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Assessments of Drying Characteristics and Physio-Organoleptic Properties of Dried Pineapple Slices under Different Pre-Treatments

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Abstract: The aim of this study was to assess the drying characteristics and physio-organoleptic properties of dried pineapple slices under different pretreatments. Four sliced pineapple treatments (ascorbic acid, salt solution, lemon juice, honey dip) and one control, each replicated four times were dried in an oven at a temperature of 65°C for 16 h. Statistical analysis using SPSS for drying characteristics of the treated pineapples revealed that treatment is significant at 5%. Ascorbic acid treated sample had the best degree of drying with mean moisture content of 20.01% followed by salt treated sample (20.10%), lemon juice (20.55%), control (21.12%) and then honey dip treated samples (25.03%). Also, the results revealed that the best time for drying the sugarloaf pineapple is 14 h at a temperature of 65°C. The sensory analysis for the most preferred dried pineapples in terms of taste, color and flavor revealed that honey treated sample was most preferred, followed by ascorbic acid, lemon juice/control and salt treated samples.

Key words: Sugarloaf pineapple, pineapple slices, drying characteristics, pretreatments, taste, color, flavor

INTRODUCTION

Pineapple production is widespread in Ghana and is grown largely in the Central and Western regions of Ghana. In Ghana, tropical fruits produced during bumper harvest are either consumed fresh, sold at relatively cheap prices, or are allowed to go waste due to inadequate processing facilities. It is estimated that out of the achievable yield of 32000 to 40000 kg acre^{-1} of pineapple produced, 25% goes to waste (Yeboah and Kunze, 2004). Post-harvest losses are a major challenge for pineapple producers especially in Ghana. Usually, a fully matured harvested pineapple takes about seven days to deteriorate. Much of the pineapple fresh fruits go to the industry for slices and juice production, while about five million tonnes are exported for the fresh fruit market (Smart and Simmonds, 1995). Little attention is given to drying of tropical fruits for consumption and storage, even though enormous market exists for dried fruits in Ghana. Drying remains the oldest and easiest method of preservation, but food drying in Ghana is typically for fish, cereals, grains and some vegetables. Little knowledge exists for drying of tropical fruits in Ghana. Drying methods include oven drying, solar drying and dehydrators, which are used for removing water or moisture from a food product. Removing moisture from foods makes them lighter and smaller and hence takes much less storage space than canned or frozen foods (Andress and Harrison, 2006). Food scientists have found that by reducing the moisture content of food to between 10 and 20%, bacteria, yeast, mold and enzymes are all prevented from spoiling it. The flavor and most of the nutritional value is preserved and concentrated (Dennis, 1999). For successful drying, heat, dry air and air movement are needed. The temperature should be high enough (about 60°C) to force out moisture, but not too high to cook the food. The dry air is needed to absorb and release moisture and air movement to carry the moisture away. When drying foods, the key activity is to remove moisture as quickly as possible at a temperature that does not seriously affect the flavor, texture and color of the food. If the temperature is too low in the beginning, microorganisms may grow before the food is adequately dried. If the temperature is too high and the humidity is too low, the food may harden on the surface. Temperature ranges between 37 and 71°C will effectively kill bacteria and inactivate enzymes, although temperatures around 43°C are recommended for solar dryers (Kendall and Allen, 1998). Rapid dehydration is desirable. The higher the temperature and the lower the humidity, the more rapid the rate of dehydration will be. Air drying of fruits especially pineapple has been reported to be limiting in some factors especially the quality of the dried fruits (McMinn and Magee, 1997). Experience with drying of tropical fruits has showed that sole dependence on air/sun drying leads to great deterioration of the fruits to be dried (Abano and Sam-Amoah, 2007). McMinn and Magee (1997) reported that quality deterioration can be categorized as nutritional, physical and chemical in nature. The removal of moisture during drying is affected by the nutritional, physical and chemical changes on the dried products (Karim, 2005). Browning and disruption of tissues of dried fruits owing to presence of polyphenols are the physical characteristics and one of the major set backs in fruit drying (Karim, 2005; Chirife, 1983). Other physical changes affecting dried fruit quality are shrinkage of the cells, loss of redrying ability, wettability and case hardening (Dalgleish and Andy, 1988; McMinn and Magee, 1997). Dried foods are tasty, nutritious, lightweight, easy-to-prepare and easy-to-store and use. The energy input is less than what is needed to freeze or can.

Pre-treatment of fruits prior to drying is highly recommended because it helps keep light-colored fruits from darkening during drying and storage and it speeds the drying of fruits with tough skins, such as grapes and cherries. Pineapples and apples are peeled, cored and sliced. Fruits should be cut into uniform pieces or slices of not more than 10 mm thick so that it will dry more evenly. Thin pieces dry faster than thick ones (Troftgruben, 1977). Different pre-treatment methods have been developed for fruit drying, among which are lemon juice, salt solution, honey dip, ascorbic acid, sulfuring, osmotic pretreatment and blanching (Karim, 2005). If no pre-treatment is done, the fruits will continue to darken after they are dried. For long-term storage of dried fruits, sulfuring or using a sulfite dip are the best pre-treatments. However, sulfites may cause asthmatic reactions in a small portion of the asthmatic population (Susan and Williams, 1993). Large differences are found on the reported data on the nutritive value of dried fruits and are reported to be due to wide variations in the preparation procedures, drying temperature and time and the storage conditions (Bharadwaj and Kaushal, 1990). Dried fruits are a good source of energy because they contain concentrated fruit sugars. Dried foods are high in fibre and carbohydrates and low in fat, making them healthy food choices. The aim of this work was to assess dried pineapple slices under different pre-treatments. Specifically, the work aimed to investigate the significance of pre-treatments on rate of drying, assess the physio-organoleptic properties of the dried pineapples and the overall acceptability of the dried pineapples. In addition, the work was expected to provide an alternative way of processing pineapple for human consumption, curtail postharvest loss of fresh pineapples and promote entrepreneurial opportunities through the sale of dried pineapples in Ghana.

MATERIALS AND METHODS

Fresh ripe pineapple fruits of the sugar loaf variety with a mean moisture content of 86% were sourced from Ataabadze, a commercial pineapple community in the Central region of

Ghana for the research in February 2009. The pineapples were brought to the laboratory, washed thoroughly, peeled and all core removed. It is then sliced into 6.5 mm thickness and the core removed prior to pre-treatment. The Completely Randomized Design (CRD) was used for the experiment with four treatments, one control, each replicated four times. Three thousand milligram (30 tablets) of ascorbic acid was dissolved in 660 mL of water in a bowl. Also, 7.25 g of salt was dissolved in 660 mL of water in another bowl. In addition, 255 mL of lemon juice was mixed with 255 mL of water in a third bowl and finally 40 mL honey and half cup sugar was measured and added to a 495 mL lukewarm water to mix.

Six hundred gram each of the sliced pineapples was soaked in the solution for 4, 15, 10 and 4 min, respectively and allowed to drain according to recommended guidelines. Each of the treated samples was divided into four equal weights of 150 g for drying. Another 600 g of the sliced pineapples was divided into four and used as the control. The pre-treated pineapples were put on a brown paper and placed onto the racks in the Gallenkamp (Sanyo OMT oven) cabinet dryer. The samples were dried at a temperature of 65°C for 16 h. The weights of the drying pineapples were determined every 2 h until drying was complete. When drying was completed the samples were allowed to cool and packed into a transparent tightly zipped bag and labeled for analysis and storage. A 30-member semi-trained panel evaluated the dried products for overall quality (taste, flavor color). Panelist were asked to evaluate the dried pineapple slices employing a structured hedonic test (scale from 1 = poor to 5 = excellent) (Larmond, 1977). The data was analysed using Analysis of Variance (ANOVA) and where significant differences were observed, Duncan's Multiple Range Test (DMRT) was used to separate the means.

RESULTS AND DISCUSSION

Figure 1 shows the drying characteristic curves of the various pretreated pineapples used for this study. Table 1 shows the mean moisture content of the treated pineapple slices as a function of drying time. The drying characteristics curves show that though drying of the pineapple started at the same moisture content and time, there was a sharper drop in moisture of the ascorbic acid and salt treated pineapples than the others in the first 2 h. There was a significant difference (p = 0.05) between ascorbic acid and salt solution treated

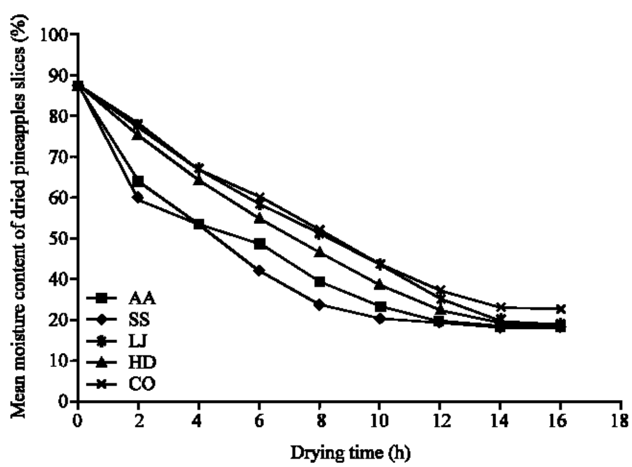

Fig. 1: Drying characteristic curves of different pretreated dried pineapples

Table 1: Mean moisture content (%) of treated pineapple slices as a function of drying time

	Drying time (h)								
Treatments	0	2	4	6	8	10	12	14	16
Ascorbic acid	86	55.09a	48.23a	35.64a	26.29a	22.65a	21.11a	20.25a	20.01a
Salt solution	86	59.83b	48.25a	43.10b	32.76b	25.76a	22.04ab	20.45ab	20.10a
Lemon juice	86	72.62c	60.12b	49.80c	40.56c	31.78b	24.91b	21.43b	20.55a
Honey dip	86	75.53c	63.31b	55.52d	46.57d	37.37c	30.18c	25.60c	25.03b
Control	86	75.72c	63.26b	53.95d	45.82d	37.22c	27.78d	21.91b	21.12a

Means in a column bearing the same letters are not significantly different at p = 0.05

pineapple in the first 2 h of drying. Lemon, honey dip and the control lost moisture steadily with no significant difference in moisture content in the first 2 h. However, after 6 h of drying there was significant difference between the mean moisture loss of ascorbic acid, salt and lemon juice solution treated samples.

A Similar trend occurred after 8 h of drying. The honey dip treated pineapples and Control recorded no significant difference (p = 0.05) in mean moisture loss in the first 10 h of drying. However, there was a significant difference (p = 0.05) between 12 and 16 h of drying. At 16 h of drying, there was no significant difference (p = 0.05) between the ascorbic, salt, lemon juice and the control products. Hence, it is likely that when drying time is increased at constant temperature, there may not be any significant differences in moisture content of the ascorbic, salt, lemon juice and the control samples. Conversely, there may be significant difference in the honey treated sample. However, honey treated samples showed significant difference (p = 0.05). The degree of drying after 16 h indicated a moisture content in the increasing trend from ascorbic acid treated products, followed by salt solution treated pineapples, lemon juice, control, to honey treated pineapples. Abano and Sam-Amoah (2007) observed similar trend in dried mangoes chips under salt, acetic acid and sugar pre-treatments. The drop in ascorbic acid treated product could be due to the leaching effect of acid in the ascorbic acid solution which caused the water content in the pineapple to lose more moisture at a faster rate in the early hours of drying.

The evaporation rate of salt solution could also account for its sharp fall in the first 4 h. Common salt made of sodium chloride in an acidic and base reaction on heating evaporates rapidly. This may have resulted in the relatively high loss of moisture in the samples pre-treated with the salt solution. The delay in drying for honey might be due to its hygroscopic nature, which when exposed to air naturally forms a coat that impedes moisture loss. It is also possible that the delay in the honey treated sample could be due to the increased sugar to acid ratio. Sugar when heated forms a gelatinous coat around the pineapples, which is impermeable to moisture loss. This sticky coat also prevented moisture loss from the products treated with honey. Sugar also becomes more viscous when melted and this viscous fluid expanded to fill the pore spaces in the pineapple slices on heating, which prolonged the rate of moisture removal from samples pre-treated with honey dip. Since samples pretreated with honey exhibited a viscous rather than an elastic behavior, it indicates that infusion of sugars caused plasticity of the pineapple slices. The degree of increased sugar impregnation by the samples pre-treated with honey dip also might cause the delay in drying. These results fully agree with those reported by Panagiotou *et al*. (1998) for osmotic dehydration of banana, apple and kiwi pieces in sucrose solution. It was observed that ascorbic acid treated samples had the highest rate of drying in terms of moisture content at 20.01%, hence had the highest reduction of moisture after drying was completed. Moisture content was highest in honey treated dried pineapples (25.03%), followed by the control (21.12%), lemon juice (20.55%), salt solution (20.10%) and then ascorbic acid treated products (20.01%). The mean final moisture content of all the products was 21.36%.

Table 2: Hedonic test of dried pineapple slices under different pre-treatments

Treatment	Taste	Flavor	Color
Ascorbic acid	3.17±0.699	3.23±0.858	3.17±1.289
Salt solution	2.47±1.008	2.60±1.003	3.30±1.149
Lemon juice	2.80±0.887	2.90±0.759	3.57±1.455
Honey dip	3.97±1.066	3.47±0.973	3.70±1.291
Control	2.70±0.794	2.80±0.961	3.77±1.382

Five point scale: 1: Poor, 2: Satisfactory, 3: Good, 4: Very Good, 5: Excellent

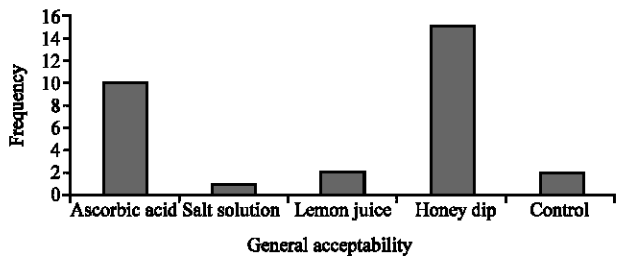

Fig. 2: Overall preference of the dried pineapple

A sensorial analysis was done to determine the quality of the dried pineapples in terms of taste, flavor and color. On the basis of taste, statistical analysis of the hedonic test showed that honey dip treated pineapples scored the highest (3.97±1.066), followed by ascorbic acid (3.17±0.699), lemon juice (2.80±0.887), control (2.70±0.794) and then salt solution treated pineapples (2.47±1.008). The taste scores by hedonic test indicated that honey and ascorbic treated dried product ranged from good to very good whereas the rest ranged from average to good. Similarly, in terms of the flavor of the dried product, the same decreasing trend was recorded. Honey dip treated dried pineapple slices scored the highest (3.47±0.973), followed by ascorbic acid (3.23±0.858), lemon juice (2.90±0.759), control (2.80±0.961) and salt solution (2.60±1.003) as shown in Table 2. However, there was a different trend of decreasing score for color, from control (3.77±1.382), honey dip treated dried products (3.70±1.291), lemon juice (3.57±1.455), salt solution (3.30±1.149) to ascorbic acid (3.17±1.289) as shown in Table 2. Overall, consumers had the highest preference for honey dip treated dried pineapples (50%), followed by ascorbic acid treated products (33%). Lemon juice treated product and the control had the same percentage consumer preference (7%) whilst salt treated product scored the lowest (3%) as shown in Fig. 2. This overall high preference trend for honey treated products could be attributable to the fact that honey contains about 75-80% sugar, which resulted in the sweet taste and subsequent preference by panelist. Also, the preference of panelist for ascorbic acid treated products could be due to the taste of vitamin C tablet, which positively influenced the original taste of the pineapple slices. The taste of lemon treated products was influenced by the sour nature of the lemon juice, which affected the taste of the pineapple slices negatively. The taste of salt treated products, which was least preferred, might be due to the chemical reaction of the salt solution with the sugary nature of the pineapple slices. Unsurprisingly, many individuals dislike such combination of salt and sugar. Pineapple contains sucrose, fructose and glucose in concentrations, which make it tastes good, which in combination with acids and other compounds, determine the typical flavor of the fruit (Gherardi *et al*., 1994). Conversely, the position of the control in the hedonic test scale indicates that pre-treatments had tremendous influence on the taste of the dried products. More so, it was revealed in Table 2 that the flavor of the dried products had an influence on taste. This is because salt, which scored least in taste by the hedonic test also, had the least score for flavor preference. There was however no direct correlation between the ranking for color and flavor as shown by the hedonic test. Nevertheless, the color of the dried pineapples should not be taken for granted. Nutritionally, the taste of dried foods is related by their flavor and texture.

The texture of the dried pineapples was described as rough. It was tender and quite chewy and generally soft. Changes in the texture of dried foods are important cause of quality deterioration. It has been explained that loss of texture is caused by gelatinization of starch, crystallization of cellulose and localized variations in the moisture content during drying, which set up internal stresses leading to rupture (Fellows, 1998). The rupture compresses and permanently distorts the relatively rigid cells, to give food a shrunken shriveled appearance. This may be responsible for the variation in the quality of texture and the collapsed cell structure of the dried pineapples. The dried pineapples had shrunk cells with dense tissue. On hydration, the samples absorbed water more slowly and did not regain the firm texture associated with the fresh pineapple (Maskan, 2001). It has been established that heat not only vaporize water during drying but also causes loss of volatile components from the food.

CONCLUSION

This study focused on the drying characteristics and physio-organoleptic properties of dried pineapple slices under different pretreatment. It is evidently clear from the study that drying of pineapples is possible and has tremendous prospects of reducing postharvest losses. It is important to note that pretreatment, drying time and temperature have great influence on the general outlook and acceptability of the dried pineapples. At a drying temperature of 65°C for 16 h, honey treated products had the highest score (50%) for general acceptability, followed by ascorbic treated product with a score of 33%, then lemon and control with a score of 7%, with salt treated products scoring the least of 3%. All the treated dried products have stored five months now without any sign of deterioration. The best drying time for pineapples of the sugar loaf variety is 14 h at a temperature of 65°C.

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