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QUALITY ASSESSMENT OF *AFRAMOMUM DANIELLI* SPICED FRUIT LEATHER FROM AFRICAN STAR APPLE FRUIT

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ABSTRACT

Quality assessment of *Aframomum danielli* spiced fruit leather from African Star Apple was investigated. The sugar sweetened fruit leather samples were spiced with 0.2g to1.0g *A. danielli* powdered extract, while the control had no *A. danielli.* The quality of the processed fruit leather was assessed over a 12-week storage period, with changes noticed in the colour of the control sample. Losses in ascorbic acid, β-carotene and lycopene followed similar trend. The percentage loss in ascorbic acid for the control and the treated samples were 23.78% and 8.18% respectively. For lycopene, the control lost 44.7%, while the treated samples, 39.2% maximum, over same storage period. Sample F had the highest mean score for β-carotene (0.117mg/100g) after 12 weeks, while the control had the least, 0.046mg/100g. Titratable acidity of the samples increased with storage, as the pH values decreased. Acidity reduced the loss rate of ascorbic acid, β-carotene and lycopene contents. Microbial load of the samples reduced with increasing quantity of the spice. Sample spiced with 1.0g *A. danielli* had no growth during the storage period, and retained nutrients better. The control sample had a better rating in all the parameters measured alongside the sample spiced with 0.2g of the spice.

1. Introduction

Nutritious, flavourful and fruit-based fruit leather is a confectionery product usually eaten as a snack or dessert (Blessing *et al*., 2015). Fruit leather could also be defined as products made from fruit purees (sometimes sweetened with sugar or honey), that are spread thinly and dried. The dried sheets are cut into desired strips or rolled into cylindrical shapes or a pureed fruit poured thinly on a flat surface and then dehydrated to yield a dry thin, pliable food product that resembles a sheet of leather (Eze *et al.,* 2014). They can have a shelf life of up to a year when stored at a favourable room temperature. Fruit leathers, loved by both adults and children, can be made at home as they are very easy to make and do not require expensive equipment or difficult techniques (Ragga, 2017). They could be made from various fruits such as apple, mango, apricot, peaches, plums, berries, pears, grapes etc. (Kumar *et al*., 2013), with high fibre fruits being of choice (Adepoju & Adeniji, 2012). African Star Apple fruit is rich in fibre (Adepoju & Adeniji, 2012) and high in pectin (Nwosu *et al*., 2014), making it an excellent choice for fruit leather production.

African star apple (*Chrysophyllum albidum*) is a tropical fruit, belonging to the family *sapotaceae* tagged star apple or gold leaf tree and native across tropical Africa especially in southern Nigeria and other areas of West Africa countries like Uganda, Niger Republic, Cameroon and Cote d'ivore (Adewusi & Bada, 1997). Harvesting is done by shaking of the tree or with forked sticks for very ripe ones, as they are attacked by biological organisms (Adepoju & Adeniji, 2012). They are high in

vitamin C (more than orange or guava), minerals and fibre, and these high nutritional contents made it an excellent nutritional fruit with quality attributes and flavour (Blessing *et al*., 2015; Adisa, 2000). The fruit serves as a cheap source of nutrients, and as a result, increasing production and consumption will significantly improve consumer's nutrition, as they are equally of great economic value to industrial, medicinal and food uses.

The fruit is nearly spherical and slightly pointed at the tip. When ripe, it is orange-red, yellow, or yellow-brown in colour, sometimes with brownish speckles (Adepoju & Adeniji, 2012). Within the fruit is a yellowish pulp surrounding five brown seeds arranged in regular star shape. The problems associated with African Star Apple fruit include that of seasonality and perishability. As a result, the fruit could be processed to other valuable products to meet the demand of consumers and solve seasonal glut problem, rapid spoilage, and unavailability in regions of poor and unfavourable condition for growth, storage and transportation (Nwosu *et al*., 2014).

Antioxidant properties of spices have been recognised years back. It has been reported that spices effectively increase the antioxidant capacity of foods, with effects depending more on food matrices (Ndukwu & Ben-Nwadiba, 2005). The use of local spices to control the activities of micro-organisms in foods has been reported by some authors such as (Adedeji & Ade-Omowaye, 2013). *Aframomum danielli* is one of the various spices that have been used and reported, and common in West Africa. It was reported to impact pungency, spicy aroma and inhibits the growth of micro-organisms like *salmonella enteriditis, pseudomonas fragi and fluorescens, proteus vulgaris, streotococcus pyrogenes, staphylococcus aureus* and some *aspergillus species* (Adegoke & Skura, 1994).

Post-harvest losses, which are common in third world countries, can be reduced through the production of more stable, economic and convenient value added products like fruit leather. Since the fruit is seasonal and unavailable during off season; processing into fruit leather could be one way of curbing or reducing the shortage. Producing fruit leather from the fruit will also help to increase farmers' income by utilization of available indigenous raw material; it will also help in giving added value to indigenous crops, as well as increase the volume and quality of agricultural output. The addition of *A. danielli* is believed to improve the flavour of the fruit leather, as well as inhibit the growth of micro-organism and probably extend the shelf life of the fruit leather.

This research was designed to evaluate the quality attributes and storage stability of *Aframomum danielli* spiced fruit leather made from African Star Apple.

2. Materials and methods

2.1. Raw materials sourcing

Fresh African Star Apple fruits used for the work were sourced from a farm in Ilorin, Kwara State; dried pods of *A. danielli* from a local market, while sucrose used was purchased from a confectionery store in Ilorin town in Kwara State.

2.2. Method and production of fruit leather

The seeds of the *A. danielli* were removed from the pods, cleaned and milled into powder and then sieved with a wired mesh to obtain fine powder. The African Star Apple fruits sourced were washed and then blanched at 70ºC for 5 minutes to ensure easy peeling and also to inactivate enzymes, after which they were peeled and de-seeded. They were cut into smaller sizes and blended at different ratios (Table 1). Properly homogenised samples were then poured onto a drying trays previously oiled with glycerol to prevent sticking, dried in a dehydrator at 60ºC for 8 hours, cooled and packaged in Ziploc bag for further processing.

2.3. Analysis of colour

The colour attributes (Hunter L, a and b values) of the raw fruit and fruit leather samples was obtained with a Rapid Visco Analyser of a Minolta portable chroma-meter. It records L*, a* and b* values and calculate

the brown index. Each sample was measured at four spots using standard L*= 53.44, a*= -24.94, b* = 12.94 values. Whiteness index (WI) was calculated according to Hsu *et al*., (*11*).

$$WI = 100[(100-L^*)^2 + (a^*)^2 + (b^*)2\ ]^{0.5} \quad (1)$$

Table 1. Blending Ratios of the Fruit Leather Samples

Samples	African Star Apple (g)	*A.Danielli* (g)	Sugar (g)
A	100	-	20
B	100	0.2	20
C	100	0.4	20
D	100	0.6	20
E	100	0.8	20
F	100	1.0	20

2.4. Lycopene

Lycopene was extracted using a mixture of hexane, ethanol and acetone in the ratio 2,1,1 (v/v) by the method of Suwanaruang, 2016. The lycopene levels were calculated thus,

Lycopene (mg/kg) = Abs (503nm) x 537 x 8 x 0.55/0.1 x172 OR Abs (503nm) x 137.4. (2)

2.5. β-Carotene estimation

β-carotene was determined by the method of Kumari *et al*., 2011, and estimated thus,

β-carotene (mg/100ml) = 0.216 x A663-0.304 x A505 + 0.452 x A453. (3)

2.6. Ascorbic Acid Determination

This was done by the method of Novozamski *et al*., 1983. It was calculated using calibrated curve of L-ascorbic acid (0.020-0.12mg/ml; Y = 3.4127X-0.0072; R2 = 0.9905). The results were expressed in terms of mg of ascorbic acid/100g of extract.

2.7. Titratable acidity (TTA)

This was determined using the method of AOAC 2000. It was calculated thus,

TTA= N (NaOH) x Titre value x Citric acid value x DF x 100/10 (4)

Where, N= normality of NaOH, which is 0.01; Citric acid value= 0.0064; DF= Dilution factor.

2.8. pH determination

The pH of the samples was determined using the method of AOAC, 2000. The pH meter was calibrated using buffer solutions of standard pH of 7.01 and 4.0.

2.9. Microbiological Analysis

Microbial load of the samples were determined by the method of Adegoke, 2000. One gramme each of the sample was dissolved in 1 ml of 2% sterile sodium citrate solution in order to prepare a suspension. 1 ml of the suspension was then used for the serial dilution. 1 ml of diluted sample was placed in sterile disposable petri-dishes (sterilin) in triplicates. At 44ºC to 50ºC, the media were poured on the samples in the petridishes and allowed to set, inverted and incubated for 48 hours.

2.10. Sensory Evaluation of the Fruit Leathers

The fruit leathers produced were judged for aroma, appearance, texture, taste and overall acceptability by 35 panel of members who are untrained, but randomly selected. A 9-point hedonic scale of the modified method of Stone & Sidel, 1992 was used for scoring with 1 corresponding to disliked extremely, while 9 was liked extremely.

2.11. Statistical analysis

The mean and standard deviation of the data obtained were calculated. The data were

evaluated for significant differences in their means with analysis of variance (ANOVA) ($p<0.05$). Differences between the means were separated using turkey test as packaged by SPSS software (version 20.0).

3. Results and discussions

For the raw African star apple fruit used, the β-carotene content was found to be 0.017mg/100g, which was lower than 340.19µg/100g (0.340mg/100g) reported by Adepoju & Adeniji, 2012. The ascorbic acid content was 10.7mg/100g, which was slightly lower than 12mg/100g reported by Dauda, 2014. The variation noticed in the reported values could be attributed to varietal differences, weather, location, soil composition, method of analysis, pre-treatments etc. (Adepoju & Adeniji, 2012; Ureigho & Ekeke, 2010). Lycopene content was 0.93mg/kg and the pH, 3.7 (similar to 3.5 reported by Dauda, 2014). Low pH value may cause carbonyl group not to dissociate and participate in hydrogen bonds that supports gel structure. The brix was 18, and TTA, 4.56g/L, reflected in the acidity level of the fruit and preservation of the fruit leather (Uzma *et al*., 2014).

The fruit yield and pulp to peel ratio were 53.57% and 2.61 respectively, and were higher than 47.74% and 2.53 reported by Dauda, 2014. The result, however, revealed that the fruit can be a good raw material for fruit leather production, as suggested by the yield.

3.1. Result of colour determination.

The sample colour after twelve weeks of storage is as shown in Tables 2. The raw African star apple fruit had initial L*, a* and b* values of 38.72, 9.30 and 12.96 respectively, but exhibited significant differences at $p<0.05$ between the treated samples and the control. The colour of the treated samples with higher quantities of the spice were brighter and better retained than those with little or no added *A. danielli*. After twelve weeks, the colour of the samples ranged from (34.05-36.63) for L*, (8.05-10.20) for a* and (3.13-7.46) for b* values. Samples A, B, E and F were not significantly different for L* values which represents whiteness. As for a* that represents redness; no significant difference in the samples with 0.6 to 1.0g of *A. danielli*. From the results however, it could be said that *A. danielli* spice had effect on the colour parameter of the fruit leather samples.

The slight changes in lycopene and β-carotene contents during storage might have contributed to the changes noticed in the colour parameters, with the intense red colour indicative of higher lycopene content.

Lycopene belongs to the group of anti-oxidants called carotenoids, an anti-oxidant responsible for the red pigmentation in fruits such as tomato and water melon (Christian *et al*., 2008). The lycopene content of the fruit leather samples appeared to increase with up to 2.91 mg/kg compared to the value recorded for the raw fruit used. The recorded increase in lycopene may probably be due to concentration. It could also be due to gradual microbial degradation of the samples. Perhaps, longer drying time, as reported, could have led to the loss of lycopene through isomerization and degradation (Okilya *et al*., 2010). Drastic reduction in the lycopene content was recorded within the first four weeks, and as storage progresses, reduction rate fell drastically (Table 3). Significant differences were noticed among the samples after week four (Table 3). The initial drastic reduction could be attributed to oxidation or degradation of the lycopene, and as the fruit leather became acidic and total titratable acidity increased, the reduction rate equally reduced, probably due to the impact of *A. danielli.*

Table 4 showed the ascorbic acid content of the samples stored for twelve weeks. The ascorbic acid of the raw fruit used was 10.70 mg/100g, while that of the samples ranged from 10.69 to 10.75 mg/100g. The values, however, reduced by 8% to 24% over the storage period, with the control sample losing about 24% (the highest). The reduction recorded could be attributed to oxidation of the ascorbic acid to dehydro-ascorbic acid, and

down to 2,3-diketogulonic acid and finally to furfural complexes, which was similar to browning reactions or consumption as a reagent in maillard reaction. Loss of ascorbic acid in fruits, juices, fruit leathers etc. had been reported severally. For example, Jain & Nema, 2007 reported 176.27 to 104.87 mg/g loss of ascorbic acid in guava leather; Rao & Roy, 1980 reported losses in mango leather stored for 3 months, while Sreemathi *et al*., 2008 equally reported losses in sapota-papaya fruit leather etc. Ascorbic acid losses in samples treated with *A. danielli* were far less than those of control with significant differences noticed (Table 4).

Table 2. Colour of the Fruit Leather Samples after 12 Weeks**.**

Sample	L*	A*	B*
A	34.98±0.52a	8.05±0.16c	3.79±1.52d
B	34.81± 0.28a	8.90±1.11b	3.13±0.08e
C	34.34±1.17b	8.44±0.88c	5.10±1.23c
D	34.05±0.93b	9.96±0.78a	5.54±1.32b
E	35.91±0.84a	10.14±0.33a	6.31±1.32b
F	36.63±3.23a	10.20±1.31a	7.46±0.14a

Values are means of 3 determinations. Means with the same letter down the column are not significantly different ($p<0.05$).
A= 100g of African Star Apple with 20g sugar;
B= 100g of African Star Apple, 20g sugar and *0.2g A. danielli*
C= 100g of African Star Apple fruit, 20g sugar and *0.4g of A. danielli*
D= 100g of African Star Apple fruit, 20g sugar and 0.6g of *A.danielli*
E= 100g of African Star Apple fruit, 20g of sugar and 0.8g of *A.danielli*
F= 100g of African Star Apple fruit, 20g of sugar and 1.0g of *A. danielli*

Table 3. Lycopene Content (mg/Kg) of Fruit Leather Samples

Samples	Initial	Week 4	Week 8	Week 12
A	3.78±0.01a	2.51±0.00c	2.30±0.01b	2.09±0.01ab
B	3.74±0.06a	2.50±0.04c	2.31±0.00b	2.32±0.11a
C	3.78±0.01a	2.59±0.01c	2.42±1.00a	2.37±0.01a
D	3.82±0.00a	3.00±0.06a	2.44±0.04a	2.32±0.11a
E	3.79±0.02a	3.04±0.01a	2.51±1.01a	2.45±0.03a
F	3.77±0.01a	2.73±0.38b	2.56±0.00a	2.47±0.01a

Values are means of 3 determinations. Means with the same letter down the column are not significantly different ($p<0.05$).
A= 100g of African Star Apple with 20g sugar;
B= 100g of African Star Apple, 20g sugar and *0.2g A. danielli*
C= 100g of African Star Apple fruit, 20g sugar and *0.4g of A. danielli*
D= 100g of African Star Apple fruit, 20g sugar and 0.6g of *A.danielli*
E= 100g of African Star Apple fruit, 20g of sugar and 0.8g of *A.danielli*
F= 100g of African Star Apple fruit, 20g of sugar and 1.0g of *A. danielli*

The initial β-carotene contents ranged from 0.174 to 0.180mg/100g with no significant differences, but reduced by 35-56% over twelve weeks. The control sample deteriorated the most, with 56.25% loss, while samples with higher contents of *A. danielli* lost minute quantities of β-carotene (Table 5).

Table 4. Ascorbic Acid Content (mg/100g) of Fruit Leather Samples

Samples	Initial	Week 4	Week 8	Week 12
A	10.72±0.22a	9.95±0.10c	9.81±0.00c	8.17±0.02c
B	10.70±0.10a	10.30±0.00b	10.09±0.00b	9.87±0.01b
C	10.75±0.03a	10.34±0.21b	10.18±1.01b	9.99±0.11a
D	10.73±0.02a	10.43±1.12a	10.30±1.13a	9.98±0.01a
E	10.69±0.00ab	10.51±0.00a	10.32±0.11a	10.14±1.02a
F	10.71±0.21a	10.52±0.22a	10.40±0.00a	10.19±0.22a

Values are means of 3 determinations. Means with the same letter down the column are not significantly different ($p<0.05$).
A= 100g of African Star Apple with 20g sugar;
B= 100g of African Star Apple, 20g sugar and *0.2g A. danielli*
C= 100g of African Star Apple fruit, 20g sugar and *0.4g of A. danielli*
D= 100g of African Star Apple fruit, 20g sugar and 0.6g of *A.danielli*
E= 100g of African Star Apple fruit, 20g of sugar and 0.8g of *A.danielli*
F= 100g of African Star Apple fruit, 20g of sugar and 1.0g of *A. danielli*

Table 5. β-Carotene Content (mg/100g) of Fruit Leather Samples

Samples	Initial	Week 4	Week 8	Week 12
A	0.174±0.00a	0.095±0.02c	0.081±0.04c	0.046±0.05b
B	0.176±0.00a	0.110±0.04b	0.089±0.01c	0.077±0.00b
C	0.175±0.01a	.120±0.00ab	0.108±0.00ab	0.097±0.01ab
D	0.180±0.02a	0.130±0.00a	0.123±0.03a	0.099±0.00ab
E	0.180±0.02a	0.140±0.01a	0.125±0.01a	0.110±0.01a
F	0.180±0.02a	0.150±0.02a	0.130±0.12a	0.117±0.02a

Values are means of 3 determinations. Means with the same letter down the column are not significantly different ($p<0.05$).
A= 100g of African Star Apple with 20g sugar;
B= 100g of African Star Apple, 20g sugar and *0.2g A. danielli*
C= 100g of African Star Apple fruit, 20g sugar and *0.4g of A. danielli*
D= 100g of African Star Apple fruit, 20g sugar and 0.6g of *A.danielli*
E= 100g of African Star Apple fruit, 20g of sugar and 0.8g of *A.danielli*
F= 100g of African Star Apple fruit, 20g of sugar and 1.0g of *A. danielli*

The titratable acidity (TTA) of a solution is an approximation of the solution's total acidity. The TTA ranged from 1.28-1.52 g\L over the period (Table 6). The increase in the value of TTA was due to the reduction of the pH values or development of acidic substances by the degradation of pectic bodies or hydrolysis of polysaccharides and non-reducing sugars through acid utilization to give hexose sugar (Ugwu & Umeh, 2015). This acid, from report, improves palatability, nutritive value, influence flavour, brightness, colour, stability, consistency and keeping quality of the product (Adisa, 2000; Dauda, 2014; Jain & Nema, 2007).

No growth was recorded until the fourth week (Table 7). Samples with *A. danielli* did not record growth until the eighth week in samples with 0.2 and 0.4 grammes of *A. danielli*. However, samples treated with 0.6 and 0.8g of *A. danielli* did not record growth until week twelve, but sample with 1.0 gramme of *A. danielli* had no growth throughout the period of storage (Table 7). The results confirmed the preservative potentials of *A. danielli* against bacterial growth and agree with the reports of Adedeji & Ade-Omowaye, 2013 and Adegoke & Skura, 1994 on the anti-microbial activities of *A. danielli*.

The inhibitory property of *A. danielli* was revealed though sugars had been reported to inhibit microbial growth through osmotic pressure. A combination of sugar or sweeteners and low pH values could decrease, but may not terminate the growth rate of spoilage yeast. It was seen that the antifungal properties of *A.*

danielli were overwhelming, as it had great effect.

Table 6. Titratable Acidity (g/L) of Fruit Leather Samples

Samples	Initial	Week 4	Week 8	Week 12
A	1.28±0.01a	1.41±0.01a	1.45±0.00ab	1.52±0.01a
B	1.31±0.01a	1.40±0.01a	1.44±0.01ab	1.49±0.00b
C	1.31±0.01a	1.40±0.01a	1.43±0.00ab	1.47±0.01b
D	1.30±0.01a	1.38±0.01b	1.42±0.00ab	1.45±0.00b
E	1.32±0.02a	1.36±0.02b	1.40±0.01ab	1.43±0.01b
F	1.31±0.01a	1.34±0.00b	1.37±0.01ab	1.40±0.00b

Values are means of 3 determinations. Means with the same letter down the column are not significantly different ($p<0.05$).
A= 100g of African Star Apple with 20g sugar;
B= 100g of African Star Apple, 20g sugar and *0.2g A. danielli*
C= 100g of African Star Apple fruit, 20g sugar and *0.4g of A. danielli*
D= 100g of African Star Apple fruit, 20g sugar and 0.6g of *A.danielli*
E= 100g of African Star Apple fruit, 20g of sugar and 0.8g of *A.danielli*
F= 100g of African Star Apple fruit, 20g of sugar and 1.0g of *A. danielli*

Table 7. Mould Count (CFU/g) of Fruit Leather Samples

Samples	Initial	Week 4	Week 8	Week 12
A	-	3±1.00a	5±1.00a	8±0.00a
B	-	-	3±0.00b	6±0.00b
C	-	-	1±0.10c	2±0.11c
D	-	-	-	1±1.00d
E	-	-	-	1±1.00d
F	-	-	-	-

Values are means of 3 determinations. Means with the same letter down the column are not significantly different ($p<0.05$).
A= 100g of African Star Apple with 20g sugar;
B= 100g of African Star Apple, 20g sugar and *0.2g A. danielli*
C= 100g of African Star Apple fruit, 20g sugar and *0.4g of A. danielli*
D= 100g of African Star Apple fruit, 20g sugar and 0.6g of *A.danielli*
E= 100g of African Star Apple fruit, 20g of sugar and 0.8g of *A.danielli*
F= 100g of African Star Apple fruit, 20g of sugar and 1.0g of *A. danielli*

Table 8. Sensory Attributes of the Fruit Leather Samples

Sample	**AROMA**	**APPEARANCE**	**TASTE**	**TEXTURE**	**OVERALL ACCEPTABILITY**
A	8.00±0.81a	7.25±0.96a	7.75±0.50a	6.50±0.58a	8.50±0.58a
B	6.50±0.58b	7.50±0.51a	7.75±0.50a	6.75±0.50a	8.50±0.58a
C	6.50±0.58b	6.25±0.50b	5.50±1.29b	4.75±0.43c	6.50±0.53b
D	6.00±0.82b	6.25±0.50b	6.25±0.50b	5.25±0.96b	6.75±0.51b
E	6.75±0.50b	6.75±0.47a	7.50±0.58a	5.25±0.96b	8.00±0.81a
F	6.00±0.82b	6.00±0.82b	6.50±1.25b	5.50±0.52b	6.35±0.50b

Values are means of 3 determinations. Means with the same letter down the column are not significantly different ($p<0.05$).
A= 100g of African Star Apple with 20g sugar;
B= 100g of African Star Apple, 20g sugar and *0.2g A. danielli*
C= 100g of African Star Apple fruit, 20g sugar and *0.4g of A. danielli*
D= 100g of African Star Apple fruit, 20g sugar and 0.6g of *A.danielli*
E= 100g of African Star Apple fruit, 20g of sugar and 0.8g of *A.danielli*
F= 100g of African Star Apple fruit, 20g of sugar and 1.0g of *A. danielli*

Table 8 shows the sensory evaluation carried out on the samples, and it shows that samples A, B and E were better accepted in terms of appearance, taste and overall acceptability, while samples A and B were better in texture. On the overall, samples A (control), B and E (0.2 and 0.8 grammes of *A. danielli*) were preferred than others. Although the sample with 1g of A. *danielli* exerted the greatest effect in terms of preservation, but was not the most preferred, most probably due to its high pungency.

4. Conclusions

It could be concluded that value can be added to African star apple fruit by processing them into various other products like fruit leather. The addition of *A. danielli* spice improved flavour and aroma and equally extend shelf life of the samples. Combination of sugar and spice increased sensory and keeping quality of samples, with higher quantities of the spice conferring longer shelf life, though with less acceptability, probably due to their pungency.

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