

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 3 months 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

28 method, and process. The fruit's flavour is refreshing because of the fruit's sugar and acid
29 balance. The pineapple is a beautiful tropical fruit that offers a tonne of health advantages along
30 with exceptional juiciness and bright tropical flavour. The significant amounts of calcium,
31 potassium, vitamin C, carbohydrates, dietary fibre, water, and other minerals found in pineapple
32 are helpful for the digestive system, aid in maintaining a healthy weight, and promote balanced
33 nutrition.

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 In this process moisture is withdrawn from the product at ambient temperature by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

51 Osmotic dehydration of foods has gained attention recently due to its potential for the food
52 process industry. Osmotic dehydration is widely used for the partial removal of water from plant
53 tissues by immersion in a hypertonic solution. Osmotic dehydration generally will not give a
54 product of sufficiently low moisture content for it to be considered shelf-stable. Osmotic lack of
55 hydration is a conventional interaction applied to food dewatering. It prompts alluring items that
56 are prepared to eat or can be applied as a pretreatment to the following system, for example,
57 drying or freezing. Water is a principal constituent of food sources, which influences food
58 security, microbial as well as compound. It is liable for the customer view of quite a large

59 number organoleptic qualities like juiciness, elasticity, tenderness and texture. In food industry,
60 food and food products are preserve by using dehydration process to remove the water from the
61 raw materials. The bringing down of water action can be accomplished in two ways, either by the
62 expansion of humectants or by the expulsion of dissolvable, for example, water .Now a days,
63 researcher focused on the improvement of product quality of preserved food products. Osmotic
64 dehydration is the cheapest and easiest method to obtain better food products by removing water
65 at low temperature (Shi and Xue, 2009). It has been broadly utilized as a pretreatment step in
66 food drying process since it can diminish generally the energy prerequisite for additional drying
67 process (Khin et al., 2006). To fulfill the developing market interest for products in a fresh like
68 state, insignificant handling like osmotic lack of hydration will be progressively utilized. The
69 dynamic exploration in the area of osmotic drying out of organic products is proceeding from
70 one side of the planet to the other.

71 Pineapple is an important fruit of India. Pineapple is cultivated in an area of 89 thousand ha and
72 total production is 1,415.00 thousand tons. It is native to Central and South America. The
73 cultivation of pineapple was initially begun in regions among Brazil and Paraguay, and afterward
74 steadily spread over the entire tropical world. The all out region under pineapple development on
75 the planet is 1.05 million hectare with creation around 25.81 million hectare (FAOSTAT, 2016).
76 The agro-climatic and physio-geographical conditions of some parts of India is most suitable for
77 the pineapple plant growth, such as the entire North-Eastern states including Assam, Meghalaya,
78 Tripura and Manipur, northern part of West Bengal, coastal parts of Andhra Pradesh, Orissa,
79 Kerala, Tamil Nadu and Goa, and some parts of Maharashtra, Gujarat and Karnataka. With over
80 0.11 million hectare area, India stands at second position just after Nigeria (0.18 million hectare)
81 in terms of area under pineapple cultivation by contributing more than 10 percent of the total
82 pineapple producing area of the world. While, in terms of production India is sixth largest
83 producer of pineapple with a production value of 1.74 million tonnes, the first being Costa Rica
84 (2.92 million tonnes). There are more than ninety variety of pineapple cultivated all around the
85 world. However, only three varieties are commercially grown in India, these are; *Giantkew*- big
86 size fruit with broad and flat eyes and colour varies from yellow to coppery yellow (12-14
87 orbix); *Queen*- small in size with small and raised eyes and colour is flesh deep golden yellow
88 (15-16 orbix); and *Mauritius*- fruit size is medium and yellow and red in colour. Pineapple is
89 known by so many names throughout India, such as *Keehom* (Manipur), *Ananus* (Marathi),

90 *Annasahannu* (Kannada), *Anasipazham* (Tamil), *Kaitachchakka* (Malayalam) and *Annasapandu*
91 (Telegu). The sunny field of north-east India having pure tropical rain brings peak flavour to our
92 pineapple. They are then packed and sent to store houses, where they are protected for
93 transportation and marketing (pineapplesinIndia.com, 2018). The total area under pineapple
94 cultivation in the world is 909.84 thousand ha with production around 19412.91 thousand tons.

Comment [t1]: abbreviation is not needed

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

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

Comment [t2]: correction of year and authors' name

114 Pineapple organic product is viewed as an exceptionally nutritious natural product since it
115 contains an elevated degree of L-ascorbic acid, a characteristic cell reinforcement which might
116 restrain the improvement of major clinical circumstances including coronary illness and certain
117 malignant growths [4]. The organic product likewise contains phenolic compounds and β -
118 carotene [5, 6], which comprise normal wellsprings of cell reinforcements. Consequently data in
119 regards to cancer prevention agents and cell reinforcement limit of "Phulae" and "Nanglae"
120 pineapples is required to serve purchasers. The target of this study is to examine the physical and

121 physicochemical qualities, including bioactive mixtures and cancer prevention agent limit of
122 these two pineapple cultivars. The data acquired from this study will be helpful for advancing
123 and expanding organic product utilization and their financial worth.

Comment [t3]: duplicate

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

126 **Materials and Methods:**

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

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

Comment [t4]: colourmn

- 134 a. Control sample(A_1)
- 135 b. Steam blanching (A_2)
- 136 c. Microwave heating(A_3)

137 **Pretreatment:**

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

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

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

Comment [t5]: Brief description needed

141 **Osmo-dehydration Procedure:**

142 Pineapple cubes were weighed approximately 15 gm for every experiment and immersed in 100
143 ml sugar syrup and left undisturbed for 24 hours at room temperature (28°C) for osmosis. The
144 samples were separately dipped in a sugar solution 30°B by using hand refractometer (Erma Inc.
145 Tokyo, Japan). The concentration of sugar syrup increased in 50°B and 60°B . The process of
146 osmosis takes place and water moves out of the fruit pieces to the syrup and fraction of solute
147 moves into the pineapple cubes. At the end of the osmosis, the fruit slices were taken out of the
148 osmotic solution and were drained in order to remove the sugar coating adhering to the surface of
149 the fruit pieces. Osmosed pineapple cubes were spread uniformly over stainless steel trays and
150 were kept in a conventional tray drier for dehydration with intermittent turning of cubes for
151 quick drying. Pineapple cubes were dried at 40°C air temperature for overnight to get the desired

Comment [t6]: g

Comment [t7]: correction needed

Comment [t8]: belongs to the introduction part.

152 moisture content and product quality. Osmodehydrated cubes were packed in 200 gauge
153 polyethylene bags and stored under ambient condition for three months. Samples were analyzed
154 for total phenol and antioxidant activity.

Comment [t9]: specify _ the meaning

155 Analytical parameters

156 Moisture Content

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

Comment [t10]: brief description needed, reference is missing from the list

159 Determination of total polyphenolic content (TPC)

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

169 Determination of total antioxidant content (FRAP)

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

Comment [t11]: missing space in the MS

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

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

181

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

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

182

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

184 W_{wo} is the initial water mass,

185 W_w is the mass of water at time t,

186 W_s is the solid mass at time t,

187 W_{so} is the initial solid mass

188 **Dehydration and rehydration ratios**

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

192 Dehydration ratio= W/WD

193 Rehydration ratio= WR/WD

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

196 **Organoleptic evaluation of osmotically dried pineapple cubes**

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

205 **Result and Discussion:**

206 **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

Comment [t12]: contradiction: TPC, determined on d.w., while fresh mat. is in the title.

Comment [t13]: correctly FRAP

207

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

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

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

Comment [t14]: belongs to the organoleptic evaluation.

223 **Table 2:** Effect of sugar concentrations on weight loss (%), dry weight (g/100g), and
 224 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
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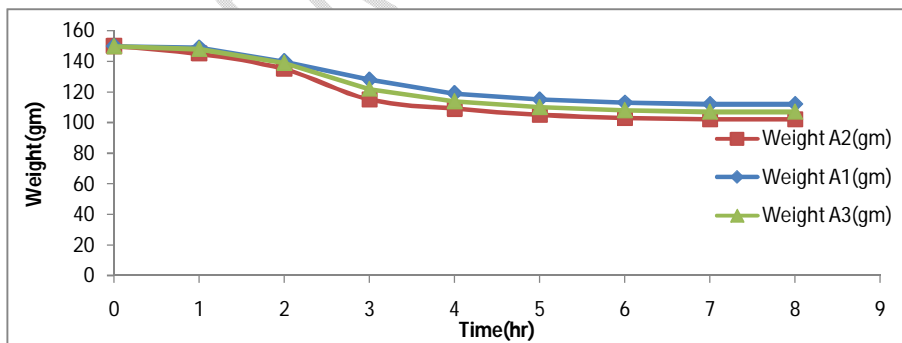
30°B	Control	69	30.75	3.25	3.43
	Steam blanching	60	34.06	2.94	2.97
	Microwave heating	65	40	2.5	2.63
50°B	Control	80	20.43	4.89	4.8
	Steam blanching	76	25.49	3.92	2.61
	Microwave heating	75	24.14	4.14	4.86
60°B	Control	75	24.89	4.01	3.88
	Steam blanching	66	21.30	4.69	4.31
	Microwave heating	79	33.84	2.95	2.84

225

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

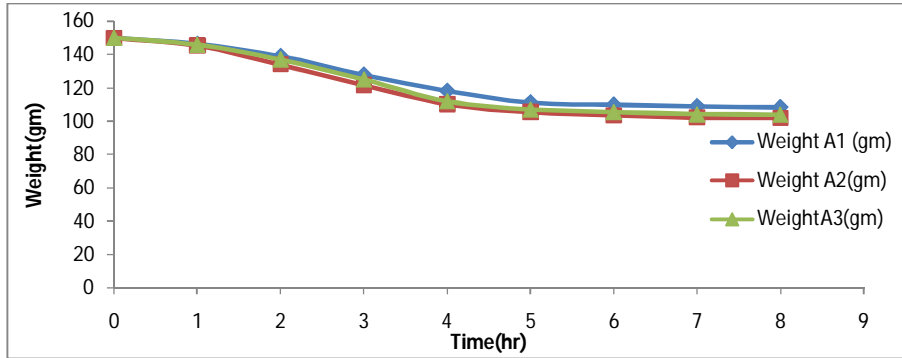
227 Effect of different concentrations of sugar and temperature of syrup on mass transfer as a
 228 function of time was studied during standardization process. The results obtained are shown
 229 graphically in Fig 1 to Fig 3. The weight was continuously reduced upto 3 hours of dipping and
 230 then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

235 **Figure 1: Effect of sugar syrup concentration 30°B on mass transfer at room temperature**



236

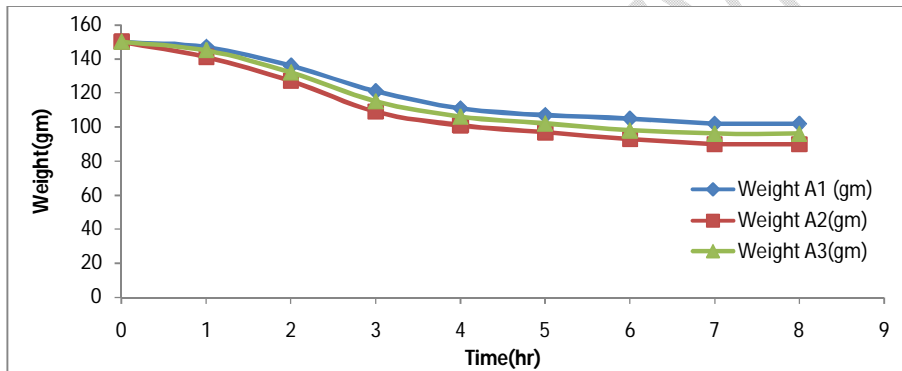
237 **Figure 2: Effect of sugar syrup concentration 50°B on mass transfer at room temperature**



238

239

240 **Figure 3: Effect of sugar syrup concentration 60° B on mass transfer at room temperature**



241

242 The results obtained regarding the effect of sugar syrup concentration on moisture content are
 243 tabulated in Table 2. The moisture content of sample was determined after removing from sugar
 244 syrup. The moisture content was found to be decreased when concentration of syrup increased.
 245 60° B sample showed the maximum reduction in moisture content. From Table 3 it is seen that
 246 the moisture content percentage is lower in 60° B sample as compared to others. The ascorbic
 247 acid content decreased gradually as the concentration increased possibly due to oxidation of
 248 ascorbic acid to dehydro-ascorbic acid

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

Concentration of sugar solution	Sample	Moisture content (%)
30° B	Control	80
	Steam blanching	76

	Microwave heating	75
50°B	Control	75
	Steam blanching	66
	Microwave heating	79
60°B	Control	69
	Steam blanching	60
	Microwave heating	65

250

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

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

253

254 **Organoleptic evaluation:**

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

	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
Steaming 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±0.02	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

269

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

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