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Air-Oven Drying of Pre-Treated Fruit Slices: A Promising Solution to Post-Harvest Losses

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Abstract: Reports have shown that over 25% of fruit are lost during their season and virtually out of the market during off season due to their high moisture content couple with poor preservation methods practiced in Nigeria. Smooth cayenne pineapple specie obtained from Ajanla Farms, Ibadan was used for the study. A two factor-factorial experimental design of 3-levels of 3 pre-treatment methods (sucrose, blanching and sulphiting) and 3-levels of drying conditions (80°C/8 h, 70°C/10 h and 50°C/16 h) resulting into 81 treatments was used. The treatments were reduced to 18 by stratified sampling method from the results of the moisture and ascorbic acid content obtained from the pre-treated slices before drying. The slices were dried in a cabinet dryer; the moisture and ascorbic acid content of the dried slices were monitored during drying and after. All the samples exhibited combinations of falling and increase in drying with increasing in drying time. The dried slices were stored for 18 weeks, at which they were analyzed at 3 week intervals. The results obtained revealed that there were significant effects ($p<0.05$) of the pre-treatments on the ascorbic acid and moisture content of the dried slices. The 60%S/60°CB/2500ppm SO_2 at 70°C/10 h had the least value of moisture content of 8.75% and 25.16 mg/100 g of ascorbic acid. Furthermore, the results indicated that drying at 70°C/10 h is suitable for drying of pineapple slices than other drying conditions. During storage, there was continuous reduction in moisture content during the early weeks of storage. However, after 9 weeks of storage the moisture content of the samples increased showing significant differences between the mean values of the samples at different weeks of storage. Though, the samples pretreated with SO_2 showed a little variation over the storage period. Drying condition of 70°C/10 h and pre-treatment of 2500 ppm SO_2/60% sucrose was found to have minimal reduction of quality and thus the most appropriate treatment for air-oven drying of pineapple slices. The study therefore, recommends that production of pre-treated dried fruit slices could be used to reduce the enormous post-harvest losses of fruits.

Key words: Pineapple, sulphiting, sucrose, blanching, food security

INTRODUCTION

In the tropics considerable research and extensive efforts made towards fruit production have started to yield results. However, much of these products are available only during their season and about 25% are lost after harvesting due to inadequate and poorly developed storage facilities (NIHORT, 1990). Thus, increasing fruit production is no more the real goal for food nutrition and security, but how these fruits may be preserved. Several preservation methods for extending shelf-life of fruits have been proposed and successfully utilized. Large capital investments and high skilled personnel that are justified only in a buoyant economy hampered the applications of these storage methods. Simple methods of preservation are a pressing need in developing nations. One of such method is air-oven drying, which is reported to be appropriate for fruits and vegetables preservation (Karim *et al*., 2008, Pappas *et al*., 1999).

Air dehydration of fruits had been reported to be limiting in some factors especially on the quality of the dried fruits (McMinn and Magee, 1997). These can be categorized as nutritional, physical and chemical in nature, which are been imposed as moisture is been removed. To alleviate these problems in air-dehydration, different pre-treatment methods have been developed and successfully used for many temperate fruits and few tropical fruits (Karim *et al*., 2008, Arthey and Dennis, 1990, Raoult-Wack *et al*., 1991).

Among the reported pre-treatment methods are sulphiting (Atkinson and Strachan, 1962; Sapers, 1993), blanching (Alvarez *et al*., 1995) and sucrose osmosis (Spaizzi and Mascheroni, 1997). Pineapple (*Ananas comosus*) is a common non-citrus fruit and a very rich source of vitamin C and organic acids (Bartolomew *et al*., 1995). About 25% losses annually were recorded from total production due to its poor storability life (NIHORT, 1990; FAO, 1990). This study was therefore designed to assess the suitability of combination of these pre-treatment methods for air-oven dehydration of pineapples slices.

MATERIALS AND METHODS

Freshly harvested pineapple fruits (*Smooth cayenne*) obtained from Ajanla Farms; Ibadan, Nigeria was used for the study.

Experimental design: A 2 factor-factorial experimental design of 3-levels of 3 pre-treatment (sucrose, blanching and sulphiting and 3-levels of drying condition (80°C/8 h, 70°C/10 h and 50°C/16 h) resulting into 81 treatments was used for the study. These were reduced to 18 samples by stratified sampling method from the result obtained on the pre-treated samples.

Pre-treatment: The fruits were hand peeled and sliced into spherical shape of 5 mm thickness and 20 cm radius. A batch each of 2 kg of slices were pre-treated accordingly with sucrose osmosis method by immersing fresh slices into aqueous solution of 40 or 60% w/w of sucrose (Food grade of 98% purity) for 10 min. The samples were drained on wire mesh and re-weighed. The blanching pre-treatment were done by immersing the fruit in warm water at 60°C held in a water bath to maintain the temperature and steam generated from boiling water for 5 and 3 min, respectively at atmospheric pressure. The sulphur dioxide pre-treatment was done by dipping the slices in 1500 and 2500 ppm sulphur dioxide solution made from potassium-meta bisulphate solution for 6 min.

The pre-treated pineapple slices were dried in cabinet dryer (Gallen Kamp hot box) under standard conditions on perforated stainless steel trays, of tray loading 1 kg with cross-through air flow. The dried samples were analyzed for moisture and ascorbic acid content after drying using AOAC (1992) methods. The results were used to select 18 samples that were packaged into high density polythene bag of 0.028 mm thickness and stored in the laboratory at ambient temperature (30±2°C) for 18 weeks. The samples were also analyzed for moisture and ascorbic acid content at 3 week intervals.

Statistical analysis: Mean separation was obtained by Duncan Multiple Range Test and analysis of Variance ANOVA was conducted on the mean values to determine the significance of any differences between the samples (Duncan, 1955).

RESULTS AND DISCUSSION

The initial moisture and ascorbic acid content of fresh slices were 81.31% and 31.46 mg/100 g respectively. The result of the moisture and ascorbic acid content obtained from the 81 freshly dehydrated samples were subjected to stratified random sampling to obtain 18 samples that were used for further study.

The effect of pre-treatment methods on the moisture and ascorbic content of 18 pre-treated dehydrated slices is shown in Table 1. The results showed that there were significant differences ($p<0.05$) between the mean values of the moisture and ascorbic acid content. The moisture content range between 15.39 and 8.46% for control sample dehydrated under 50°C/16h and sample pre-treated with 40% sucrose and 60°C blanching and sulphiting at 2500 ppm SO_2 and dehydrated at 70°C/0 h. The result indicated that the pre-treatment methods influenced moisture removal. The samples that were sulphated recorded the low moisture content when compared with the samples that were blanched and osmotically pre-treated. This effect might be due to the effect of SO_2 pre-treatment on physical and chemical changes on the water binding components of these slices and on the cellular membrane permeability as reported by Karim (2005) and Karim and Adebowale (2009). The high moisture content of the osmotically pre-treated samples may be due to the severe ultra structural damage of the cell walls. From the report of Alvarez *et al.* (1995) such material exhibit a reduced optical density, which is due to the fact the binding force between the cell wall and the higher concentration of hydrozium ions present in the high acid fruit may accelerate the breakdown of the binding materials. While the blanching pre-treatment was found to enhance the moisture removal due to elimination of the cell membranes resistance to water diffusion (the membrane integrity is destroyed by heat treatment) and decrease on the resistance of the cell walls to water flux (Del Valle *et al.*, 1998; Alvarez *et al.*, 1995).

Table 1: Moisture and Ascorbic acid content of pre-treated and air-dehydrated pineapple slices

Pre-treatment/Drying conditions	Moisture (%)	Ascorbic acid (mg/100 g)
Control/ D_1	15.39a	5.54h
60% S/Steam B/D_1	9.34gh	8.48f
60% S/Steam B/D_2	8.99h	9.05f
Steam B/2500 ppm SO_2/D_3	9.34gh	25.35b
40% S/2500 ppm SO_2/D_2	9.36gh	21.16c
60% S/1500 ppm SO_2/D_2	10.96d	19.36d
60% S/2500 ppm SO_2/D_3	10.53e	27.35a
2500 ppm SO_2/D_2	10.42e	27.58b
40% S/60°C B/2500 ppm SO_2/D_2	8.46j	25.12b
40% S/60°C B/2500 ppm SO_2/D_3	9.17h	29.95a
60% S/60°C B/2500 ppm SO_2/D_2	8.75i	25.16b
40% S/Steam B/1500 ppm SO_2/D_1	9.66g	13.48d
60% S/Steam B/2500 ppm SO_2/D_2	9.24h	28.53a
60% S/Steam B/2500 ppm SO_2/D_3	8.97h	27.78a
2500 ppm SO_2/D_3	10.41e	25.58b
40% S/D_2	10.41f	5.97h
Steam B/D_1	11.93c	10.48e
Control/D_2	14.67b	6.56g

S-Sucrose; B-Blanching; D_1-50°C/16 h Drying, D_2-70°C/10 h Drying, D_3 -80°C/8 h Drying. Means with the same alphabet in the column are not significantly different at 5% level

The ascorbic acid content ranged between 5.54 and 29.95 mg/100 g for the control sample dehydrated under 50°C/6 h and sample pre-treated with 40% sucrose, 60°C and sulphiting at 2500 ppm SO_2 and dehydrated at 70°C/10 h. This indicated that the pre-treatment methods protected the ascorbic acid of the fruit, most especially the sulphiting method. Furthermore, the reduction in ascorbic acid indicates the instability of ascorbic acid of

Table 2: Effect of pre-treatment on moisture content of dehydrated pineapple slices

	Moisture content%/Week						
Treatments	*0	*3	*6	*9	*12	*15	*18
Control/D_1	15.39c	14.89d	13.97e	13.63e	14.99d	17.58b	19.05a
60% S/Steam B/D_1	9.34a	9.32b	9.17b	9.13b	9.07b	9.14b	9.82a
60% S/Steam B/D_2	8.99hc	8.93e	8.91c	8.83c	8.84c	11.18b	13.93a
Steam B/2500 ppmSO_2/D_3	9.34a	9.32a	9.17a	9.13a	9.07a	9.04a	9.02a
40% S/2500 ppm SO_2/D_2	9.36a	9.31a	9.23a	9.21a	9.18a	8.79b	8.79b
60% S/1500 ppm SO_2/D_2	10.96a	10.88a	10.56a	10.42a	10.12a	9.38b	9.18b
60% S/2500 ppm SO_2/D_3	10.53a	10.59a	10.60a	10.52a	10.28a	10.23a	10.07a
2500 ppm SO_2/D_2	10.42a	10.37a	10.29a	9.73ab	9.31b	9.74ab	10.44a
40% S/60°C B/2500 ppm SO_2/D_2	8.46ba	8.72a	8.72a	8.55a	8.40a	8.39a	8.45a
40% S/60°C B/2500 ppm SO_2/D_3	9.17a	8.46b	8.50b	8.79ab	8.12b	9.39a	9.34a
60% S/60°C B/2500 ppm SO_2/D_2	8.75a	8.70a	8.80a	8.90a	8.98a	9.12a	9.32a
40% S/Steam B/1500 ppm SO_2/D_1	9.66a	9.22ab	9.05ab	8.86b	8.67b	8.39b	8.45b
60% S/Steam B/2500 ppm SO_2/D_2	9.24a	8.97a	8.92a	8.80a	8.79a	8.36a	8.52a
60% S/Steam B/2500 ppm SO_2/D_3	8.97b	9.23a	9.18a	9.14a	9.16a	9.09a	9.05a
2500 ppm SO_2/D_3	9.21a	9.17b	9.09b	9.19ab	9.23a	9.30a	9.36a
40% S/D_2	10.14b	10.11b	9.90b	8.68a	11.43c	13.47d	15.05e
Steam B/D_1	11.93c	11.76d	11.58d	11.29d	12.06c	14.10b	16.87a
Control/D_2	14.67d	14.58d	14.24d	14.13d	15.52c	16.35b	17.42a

S-Sucrose; B-Blanching; D-Drying. Each value represents mean scores of three replicates. *-Significant difference at <0.05%
Mean values having the same letter within row are not significantly different at <0.05%

food during drying. The sucrose osmosis pre-treatment did not show much protective effect on the ascorbic acid loss, while the blanching pre-treatment showed a better retention of ascorbic acid content, which was due to the earlier observed protective effect of blanching pre-treatment on ascorbic acid content of food (Levi *et al.*, 1980). The SO_2 pre-treatment exhibited the greatest protection on ascorbic acid content which is in line with earlier reports of Levi *et al.* (1980) and Karim (2005).

Also noticed on the result is the influence of the dehydration condition of time and temperature. Drying of fruit between 8-10 h using 60-70°C temperature is been reported to be adequate for good product quality (Karathanos and Belessiotisi 1997; Jayaraman and Das-Gupta, 1992; Maskan, 2001). This might have influenced the rate of moisture and ascorbic acid removal and supported the differences observed in the values of the samples pre-treated under the same condition.

The result of moisture content of pre-treated and dehydrated pineapple slices during 18 weeks storage is presented in Table 2. The results revealed that there was continuous reduction in moisture content during the early weeks of storage. However, after 9 weeks of storage, the moisture content increased. The results therefore showed that there were significant differences ($p<0.05$) between the mean values of the samples at different week of storage. The sample pre-treated with 2500 ppm SO_2 had the highest retention of moisture content with no significant difference ($p<0.05$) between the mean values across the storage weeks. While the samples pre-treated with 2500 ppm SO_2 at drying condition of 70°C/10 h and 80°C/8 h had 9.36 and 8.45% respectively at the end of drying. Maximum moisture and ascorbic acid content retention recorded in samples pre-treated with SO_2 may be due to the protective effect of SO_2 on the moisture content during storage (Bhardwaj and Kaushal, 1990). The effect was also complemented with sucrose-osmosis pre-treatment. The variation in moisture content might also be influenced with the air-impermeable polyethylene bag used for packaging.

The trend of ascorbic acid losses (Table 3) during storage clearly supported the fact that, it is not a stable component during storage. The result is likened to the earlier findings by Atkinson and Strachan (1962) on the uses of SO_2 for food preservation. Sapers (1993), Sapers *et al.* (1994) also showed that SO_2 for protection of vitamins and organic acids of fruits and vegetables cannot be nullified.

The result indicated that as the storage period increased the level of ascorbic acid reduced. This was also noticed with the significant differences ($p<0.05$) between the values obtained across the storage period. The variation in moisture and ascorbic acid content might also be influenced with the air-impermeable polyethylene bag used for packaging.

It has been reported that it does not provide good barrier against moisture loss or gain (Jenkins and Harrington, 1991). However, the samples pre-treated with SO_2 indicated a better retention of ascorbic than others. The sample pre-treated with 2500 ppm SO_2 had the highest value of 19.20 mg/100 g ascorbic acid at the end of 18 weeks storage.

Table 3: Effect of pre-treatment on ascorbic acid content of dehydrated pineapple slices

	Ascorbic acid content (mg/100 g)/Week						
Treatments	*0	*3	*6	*9	*12	*15	*18
Control/ D_1	5.54^a	3.45^b	2.17^c	1.35	0.21	0.19	0.10
60% S/Steam B/D_1	8.48^a	7.12^b	5.62^c	5.57	3.68	2.51	2.24
60% S/Steam B/D_2	9.05^a	6.56^b	5.54^c	4.61	3.21	2.03	1.68
Steam B/2500 ppmSO_2/D_3	25.35^a	23.56^b	20.54^c	16.61	18.21	12.03	11.68
40% S/2500 ppm SO_2/D_2	21.16^a	19.12^b	15.62^c	15.57	13.68	12.11	11.41
60% S/1500 ppm SO_2/D_2	19.36^a	17.22^b	15.12^c	14.23	12.93	10.48	9.12
60% S/2500 ppm SO_2/D_3	27.35^a	26.03^b	25.38^c	22.61	21.32	19.28	18.52
2500 ppm SO_2/D_2	25.58^a	23.91^b	20.41^c	19.39	18.71	17.91	15.67
40% S/60°C B/2500 ppm SO_2/D_2	25.12^a	24.97^a	24.75^a	23.41	20.24	19.36	12.39
40% S/60°C B/2500 ppm SO_2/D_3	29.95^a	24.61^b	24.32^b	23.12	22.43	20.21	17.21
60% S/60°C B/2500 ppm SO_2/D_2	25.16^a	24.28^b	23.84^b	21.38	17.81	16.42	15.21
40% S/Steam B/1500 ppm SO_2/D_1	13.48^a	12.88^a	12.01^{ab}	10.43	8.63	7.88	7.61
60% S/Steam B/2500 ppm SO_2/D_2	28.53^a	27.79^a	27.41^a	26.36	23.22	22.25	16.03
60% S/Steam B/2500 ppm SO_2/D_3	27.78^a	27.11^a	26.01^b	24.91	23.18	21.36	18.43
2500 ppm SO_2/D_3	25.58^a	23.95^b	22.31^c	21.42	20.61	19.53	19.20
40% S/D_2	5.97^a	3.32^b	1.72^c	1.08	0.84	0.72	0.62
Control/D_2	6.56^a	5.85^b	3.13^c	1.33	0.77	0.74	0.62
Steam B/D_1	10.48^a	6.65^b	3.67^c	1.64	1.02	0.87	0.81

S-Sucrose; B-Blanching; D-Drying. Each value represents mean scores of three replicates. *-Significant difference at p>0.05

Conclusion: The study could be concluded with the following findings that blanching pre-treatment alone was not found suitable for the drying of pineapple slices, while sulphiting pre-treatment protected the moisture and ascorbic acid loss during storage. Also pre-treatment with 60%S/2500 ppmSO_2 and 2500 ppm SO_2 and drying condition of 70°C/10 h will be suitable for production of dehydrated pineapple slices. Thus, this study suggests that production of pre-treated dried pineapple slices could be encouraged as a means of reducing the high post-harvest losses of pineapple fruit. This could be an alternative way of boosting food and nutrition security in Africa.

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