cut into rectangular pieces and subjected to osmosis for 24 h in 50^{0}, 60^{0} and 70^{0} B sugar syrup along with 0.2% citric acid and 700 ppm of potassium meta bisulphate followed ON draining and drying at 60-65^{0} C. Significantly higher amount of moisture was removed ON 70^{0} B sugar syrup closely followed ON 60^{0} B syrup. At 60^{0} B, maximum dry fruit yield was obtained and showed lower moisture, higher ascorbic acid, carotenoids and also higher overall acceptability scores in sensory evaluation before and after storage for 6 months at ambient conditions.

Rios-Perez et al., 2005 Pieces of Hawaiian papaya (Carica papaya) fruits were subjected to osmotic dehydration using 4 sweetener agents viz., honey, molasses, honey cream and sucrose in 79°B aqueous solution at 20°C for 23 hours. Honey recorded the highest osmotic capacity while sucrose recorded the lowest. Kinetic analysis showed that the maximum mass transfer occurs during the first 4 hours and maximum mass loss of the product was 32 % with a final moisture content of 41.3% .

Valera et al. (2005) studied the effect of osmotic agent (glucose in the syrup of 50, 60 and 70°B) concentration on the osmotic dehydration of tropical fruits (pineapple and papaya) in cubes. Solute gain for both fruits was proportional to the concentration of osmotic agent.Pineapple absorbed slightly more sugar than papaya. The lowest aw values were obtained for fruits treated with syrup at 70°B. It is concluded that the concentration of the syrup influenced the process of osmotic dehydration of pineapple and papaya.

Anoar et.al (2006) studied on the Influence of osmotic agent on osmotic dehydration of papaya and reported that the value obtained for weight reduction water loss and Solid gain for dehydration in sucrose solution were higher than those obtained in corn syrup solution due to their high viscosity and polysaccharide content.

Babic et al. (2006) studied a new technology which includes osmotic dehydration combined with conventional drying for the production of dried fruits. Observations on fruit behavior during osmotic drying were recorded on apricot cultivars Ambrozia, Ananasnii, Novosadska Rodna and Keckemetska Ruza. Temperature and concentration of the solution had significant effects on the osmotic dehydration of fruits.

Anitha (2007) studied the effect of different osmotic pre-treatments on weight loss, yield and moisture loss in osmotically dehydrated guava and they observed that when guava slices were pre treated with 70°B syrup for 24 hours there was increase in weight loss, moisture loss and solid gain in slices of both Allahabad Safeda and Pink Flesh.

Singh et al. (2007) studied nutritional quality of osmotically dehydrated and blanched aonla fruit segments and concluded that immersing in 60°B for 24 hrs and fallen B maintained after 24, 48 and 72 hrs ON heating and left for 24 hrs were found to be the best in nutritional as well as organoleptic qualities and had a shelf life of 3 months.

Alam and Singh (2008) studied the modeling of mass transfer in osmotic dehydration of aonla slices and concluded that the water loss and solute gain ON the aonla samples increased non- linearly with the duration of osmosis at an interval of 15, 30, 60, 90, 120, 180 and 240 min, all sugar concentrations (30□ C, 45□C and 46□C).Water loss and solute gain were higher in the initial period of osmosis than the later period. Further, both increased with increasing sugar concentration.

Dhingra et al. (2008) studied the osmo-air dehydration of fruits and vegetables. Osmo-air dehydration has the potential to extend their shelf life. The product obtained ON osmo-air dehydration is more stable during storage due to low water activity impacted ON solute gain water loss. It is use full method as it results in high quantity product ON retaining the color, flavor and other volatiles.

Konapacka et al(2008) studied on the effect of different osmotic agents an the sensory perception of osmo-treated dried fruit and concluded that osmotic solutions significantly influenced the taste and texture profile of dehydrated fruit and affect their sensory acceptability.

Kumar et al. (2008) studied about the observed values of ripening stages on osmo-dehydrated guava pieces ON placing fruits at ambient condition (25-35°C, 50-60%RH). He found that fourth day after harvest of the full mature fruits is the best ripening stage for the preparation of osmo-dehydrated guava pieces.

Manivannan et.al (2008) studied quantitative investigation of water and solids transfer during osmotic dehydration of beetroot in aqueous solution of salt. Effects of temperature (25-45°C), processing time (30-

150min), salt concentration (5-25%, w/v) and solution to sample ratio (5:1- 25:1) on osmotic dehydration of beetroot were estimated.

Manivannan and Rajasimman (2008) studied the effect of temperature (25- 45□C), processing time (30-150 min), salt concentration (5-25%, w/w) and solution to sample ratio (5:1-25:1) on osmotic dehydration of beetroot and indicated that the optimum conditions for water loss, solid gain and weight reduction effective at 35□C temperature, 90min processing time, 14.31% salt concentration and 8.5:1 solution to sample ratio.

Patricia et al (2008) studied on the optimization of Osmotic dehydration of Tommy Atkins mango fruit and reported that optimum conditions to obtain water removal less 25% with solid uptake lower than 6% could be obtained ON using a 44% sucrose solution concentrationtemperature up to 38 and immersion time up to 80 minutes. Patricia et al(2009) studied on the effect of osmotic dehydration on the drying kinetics and quality of cashew apple and reported that osmotic pretreated samples showed the highest vitamin–c losses and the lowest water activity and the sample treated with sucrose solution had the highest acceptance. Phisut(2012) studied on the factors affecting mass transfer during osmotic dehydration of fruits and reported that osmotic dehydration is a traditional process applied to food dewatering.

Prathibhasingh et.al (2008) studied the optimization of osmotic dehydration of carrot cubes in sucrose solution. The independent process variables were osmotic solution concentration (45- 55^{o} B), temperature (35-55°C) and process durations (120-240 min) and process was optimized on maximum water loss, minimum sugar gain ,sensory score, rehydration ratio, retention color and concluded that optimum conditions were 52.5° B concentration, 49°C osmotic solution temperature and 150 min process duration.

Singh et.al (2008) studied on optimization of process conditions during osmo-air dehydration offresh pineapple. Fresh pineapple samples were osmotically dehydrated with different sucrose concentrations, temperatures, time and fruit solution ratio. Pineapple samples when osmotically dehydrated in sucrose solution of 55-75□ B at 20-40□C, for 2 hours with solution ratio of 1:3 to 1:7 resulted in weight loss ranging from 39.0 to 47.55, SG 11.0 to 17.2%, WL/SG 2.1 to 4.3 and
WR 22.9 to 36.5%.

Thakor and Sawanth (2008) observed that weight loss was higher (47.89 %) at 40°B sugar concentration and 30°C soaking temperature for 8 hours over fresh pineapple slices. Kumar and Sagar (2009) conducted experiment to find out the optimum osmotic concentration and temperature for the better dehydration of mango, guava slices and aonla segments. Slices and segments of the fruits were dipped in various sugar concentrations, i.e. 40, 50, 60 and 70°B,with temperatures of 40, 50, 60 and 70□C for 6 hrs without any agitation and found that 60°B sugar concentration with 60□C temperature gave better results.

Bakhara et.al (2009) studied the mass transfer kinetics model of osmotic dehydration of tender jackfruit pieces and concluded that nearly 85% of total water loss and 70% of total salt gain tookplace during u 2 h of experiment.

The water loss and salt gain showed an increasing trend with increase in salt solution concentration, temperature and solution to solid ratio.

Torte (2009) studied osmotic dehydration experiments had been reported plant and animal materials. Minimal improvement on amount and rate of water loss and corresponding solid gain has been reported in the presence of sodium chloride and agitation especially for the first 30 minof osmotic dehydration.

Alam and Singh (2010) found that sugar concentration of 59°B, at temperature of 51°C, solution to fruit ratio of 4:1 and immersion time of 60 min were best for osmotic dehydration process for aonla slices ON using response surface method. Kumar and Devi (2011) studied on optimization of some process variables in mass transfer kinetics of osmotic dehydration of pineapple slices and they found that optimum osmotic dehydration corresponded to 58-63°B sugar concentration, 55°C temperature, 6 mm slice thickness and 0.05 -0.065% KMS concentration.

Chandan et al. (2012) conducted an experiment to study osmotic dehydration of aonla fruits and reported that better quality was obtained ON blanching for five minutes and sliced pieces steeped in two per cent salt for two hours + steeping in 60°B sugar syrup for 24 hours followed ON drying under open sun.

Chavanand Amarowicz (2012) studied on the osmotic dehydration process for preservation of fruits and vegetables and reported that it has potential advantage for the processing industry to maintain the food quality to preserve the wholesomeness of food.

Moazzam (2012) studied on the osmotic dehydration technique for fruit preservation andreported that osmotic dehydration is an operation used for the partial removal of water from plant tissue ON immersion in an osmotic solution.

Nutthanun et al (2013) studied on the effect of osmotic dehydration time on hot air drying and microwave vacuum drying of papaya and reported that an increase in osmotic dehydration time for 1-4 hours followed ON hot air drying and microwave vacuum drying at 70.

Fasogbon et al (2013) studied on the Osmotic Dehydration and Rehydration Characteristics of Pineapple Slices and found out Osmotic dehydration enhanced solid gain water loss drymatter loss and rehydration capacity.

Priya and Khatkar (2013) conducted an investigation on effect of processing methods on keeping quality of aonla (Emblica officinalis Gaertn.) preserve and they reported that sugar syrup of 70°B was found most effective in retention of ascorbic acid and tannins in the preservesand carried low microbial-load.

CHAPTER III MATERIALS AND METHODS

In this chapter various materials instruments, equipment's, techniques and experimentalprocedures used to fulfill the objectives of present investigation have been dealt with.

4.1 Raw materials

Fresh pineapple and papaya were procured from local market and brought to the laboratory. Fully matured fresh fruits with uniform size and shape, free from transportation injuries, bruises,insect damages and diseases were selected for making the nutritious osmotically dehydrated cubes.

4.2 Stage of fruit maturity

Fully matured pineapples and papayas were selected for the study i.e. when skin color of the fruit changes from dark green to light yellow. The fruits were medium to larger in size and fruits were sweet in taste.

4.3 Osmo-air agent

Sugar was used as osmo-air agent and was procured from local market to prepare osmo-air solution of different concentrations on the basis of (% W/V).

Tab 3.1 Experimental Plan Independent variables:

1.	Osmo-air solution concentration	30^{0}, 40^{0} (%W/V)
2.	Size of sample	15 mm thickness
3.	Osmo-air agent	sugar

4.4 Fruit cube preparation

Pineapple and papaya fruits of uniform size and colour were selected. Fruits were weighed using electronic balance, washed thoroughly with tap water. The washed fruits were peeled withstainless steel knife. Edible portion of the whole fruit, was cut in to uniform cubes having 15 mm size. The cube size of pineapple and papaya fruit was measured with the help of centimeter scale. Prepared cubes were weighed to record the yield recovery of fresh cubes for osmotic dehydration. Peeling of pine apple is usually done by knife, we can also use some of the peelers which are used to separate the fruit from outer most skin of the fruit.

4.5 Preparation of sugar syrup

Sugar syrup of two different concentrations viz., 30^{0} and 40°B was prepared for each pineapple and papaya fruits. For 250g of prepared fruit cubes, 300 g of sugar and 1 lit of waterwas mixed and prepared to 30°B. Similarly, for 250 g of prepared fruit cubes, 400 g of sugar and l lit of water was mixed and preapared to 40^{0}B. Stir it until sugar particles melt in water. Take a refractometer readings before osmosis.

4.6 Apparatus used for the study

The important apparatus used during the study includes the following:

1. Hot air oven
2. Electrical digital balance of 0.01g accuracy
3. Refract meter

4. Desiccators

4.6.1 Refractometer

A refractometer is a simple instrument used for measuring concentrations of aqueous solutions. It requires only a few drops of liquid and is used as lab equipment throughout the food, agricultural, chemical, and manufacturing industries.

Refractometers measure the degree to which the light changes direction, called the angle of refraction. A refractometer takes the refraction angles and correlates them to refractive index values that have been established.

Table 3.2: Refractometer readings before osmosis:

S.NO	NAME OF FRUIT	BRIX	REFRACTOMETER READING
1	Papaya	30^0	20.10
		40^0	24.80
2.	Pineapple	30^0	20.50
		40^0	25.8

4.6.2 DESICCATOR:

A traditional desiccator is a glass bowl and lid each with thick glass rims that permit a seal when greased. Desiccant (a hygroscopic chemical that absorbs water out of the air) is placed beneath the perforated ceramic disk. A sample in a beaker or crucible is placed on the top of thisdisk. The purpose of the desiccator is to either dry a chemical or keep a chemical from becoming “wet” from atmospheric humidity (water in the air).

4.7 Immersion of cubes in sugar syrup (Osmosis)

Prepared pineapple and papaya cubes of 250 g of 15 mm thickness. These are dipped in 30°, 40°B sugar syrup solution and this setup was left undisturbed for 4 hours at room temperature (25□C). The process of osmosis takes place and water moves out of the fruit pieces to the syrup and fraction of solute moves into the fruit slices or cubes. At the end of the osmosis, the fruit r cubes were taken out of the osmotic solution and were drained in order to remove the sugar coating adhering to the surface of the fruit pieces. These osmosized pineapple and papaya cubes were weighed to know the extent of water removal from the slices or cubes on osmosis.

The pineapple pieces were put in sugar syrup in a proportion of 1:2 (fruit pieces: syrup) and left for 4 hours in a tray for osmosis. After osmosis, the fruit pieces were taken out of the osmo- air solution and rinsed quickly with water to remove the sugar syrup adhering to fruit pieces and thendried.

After osmosis remove pineapple and papaya fruit from sugar syrup and take refractometerreading which are as follows.

Table 3.3: Refractometer readings after osmosis

S.NO	NAME OF FRUIT	Brix	REFRACTOMETER READING AFTEROSMOSIS
1.	Papaya	30^0	20.05
		40^0	25.00
2.	Pine apple	30^0	20.00
		40^0	25.00

4.8 Cabinet drier

The osmotically dehydrated pineapple pieces are kept in cleaned aluminum trays. These trays are kept in hot air oven drier for drying. Pineapple pieces are dried at temperature of 60°C.The drying was performed continuously, until the material was dried to approximately below 10% ofmoisture content. The dried samples were taken out from the dryer and cooled to room temperature and packed in polythene covers on which the concentrations were noted respectively.

Process Flow chart for preparation of dried Papaya and Potato samples:

The various steps involved in the production of papaya pieces are given in form of flow chart asshown in fig 3.5

Matured & Ripe Samples(pineapple, papaya)

⇩

Washing of samples

⇩

Peeling

⇩

Cutting into slices (15 mm thickness)

⇩

Weighing of pineapple & papaya slices

⇩

Osmotic treatment

⇩

Steeping in sugar syrup solution ($30^0$and 40^0B concentration for 4 hours)

⇩

Rinsing with water (to remove adhering sugar syrup)

⇩

Osmotically dehydrated pineapple & papaya slices

⇩

Hot air oven drying

⇩

Packing

Fig 3.1 Flow chart for drying Papaya and Pineapple slices

Moisture Content Determination

The initial weight of the sample was taken as W_o and then it was kept in open field for day in order to determine the amount of moisture content present in the fresh papaya and potatoes thickness sample. The sample kept in drying chamber undergoes charring and looses all the moisture and reaches dry state. The weight of this dry matter is considered as final weight W_t. All the measurements were recorded by using digital weighing balance. The moisture content was determined as follows **(Mohanraj and Chandrasekar, 2008).**

$$M_{wb} = \left(\frac{w0 - wt}{w0}\right) \times 100 \text{--- Eq. (3.1)}$$

Where,

M_{wb} = moisture content in wet bases (%)W_o= weight of initial sample (kg)

W_t = weight of final dry sample (kg)

4.9 WATER LOSS:

The water loss during osmotic dehydration was calculated by the equation given by Ozen et al.and Singh et al.

$$\text{Water loss (WL) g/100 g of fresh fruit} = \frac{(w0 - wt) + (st - so)}{wo} \times 100 \text{ -------Eq. (3.2)}$$

It is calculated based on this equation.Where:

W_0 – initial weight of pine apples, g

W_t – weight of pine apples after osmosis, gS_0 – initial weight of solids in osmosis, g

S_t – weight of solids in pine apples after osmosis, g

4.10 SOLUTE GAIN:

The solute gain during osmotic dehydration was calculated by the equation given by Ozen et al.

Solute gain/100 g of sample = $(St - So) / W_o \times 100$

4.11 Weight Reduction:

It is determine ON the following formula

Weight reduction = Water loss – Solute gain -- Eq. (3)

3.12. Sensory Analysis:

Nine point hedonic scale

The sensory analysis of the prepared samples was done by using 9 point hedonic scale forcolor, appearance, flavour and texture and overall acceptability.

Evaluation of the solar cabinet dried papaya & potato slices for color, texture, flavour, appearance, mouth feel and overall acceptability was done by a semi trained panel of judges. Thepanel of judges scored on a 9 point hedonic scale.

Table 3.4: Sensory Evaluation Chart (9 point hedonic scale) Expert Name…………

Product Name…………

Product	Colour	Taste	Flavor	Textue	Appearance	Overall acceptability

Score card

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

CHAPTER IV RESULTS AND DISCUSSION

This chapter deals with the observed values of different osmo-air solution concentrationson the water loss, solute gain of fresh pineapple fruit pieces after the osmo-air dehydration. The pretreated pineapple pieces are subjected to different driers with different concentrations and analysis of data.

The values of water loss were observed at different osmotic solution concentrations are shown in Table 4.1

Table 4.1 water reduction of pineapple fruit pieces at different concentrations

Syrup concentration (°B)	Initial weight(gm)	Final weight (gm)	Water loss (%)	Weight reduction (%)
30	250	244.87	2.252	5.13
40	250	241.95	3.540	8.05

4.1.1 Observed values of osmotic solution concentration on water loss of pineapple

The observed values of osmotic solution concentration on water loss at constant temperature during osmo-air dehydration has been studied and presented in Fig. 4.1. Significantly higher moisture loss was observed in the sugar syrup concentration of 40^0 B, closely followed ON 30^0B. This is due to the diffusion of water from medium (fruits) to concentrated solution of sugar syrup through a semi-permeable membrane until the concentration equilibrium was reached. The rate removal of moisture from fruit pieces was higher at 40^0 B solutions due to higher sugar concentration leading to lower water potential than other concentrations. These findings are in agreement with the findings of **Bongirwar and Sreenivasan (1977**).

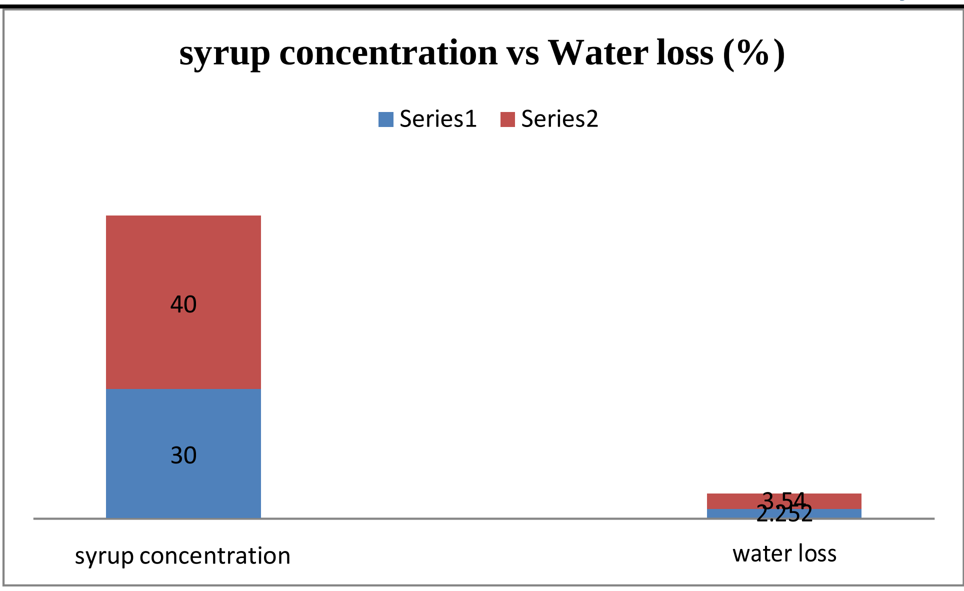

Fig.4.1 Observed values of osmotic solution concentration on water loss of pineapple

4.1.2 Observed values of osmotic solution concentration on weight reduction of pineapple

The observed values of osmotic solution concentration on weight reduction at constant temperature during osmo-air dehydration has been studied and presented in Fig.4.3**.** The weightreduction was increased from % with increase in concentration form 30 to 40^0 B. It was observed from the graph that an increase in weight reduction with increase in osmotic solution concentration. This was attributed due to the water activity of the osmotic solution which decreases with increase in sugar concentration in the osmotic solution concentration.

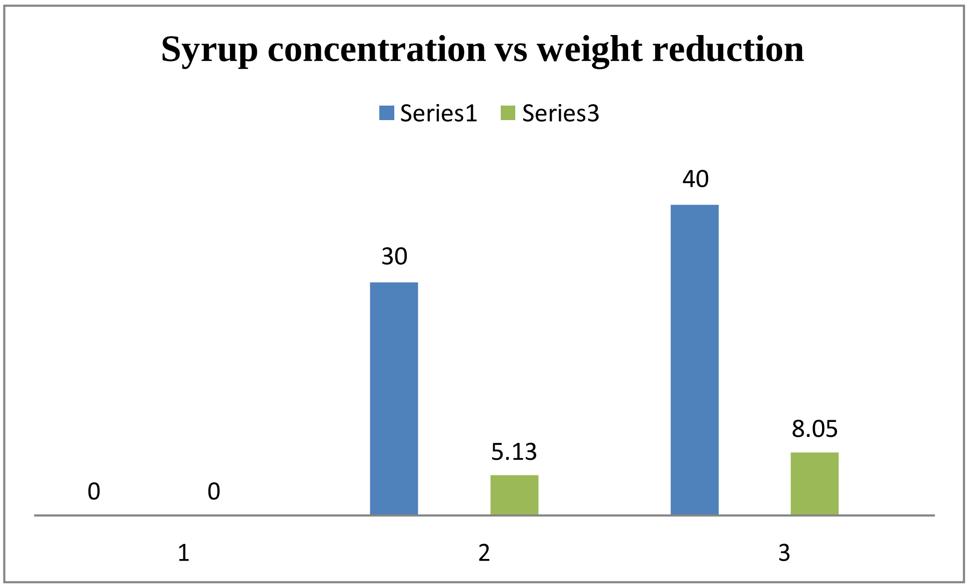

Fig.4.2 Observed values of osmotic solution concentration on weight reduction of pineapple

Table 4.2 water reduction of papaya fruit pieces at different concentrations

Syrup concentration (°B)	Initial weight(gm)	Final weight (gm)	Water loss (%)	Weight reduction (%)
30	250	248.80	0.5	1.02
40	250	239.00	4.72	11.0

4.2.1 Observed values of osmotic solution concentration on water loss

The observed values of osmotic solution concentration on water loss at constant temperature during osmo-air dehydration has been studied and presented in Fig. 4.1. Significantly higher moisture loss was observed in the sugar syrup concentration of 40^0 B, closely followed ON 30^0
B. This is due to the diffusion of water from medium (fruits) to concentrated solution of sugar syrup through a semi-permeable membrane until the concentration equilibrium was reached. The rate removal of moisture from fruit pieces was higher at 40^0 B solutions due to higher sugar concentration leading to lower water potential than other concentrations. These findings are in agreement with the findings of **Bongirwar and Sreenivasan (1977).**

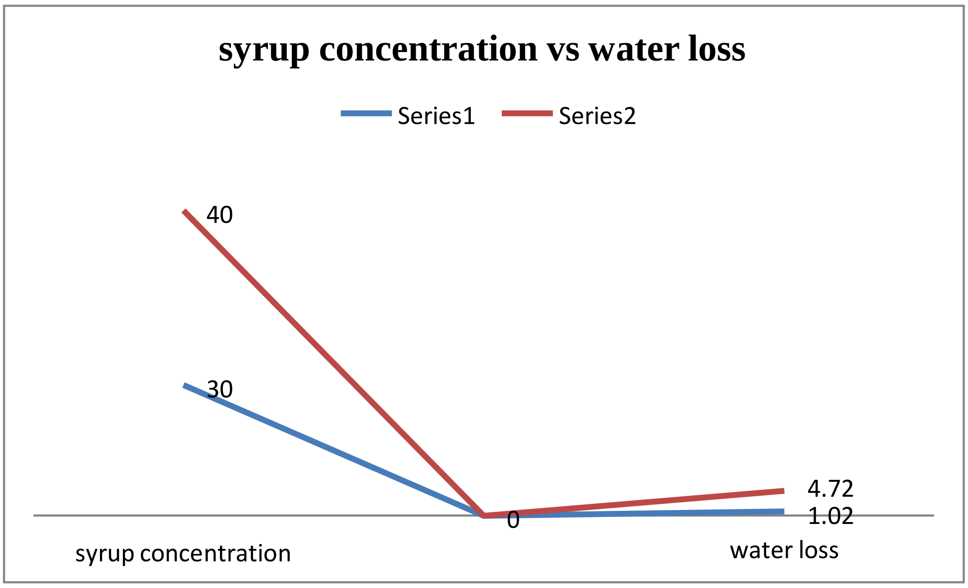

Fig.4.3 Observed values of osmotic solution concentration on water loss of papaya

4.2.2 Observed values of osmotic solution concentration on weight reduction of papaya

The observed values of osmotic solution concentration on weight reduction at constant temperature during osmo-air dehydration has been studied and presented in Fig. 4.3. The weight reduction was increased from % with increase in concentration form 30 to 40^0 B . It was observed from the graph that an increase in weight reduction with increase in osmotic solution concentration. This was attributed due to the water activity of the osmotic solution which decreases with increase in sugar concentration in the osmotic solution concentration.

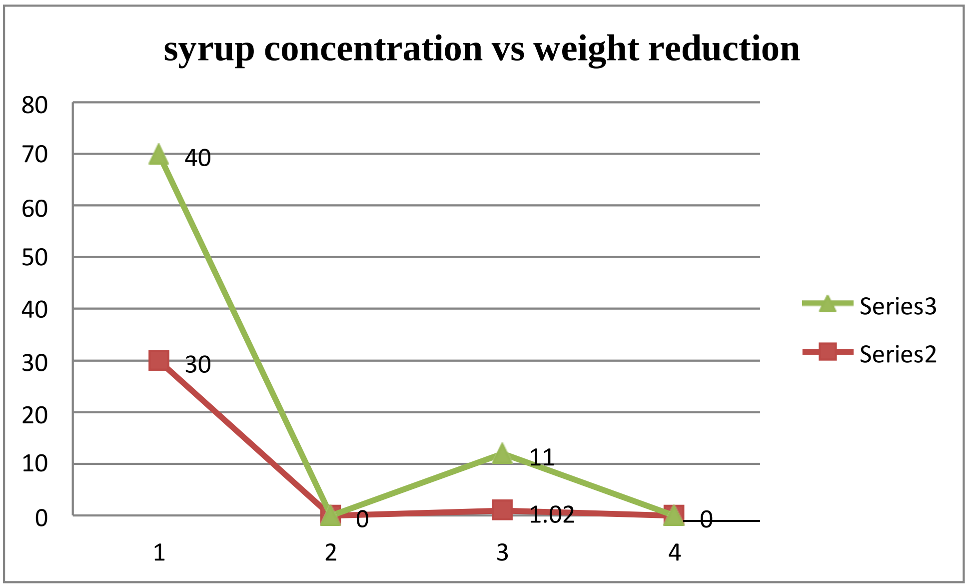

Fig.4.4 Observed values of osmotic solution concentration on weight reduction ofpapaya

4.3. Observed values of pre-treatments on moisture content of dried pineapple andpapaya in cabinet dryer

The osmotically pretreated samples of pineapple and papaya were dried in hot air oven drier and moisture content was calculated at different drying time intervals and data were analysed.

The variation in moisture content with drying time for samples osmotically pre-treated atdifferent concentrations. It was observed that the moisture content of osmotically pre-treated pineapple samples decreases with increase in drying time for both concentrations 30□B and 70□B. The drying was carried out at the temperature of 70□C for both concentrations 30□B and 40□B. The moisture content of osmotically dehydrated pineapple and papaya samples at 30□B and 40□B decreased.

Table 4.3: weight of 5 g of Pineapple in cabinet dryer for every one hour at 60^0c

s.no	30ºB	40ºB
1	3.9	4.18
2	3.02	3.61
3	2.35	3.11
4	1.89	2.65
5	1.6	2.31
6	1.4	2.00
7	1.28	1.76
8	1.21	1.58
9	1.17	1.47
10	1.16	1.40
11	1.14	1.35
12	1.13	1.31
13	1.13	1.30
14	1.12	1.28

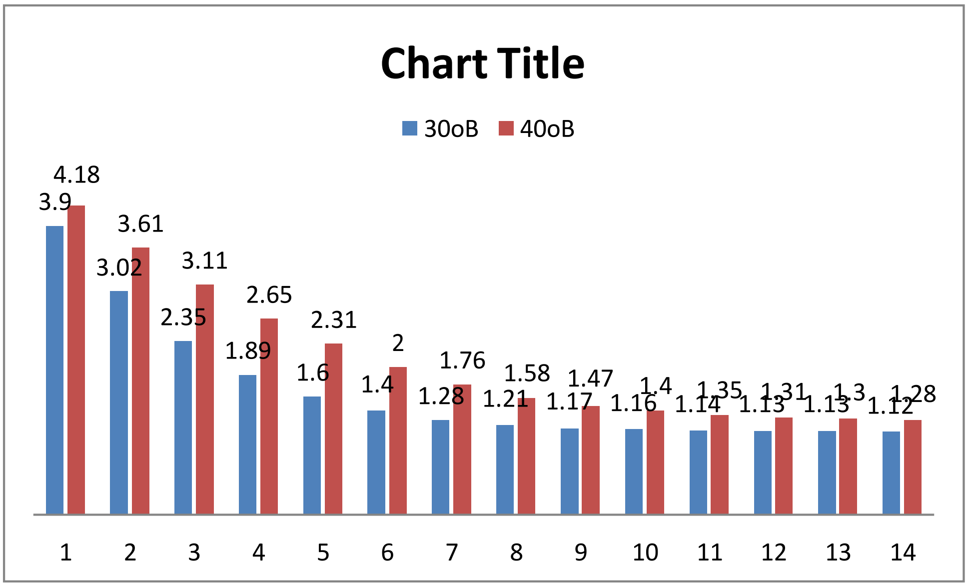

Fig 4.5: Variation of moisture content against drying time at different sugar syrup concentrations in cabinet drying of pineapple

Table 4.4: weight of 5 g of Papaya in cabinet dryer for every one hour at 60°c

s.no	30°B	40°B
1	4.66	4.15
2	4.31	3.51
3	3.99	2.92
4	3.66	2.47
5	3.30	2.06
6	2.96	1.78
7	2.60	1.59
8	2.26	1.47
9	1.93	1.38
10	1.66	1.33
11	1.47	1.30
12	1.24	1.27
13	1.17	1.25
14	1.15	1.24

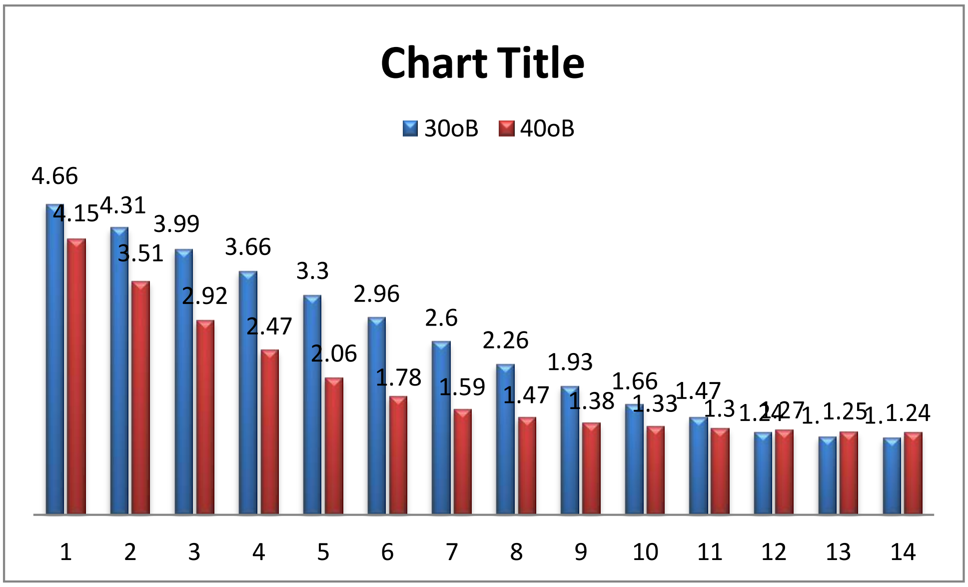

Fig 4.6: Variation of moisture content against drying time at different sugar syrupconcentrations in hot air oven drying of papaya

Table 4.5 weight of pineapple and papaya after dehydration:

S.NO	NAME OF FRUIT	WEIGHT OF FRUIT	
		30^0B	40^0B
1.	Papaya	67.89	67.26
2.	Pine apple	70.12	67.40

The above same procedure is carried out for Pine apple and Papaya at a temperature 80^0 in the cabinet dryer. Table below shows the drying values of Pine apple and Papaya for every 1 hour interval for duration of 12 hours.

Table 4.6: Weight of 5g of pineapple in cabinet dryer at 80^0

S.NO	40^oB	30^oB
1	4.29	3.5
2	3.32	2.48
3	2.64	1.68
4	2.03	1.35
5	1.54	1.12
6	1.14	1.10
7	1.09	1.08
8	1.07	1.06
9	1.06	1.05
10	1.01	1.02
11	1.01	1.01
12	1.00	1.05

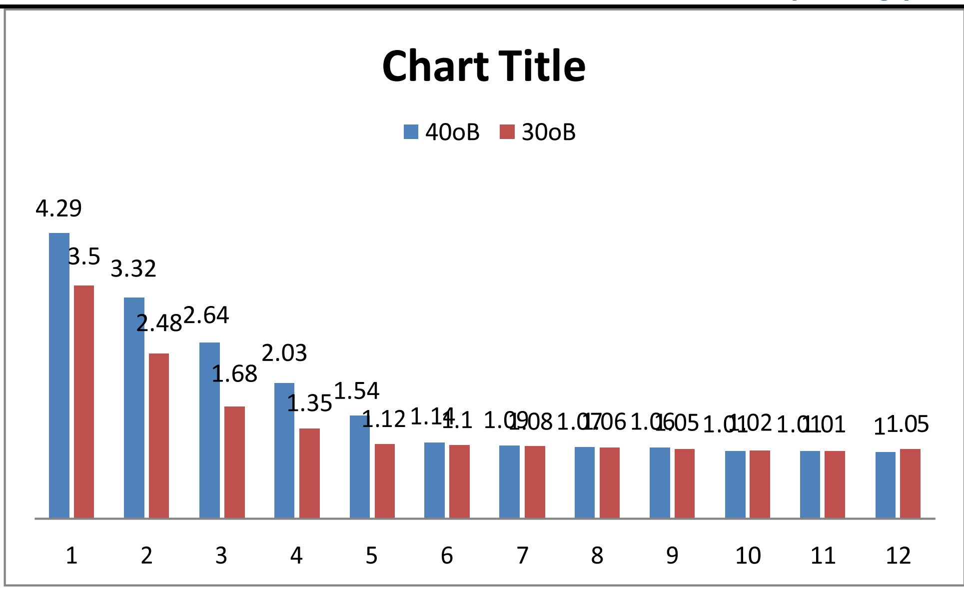

Fig 4.7: variation of moisture content against drying time at different sugar syrupconcentration in cabinet dryer at 80^0

TABLE 4.7: Weight of 5g of papaya in cabinet dryer at 80^0

S.NO	40^{o}B	30^{o}B
1	4.52	4.54
2	3.14	4.05
3	2.43	3.41
4	2.05	2.99
5	1.74	2.59
6	1.26	1.84
7	1.13	1.58
8	1.06	1.29
9	1.03	1.12
10	0.99	1.06
11	0.99	1.06
12	0.98	1.00

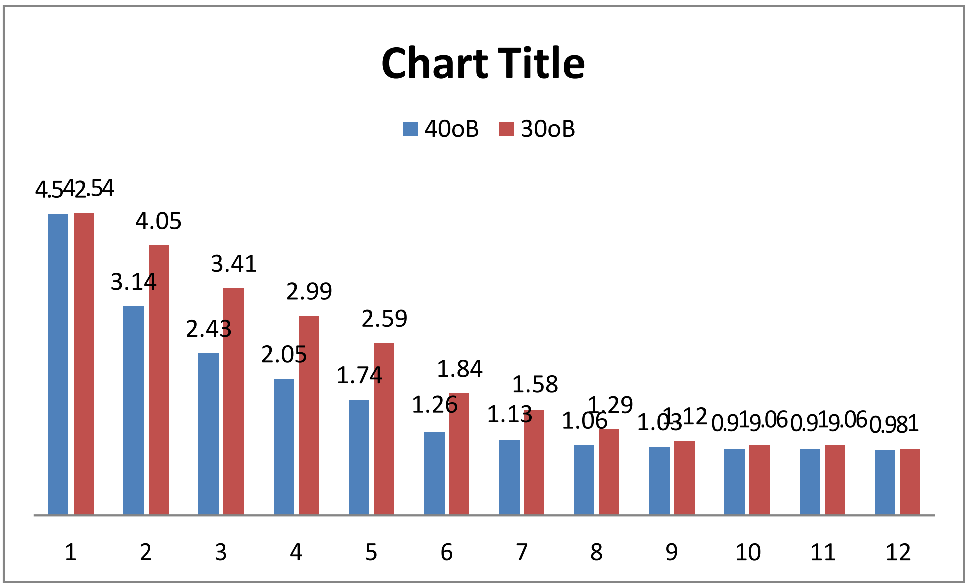

Fig 4.8: variation of moisture content against drying time at different sugar syrupconcentration in cabinet dryer

Table 4.8: Weight of pineapple and papaya after dehydration:

S.NO	NAME OF FRUIT	WEIGHT OF FRUIT	
		30^0B	40^0B
1.	Papaya	62.54	60.54
2.	Pine apple	65.28	61.58

4.4 Sensory evaluation:

Sensory evaluation of osmo-air dehydrated pineapple fruit were carried out on a panel of ten judges in the department using hedonic scale having score for colour (30 marks), texture (30 marks), flavor (40 marks) and overall acceptability score 100 marks and were shown in Fig.4.10 and 4.11

Highest overall acceptability scores were observed in 30^0B sugar syrup concentrations in cabinetdryer.

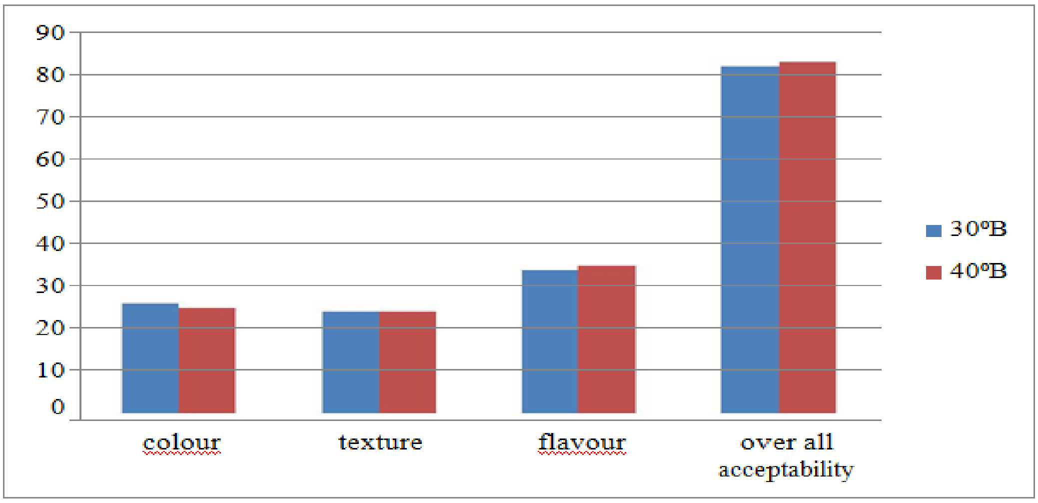

Fig. 4.9 Sensory evaluation of osmotic dehydrated pineapple and papaya pieces

CHAPTER V SUMMARY AND CONCLUSIONS

Pineapple and papaya are commercially important fruit crops globally, known for their taste, flavor, and nutritional benefits. Pineapple contains essential nutrients such as calcium, potassium, fiber, and vitamin C, making it low in fat and cholesterol. Additionally, it is a good source of vitamin B1, vitamin B6, copper, and dietary fiber, with approximately 90% moisture in fresh ripened pineapple. Papaya, likewise, is rich in antioxidants like vitamin C, as well as vitamins B, minerals, and fiber.

Various preservation methods are employed to extend the shelf life of pineapples, necessitating a simple and cost-effective approach. Osmo-air dehydration emerges as a viable method for preserving the moisture content of fruits, offering reduced drying costs and minimized quality losses, while enabling high reconstitution ratios upon rehydration.

1. Pineapple exhibited 3.54% water loss with a sugar syrup concentration of 400 B and 2.52% water loss with a concentration of 300 B during osmosis.
2. Papaya showed 4.72% water loss with a sugar syrup concentration of 400 B and 0.5% water loss with a concentration of 300 B during osmosis.
3. Weight reduction increased from 179.88 to 182.6 g with an increase in sugar syrup concentration for pineapple.
4. Weight reduction increased from 182 to 183 g with an increase in sugar syrup concentration for papaya.
5. Cabinet dryer operation at 800 resulted in significantly shorter drying times compared to 600.
6. There was a time-saving of approximately 3 hours in the cabinet dryer at 800 compared to 600.
7. Results indicate that a sugar syrup concentration of 400 B yielded the lowest moisture content.
8. Preservation for up to 2 months was achieved.
9. The highest overall acceptability scores were observed with a sugar syrup concentration of 400 B.

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