



Studies on the Chemical and Sensory Properties of Jam from Osmotically Dehydrated Pineapple Slices

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Authors' contributions

This work was carried out in collaboration between all authors. Authors SOG and KAT designed the study, while author BMF collected the samples, performed the statistical analysis, wrote the protocol, wrote the first draft of the manuscript and managed literature searches. Authors BMF, SOG and KAT managed the analyses of the study and literature searches. All authors read and approved the final manuscript.

Research Article

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ABSTRACT

Dried fruits have limited food use, this study explored 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 at room temperature (RT) for 6 hr. Jams were made from dried pineapple slices (with or without osmotic dehydration), fresh pineapple and compared with commercial pineapple jam. 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 of the samples dehydrated in sugar/salt solution, also the moisture content increased as the rehydration temperature was increased. Osmotic dehydration of fruits prior to drying had effect on the retention of the vitamin C and protected reducing sugar from being lost. 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.

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1. 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 [1]. About 70% of the pineapple is consumed fresh in the producing countries [2]. The fruit has high sugar content and is rich in vitamins A and C [3]. About 20 - 40% of wastage has been recorded annually in Nigeria [4] because the fruits are prone to spoilage and poor preservation facilities; hence there is a need for the preservation of pineapple to reduce wastage.

Sun drying is the cheapest and most common technique employed in the preservation of many agricultural materials in Nigeria, but this result in a product of poor quality. Conventional oven drying yields products of leathery texture and dark colour. The use of osmotic dehydration in combination with oven drying has been suggested to improve product quality with a high content of naturally occurring vitamins and microelements [5,6].

Osmotic dehydration entails the partial removal of water from food in a higher osmotic pressure solution. Mass transfer rate during osmotic dehydration depends on factors such as temperature, concentration of the osmotic medium, size and geometry of the sample, sample to solution ratio and the degree of agitation. Pretreatment has been reported to enhance the mass transfer kinetics during osmotic dehydration [7].

Jam processing is one of the most important methods of fruit preservation. Jam differs from each other in the raw materials used, processing methods and additives [8]. Commercially, jams are prepared by concentrating the mix using thermal treatment at normal or reduced pressure, which results in a thick or gelled consistency. It also ensures destruction of fruit enzymes, pectin from the fruit and concentrates the product to a point where its acidity and reduced water activity are self-preserving [9]. Many studies have been undertaken to reduce nutrient losses during jam making. [9] reported reduced mineral losses in jam made from osmo-dehydrated kiwi fruits. The low temperature involved in the osmotic dehydration process prior to jam formulation has been reported to result in products with higher overall quality [9]. [10] reported the production of acceptable jam products from osmo-dehydrated cashew apple.

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

2. MATERIALS AND METHODS

2.1 Collection of Materials

Fresh pineapple fruits (smooth cayenne) were procured from a local market in Ile-Ife. The pure table sugar (raffinade grade), NaCl, gelling agent (Fine pectin) and acidity agent (M & B citric acid) were purchased from Fortel Chemical Laboratory in Ile-Ife, Osun State, Nigeria.

2.2 Osmotic Treatment

Pineapple fruit was rinsed with potable water, peeled and sliced into a uniform diameter (40 ± 0.1 mm) and thickness (5 ± 0.2 mm) using a corer and vernier caliper. Slices were placed in a beaker containing the osmotic solution (aqueous sugar solution of 50 °Brix and sugar/salt solution of 47:3 % w/w) and maintained at 40 °C for 4 hr in a thermostatically controlled water bath (SW22, Julabo USA). The ratio of fruit pieces to that of the medium was maintained at 1:10 in order to ensure that the concentration of the osmotic solution did not change significantly during the experiment [10]. Samples were gently blotted with tissue paper before weighing and drying [11].

2.3 Convective Air Drying and Rehydration Process

Osmotically dehydrated pineapple slices were dried in hot air oven (MRC Oven/Incubator, Model DP/DK 500/600/800, MRC Ltd. Hahystadnit) at 60 °C for 27 h to obtain dried products which were kept in sealed polythene bags and stored in a cupboard at room temperature until used. The samples were rehydrated at two different conditions in glass beakers containing distilled water at 90 °C for 15 min and at room temperature ($27 \pm 2^\circ\text{C}$) for 6 h using the method of [12]. Excess water was blotted carefully from the samples using paper towel and weighed before further processing into jam.

2.4 Jam Production

Operating conditions were determined from preliminary studies. The rehydrated fruit samples were blended using a laboratory blender (Twister mixer and grinder, Gazab KA, Kanchan Internation Ltd. Dabhel, Duman - 396210), the ratio of water to that of crushed pineapple was 18:34 g/g. Sugar (65%) was added to the crushed pineapple (34.2%) followed by the addition of 0.4% citric acid and 0.4% pectin [10]. The resultant mixture was heated between 80 °C and 100 °C until it set between 22 – 23 min. The jam samples were hot-filled into sterilized jars, sealed and rapidly cooled under running water to minimize thermal stress. The products were stored under refrigeration condition for further analysis [10]. Jam samples were also produced from fresh and dried non-osmodehydrated samples.

2.5 Chemical Analysis

Titrateable acidity (TTA), pH, total soluble solid (° Brix) vitamin C content, moisture content, reducing sugar and total sugar were determined using methods described by [13].

2.6 Sensory Evaluation

Each jam sample was coded and served in a clean plate with white bread to 16 untrained panelists (but consumers of jam). Quality attributes of jam made from fresh pineapple slices and commercial jam samples were compared with those jam made from osmo-dehydrated fruits and dried non-osmodehydrated samples. The samples were assessed for aroma/flavour, colour, taste, texture/spread ability and general acceptability using a five point hedonic scale where five represents 'like extremely' and 1 represents 'dislike extremely'.

2.7 Statistical Analysis

All analyses were carried out in triplicates. Analysis of variance (ANOVA) was conducted on the mean values to determine significant differences among samples followed by mean separation using Duncan Multiple Range Test [14]. Tests were done in triplicates.

3. RESULTS AND DISCUSSION

The results of the chemical composition of the jam samples are presented in Table 1. The observed titratable acidity (TTA) of the jam samples dehydrated in sugar/salt medium and rehydrated at RT had the highest TTA value (1.88 ± 0.01 g/100g) while the samples dehydrated in sugar medium and rehydrated at 90°C had the least TTA (1.35 ± 0.30 g/100g). This result suggests that low temperature rehydration process resulted in increased TTA of the OD jam samples, which were significantly ($P < 0.05$) different from those rehydrated at high temperature. Effect of the osmotic solutions used showed that the presence of salt (NaCl) in the sugar/salt mix increased the percent TTA compared to that of jam produced from samples dehydrated in sugar solution.

Results of pH showed that jam produced from samples dehydrated in sugar/salt solution had lower pH values (3.41-3.64) compared to those produced from samples dehydrated in sugar solution (3.75-3.79). Jam produced from dried non-osmotically dehydrated slices exhibited lower acidity (pH 3.83) when compared with those produced from osmotically dehydrated samples. The higher TTA and lower pH values exhibited by jams produced from pineapple slices dehydrated in sugar/salt solution may preserve the jam better than those produced from sugar dehydration. Results of pH obtained in this study are within range of values reported by [9] for kiwi jam and orange marmalade where pH values are between 3.04 and 4.68.

Temperature of rehydration had no significant ($P > 0.05$) effect on total soluble solid (TSS) of the OD jam samples. Jam made from pineapple fruits dehydrated in sugar solution had 70 – 72 °Brix while those osmotically dehydrated in sugar/salt had 62 °Brix. These values are comparable to those reported by [9] for kiwi jam and orange marmalade (32.1 – 68.4 °Brix). The TSS value of the sugar jam samples (70 -72 °Brix) are also comparable with the values reported by [10] for osmotically dehydrated cashew jam where TSS value obtained is 68 °Brix. Effect of osmotic solutions on the total soluble solids showed that the jam samples made from fruits dehydrated in sugar solution had the highest °Brix. Sugar influences the shelf-life of jam products decisively through the soluble solid content [15].

Results of the moisture content (MC) of jam produced from samples dehydrated in sugar/salt solutions and rehydrated at 90 °C and RT had the least MC (13.28 and 9.64 g/100g respectively), indicating a harder gel compared to commercial jam with a MC of 29.83 %.

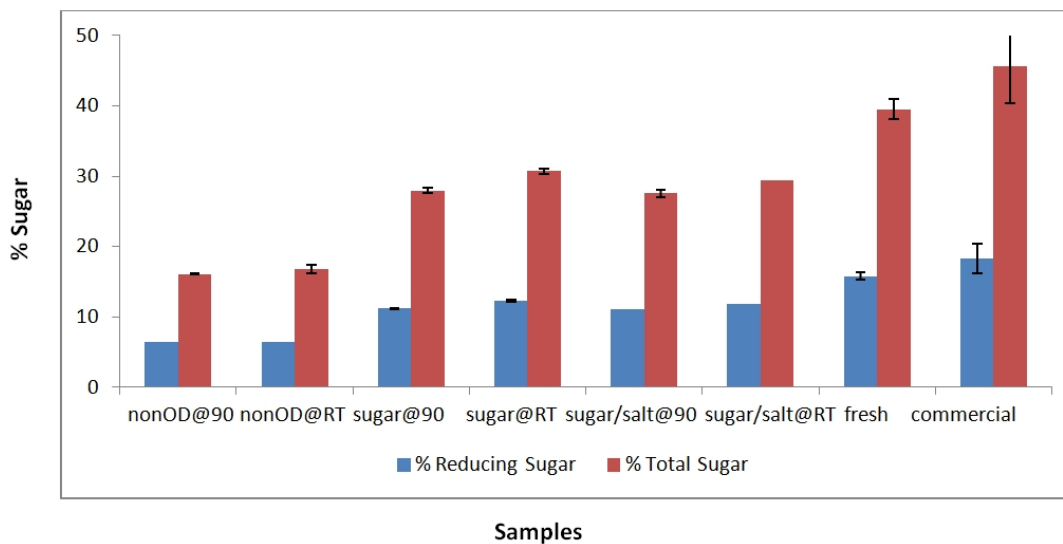
Among the jam samples made from osmotically dehydrated fruits, jam from sugar-OD sample rehydrated at 90 °C had the highest MC (20.42 g/100g). It is expected that the lower MC will deter microbial proliferation. The MC of samples rehydrated at 90 °C was higher than those rehydrated at room temperature. The MC values obtained in this study are within literature values for jam reported by [16] where the values are 28.6 - 30.1%. MC affects the gel strength, as moisture content decrease the gel becomes increasingly firmer. Higher gel strength indicates the presence of higher amount of Ca²⁺ thereby affecting the rheological and sensory property such as spread-ability and these explains the reason why samples with low moisture content may have poor spreading ability [15].

Among the osmotically dehydrated pineapple jams, jam produced from sugar/salt OD samples and rehydrated at room temperature had the highest vitamin C content while 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 at higher rehydration temperature except for sugar jam samples which had higher vitamin C values when 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 RT).

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 [15]. The values observed are within literature (15.9 – 23.5 %, [16]). Total sugar in the jam showed the same trend as the reducing sugar (Fig. 1), 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 %. 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.

Table 1. Chemical composition of the various jam samples

Samples code	TTA (g/100g)	M.C (g/100g)	Vitamin C (mg/100g)	Total soluble Solid (° Brix)	pH
No OD @ 90 °C	1.41±0.31 _{bc}	15.62±0.50 _e	13.33±0.03 _f	70.00±0.00	3.83±0.02 _b
No OD @ RT	1.36±0.35 _c	15.30±0.06 _e	14.63±0.00 _d	60.00±0.00	3.83±0.00 _b
Sugar @ 90 °C	1.35±0.30 _c	20.42±0.22 _c	14.62±0.02 _d	70.00±0.00	3.75±0.01 _d
Sugar@ RT	1.38±0.06 _{bc}	16.36±0.35 _d	14.34±0.03 _e	72.00±0.00	3.79±0.02 _c
Sugar/salt @ 90°C	1.83±0.01 _a	13.28±0.16 _f	14.52±0.19 _d	62.00±0.00	3.64±0.01 _e
Sugar/salt @ RT	1.88±0.01 _a	9.64±0.31 _q	15.96±0.00 _c	62.00±0.00	3.41±0.01 _f
Fresh	1.38±0.06 _{bc}	21.64±0.20 _b	17.29±0.00 _b	64.00±0.00	3.95±0.02 _a
Commercial	1.43±0.01 _b	29.83±0.38 _a	18.40±0.19 _a	62.00±0.00	3.73±0.02 _d

**Fig. 1. Values of reducing sugar and total sugar**

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

Results of the data on sensory evaluation of the jam samples presented in Table 2 revealed that both osmotic solution and rehydration temperature had significant ($P > 0.05$) influence on all the sensory attributes measured. The panelists scored jam samples obtained by rehydrating samples at RT 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 [9] 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.

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 @ RT	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@ RT	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 @ RT	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

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

No significant difference ($P < 0.05$) in the flavor of jam scored, but jam from fruit slices dehydrated in sugar solution had lower values in flavor compared to all other samples. Jam produced from fruits dehydrated in sugar/salt 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.

The overall acceptability of the sensory attributes of the OD samples revealed that sugar/salt OD samples were highly scored at 90°C than sugar OD samples for colour but reverse is the case at RT. No significant different ($P < 0.05$) in the flavor, but the least score are samples OD in sugar at both temperatures considered. For texture, samples OD in sugar/salt

rehydrated at RT had the least value than samples OD in sugar but reverse is the case at 90°C, the same result was revealed in terms of taste and overall acceptability. Overall acceptability showed that jam samples dehydrated in sugar/salt solution and rehydrated at 90°C scored high in colour, flavor, texture, taste and overall acceptability.

4. CONCLUSION

This study demonstrated the potential use of osmotically dehydrated pineapple fruit in jam production. The results of the chemical composition of the jam samples were comparable to that of the commercial jam and also within literature ranges. Although osmotic dehydration improved the colour of dried slices, colour of jam samples need improvement except for pineapple slices dehydrated in sugar/salt solution and rehydrated at 90°C. Jam produced from pineapple slices osmotically dehydrated in 50 ° Brix and rehydrated at RT had the best overall acceptability. Osmotically dehydrating pineapple and processing into jam later will help reduce post harvest losses of fruits during harvest or glut and also reveal the utilization potential of dried fruits.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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