Original Research Article

Effect of Different Processing Methods on the Quality of Ackee Fruit Arils

Abstract

Ackee (*Blighiasapida*) fruit has a nutritional composition comparable to other commonly consumed fruits although its consumption is limited by the presence of anti-nutrients. This studyinvestigated the effect of processing on some anti-nutrients (oxalate and phytate) as well as on ascorbate, carotenoids and phenolic compounds in ackee arils. Changes in physicochemical (pH, titratable acidity, brix and color) were also analysed. Ackee fruit was cut into arils and cooked for 15 min either by boiling in water at 100 °C or steamed or fried in oil at 180 °C.The unprocessed ackee aril had a pH, titratable acidityand brix of 5.79, 0.52 % and 2.70, respectively. Significant changes in these physicochemical properties were only observed in the boiled arils while the highest change in color was observed in the steam fruits. Significant reductions in ascorbate levels of 49.27, 32.86 and 56.29 % were observed after boiling, steaming and frying, although these processing methods did not significantly affect carotenoid and phenol levels. The levels of the anti-nutrients reduced significantly with oxalate reducing by 22.37, 26.67 and 37.42 % and phytate levels reducing by 62.50, 66.67 and 54.17 %, after boiling, steaming and frying, respectively.

Keywords: processing, phytochemicals, colour, anti-nutrients

1. Introduction

Ackee (*Blighiasapida*), is a commonly consumed fruit in the Caribbean, with the fruit either eaten fresh, or processed [1,2]. With a nutritional composition comparable to other commonly consumed fruits[3,4],the consumption of ackee fruit in Ghana and other African countries is limited [5]. Amongthe main factor limiting ackee consumption is the presence of toxic compounds such as hypoglycin A [4,6] and other anti-nutrients such as phytatesand oxalates present in the fruit [7]. Indeed, the consumption of ackee fruit containing hypoglycin A can result in diarrhea, hypoglycemia, nausea and vomiting, a condition commonly referred to as called Jamaican vomiting sickness[4,8]. Hypoglycin A, however, is predominant in the immature fruit,with the levels of this toxic compound decreasing to acceptable levels as ackee fruit matures[4,8].

Several food processing methods can be employed to reduce the toxic compounds and anti-nutrients present in ackee to help enhance the usage of the fruit. This is especially important in Ghana and other African countries where ackee fruit occurs abundantly and are mostly underutilized [5]. Among the most commonly employedfood processing methods in Africa and other tropical countries that can be employed to reduce the toxic compounds and anti-nutrients in ackee fruit include boiling, steaming and frying. These methods when used to process ackee fruits will, however, have an effect on the nutritional composition of the fruit.

The aim of this study was, therefore, to investigate the effect of these three processing methods on the physicochemical and nutritional properties of ackeefruit. Matured and ready-to-eat ackee fruits were cut into arils and processed by cooking in boiling water, steamed and fried, and the effect of these processing methods on ascorbate, carotenoids and phenolic levels determined.

Also, the effect of processing on brix, pH, titratable acidity and color were determined. Additionally, the effect of these processing methods on phytate and oxalate levels were analysed.

2. Materials and Methods

2.1 Processing of ackee fruit arils

Mature ready-to-eat ackee fruits were harvested from the School of Biological Science Garden of the University of Cape Coast, Ghana. The fruit was cut into arilsfor cooking in boiling water, steam or hot oil(frying) after removal of the seeds. The ackeearils (50 g)was boiled in water at 100 °C for 15 min. A similar portionwas cooked for 15 min in steam produced from water boiling at 100 °C(steaming) and a thirdportion was fried in oil for 15 min at a temperature of 180 °C. The processing conditions were selected based on the fact that arils are delicate and require short cooking times of between 15-20 min[9](National Research Council, 1973).

Unprocessed ackee arils was used as the control for comparative purposes.Four independent replicate experiments were carried out for each processing method.The proximate composition (moisture, ash, crude protein, crude fat, crude fibre and carbohydrate) of the unprocessedackee arilswas also determined based on the AOAC (2010) [10] protocol after grinding the arils to powder using a mortar and pestle.

2.2 Determination of pH, Brix, titratable acidity and color

Ackee arils (10 g) were homogenized with 100 mL distilled water using a blender and filtered with a cheese cloth. The filtrate was used in the determination of pH (using a B10P Benchtop pH Meter), titratable acidity (by titrating 5 mL of the filtrate against 0.1 N NaOH using phenolphthalein as indicator) and brix (using digital refractometer- MA871, Milwaukee Instruments USA)[11].

The L*a*b* colorof the ackee arilswas determined using a color meter (CS-10, CHN Spec, China). The color loss (ΔE) after processing was estimated based on the equation:

$$\Delta E = \sqrt{(L - L_0)^2 + (a - a_0)^2 + (b - b_0)^2}$$

where L and L_0 are the $L*$ values of the unprocessed and processed ackee arils, a and a_0 are the $a*$ values of the unprocessed and processed ackee arils, and b and b_0 are the $b*$ values of the unprocessed and processed ackee arils, respectively.

2.3 Determination of ascorbate, carotenoid and phenolic levels

The levels of ascorbate were determined according to the method of Ampofo-Asiama and Quaye[12]. Homogenised samples (1 g) were mixed with a solution of metaphosphoric-acetic acid to 10 mL, centrifuged and a portion of the supernatant mixed with bromine water, thiourea and incubated for 3 h. Afterwards,2,4-dinitrophenolhydrazine and chilledH_2SO_4were added and absorbance measured at 521 nm using a spectrophotometer (Jenway 6400, Bibby Scientific Ltd.).

Carotenoid content was determined by mixing 1 g of homogenized ackee aril with 50 mL n-hexane[13]. The mixture was centrifuged at 4000 rpm for 5 min and the absorbance of the supernatant measured at 446 nm using a spectrophotometer

Total phenols were extracted by homogenizing 10 g ackee aril with 50 mL methanol solution (80 %) and centrifuged at 4000 rpm for 20 min[12].Folin-Ciocalteu's reagent (0.5 mL) was added to 0.5 mL of the supernatant in a solution containing 5 mL of distilled water and 1.5 mL of

Na_2CO_3. The mixture was incubated in the dark at room temperature for 2 h and the absorbance measured at765 nm. Gallic acid was used as the standard.

3.2 Determination of oxalate and phytate levels

Oxalate levelin the ackee arils was determined by titration against $KMNO_4$as described by Day and Underwood [14]. To 1 g of homogenisedackee aril, 100 mL of 6 N H_2SO_4 was added and digested for 1 h at 100 °C. After cooling the digest was filtered and 25 mL of the filtrate was titrated against $KMNO_4$until a pink persistent colourwas observed.

Phytate levels was determined by digesting 4 g of homogenised ackee samples with 100 mL of 2 % HCl. After 3 h, the digest was filtered and 0.3 % (5 mL) NH_4SCN added to 25 mL of the filtrate. This mixture was titrated against 0.1 M $FeCl_3$ until a persistent brownish-yellow colour was obtained [15].

2.6 Statistical analysis

The student's t-test was used to identify significant differences between the control and the processed fruits at a significance level of p 0.05 using SPSS (IBM, SPSS Statistics 20). Significant differencesamong thedifferent processing methods was tested using analysis of variance (ANOVA).

3. Results and discussion

3.1 Proximate composition and the effect of processing on physicochemical quality

Table 1 shows the proximate composition of the studied ackee fruit arils. The arils had an ash, protein, and crude fat content of 1.28, 11.20 and 2.4 g/100 g, respectively.The measured proximate composition of the ackee arils is comparable to that reported in other studies [3,4,16,17].

The effect of the different processing methods on the pH, titratable acidity and brix of ackee arils is shown in Table 2. The unprocessed ackee aril (control) had a pH of 5.23 which changed to 5.79, 5.08 and 5.40 upon boiling, steaming and frying, respectively. The pH of the boiled fruit was significantly higher compared to the control. Similar to the changes in pH, significantly lower titratable acidity and brix were observed in the boiled samples compared to the control (Table 2). The reduction in titratable acidity (with an increase in pH) and brix could be due the leaching of hydrogen ions and sugars, respectively, into the water upon boiling. The pH and titratable acidity of the ackee arils observed in this study is similar to that reported by Morgan and Benkeblia[18].

The effect of the different processing methods on the color of ackee arils is shown in Table 3. The three processing methods had a significant effect in reducing the shiny appearance (L* value) of the arils. While the a* and b* values were also affected by processing, significant differences were only observed upon boiling (a* value) and steaming (b* value). The highest total color change (ΔE) was observed in the steam fruits.

3.2 Effect of processing on ascorbate, carotenoids and phenolic content

The ascorbate content of the ackee arils decreased from 42.68 in the unprocessed fruit to 21.65, 28.65 and 18.65 mg/100 g upon boiling, steaming and frying, respectively (Table 4). These represent reductions of 49.27, 32.86 and 56.29 % of the initial ascorbate levels upon processing. These reductions were significantly different compared to the unprocessed arils. The decreases could be due to the heat labile nature of ascorbate leading to its destruction upon exposure to the different processing conditions. Also, leaching into the boiling water and the very high temperature of frying, compared to the others, could have resulted in the higher losses observed in these two processing methods. The level of ascorbate measured in the unprocessed aril is lower than the range of 60-66 mg/100 g observed in other studies[19,20].Similar reductions in ascorbate levels has been reported in other studies upon processing [4].

Table 4 also shows the effect of processing on the phenolic and carotenoid content upon processing. A phenolic content of 1.19 mg/100 was observed in the unprocessed arils. This changed to 0.90, 1.05 and 0.99 mg/100 upon boiling, steaming and frying, respectively. No significant effect of processing was observed with respect to phenolic content. The initial level of carotenoids in the unprocessed fruit was 39.95 ppm. This changed to 43.88, 40.47 and 46.75 ppm upon boiling, steaming and frying, respectively. Similar to the phenolic content,carotenoid levels were not affectedly significant by the different processing methods.

3.3 Effect of processing on oxalate and phytate levels

Table 5 shows the effect of the different processing methods on the two anti-nutrients. The levels of oxalate and phytate in the unprocessed ackee arils were 5.63 and 32.70 mg/100 g, respectively. The different processing methods lead to significant reductions in oxalate and phytate levels. The level of oxalate reduced by 22.37, 26.67 and 37.42 % after boiling, steaming and frying, respectively, ~~while~~ withreductions in phytate levels of62.50, 66.67 and 54.17 %, respectively.

The reductions in oxalateis similar to the observation of Asiamah (2020)[7]who reported 20.70 and 15.85 % decrease in oxalate levels after boiling and steaming ackee arils, respectively, for 20 min. Also, phytate levels reduced by 66 and 54.95 %, respectively under similar processing conditions [7]. Oxalate and phytate levels have been observed to decrease after processing. In peas, reductions in phytate were observed after thermal processing[21,22], while reductions in oxalate have been observed in several fruits and vegetable after processing[23–25].

4. Conclusions

Boiling, steaming and frying ackee arils reduced the levels of some anti-nutrients as well as some essential compounds. Oxalate levels reduced by 22.37, 26.67 and 37.42 % while phytate levels reduced by 62.50, 66.67 and 54.17 %, after boiling, steaming and frying, respectively. Significant losses in ascorbate were observed while ~~the~~ no changes in carotenoid and phenol levelswere observed. With respect to physicochemical properties, significant changes in pH and colour were observed in the boiled and steamed arils, respectively.

5. References

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Tables

Table 1: Proximate composition (g/100 g fresh weight) of ackee fruit.

Moisture	80.03	±	0.59
Ash	1.28	±	0.03
Protein	11.20	±	0.33
Crude fat	2.40	±	0.20
Crude fiber	1.67	±	0.29
Carbohydrate	3.42	±	0.71

Table 2: Effect of different processing methods on pH, titratable acidity and brix.

Processing method	pH			Titratable acidity (%)			Brix		
Unprocessed	5.23	±	0.16	0.52	±	0.05	2.70	±	0.41
Boiled	5.79	±	0.11	0.49	±	0.04	1.80	±	0.32
Steamed	5.08	±	0.11	0.56	±	0.07	3.90	±	0.15
Fried	5.40	±	0.09	0.52	±	0.03	2.13	±	0.11

Table 3: Effect of different processing methods on the colour of ackee fruit arils.

Processing method	*L**			*a**			*b**			ΔE
Unprocessed	69.20	±	0.89	5.61	±	1.15	29.75	±	1.29	
Boiled	50.89	±	0.71	3.26	±	0.33	21.98	±	0.81	18.32
Steamed	43.73	±	1.90	6.24	±	0.61	16.21	±	1.86	25.49
Fried	48.93	±	1.95	5.42	±	0.95	26.30	±	1.14	20.30

Table 4: Effect of different processing methods on the ascorbate, phenolic and carotenoid levelsof ackee arils.Results are expressedbased on the fresh weight.

Processing method	Ascorbate (mg/100 g)	Phenolic content (mg GAE/100 g)	Carotenoids (ppm)
Unprocessed	42.68 ± 2.65	1.19 ± 12.37	39.95 ± 4.08
Boiled	21.65 ± 1.27	0.90 ± 18.54	43.88 ± 3.80
Steamed	28.65 ± 2.65	1.05 ± 8.69	40.47 ± 3.59
Fried	18.65 ± 1.07	0.99 ± 14.37	46.75 ± 5.40

Table 5: Levels of oxalate and phytate following processing of ackee fruit arils.Results are expressed based on fresh weight.

Processing method	Oxalate (mg/100 g)	Phytate (mg/100 g)
Unprocessed	5.63 ± 1.13	32.70 ± 5.64
Boiled	4.37 ± 0.23	12.26 ± 4.35
Steamed	4.13 ± 0.65	10.90 ± 2.36
Fried	5.25 ± 0.65	14.99 ± 2.36