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EFFECT OF DRYING TEMPERATURE ON THE QUALITY OF PAWPAW (*CARICA PAPAYA*) FRUIT LEATHER

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ABSTRACT

Experiments were conducted to investigate the effect of drying temperature (50 ^{o}C, 60 ^{o}C and 70 ^{o}C) on the quality of pawpaw (*Carica papaya*) fruit leather. The physic-chemical, microbial and sensory attributes of the fruit leathers were evaluated. Moisture content of the leather samples differed significantly ($p<0.05$) with values ranging from 17.09 to 24.65 %. Similarly, fat (0.44 to 0.42 %), protein (2.10 to 1.83 %) and ash (2.44 to 2.42 %) contents decreased significantly ($p<0.05$) with increasing drying temperature. The decrease in fibre content (2.06 to 2.00 %) was not significant ($p>0.05$). On the other hand, carbohydrate content of the fruit leathers however increased significantly ($p<0.05$) from 68.36 to 76.21 % with increasing drying temperature. Likewise, pH of the leathers increased from 3.96 to 3.91. Highest retention of vitamin C (67.32 mg/100 g) and beta carotene (3.45 mg/100 g) were observed in leather dried at 50 ^{o}C. Bacterial and fungal populations decreased from 3.15×10^{3} to 1.1×10^{1} Cfu/g and 1.0×10^{3} to 1.1×10^{1} Cfu/g respectively as drying temperature increased, all of which were lower than those in standards (10^{6} and 10^{3}) for bacterial and fungal populations respectively. Sensory scores revealed that with the exception of colour, all leather samples were not significantly ($p>0.05$) affected by increasing drying. Increasing temperature favoured the taste of the fruit leathers. In addition to moisture removal, drying temperature affected the chemical composition of pawpaw fruit leather. The low pH and microbial counts could translate to good shelf life of the leathers. Samples dried at 50 ^{0}C were generally more accepted by the panellists.

Keywords: Drying, Quality, *Papaya*, Leather

INTRODUCTION

Pawpaw (*Carica papaya*) is a widely grown tropical fruit with considerable health and dietary benefits. It is rich in carbohydrate and micronutrients including Beta-carotene [1].

In Nigeria, pawpaw is one of the most popular and cheapest economically important fruit trees grown and consumed for its nutritional benefits [2].

Gaining in popularity among tropical fruits worldwide, pawpaw is ranked fourth in total tropical fruit production after bananas, oranges, and mango [3]. Global pawpaw production has grown significantly over the last few years making it an important agricultural export commodity for developing countries.

Fruits generally are high in moisture and highly perishable, thus cannot be preserved for extended period of time. According to Gajanana *et al.* [4], the annual total postharvest losses of pawpaw worldwide amounted to 25.49 %. The climacteric nature, propensity to deteriorate in ambient storage conditions and inadequate preservation techniques are some of the reasons for losses associated with the commodity. As with other fruits, when the moisture is reduced, the pawpaw fruit can be preserved over a longer period of time with minimal deterioration.

One of the best ways of utilizing and preserving fresh fruits is by processing them into shelf stable products such as leathers [5]. Fruit leathers are prepared by dehydrating fruit puree into leathery sheets. They are made by removing the moisture of the fruit puree, using a large flat tray, until the desired cohesive 'leather' is obtained [5]. Fruit leathers are eaten without further preparation and can be consumed directly as a snack or chopped into small pieces combined with nuts and breakfast cereals [5]. Like their parent fruit material, they are generally nutritious.

The purpose of drying fruit pulps into leather is to produce a stable and easily handled product which will yield maximum quantity for the least volume, improve shelf life, reduce packaging costs, lower shipping weights, enhance appearance, encapsulate original flavour and maintain nutritional value in many agricultural products [6].

The action of applying heat to fruit leathers in order to dry it does not only remove the moisture but can also affect the nutritional and sensory qualities of the dried product. Therefore, the drying temperature is a critical factor to be taken into consideration.

Having identified post-harvest losses as an underlying factor leading to food insecurity in many parts of the world, it is imperative to process freshly harvested pawpaw fruits into shelf stable fruit leather at selected drying temperatures with a view to ascertaining the best suitable temperature for optimum quality of the leather.

MATERIALS AND METHODS

Materials

Pawpaw was purchased from Railway market, Makurdi, Benue State, Nigeria. Citric acid and domestic granulated sugar used as ingredients in pawpaw leather production were purchased from North bank market, Makurdi, Benue State, Nigeria. Glycerol was obtained from the Department of Food Science and Technology, University of Agriculture, Makurdi.

Production of Pawpaw Leather

Pawpaw leather was prepared from evenly ripened fruit following the method of Ashaye *et al.* [7] with slight modifications. Pawpaw fruit was washed with potable water to remove adhering foreign materials as well as reduce microbial load. Peeling and deseeding were done manually with the use of knives. Pulping was performed using an electric juice mixer. The fruit pulp (1 kg) was mixed with 250 g of sugar and 2.5 % citric acid for the preparation of papaya fruit leather. The mixture was heated at 75 ^{o}C with continuous stirring for 5 min to inactivate enzymes, cooled and spread in forms of thin layers on trays smeared with glycerol. This was then dried in a hot air oven at temperatures of 50, 60 and 70 ^{o}C for 10 h. The dried leathers were cut into rectangular pieces and packed in polyethylene bags prior to further analysis.

Chemical Analysis of Pawpaw Fruit Leather

Protein, moisture, fat, ash and fibre contents were determined using standard methods described by AOAC [8]. Carbohydrate content was determined by difference [9]. The pH of the pawpaw fruit leathers was determined using a pH meter. Vitamin C content was determined using vitamin C indophenol titration procedure [8]. Beta carotene was determined using a spectrophotometer method as described by AOAC [8].

Microbiological Evaluation of Pawpaw Fruit Leather

Microbial evaluation of the leather samples were carried out using the methods described by Cappucino and Sherman [10].

Sensory Evaluation of Pawpaw Fruit Leather

Sensory evaluation of the fruit leathers was carried out using a 15-member panel to assess sensory attributes such as appearance, aroma, taste, texture and general acceptability by means of a 9-point hedonic scale questionnaire [11].

Statistical Analysis

Experiments were conducted in triplicates. Data obtained from experiments were subjected to analysis of variance (ANOVA). Means were separated using Duncan's Multiple Range Test [12]. Significant difference was accepted at 5 % probability level.

Results and Discussion

Table I shows the effect of drying temperatures on the proximate composition and pH of pawpaw fruit leather. Moisture content of the leather samples differed significantly ($p<0.05$) in all cases with values ranging from 17.09 to 24.65 %. Drying at 50 ^{o}C resulted in leather with appreciably higher moisture content than at other temperatures. The moisture contents of the leather samples were within the range for acceptable moisture (15 to 25 %) for fruit leathers [5]. Variation in moisture contents is consequential from the drying temperature during processing as temperature is an important factor affecting drying rate. Drying at 50 ^{o}C resulted in leather significantly ($p<0.05$) different in fat content than those dried at 60 and 70 ^{o}C. Values were generally low ranging from 0.42 to 0.44 %. The values were similar to those reported by other researchers [7, 13]. Protein content was least (1.83 %) with leather dried at 70 ^{o}C. Generally pawpaw fruit leathers are low in protein as with other fruit leathers. The loss of protein may be due to denaturation or changes in solubility during drying [14, 15, 16]. Ashaye *et al.* [7] reported similar results for papaya and guava leathers. Drying at the experimental temperatures did not significantly ($p>0.05$) affect the fibre contents of the leathers, although, highest fibre retention was observed for leather dried at 50 ^{o}C (2.06 %). The reduction in fibre content with increasing temperature was likely due to thermal degradation resulting in disruption of the polysaccharide network of the cell wall [15, 16]. Ash content, which is an indication of mineral composition ranged from 2.42 % to 2.44 %. There was no significant ($p>0.05$) difference between leather samples dried at 60 ^{o}C and 70 ^{o}C in terms of ash contents, whereas significant ($p<0.05$) difference was observed between leather dried at 50 °C and other temperatures. The difference in ash contents could be attributed to the expulsion of volatile compounds during heat treatments at elevated temperatures. Carbohydrate contents were significantly ($p<0.05$) different in all pawpaw leather samples dried at the various temperatures. Highest carbohydrate content (76.21 %) was reported for leather dried at 70 °C as compared with 73.77 % and 68.36 % for sample leathers dried at 60 and 50 °C respectively. Moisture content of food exhibits an inverse relationship with total solids of which carbohydrate is the major component for many food products.

The pH values of the pawpaw fruit leather samples showed significant ($p<0.05$) differences between all leather samples dried at 50, 60 and 70 °C (Table I). However, drying at 70 °C resulted in fruit leather with lowest pH (highest acidity) of 3.91, while leather dried at 50 °C had the highest pH (3.96). The decreasing pH and increasing acidity of the samples may be attributed to concentration effect as more moisture was removed from the material. The pH of foods gives an indication of their microbiological safety and shelf life. Similar results (3.57 to 3.98) have been reported by other researchers for guava fruit leather [17, 18].

The effect of drying temperatures on the Vitamin C and β-carotene contents of pawpaw fruit leather is shown in Table II. Vitamin C contents ranged from 47.66 to 67.32 mg/100 g with sample dried at 50 °C having the highest retention. Degradation of vitamin C (ascorbic acid) in foods is directly proportional to increasing temperature as prolonged thermal treatment increases the likelihood of its oxidation [19]. Vitamin C is an important antioxidant and is helpful in the absorption of iron. Although β-carotene losses were not as high as vitamin C, values were significantly ($p<0.05$) different between each leather sample. In an analogous manner with vitamin C losses, Beta-carotene contents of the papaya leathers decreased with increasing drying temperature from 3.45 to 3.12 mg/100 g. β-carotene (precursor vitamin A) is more heat stable than vitamin C. It is converted to Vitamin A by enzymes in the intestinal mucosa of animals and is crucial for the development of children's immune and visual systems.

Table I: Effect of Drying Temperatures on the Proximate Composition (%) and pH of Pawpaw Fruit Leather

Sample	Moisture	Fat	Protein	Fibre	Ash	CHO	pH
A	24.65^{a}±0.03	0.44^{a}±0.01	2.10^{a}±0.03	2.06^{a}±0.01	2.44^{a}±0.02	68.36^{c}±0.01	**3.96^{a}±0.03**
B	19.39^{b}±0.02	0.42^{b}±0.01	2.00^{b}±0.04	2.02^{a}±0.01	2.42^{b}±0.01	73.77^{b}±0.19	**3.94^{b}±0.03**
C	17.09^{c}±0.02	0.42^{b}±0.01	1.83^{c}±0.03	2.00^{a}±0.01	2.42^{b}±0.01	76.21^{a}±0.01	**3.91^{c}±0.03**
LSD	0.01	0.01	0.01	0.06	0.01	0.37	**0.09**

***Values are means ± standard deviation of duplicate determination**
***Means with different superscript within the same column are significantly (p<0.05) different**
KEY
A: Pawpaw Fruit Leather dried at 50^{o}C
B: Pawpaw Fruit Leather dried at 60^{o}C
C: Pawpaw Fruit Leather dried at 70^{o}C
CHO: Carbohydrate
LSD: Least Significant Difference

Table II: Effect of Drying Temperatures on the Vitamin C and β-Carotene contents of Pawpaw Fruit Leather (mg/100 g)

Samples	Vitamin C	β-Carotene
A	67.32^{a}±0.006	**3.45^{a}±0.004**
B	53.41^{b}±0.003	**3.30^{b}±0.002**
C	47.66^{c}±0.002	**3.12^{c}±0.002**
LSD	0.08	**0.01**

***Values are means ± standard deviation of duplicate determination**
***Means with different superscript within the same column are significantly (p<0.05) different**
KEY
A: Pawpaw Fruit Leather dried at 50^{o}C
B: Pawpaw Fruit Leather dried at 60^{o}C
C: Pawpaw Fruit Leather dried at 70^{o}C
LSD: Least Significant Difference

Total bacterial counts for pawpaw fruit leathers dried at the selected experimental temperatures decreased from $3.2x10^{3}$ to $1.1x10^{1}$ Cfu/g in leather dried at 50 and 70 ^{o}C respectively (Table III). Similarly, fungal counts reduced with increasing temperatures from $1.0x10^{3}$ to $1.1x10^{1}$ Cfu/g (Table III). Microbial load is to a great extent reduced at elevated temperatures. The reduced moisture content and pH in the samples could also hinder microbial activities. All samples were however within safe limits for bacteria (10^6) and fungi (10^3) respectively in dried fruit samples [20].

Table IV shows the sensory scores of pawpaw fruit leather dried at selected temperatures. Scores of the samples were not significantly (p>0.05) different in terms of taste, aroma, texture and general acceptability. However, there was significant (p<0.05) difference in appearance of the samples. Leather dried at 50 °C had the highest score for colour (6.87), aroma (5.63), texture (5.33) and overall acceptability (5.53). Conversely, highest taste score (5.13) was linked with leather dried at 70 °C. Sensory scores were generally low and were similar with findings of Ashaye *et al.*, [7] for pawpaw and guava leathers.

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Table III: Effect of Drying Temperature on the Microbial quality of Pawpaw Fruit Leather (Cfu/g)

Samples	Total Bacteria Count	Fungi Count
A	3.2×10^3	$\mathbf{1.0\times10^3}$
B	1.1×10^2	$\mathbf{2.1\times10^1}$
C	1.1×10^1	$\mathbf{1.3\times10^1}$

KEY
A: Pawpaw Fruit Leather dried at 50°C
B: Pawpaw Fruit Leather dried at 60°C
C: Pawpaw Fruit Leather dried at 70°C
LSD: Least Significant Difference

Table IV: Effect of Drying Temperature on the Sensory Attributes of Pawpaw Fruit Leather

Samples	Appearance	Taste	Aroma	Texture	General Acceptability
A	6.87[a]	4.80[a]	5.63[a]	5.33[a]	**5.53[a]**
B	6.27[b]	4.73[a]	5.13[a]	5.01[a]	**5.23[a]**
C	5.76[b]	5.13[a]	4.93[a]	5.11[a]	**5.27[a]**
LSD	0.54	0.96	1.21	1.05	**0.86**

***Means with different superscript within the same column are significantly (p<0.05) different KEY**
A: Pawpaw Fruit Leather dried at 50°C
B: Pawpaw Fruit Leather dried at 60°C
C: Pawpaw Fruit Leather dried at 70°C
LSD: Least Significant Difference

CONCLUSION

Findings from the study show that in addition to moisture removal, increased drying temperature affected the chemical composition of pawpaw fruit leather. Vitamin C and β-carotene were not adversely affected by the drying temperatures. The low pH of the leathers combined with their low microbial scores indicates good keeping quality. Leather samples dried at 50 ^{o}C were generally more accepted by the panelists.

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