*Original Research Article*

# Studies on impact of processing on physiochemical and biochemical properties of osmodehydrated pineapple (*Ananas comosus(L)Merr.*) cube and its storage stability



## Abstract:

To evaluate the effectiveness of osmodehydration process as pretreatment for further drying of pineapple cubes, the effects of osmotic dehydration on mass transfer and weight reduction during osmotic dehydration of pineapple cubes were examined. As treatment time went on, there was an increase in water loss, weight loss, and solids accumulation. The sample treated with 60°B experienced the highest mass transfer during the osmotic dehydration of pineapple cubes, whereas the sample treated with 30°B experienced the lowest mass transfer. The pineapple cubes coated in 60˚B sugar syrup dried in a tray drier with a maximum weight loss. Microwave heated samples dipped in 60˚B sugar syrup gives the better nutritive value(total phenol content, vitamin C and antioxidant activity) as well as the better color ,texture ,taste and mouth feel .According to the organoleptic analysis, the sample treated with 60°B solution, which received the highest acceptability for color, flavour, texture, mouth feel, and taste. Osmodried samples are stored for 3months at ambient condition without any adverse effect on the quality.

**Keyword:** Osmodehydration; pineapple; Kinetic study; bioactive compound; storage stability

## Introduction:

One of the most significant commercial fruit crops in the world is the pineapple (Ananas comosus (L.) Merr., Family: Bromeliaceae). Because of its superior flavour and taste, it is referred to as the "queen of fruits" [Baruwa et al.,2013]. After citrus and bananas, pineapple is the third most significant tropical fruit in the world [Bartholomew et al., 2003]. Fresh, cooked, juiced, and preserved pineapples are all consumed or served. This fruit is seasonal and extremely perishable. A good amount of bromelin, a protein-digesting enzyme, citric acid, malic acid, and vitamins A and B are also present in mature fruit, which also includes 14% of sugar [Joy,p.p. 2010]. The ingredients in pineapple juice vary based on the region, time of year, harvesting method, and process. The fruit's flavour is refreshing because of the fruit's sugar and acid balance. The pineapple is a beautiful tropical fruit that offers a tonne of health advantages along with exceptional juiciness and bright tropical flavour. The significant amounts of calcium, potassium, vitamin C, carbohydrates, dietary fibre, water, and other minerals found in pineapple are helpful for the digestive system, aid in maintaining a healthy weight, and promote balanced nutrition.

In recent years much attention has been focused on maintaining the freshness of fruits and vegetables by immersion of cellular materials containing water in an osmotic solution. It results in the development of intermediate moisture products having lower water activity, which is imparted by solute gain and water loss. During the process, chemical, physical and biological activities, which deteriorate the foods, are lowered considerably; hence extends the shelf life of food products. In this process moisture is withdrawn from the product at ambient temperature by diffusion, so phase change has been avoided. Besides, it helps to improve the nutritional and sensory attributes of food products and is less energy intensive process as compared to other drying techniques. Osmotic dehydration is influenced by various factors such as osmotic agent, time and temperature, solute concentration, solution to sample ratio, agitation and geometry of the materials. Recently, osmotic dehydration has been combined with several other methods namely, pulsed high electric field, high hydrostatic pressure, microwave heating, pasteurization, ultrasound, centrifugal force, vacuum and gamma irradiation, blanching. These techniques have been employed during or after osmotic treatment to enhance osmotic dehydration performance by increasing the cell membrane permeability and mass transfer rate. These combined operations reduce the drying time, minimizing further energy costs as well as improving the quality of fruits and vegetables during storage.

Osmotic dehydration of foods has gained attention recently due to its potential for the food process industry. Osmotic dehydration is widely used for the partial removal of water from plant tissues by immersion in a hypertonic solution. Osmotic dehydration generally will not give a product of sufficiently low moisture content for it to be considered shelf-stable. Osmotic lack of hydration is a conventional interaction applied to food dewatering. It prompts alluring items that are prepared to eat or can be applied as a pretreatment to the following system, for example, drying or freezing. Water is a principal constituent of food sources, which influences food security, microbial as well as compound. It is liable for the customer view of quite a large number organoleptic qualities like juiciness, elasticity, tenderness and texture. In food industry, food and food products are preserve by using dehydration process to remove the water from the raw materials. The bringing down of water action can be accomplished in two ways, either by the expansion of humectants or by the expulsion of dissolvable, for example, water .Now a days, researcher focused on the improvement of product quality of preserved food products. Osmotic dehydration is the cheapest and easiest method to obtain better food products by removing water at low temperature (Shi and Xue, 2009). It has been broadly utilized as a pretreatment step in food drying process since it can diminish generally the energy prerequisite for additional drying process (Khin et al., 2006). To fulfill the developing market interest for products in a fresh like state, insignificant handling like osmotic lack of hydration will be progressively utilized. The dynamic exploration in the area of osmotic drying out of organic products is proceeding from one side of the planet to the other.

Pineapple is an important fruit of India. Pineapple is cultivated in an area of 89 thousand ha and total production is 1,415.00 thousand tons. It is native to Central and South America. The cultivation of pineapple was initially begun in regions among Brazil and Paraguay, and afterward steadily spread over the entire tropical world. The all out region under pineapple development on the planet is 1.05 million hectare with creation around 25.81 million hectare (FAOSTAT, 2016). The agro-climatic and physio-geographical conditions of some parts of India is most suitable for the pineapple plant growth, such as the entire North-Eastern states including Assam, Meghalaya, Tripura and Manipur, northern part of West Bengal, coastal parts of Andhra Pradesh, Orissa, Kerala, Tamil Nadu and Goa, and some parts of Maharashtra, Gujarat and Karnataka. With over 0.11 million hectare area, India stands at second position just after Nigeria (0.18 million hectare) in terms of area under pineapple cultivation by contributing more than 10 percent of the total pineapple producing area of the world. While, in terms of production India is sixth largest producer of pineapple with a production value of 1.74 million tonnes, the first being Costa Rica (2.92 million tonnes). There are more than ninety variety of pineapple cultivated all around the world. However, only three varieties are commercially grown in India, these are; *Giantkew*- big size fruit with broad and flat eyes and colour varies from yellow to coppery yellow (12-14 orbix);*Queen*- small in size with small and raised eyes and colour is flesh deep golden yellow (15-16 orbix); and *Mauritius*- fruit size is medium and yellow and red in colour. Pineapple is known by so many names throughout India, such as *Keehom* (Manipur), *Ananus* (Marathi), *Annasahannu* (Kannada), *Anasipazham* (Tamil), *Kaitachchakka* (Malayalam) and *Annasapandu* (Telegu). The sunny field of north-east India having pure tropical rain brings peak flavour to our pineapple. They are than packed and sent to store houses, where they are protected for transportation and marketing (pineapplesinIndia.com, 2018).The total area under pineapple cultivation in the world is 909.84 thousand ha with production around 19412.91 thousand tons.

Pineapple *(AnanasComosus)* is a very delicious tropical fruit of the Bromeliaceae family. It is popularly known as Ananas all over the India and it has an excellent flavour as well as high nutritive value. Pineapple is rich in Vitamin C and is a good source of Vitamin A and B. It contains a special enzyme called 'Bromelin' which helps in digestion of protein. According to the USDA nutrient database, each 100 gm of edible pineapple include 50 K cal. A study published in 'Alternative Therapies in Health and Medicine' states that pineapple has a therapeutic effect for allergies and asthma. It also alleviates anxiety and calms the heart. Generally, ripen pineapple is consumed by people in India and after extraction of juice the dried waste is used as animal feed. Besides this, pineapple is useful for making pickles, squash, jelly, vinegar, alcohol and syrup **(Geocoppens, 2001)**. Pineapple is highly perishable in nature; it cannot be stored for more than 4-5 days after harvesting..Pineapple is largely consumed around the world as canned pineapple slices, chunk and dice, pineapple juice, fruit salads, sugar syrup, alcohol, citric acid, pineapple chips and pineapple puree. It mainly contains water, carbohydrates, sugars, vitamins A, C and carotene.

Up to 40% of agricultural produce is wasted in developing countries, mainly due to the lack of storage and processing facilities, as well as to a limited knowledge of processing technologies (Brahim, 2000). Osmotic dehydration is widely used to remove part of the water content of fruit to obtain a product of intermediate moisture or as a pre-treatment before further processing (Lenart, 1996; Torreggiani, 2004). Rehman (1990) studied the osmotic dehydration of pineapple.

Pineapple organic product is viewed as an exceptionally nutritious natural product since it contains an elevated degree of L-ascorbic acid, a characteristic cell reinforcement which might restrain the improvement of major clinical circumstances including coronary illness and certain malignant growths [4]. The organic product likewise contains phenolic compounds and β-carotene [5, 6], which comprise normal wellsprings of cell reinforcements. Consequently data in regards to cancer prevention agents and cell reinforcement limit of "Phulae" and "Nanglae" pineapples is required to serve purchasers. The target of this study is to examine the physical and physicochemical qualities, including bioactive mixtures and cancer prevention agent limit of these two pineapple cultivars. The data acquired from this study will be helpful for advancing and expanding organic product utilization and their financial worth.

The objective of this study is to investigate the physical and physicochemical characteristics, including bioactive compounds and antioxidant capacity of these pineapple cultivars.

**Materials and Methods:**

**Preparation of osmo-dehydrated pineapple cube:**

Raw pineapples were obtained from Jadavpur market near Jadavpur University, Kolkata, India. Well maturated and ripe pineapples were selected for this study. Cleaned thoroughly with distilled water to remove adhering, dust, foreign matter and wiped with a muslin cloth. The selected pineapples were peeled using stainless steel knife. The edible portion was cut into cubes after removing the core. Size of the pineapple cube is (5×2×2) $mm^3$ .The treatments prior to osmo-dehydration consisted of-

a. Control sample($A_1$)
b. Steam blanching ($A_2$)
c. Microwave heating($A_3$)

**Pretreatment:**

**Control:** Pineapple cube without any treatment were considered as control

**Microwave heating:** Pineapple cubes are put into microwave at 300W for 5 min

**Steam blanching:** Steam blanching was done in a steamer for 5 min.

**Osmo-dehydration Procedure:**

Pineapple cubes were weighed approximately 15 gm for every experiment and immersed in 100 ml sugar syrup and left undisturbed for 24 hours at room temperature (28 $^0$C) for osmosis. The samples were separately dipped in a sugar solution 30˚B by using hand refractometer (Erma Inc. Tokyo, Japan). The concentration of sugar syrup increased in 50˚B and 60˚B. The process of osmosis takes place and water moves out of the fruit pieces to the syrup and fraction of solute moves into the pineapple cubes. At the end of the osmosis, the fruit slices 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. Osmosed pineapple cubes were spread uniformly over stainless steel trays and were kept in a conventional tray drier for dehydration with intermittent turning of cubes for quick drying. Pineapple cubes were dried at 40°C air temperature for overnight to get the desired moisture content and product quality. Osmodehydrated cubes were packed in 200 gauge polyethylene bags and stored under ambient condition for three months. Samples were analyzed for total phenol and antioxidant activity.

**Analytical parameters**

**Moisture Content**

Moisture Content was calculated according to the method described by Ranganna (1986) and expressed as dry basis.

**Determination of total polyphenolic content (TPC)**

Total phenol content was determined using the Folin-ciocalteu's reagent as described by Singleton and Rossi(1965).The sample extract (200µL)was mixed with 1.5ml of Folin-ciocalteu reagent (Previously diluted tenfold with distilled water). Allow to stand for 5min at room temperature. Then 1.5ml sodium bicarbonate solution (60gm/L) was added to the mixture. Mixture was vortexed, covered and allowed to stand for 120 min in a dark place. Triplicate measurements were carried out and the absorbance was measured by spectrophotometer (Hitachi U- 2000) at 765nm against a blank containing all the reagents without the sample and plotted in a standard calibration curve of Gallic Acid. These results have been expressed as Gallic Acid Equivalents per gram of dry sample.

**Determination of total antioxidant content (FRAP)**

The FRAP assay has been carried out according to Benzie & Strain, 1996. Briefly, the FRAP reagent has been prepared from sodium acetate buffer (300 mM, pH 3.6), 10 mM TPTZ solution (dissolved in 40 mM HCl) and 20 mMiron(III) chloride solution in a ratio (v/v) of 10:1:1, respectively. The FRAP reagent has been prepared freshly and warmed to 37°C in a water bath before use. 100 µl of the sample solution has been added to 3 ml of the freshly prepared FRAP reagent. The absorbance has been measured at 593 nm using spectrophotometer after 4 min and plotted in a standard calibration curve of FeSO4 solution. The results have been expressed as µmol Fe (II)/g dry sample.

**Determination of water loss (WL) and solid gain (SG)**

Osmotic dehydrated samples were blotted with tissue paper and later weighed for determination of WL and SG as shown by the following equation (Aktas *et al.*, 2007)

$$WL = \frac{W_{wo} - W_w}{W_o} \times 100$$

$$SG = \frac{W_s - W_{so}}{W_o} \times 100$$

Where, WL and SG are water loss and solid gain in %, respectively.

Wwo is the initial water mass,

Ww is the mass of water at time t,

WS is the solid mass at time t,

Wso is the initial solid mass

**Dehydration and rehydration ratios**

Dehydration ratio was determined as the ratio of weight of the sample before drying to the dried weight of sample .Whereas rehydration ratio was determined as the ratio of the weight of the rehydrated sample to that of dehydrated (Kalra, Tandon, & Singh, 1995).

Dehydration ratio=W/WD

Rehydration ratio=WR/WD

Where, W and WD are the weight of the sample before and after drying respectively, and WR is the rehydrated sample weight in (g).

**Organoleptic evaluation of osmotically dried pineapple cubes**

Descriptive sensory evaluation was carried out to determine the effect of osmo-drying on the quality attributes of osmo-dehydrated pineapple slices. A 6-member sensory panel was used to evaluate the various descriptors for colour, texture and taste of osmotic dehydrated fruits. The samples were evaluated for color and appearance, flavor, texture, taste and overall acceptability by a panel of semi trained judges on the basis of 9 point hedonic scale (Ranganna, 2004). Attributes were scored for degree of liking on 9-point hedonic scale of 1 to 9 (1=dislike extremely, 9=like extremely) and the average value was recorded. Score of 5.5 and above were considered acceptable. The average of all the sensory parameters was recorded.

**Result and Discussion:**

**Table 1:** Physicochemical properties of fresh pineapple

| Characteristics | Value |
|---|---|
| Average weight(gm) | 1500 gm |

| | |
|---|---|
| Pulp (%) | 70 |
| Peel (%) | 50 |
| Core (%) | 17 |
| Waste Index (%) | 58 |
| Total Soluble solids (˚B) | 11 |
| Moisture Content (%) | 88 |
| Vitamin C (% mg) | 38 |
| Total phenol Content | 51.1 |
| Antioxidant Activities | 62.4 |

**Effect of different concentration of sugar syrup on mass transfer:**

Effect of different concentrations of sugar and temperature of syrup on mass transfer as a function of time was studied during standardization process. The results obtained are shown graphically in Fig 1 to Fig 3. The weight was continuously reduced upto 3 hours of dipping and then slightly decreased for all the concentrations. Initially the rate of mass transfer was higher but it was reduced gradually as time progressed. Maximum mass transfer was found in case of sample treated with 60° B at room temperature of sugar syrup while minimum mass transfer was observed in sample treated with 30° B and 50° B sugar syrup. These are significantly hampered as compared to sample treated with 30° B & 50° B.

From these treatments we see that after dipping in sugar syrup every pretreated sample look like same but after drying steam blanching and microwave heated samples are looks better. Microwave heated samples gives the better retention of vitamin C, it gives higher amount of total phenol content and antioxidant activity. So the overall acceptability of osmodehydrated microwave heated pineapple cubes is higher than the steam blanched sample. Osmodehydrated control samples are not accepted due to bad color.

**Table 2:** Effect of sugar concentrations on weight loss (%), dry weight (g/100g), and dehydration ratio (%), rehydration ratio (%) on osmotic dehydration of pineapple after drying

| **Sugar Concentration (˚B)** | **Treatment** | **Weight loss (%)gm** | **Dry weight (%)gm** | **Dehydration Ratio** | **Rehydration Ratio** |
|---|---|---|---|---|---|

| | | | | | |
|---|---|---|---|---|---|
| 30˚B | Control<br>Steam blanching<br>Microwave heating | 69<br>60<br>65 | 30.75<br>34.06<br>40 | 3.25<br>2.94<br>2.5 | 3.43<br>2.97<br>2.63 |
| 50˚B | Control<br>Steam blanching<br>Microwave heating | 80<br>76<br>75 | 20.43<br>25.49<br>24.14 | 4.89<br>3.92<br>4.14 | 4.8<br>2.61<br>4.86 |
| 60˚B | Control<br>Steam blanching<br>Microwave heating | 75<br>66<br>79 | 24.89<br>21.30<br>33.84 | 4.01<br>4.69<br>2.95 | 3.88<br>4.31<br>2.84 |

**Effect of different concentration of sugar syrup and the temperature on mass transfer:**

Effect of different concentrations of sugar and temperature of syrup on mass transfer as a function of time was studied during standardization process. The results obtained are shown graphically in Fig 1 to Fig 3. The weight was continuously reduced upto 3 hours of dipping and then slightly decreased for all the concentrations. Initially the rate of mass transfer was higher but it was reduced gradually as time progressed. Maximum mass transfer was found in case of sample treated with 60° Brix at room temperature of sugar syrup while minimum mass transfer was observed in sample treated with 30° Brix and 50° Brix sugar syrup. These are significantly hampered as compared to sample treated with 30° Brix & 50° brix.

**Figure 1: Effect of sugar syrup concentration30˚B on mass transfer at room temperature**

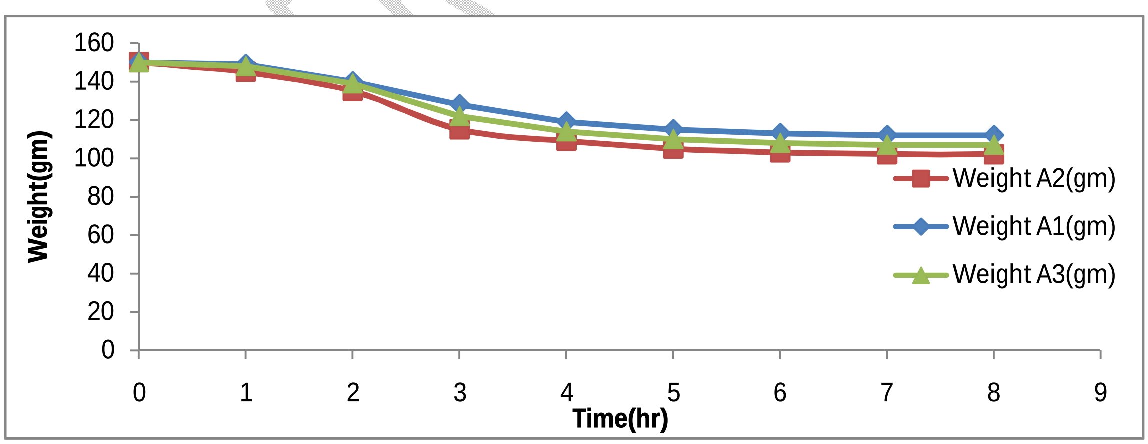



**Figure 2: Effect of sugar syrup concentration50˚B on mass transfer at room temperature**

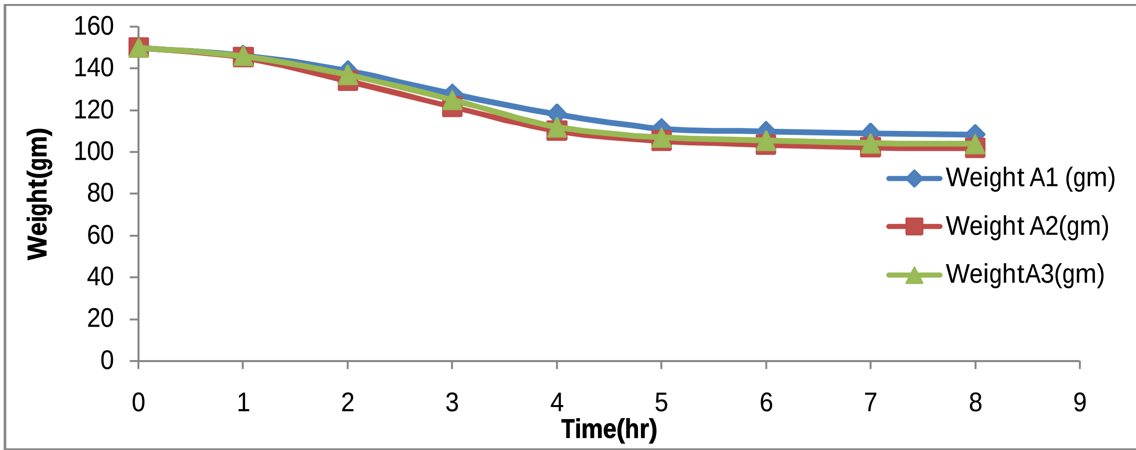
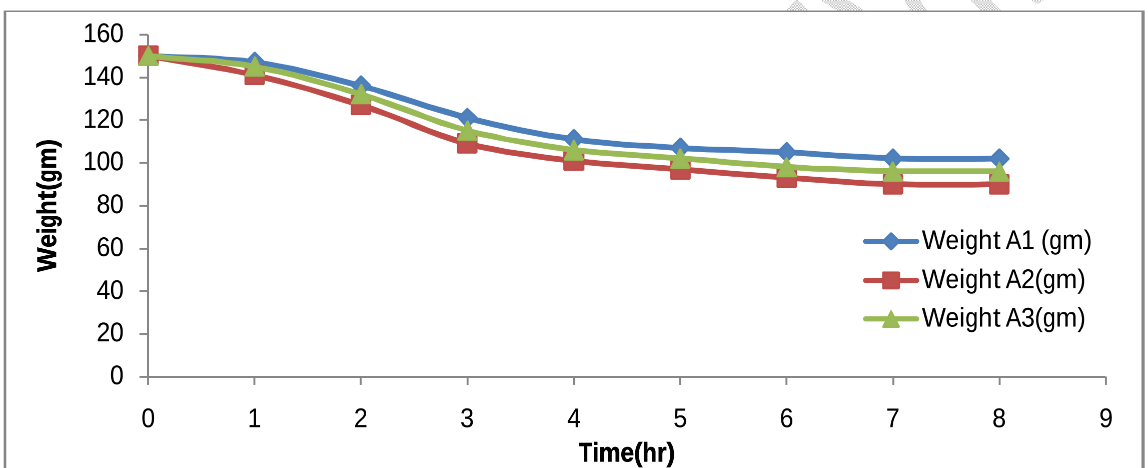



**Figure 3: Effect of sugar syrup concentration60˚B on mass transfer at room temperature**




The results obtained regarding the effect of sugar syrup concentration on moisture content are tabulated in Table 2. The moisture content of sample was determined after removing from sugar syrup. The moisture content was found to be decreased when concentration of syrup increased. 60° B sample showed the maximum reduction in moisture content. From Table 3 it is seen that the moisture content percentage is lower in 60° B sample as compared to others. The ascorbic acid content decreased gradually as the concentration increased possibly due to oxidation of ascorbic acid to dehydro-ascorbic acid

**Table 3:** Effect of sugar syrup concentration on moisture content

| **Concentration of sugar solution** | **Sample** | **Moisture content (%)** |
|---|---|---|
| 30˚B | Control<br>Steam blanching | 80<br>76 |

| | | |
|---|---|---|
| | Microwave heating | 75 |
| 50˚B | Control<br>Steam blanching<br>Microwave heating | 75<br>66<br>79 |
| 60˚B | Control<br>Steam blanching<br>Microwave heating | 69<br>60<br>65 |

**Table4:** Effect of sugar syrup concentration on Vitamin C, total phenol content and antioxidant content of pineapple cube

| **Sample** | **Sugar syrup concentration** | **Vitamin C (mg/g)** | **Total phenol content (mg GAE/g)** | **Antioxidant activity** |
|---|---|---|---|---|
| **Control(A1)** | 30˚B<br>50˚B<br>60˚B | 18.5±0.4<br>12.03±0.08<br>5±0.04 | 48.12±0.3<br>35.5±0.1<br>27.6±0.4 | 57.4±0.2<br>48.3±0.7<br>33.3±0.1 |
| **Steam blanching(A3)** | 30˚B<br>50˚B<br>60˚B | 15.6±0.05<br>9.67±0.9<br>2.7±0.2 | 49.5±0.3<br>38.7±0.5<br>30.5±0.8 | 59.8±0.3<br>50.43±0.2<br>38.56±0.6 |
| **Microwave heating(A2)** | 30˚B<br>50˚B<br>60˚B | 17±0.3<br>10±0.7<br>3.8±0.4 | 49.67±0.3<br>39.5±0.8<br>39.9±0.3 | 57.1±.3<br>49.2±0.46<br>48.14±0.5 |
| **Fresh** | | 21.5 | 51.1±0.2 | 62.4±0.2 |

**Organoleptic evaluation:**

Osmotically dehydrated pineapple cubes were analyzed using 9 point scale for various quality attributes and results are summarized in Table 4. It is found that the sample dipped in 60° Brix solution and dried is significantly superior to other samples in terms of color. The sample dipped in 60° Brix solution dried got a good texture and 60° Brix solution, dried got inferior texture. The taste of sample dipped in 50° Brix solution and dried has good taste over other samples.

**Osmotically treated pineapple cubes:**

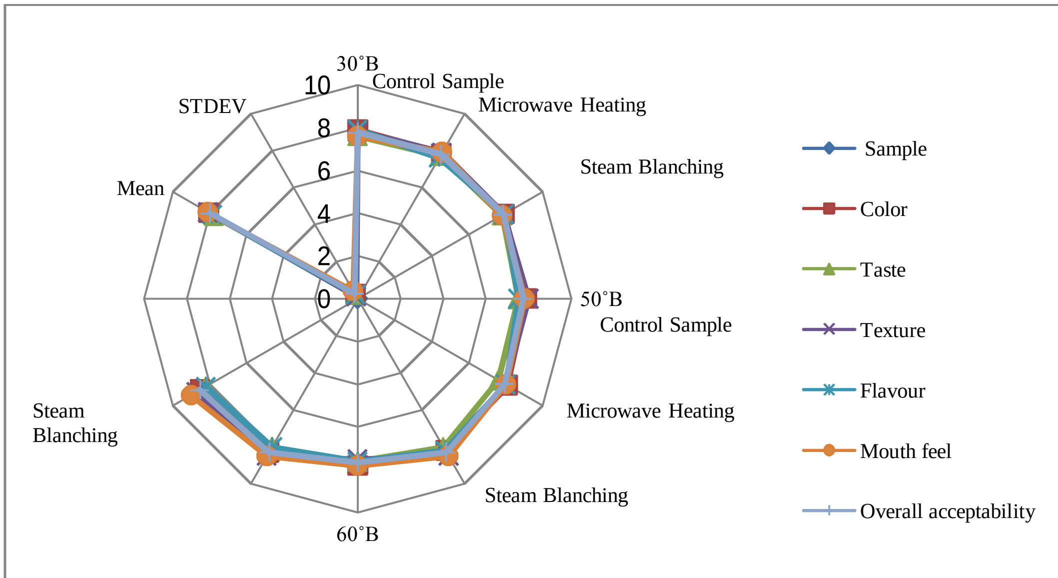



**Figure 4:** Sensory analysis of Pre-treated osmodehydrated Pineapple cube

**Storage study of Pre-treated pineapple cubes:**

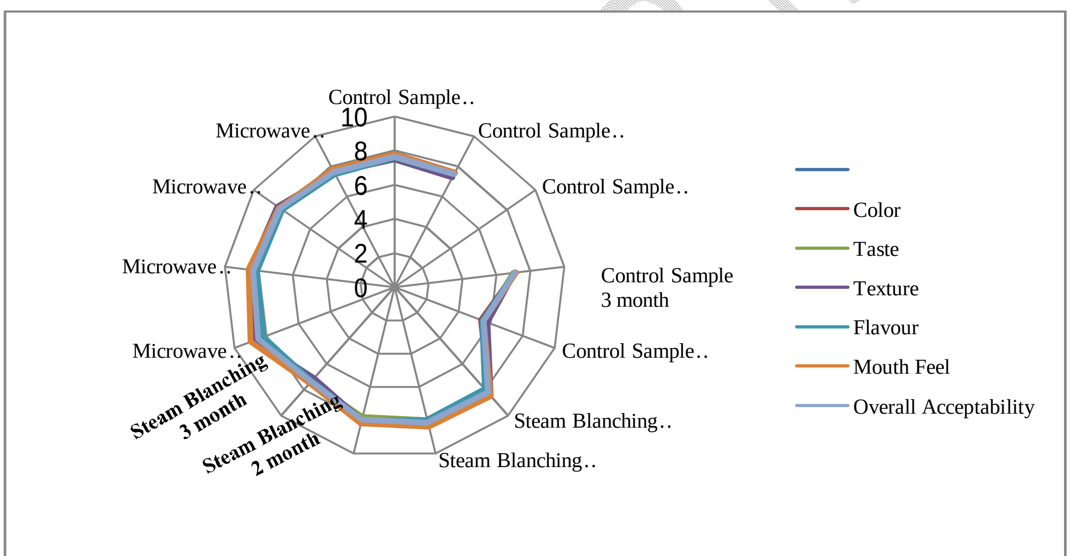



**Figure 5:** Descriptive analysis on Sensory score of pre-treated samples dipped in 60˚B sugar syrup

**Table5:** Effect of sugar syrup concentration on vitamin C, total phenol and antioxidant activity of osmodehydrated pineapple cube during storage

| **Samples** | **Vitamin-C** | | | | **Total phenol Content** | | | | **Antioxidant Activity** | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Initi | 1mo | 2mo | 3mo | Initi | 1mont | 2mon | 3mon | Initi | 1mon | 2mo | 3mon |

| | al | nth | nth | nth | al | h | th | th | al | th | nth | th |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Control** | 5±0.02 | 2.67 ±0.05 | 0.8±0.02 | 0.4±0.06 | 27.6±0.1 | 18.6±0.2 | 11.32±0.3 | 8.7±0.45 | 33.3±0.1 | 17.04±0.02 | 9.07±0.06 | 4.06±0.05 |
| **Steam Blanching** | 2.7±0.02 | 2.5±0.4 | 1.8±0.05 | 1.5±0.02 | 30.4±0.8 | 29.89±0.034 | 23.04±0.05 | 16.07±0.02 | 38.2±0.5 | 35.02±0.3 | 28.4±0.2 | 21.5±0.4 |
| **Microwave Heating** | 3.8 ±0.47 | 3.5±0.05 | 3.1±0.023 | 2.5±0.04 | 39.8±0.3 | 36.5±0.07 | 31.7±0.02 | 27.6±0.03 | 48.1±0.3 | 45.5±0.03 | 39.8±0.04 | 30.06±0.02 |



**Conclusion:** Osmotic dehydration kinetics indicated that both Water loss and solid gain increased with the increase of sugar syrup concentration. Pineapple cubes were osmo-dehydrated by using 60˚B sugar syrup concentration gives the better vitamin C retention , total phenol content is high better than the other. Also osmodried pineapple cube dipped in 60˚B gives the better antioxidant activity. Color , flavour, texture and the overall acceptability is high and stored for 3months at ambient condition without any adverse effect on the quality.

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