

*Research paper

STUDIES ON THE PHYSICO-CHEMICAL AND SENSORY PROPERTIES OF JAM FROM OSMOTICALLY DEHYDRATED PINEAPPLE SLICES

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ABSTRACT:

Dried fruits have limited food use, this study thereby explore the food utilization potential of dehydrated pineapple slices. The influence of 50 °Brix sugar and 47:3 % w/w sugar/salt solutions on the quality of jam produced were investigated. Pineapple slices were osmotically dehydrated (4 hr), oven dried (60 °C 27 hr), and rehydrated at 90 °C for 15 min and room temperature for 6 hr. Jams were made from dried pineapple slices (with or without osmotic dehydration), fresh pineapple and compared with commercial pineapple jam. Physico-chemical and sensory properties of the jam were conducted. Osmotic dehydration contributed to the titratable acidity values, rehydration temperature had no significant ($P < 0.05$) effect on total soluble solid, while the moisture content increased as the rehydration temperature increased. Osmotic dehydration of fruits prior to drying had effect on the retention of the vitamin C and protected reducing sugar from being lost. No significant ($P < 0.05$) influence of rehydration time and temperature on the total sugar of the samples. Panelist revealed that jam samples produced from pineapple dehydrated in sugar solution and rehydrated at room temperature were most preferred. The results suggest that surplus fruits can be preserved by osmotic dehydration followed by oven drying for later use in jam production.

Keywords: Pineapple, Nigeria, Osmotic dehydration, Rehydration, Dried Fruits, Jam, Physico-chemical and Sensory evaluation.

INTRODUCTION

Nigeria is the largest producer of pineapple in Africa and the eighth largest in the world with a total production of 810,332 metric tons per year (FAO, 2008). About 70% of the pineapple is consumed fresh in the producing countries (Coveca, 2002). The fruit has high sugar content and is rich in vitamins A and C (Arc-Institute, 2000). About 20 - 40% of wastage has been recorded annually in Nigeria (thetidenews.com, 2008) because the

37 fruits are prone to spoilage and poor preservation facilities,hence there is a need for the
38 preservation of pineapple to reduce wastage.

39 Sun drying is the cheapest and most common technique employed in the
40 preservation of many agricultural materials in Nigeria, but this result in a product of poor
41 quality. Conventional oven drying yield products of leathery texture and dark colour.
42 The use of osmotic dehydration in combinations with oven drying has been suggested to
43 improve product quality (Aworhet *al.*, 1983).

44 Osmotic dehydration entails the partial removal of water from food in a higher
45 osmotic pressure solution. Mass transfer rate during osmotic dehydration depends on
46 factors such as temperature, concentration of the osmotic medium, size and geometry of
47 the sample, sample to solution ratio and the degree of agitation. Pretreatment has been
48 reported to enhance the mass transfer kinetics during osmotic dehydration (Shi and Fito,
49 1994, Ade-Omowayeet *al.*, 2002).

50 Jam processing is one of the most important methods of fruit preservation. Jam
51 differ from each other in the raw materials used, processing methods and additives
52 (Isabellefruits, 2004).Commercially, jams are prepared by concentrating the mix using
53 thermal treatment at normal or reduced pressure, which results in a thick or gelled
54 consistency. It also ensures destruction of fruit enzymes, pectin from the fruit and
55 concentrates the product to a point where its acidity and reduced water activity are self-
56 preserving (May, 1997). Many studies have been undertaken to reduce nutrient losses
57 during jam making. Garcia-Martinez *et al.*(2002) reported reduced mineral losses in jam
58 made from osmo-dehydrated kiwi fruits. The low temperature involved in the osmotic
59 dehydration process prior to jam formulation has been reported to result in products with
60 higher overall quality (Lenart and Flink, 1984, Garcia-Martinez *et al.*, 2002). Oyeyinkaet
61 *al.* (2011) reported the production of acceptable jam products from osmo-dehydrated
62 cashew apple.

63 This research was aimed at investigating the influence of different osmotic
64 conditions on the characteristics of dried pineapple slices and to explore the utilization
65 potential of osmodehydrated pineapple slices in jam production in order to increase the
66 use of dried fruits which until now has remained grossly underutilized in Nigeria. In this
67 study, the physico-chemical properties of the jam samples were reported.

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69 MATERIALS AND METHODS

70 **Collection of materials:** Fresh pineapple fruits (smooth cayenne) were procured from a
71 local market in Ile-Ife.The pure table sugar (raffinade grade), NaCl, gelling agent (Fine
72 pectin) and acidity agent (M &B citric acid)were purchased from Fortel chemical
73 laboratory in Ile-Ife, Osun State, Nigeria.

74 **Osmotic Treatment:** Pineapple fruit was rinsed with potable water, peeled and slicedinto
75 a uniform diameter ($40 \pm 0.1\text{mm}$) and thickness ($5 \pm 0.2 \text{ mm}$) using a corer and vernier
76 caliper. Slices were placed in a beaker containing the osmotic solution (aqueous sugar

77 solution of 50 °Brix and sugar/salt solution of 47:3 % w/w) and maintained at 40 °C in a
78 thermostatically controlled water bath(SW22,Julabo USA). The ratio of fruit pieces to
79 that of the medium was maintained at 1:10 in order to ensure that the concentration of the
80 osmotic solution did not change significantly during the experiment. Samples were
81 withdrawn at 60, 120, 180 and 240 minutes with their surfaces gently blotted with tissue
82 paper before weighing (Taiwoet *al.*, 2002).

83 **Convective Air Drying and Rehydration Process:** Osmotically dehydrated pineapple
84 slices were dried in hot air oven(MRC Oven/Incubator, Model DP/DK 500/600/800,
85 made by MRC Ltd. Hahystadnit) at 60 °C for 27 h to obtain dried products which were
86 kept in sealed polythene bags and stored in a cupboard at room temperature until used.
87 The samples were rehydrated at two different conditions in glass beaker containing
88 distilled water at 90 °C for 15 min and at room temperature (27± 2°C) for 6 h using the
89 method of Taiwoet. *al.*(2002). Excess water was blotted carefully from the samples using
90 paper towel and weighed before further processing into jam.

91 **Jam production:** Operating conditions were determined from preliminary studies. The
92 rehydrated fruit samples were blended using a laboratory blender (Twister mixer and
93 grinder, Gazab KA, KanchanInternation Ltd. Dabhel, Duman - 396210), the ratio of
94 water to that of crushed pineapple was 18:34 g/g. Sugar (65%) was added to the crushed
95 pineapple (34.2%) followed by the addition of 0.4% citric acid and 0.4% pectin
96 (Oyeyinkaet *al.*, 2011). The resultant mixture was heated between 80 °C and 100 °C until
97 it set between 22 – 23 min. The jam samples were hot-filled into sterilized jars, sealed
98 and rapidly cooled under running water to minimize thermal stress. The products were
99 stored under refrigeration condition for further analysis (Oyeyinkaet *al.*, 2011). Jam
100 samples were also produced from fresh, dried but not osmodehydrated samples.

101 **ChemicalAnalysis:** Titratable acidity (TTA), pH, total soluble solid (° Brix) vitamin C
102 content, moisture content, reducing sugar and total sugar were determined using methods
103 described by AOAC (2005).

104 **Sensory Evaluation:** Each jam sample was coded and served in a clean plate with white
105 bread to 16 untrained panelists (but consumers of jam). Quality attributes of jam made
106 from fresh pineapple slices and commercial jam samples were comparedwith those jam
107 made fromosmo-dehydrated fruits and dried but not osmodehydrated samples. The
108 samples were assessed for aroma/flavour, colour, taste, texture/spread ability and general
109 acceptability using a five point hedonic scale where five represents 'like extremely' and 1
110 represents 'dislike extremely'.

111 **Statistical Analysis:** All analyses were carried out in triplicates. Analysis of variance
112 (ANOVA) was conducted on the mean values to determine significant differencesamong
113 samples followed by mean separation using Duncan Multiple Range Test (SPSS 15.0,
114 2006).

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117 RESULTS AND DISCUSSION

118 The results of the chemical composition of the jam samples are presented in Table 1. The
 119 observed titratable acidity (TTA) of the jam samples dehydrated in sugar/salt medium
 120 and rehydrated at 28 °C had the highest TTA value (1.88 ± 0.01 %) while the samples
 121 dehydrated in sugar medium and rehydrated at 90 °C had the least TTA (1.35 ± 0.30 %).
 122 This result suggests that low temperature rehydration process resulted in increased TTA
 123 of the jam samples, which were significantly ($P < 0.05$) different from those rehydrated at
 124 high temperature. Effect of the osmotic solutions used showed that the presence of salt
 125 (NaCl) in the sugar/salt mix increased the percent TTA compared to that of jam produced
 126 from samples dehydrated in sugar solution.

127 Results of pH (Table 1) showed that jam produced from samples dehydrated in
 128 sugar/salt solution had lower pH values (3.41-3.64) compared to those produced from
 129 samples dehydrated in sugar solution (3.75-3.79). Jam produced from dried non-
 130 osmotically dehydrated slices exhibited lower acidity (pH 3.83) when compared with
 131 those produced from osmotically dehydrated samples. The higher TTA and lower pH
 132 values exhibited by jams produced from pineapple slices dehydrated in sugar/salt solution
 133 may preserve the jam better than those produced from sugar dehydration. Results of pH
 134 obtained in this study are within range of values reported by Garcia-Martinez *et al.*
 135 (2002) for kiwi jam and orange marmalade where pH values are between 3.04 and 4.68.

136 Temperature of rehydration had no significant ($P > 0.05$) effect on total soluble
 137 solid (TSS) of the jam samples. Jam made from pineapple fruits dehydrated in sugar
 138 solution had 70 – 72 °Brix while those osmotically dehydrated in sugar/salt had 62 °Brix.
 139 These values are comparable to those reported by Garcia-Matrinez *et al.* (2002) for kiwi
 140 jam and orange marmalade (32.1 – 68.4 °Brix). The TSS value of the sugar jam samples
 141 (70 -72 °Brix) also agrees with the values reported by Oyeyinka *et al.* (2011) for
 142 osmotically dehydrated cashew jam where TSS value obtained is 70 °Brix. Effect of
 143 osmotic solutions on the total soluble solids showed that the jam samples made from
 144 fruits dehydrated in sugar solution had the highest °Brix. Sugar influences the shelf-life
 145 of jam products decisively through the soluble solid content (Herbstreith and Fox, 2011).

146 Results of the moisture content (MC) of jam produced from samples dehydrated
 147 in sugar/salt solutions and rehydrated at 90 °C and room temperature had the least MC
 148 (13.28 and 9.64 % respectively), indicating a harder gel compared to commercial jam
 149 with a MC of 29.83 %. Among the jam samples made from osmotically dehydrated fruits,
 150 jam from sugar-OD sample rehydrated at 90 °C had the highest MC (20.42 %). It is
 151 expected that the lower MC will deter microbial proliferation. The MC of samples
 152 rehydrated at 90 °C was higher than those rehydrated at room temperature. The MC
 153 values obtained in this study are within literature values for jam reported by Winus, 2011
 154 where the values are 28.6 - 30.1%. MC affects the gel strength, as moisture content
 155 decrease the gel becomes increasingly firmer. Higher gel strength indicates the presence
 156 of higher amount of Ca^{2+} thereby affecting the rheological and sensory property such as
 157 spread-ability and these explains the reason why samples with low moisture content may
 158 have poor spreading ability (Herbstreith and Fox, 2011).

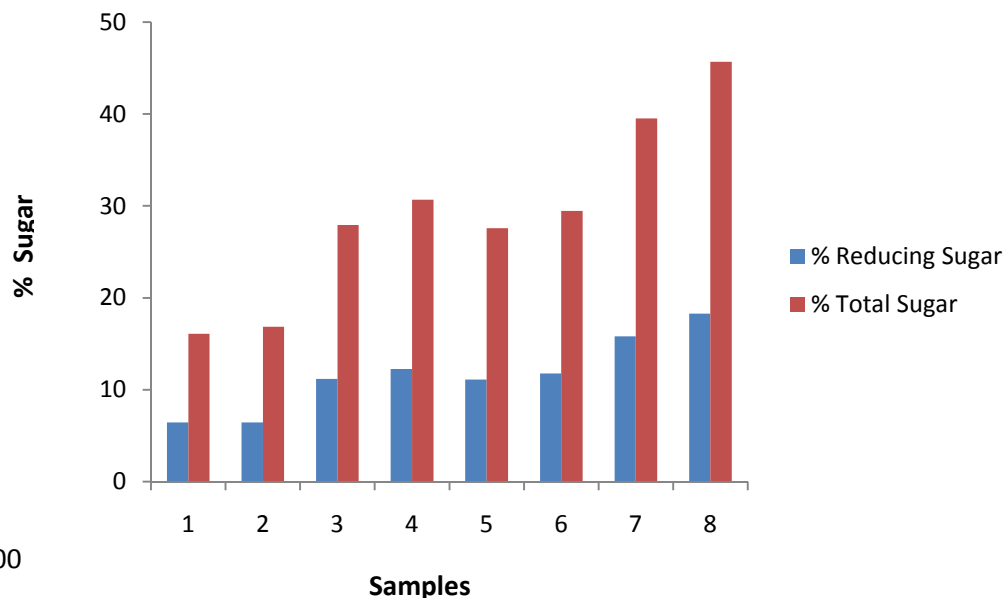
159 Among the osmotically dehydrated pineapple jams, jam produced from sugar/salt
 160 OD samples and rehydrated at room temperature had the highest vitamin C content while
 161 the jam produced from samples dehydrated in sugar solution and rehydrated at room

temperature had the least value. Commercial jam had a vitamin C value of 18.40 mg/100g while those produced from dried non-osmotically dehydrated slices and rehydrated at 90 °C had the least vitamin C content had 13.33 mg/100g. Jam samples still retained greater percentage (13.33 – 15.96 mg/100g) of vitamin C content despite all the processes the pineapple slices were subjected to when compared with the vitamin C content of the fresh pineapple slice (18 mg/100g), this suggests that osmotic dehydration of fruits prior to drying had significant effect on the retention of the vitamin C of the fruits. The trend shows that the value of vitamin C decreased as temperature of rehydration increased except for sugar jam samples which had higher vitamin C values for samples rehydrated at 90°C. The loss in vitamin C at low temperature rehydration may be due to the fact that vitamin C is water soluble and may have leached into the rehydration medium at longer periods (15 minute for 90 °C and 6 hrs for room temperature) as reported by Torreggiani (1993).

Results of the reducing sugar in Fig. 1 showed that OD jam samples had significantly ($P<0.05$) higher reducing sugar values (11.10 – 12.27 %) compared to the dried non-OD samples which had low sugar value in the range 6.43 – 6.45 %. The values for reducing sugar for osmotically dehydrated samples were lower compared to the fresh and commercial jam samples (15.81 and 18.27 % respectively). This suggests that osmotic dehydration had preservative effect on reducing sugar. It is probable that reducing sugar present in the jam samples prevents crystallization during boiling because the sugar added partly gets converted into invert sugar (Herbstreith and Fox, 2011). The values observed are within literatures 15.9 – 23.5 % (Winus, 2011) and 14 % (Oyeyinka *et al.*, 2011). Total sugar in the jam showed the same trend as the reducing sugar, and the results showed that jam produced from osmotically dehydrated samples had low (27.57 – 30.68 %) total sugar compared to values reported by Winus (2011) 65.3 – 66.2 % and Oyeyinka *et al.* (2011) 42.9 % The total sugar was very low for jam samples made from non OD samples (16.08 – 16.85 %) which was about half the total sugar of jam made from OD samples (27.57 – 30.68 %). The total sugar of the jam made from fresh pineapple fruit (39.53 %) was greater than that made from non OD fruits (16.08 – 16.85 %) which suggest that the sugar in the non OD fruits may have been lost during drying. The result suggests that osmotic dehydration could lower the total sugar content of the jam made from OD samples when compared to commercial and fresh pineapple jam. In addition, persons desiring jam of reduced sugar can benefit from using jam from OD fruits.

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Fig. 1: Values of Reducing Sugar and Total Sugar



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203 The value for soluble solids is an indicator of the fruit content of the jam which
 204 helps prevent the growth of mould and yeast. The degree brix for the samples ranged
 205 between 62 and 70. Interestingly, jam made from dried non OD fruits had the highest
 206 values of 70 °brix, this is not unexpected as the dried fruit was sugar free. The results
 207 showed that osmotic dehydration significantly reduced the loss of sugars (reducing and
 208 total sugar) and vitamin C in the samples compared to jam produced from dried non-
 209 osmotically dehydrated samples.

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Table 1 Chemical composition of the various jam samples

Samples	TTA (%)	M.C (%)	Vitamin C (mg/100g)	Total Soluble Solid (° Brix)	pH
1	1.41±0.31 _{bc}	15.62±0.50 _e	13.33±0.03 _f	70.00±0.00	3.83±0.02 _b
2	1.36±0.35 _c	15.30±0.06 _e	14.63±0.00 _d	60.00±0.00	3.83±0.00 _b
3	1.35±0.30 _c	20.42±0.22 _c	14.62±0.02 _d	70.00±0.00	3.75±0.01 _d
4	1.38±0.06 _{bc}	16.36±0.35 _d	14.34±0.03 _e	72.00±0.00	3.79±0.02 _c
5	1.83±0.01 _a	13.28±0.16 _f	14.52±0.19 _d	62.00±0.00	3.64±0.01 _e
6	1.88±0.01 _a	9.64±0.31 _g	15.96±0.00 _c	62.00±0.00	3.41±0.01 _f
7	1.38±0.06 _{bc}	21.64±0.20 _b	17.29±0.00 _b	64.00±0.00	3.95±0.02 _a
8	1.43±0.01 _b	29.83±0.38 _a	18.40±0.19 _a	62.00±0.00	3.73±0.02 _d

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223 1 = Jam produced from dried pineapple without osmotic dehydration and rehydrated at 90°C

224 2 = Jam produced from dried pineapple without osmotic dehydration and rehydrated at Room
225 temperature

226 3 = Jam produced from pineapple dehydrated in sugar solution and rehydrated at 90°C

227 4 = Jam produced from pineapple dehydrated in sugar solution and rehydrated at Room
228 temperature

229 5= Jam produced from pineapple dehydrated in sugar/salt solution and rehydrated at 90°C

230 6 = Jam produced from pineapple dehydrated in sugar/salt solution and rehydrated in Room
231 temperature

232 7 = Jam produced from fresh Pineapple pulp

233 8= Commercial jam

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Results of the data on sensory evaluation of the jam samples presented in Table 2 revealed that both osmotic solution and rehydration time had significant ($P > 0.05$) influence on all the sensory attributes measured. The panelists scored jam samples obtained by rehydrating samples at room temperature higher in colour for both media used than those produced from samples rehydrated at 90 °C suggesting that osmotic dehydration improved colour of jam produced from osmotically dehydrated pineapple slices. This agrees with the result of Garcia-Matrinez *et al.* (2002) who reported that osmotic dehydration of fruits prior to formulation seemed to preserve the colour of the final product better in kiwi jam and orange marmalades. It is probable that colour additives were used in the commercial samples.

Two of the samples rehydrated at 90 °C (jam sample produced from fruits dehydrated in sugar and jam produced from dried non-OD pineapple slices) were significantly ($P < 0.05$) different in colour from the other samples. The dark colour of the jam sample rehydrated at 90 °C may be attributed to browning reactions.

Jam from fruit slices dehydrated in sugar solution scored significantly lower values in flavor compared to all other samples. Jam produced from fruits dehydrated in sugar/salts solution had the highest score which was however lower compared to the sensory scores obtained for jam prepared from fresh pineapple and commercial jam samples. Panelists tested for spreading ability of the jam samples as an indicator of texture. The texture of jam made from osmotically dehydrated fruits had lower scores compared to the jam samples made from dried non-OD samples, fresh pineapple slices and commercial jam samples. This may be as a result of the low moisture content of the non-OD samples (Table 2) and also may be due to the presence of the solutes absorbed during osmotic dehydration which cause hardening of the samples. The least score was recorded for jam produced from samples dehydrated in sugar/salt solution and rehydrated at room temperature.

The taste of the osmotically dehydrated samples received lower scores compared to samples without OD and the commercial jam samples. The highest score among the osmotically dehydrated sample (3.5) was obtained from the jam prepared from samples dehydrated in sugar/salt OD and rehydrated at 90 °C while the least score was the jam prepared from samples dehydrated in sugar solution and rehydrated at 90 °C. Osmotic dehydration did not improve the taste of the jam samples.

The panelists adjudged the commercial jam as the most preferred, but among the osmotically dehydrated jam samples, jam made from samples dehydrated in sugar and rehydrated at room temperature was best accepted. Jam samples from osmotically dehydrated fruits has the least overall acceptability compared with jam samples from the fresh, or non OD fruits. It should be noted that although jam samples from OD fruits were the least preferred, these samples had overall acceptability scores above 2.50 indicating some measure of acceptability but requiring further improvement.

279 **Table 2** Mean sensory scores of jams made from pineapple slices

Samples code	Colour	Flavor	Texture	Taste	Overall acceptability
No OD @ 90°C	3.00 _b	3.44 _a	3.56 _{abc}	4.13 _{ab}	3.56 _{bc}
No OD @ room	3.69 _a	3.31 _a	3.31 _{ab}	3.88 _{abc}	3.69 _{abc}
Sugar @ 90°C	2.31 _c	3.06 _a	2.50 _{cd}	3.19 _c	2.56 _d
Sugar@ room	3.88 _a	3.13 _a	2.75 _{bcd}	3.44 _{bc}	3.50 _{bc}
Sugar/salt @ 90°C	3.75 _a	3.50 _a	3.00 _{bc}	3.50 _{abc}	3.31 _c
Sugar/salt @ room	3.81 _a	3.31 _a	1.94 _d	3.38 _{bc}	3.13 _{cd}
Fresh	3.75 _a	3.63 _a	3.94 _a	3.31 _c	4.06 _{ab}
Commercial	4.31 _a	3.75 _a	3.63 _{ab}	4.25 _a	4.25 _a

280 Means with the same alphabets within a column are not significantly different from each
 281 other at ($P < 0.05$).

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284 CONCLUSION

285 This study demonstrated the potential use of osmotically dehydrated pineapple fruit in jam
 286 production. The results of the chemical composition of the jam samples were comparable
 287 to that of the commercial jam and also within literature ranges. Although the sensory tests
 288 showed that osmotic dehydration improved the colour of jam samples, except for jam
 289 samples of pineapple slices dehydrated in sugar/salt solution and rehydrated at 90 °C
 290 which need improvement. Further tests to establish optimal osmotic conditions that will
 291 enhance the sensory attributes of the resulting jam products should be done. Jam
 292 produced from pineapple slices osmotically dehydrated in 50 ° Brix for 4 hr sugar
 293 solution and rehydrated at room temperature for 6 hr had the best overall acceptability.
 294 The result of this research will help reduce post harvest losses of fruits.

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