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Effects of Some Traditional Processing Methods on the Nutrient Composition of Two Varieties of the African Pear (Dacryodes Edulis)

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Abstract: A study on the effects of some traditional processing methods (boiling and roasting) on the nutrient composition of two varieties of African pear (var. edulis and var. parvicarpa) was done. Analyses on the proximate, anti-nutrient, mineral, vitamin, fatty acid composition, caloric and pH values, as well as the titratable acidity of the processed and unprocessed fruits of the two varieties were carried out using standard methods. The results showed that the two varieties of the African pear (D. edulis) were high in moisture (fresh weight) and(on dry weight basis) in nutrients such as fat/oil (with crude fat values of 35.93±0.24% in var. edulis and 35.21±0.04% in var. Parvicarpa), carbohydrates (26.40±0.02% in var. edulis and 27.00±0.02% in var. parvicarpa), vitamins (having the highest value for vitamin C of 6.32mg/100g in var. edulis and 6.17mg/100g in var. parvicarpa) and minerals (with highest value for potassium at 6630.31±0.12ppm in var. edulis and 6360.58±0.05ppm in var. parvicarpa), and generally low in anti-nutrients. The var. parvicarpa was more acidic than the var. edulis both having values of 5.11±0.09 and 5.27±0.15 respectively. They are rich sources of oils, especially the var. edulis which contained more of unsaturated fatty acids (66.64%) than var. parvicarpa (64.67%). Processing significantly ($p<0.05$) reduced the protein and ash content from 5.45% and 4.81% respectively to 4.35% and 4.40% in the boiled samples while roasting reduced the fat content from 35.93% to 33.22% in both varieties. Although processing did not significantly reduce the anti-nutrient composition, it, possibly, led to a significant reduction in the level of vitamins especially in the roasted samples as seen in vitamin C from 6.32mg/100g to 5.83mg/100g. Roasting significantly ($p<0.05$) increased the concentrations of macro and micro elements of the African pear. Summarily from this research, the var. edulis is more nutritious and contains less anti-nutrients and acidity levels than the var. parvicarpa.

1. Introduction

In Africa, fruits are on very high demand because people have become increasingly aware that fruits can complement the nutritional needs of individuals as excellent sources of vitamins and minerals (Nneka, and Ejike, 2020). Researchers have become convinced that the nutrients in fruits and vegetables do a lot more than just to prevent deficiency diseases like scurvy, beriberi or rickets. Recent findings reveal that some vitamins or vitamin precursors in foods, e.g. Vitamin C, polyphenols and beta-carotene, are potent anti-oxidants which are very helpful in preventing muscular damage caused by the oxidative processes of some food substances that may possibly lead to muscle degeneration, cardiovascular disease and cancer (Sodamade et al., 2013).

The contributions of seeds, vegetables and fruits of some plants in Nigeria, to the vitamin, mineral and amino acids composition of human nutrition, have been shown not to be fully achieved because of the presence of anti-nutrients which make some of these essential nutrients and protein unavailable when consumed (Essack et al., 2017). However, some processing methods, such as soaking, boiling, fermentation, roasting etc. are known to reduce or eliminate some of these anti nutrients (Cyril et al., 2022).

Heat processing such as boiling (or blanching), roasting and others inactivate some toxic substances and organisms, and enhance digestibility of certain foods. These processes, however, may lead to the destruction or removal of micronutrients, such as vitamin C, which are very disposed to oxidation and are heat labile. Although, the bioavailability of some vitamins such as thiamin, folate, vitamin B6, carotenoids and niacin may increase by processing as they are being freed from the food microstructure (Yahaya et al., 2014).

Dacryodes edulis, known as the African Pear, is an indigenous fruit tree grown in the humid low lands and Plateau regions of West and Central Africa.In South-Eastern Nigeria, the trees are grown around homesteads and flowering takes place from January to April, with fruiting between May and October. It is an annual fruit and contains a leathery shelled stone surrounded by a pulpy pericarp which is butyraceous, i.e. it has the qualities of butter (Nwaogu and Oluwamukomi, 2024).It is this portion of the pear which is eaten, either raw or cooked (by boiling or roasting).On the basis of long-term and extensive field observations, two varieties of D. edulis were distinguished: D. e. var. edulis which is large, elongated, and cylindrical and the fruit pulp is thick and D. e. var. parvicarpa which is small, rounded or more or less conical, having a thin pulp (Isaac et al., 2014). The two varieties are shown in plate 1a and 1b. The African Pear makes a lot of contributions to the livelihood of farmers, consumers and traders, as direct consumption has nutritional benefits, and also fruit sales is an important source of income especially for women, who are mostly involved in the African pear trade.

The need for nutritious, ready-to-eat processed foods is now on the increase because of growing urbanization. More so, consumers need to know what they are consuming, and to what extent their nutritional attributes are affected by processing. One of the major setbacks in the commercial utilization of the African pear is the lack of adequate and consistent data on the fruit as most of the published data on the nutrient and anti-nutrient composition of the fruit differ from each other.Difference in chemical composition has been identified in the two varieties (the short and the large fruit types) as reported by Isaacand Ekpa (2009). Also, there is a dearth of information on the effects of the different traditional processing methods on the nutrient and anti-nutrient composition of the African pear.

Plate 1: (a) D. e. var. edulis (b) D. e. var. parvicarpa.

2. Materials and methods

2.1 Collection and treatment of samples

The two varieties of Dacryodes edulis (D.e.var.edulis and D.e. var. parvicarpa) as described by Isacc and Ekpa (2009) were plucked directly from trees in Ikom (D.e. var. edulis) and Akamkpa (D.e. var. parvicarpa) Local Government Areas both in Cross River State, Nigeria, and identified in the Department of Botany, University of Calabar, Nigeria. Thirty (30) ripe fruits of each variety were washed thoroughly with tap water and the excess water dried off using a paper towel. Each batch of thirty fruits was divided into three groups of ten each. Group A was treated as raw, group B was roasted over hot coals, with constant turning until soft, and group C was put into boiled water poured into a bowl and left for five minutes to soften.

2.2 Preparation of samples for analysis

The seeds of the raw and processed D. e. variety edulis and D. e. variety parvicarpa fruits were removed, the skin and flesh (as consumed) ground into a pulp using a manual grinder. A portion of the pulp was used for moisture determination. The remaining blended pulp was then dried at 50°C in an air-circulating oven (Astell-Hearson) for 12 hours and then ground into fine powder using a laboratory mortar and pestle; fractions of each was used for analyses.

3. Chemical analysis of samples

3.1 Proximate analysis/caloric value

Proximate analysis was carried out on all six (6) samples of D. edulis according to the methods of the Association of Official Analytical Chemists (AOAC, 2010) to determine the moisture content of the fresh and dry samples, crude protein, crude fat, ash, and available carbohydrate of the dry samples. Total dietary fibre was determined by enzymatic digestion, gravimetric method of AOAC (2010) – Prosky (985.29). The calorific value was calculated by multiplying the percentage of available carbohydrate and crude protein with 16.8 kJ and crude lipid with 37.8 kJ. The sum of values was then obtained in kilojoules per 100 g of the sample. All data were obtained in triplicates.

3.2 Anti-nutrients

3.2.1 Phytate

Phytate was determined according to the method of AOAC (2010). A 4.0 g portion of the sample was soaked in 100 ml of 2% HCI for 3hrs and later filtered through Whatman No. 2 filter paper. A portion of 25 ml of the filtrate was placed in a conical flask and 5 ml of 0.3% ammonium thiocyanate solution was added, after which 53.5% of distilled water was added and titrated against a standard iron (Ill) chloride solution to end point. Phytate content was expressed as the percentage (%) phytate in the sample.

3.2.2 Total oxalate

The modified method of Day and Underwood (1986) was employed for the analysis of oxalate. 1.00g of the sample was weighed into 100ml borosilicate glass flask, 75ml of 3M H_2S0_4 was added and the solution was stirred carefully intermittently with magnetic stirrer for about 1hr and later filtered with Whatman No 1 filter paper. 25ml of the sample filtrate was collected and then titrated at hot condition of about 90°C against 0.1M KMnO4 solution to the end point.

3.2.3 Hydrogen cyanide (food toxicant)

The method described by Onwuka (2005) was used; 10.00g of the sample was pulverized and homogenized with 250 ml of 0.1M othophosphoric acid. The homogenate was centrifuged and the supernatant taken as the extract. 3.4 ml of acetate buffer was added and stirred to mix together, after which 0.2 ml of 0.5% chloramin-T and 0.6 ml of color reagent were added and allowed to stand for 15 min for colour development in darkness. The absorbance value was read at 605 nm against a blank. The data from the standard values were used for the standard curve and its slope by plotting absorbance values against standard concentrations. The unknown mean absorbance and the weight of the sample were used to calculate the cyanide content.

3.3 Vitamin analysis

The samples were removed out of the less than 4°C compartment in the laboratory and placed on the bench to allow acclimatizing to the laboratory conditions. The vitamin analyses were done according to the method of Onwuka, (2005).

3.3.1 Extraction of water-soluble vitamins

The sample was grinded with the aid of the laboratory mortar and pestle. The accurately weighed 0.100 g of ground powder was put into 100 mL volumetric flasks and 80 ml of water was added. After 15 minutes of ultrasonic extraction, the water was added to the volumetric flask mark. The prepared sample solution was stored in the dark and diluted if necessary. Prior to injection, the solutions were filtered through a 0.2 um filter (Millex-GN).

3.3.2 Extraction of fat-soluble vitamins

The accurately weighed 0.125g of grounded sample was added into 10 mlvolumetric flasks and 8 ml of CH_3OH-CH_2Cl_2 (1:1, v/v) was added to the flask. After 15 minutes of ultrasonic extraction, CH_3OH-CH_2Cl_2 (1:1, v/v) was added to the volumetricflask mark. The prepared sample solution was stored in the dark and diluted if necessary. Prior to injection, the solutions were filtered through a 0.2 um filter (Millex-GN).

3.4 Mineral analysis

The Mineral composition was estimated using Atomic Absorption Spectrophotometer, AAS (Perkin Elmer model 703, USA). Standard solutions containing known amounts of the minerals to be determined was used to calibrate the machine, with the use of analytical reagents, results were expressed in parts per million of dry matter. A0.1g of the ash sample was weighed into the pre-cleaned

borosilicate 250ml capacity beaker for digestion. 20 ml of the nitric acid was added into the weighed sample in the beaker. The sample with the digesting solvent was placed on the hot plate for digestion in the fume cupboard. The beaker and its contents after the digestion were allowed to cool. Another 20ml of the digesting solvent was added and digested further in the fume cupboard and the mixture was allowed to cool to room temperature. The mixture was filtered into the 259ml volumetric capacity borosilicate container. The filtrate was made up to the mark with the de-ionized water.

All the digested samples were sub-sampled into pre-cleaned borosilicate glass containers for Atomic Absorption Spectrophotometer analysis.

3.4.1 Iron, Calcium, Potassium, Sodium and Zinc

The methods of James (1995) and A.O.A.C (2010) were used for the determinations. Standards of iron, Calcium, Potassium, Sodium and Zinc solutions of 0.2, 0.4, 0.6, 0.8 and 1.0mg/l were made from each of the heavy metals solution of 1000mg/l stock solutions of the analytes. The set of standard solutions and the filtrate of the digested samples were analyzed by AAS. The detection limit of the metals in the sample was 0.0001mg/l by means of the UNICAM 929 London, Atomic Absorption Spectrophotometer powered by the SOLAAR software. Iron, Calcium, Potassium, Sodium and Zinc cathode lamps were used for the analysis of the respective mineral ions in the standards and the filtrate of the samples. Gas mixtures of compressed air and acetylene were used in the generation of the flame. The calibration curve is shown in the appendix for each of the metal analysis. Equation and the correlation coefficient are also included in the calibration curve.

3.4.2 Phosphorus

Phosphorus was determined routinely by the vanado-molybdate spectrophotometric method of Association of Official Analytical Chemist A.O.A.C (2010). The ash of each sample obtained was treated with 2M HCl solution. A 10ml portion of the filtrate solution was pipetted into 50ml standard flask and 10ml of vanadate yellow solution was added and the flask was made up to mark with distilled water, stoppered and left for 10 minutes for full yellow development. The concentration of phosphorus was obtained by taking the optical density (OD) or absorbance of the solution on a spectrophotometer at a wavelength of 470nm.

3.5 Fatty Acid Methyl Ester Analysis

The Fatty acid profile analysis was carried out by Gas Chromatography (GC) instrument (Perkin Elmer, Model –Auto System XL) according to the method suggested by Petrovic et al. (2010). Fifty (50) mg of the extracted fat content of the

sample was saponified (esterified) for five (5) minutes at 95°c with 3.4 ml of the 0.5 M KOH in dry methanol. The mixture was neutralized by using 0.7M HCL. 3ml of the 14% boron triflouride in methanol was added. Then the mixture was heated for 5 minutes at the temperature of 90°C to achieve complete methylation process. The Fatty Acid Methyl Esters were thrice extracted from the mixture with redistilled n-hexane. The content was concentrated to 1ml for gas chromatography analysis and 1µl was injected into the injection port of the gas chromatogram. The gas chromatography conditions of the analysis are as attached in the appendix.

3.6 pH

pH measurements were performed using a table top pH meter as described by Nielsen (2003).The electrode of the pH meter was put inside the sample solution and the reading was read directly from the screen of the meter when the pointer becomes steady.

3.7 Titratable acidity

This determination was carried out in accordance with the method by Nielsen (2003). Titratable acidity was measured as % citric acid and determined by titrating the pulp with 0.1 N NaOH according to the standard procedure.

3.8 Statistical Analysis

All data were expressed as mean ± Standard deviation. The data was analysed by one way ANOVA with post hoc corrected two tailed t-tests using the IBM SPSS statistic software version 22 (SPSS: Statistical Package for Social Sciences). Differences at $P< 0.05$ were considered significant.

4. Results

4.1 Proximate composition

Result of moisture content of the pulp before drying for boiled var. edulis (59.32±0.01 %) was not significantly ($p>0.05$) different compared to raw var. edulis (58.31±0.02 %), though was significantly ($p<0.05$) different from roasted var. edulis (55.39±0.02 %). Moisture content (dry matter basis) analysis showed that boiled var. edulishad significantly ($p<0.05$) higher (23.50±0.20 %) moisture content than that of both the raw and roasted samples, though there was no significant difference in the raw, roasted and boiled var. parvicarpa.

Raw var. edulis and var. parvicarpa had a significantly ($p<0.05$) high protein values of 5.45±0.28 % and 5.50±0.02 % respectively, compared to the processed samples. Crudefat content for raw var. edulis and var. parvicarpa was significantly ($p<0.05$) higher (35.93±0.24 %; 35.21±0.04 %) compared to the processed samples.

Dietary fiber for roasted var. edulis and var. parvicarpa was significantly ($p<0.05$) higher (7.51±0.03 %; 7.20±0.02 %) compared to raw and boiled samples of both species. The crude ash content in roasted var. edulis and var. parvicarpa was significantly ($p<0.05$) higher (4.85±0.02 %; 4.81±0.03 %) compared to other sa mples.

Also, carbohydrate content in roasted var. edulis and var. parvicarpa was significantly ($p<0.05$) higher (27.64±0.03 %; 27.20±0.02 %) compared to the raw sample (26.40±0.02 %; 27.00±0.02%) in both species respectively. Calorific values in roasted var. edulis and var. parvicarpa was significantly ($p<0.05$) higher (712.49±0.01 kcal/100g; 712.49±0.01 kcal/100g) compared to the raw samples (680.46±0.12 kcal/100g; 685.60±0.02 kcal/100g) of both species respectively. Proximate parameters analysed in this study were significantly ($p<0.05$) higher in var. edulis samples when compared with that of var. parvicarpa, except in the case of dried weight moisture and crude protein where there was no significant ($p>0.05$) difference between the two species (Table 1).

4.2 Anti-nutrient composition

Anti-nutrient results showed that phytate, oxalate and hydrogen cyanide concentrations in roasted var. edulis and var. parvicarpa was significantly ($p<0.05$) higher (15.85±0.01ppm, 86.94±0.02ppm and 0.09±0.00ppm)compared to the raw sample (8.47±0.02ppm, 39.47±0.01ppm and 0.07±0.02ppm) of both species respectively. Anti-nutrients were significantly ($p<0.05$) higher in var. parvicarpa samples when compared with that of var. edulis(Table 2).

4.3 Vitamins composition

Table 3 presented the vitamin composition of raw, roasted and boiled var. edulis and var. parvicarpa samples. Both fat and water soluble vitamins were detected in all samples, except in the case of vitamins B_4, B_6 and B_9, D and K, which were either not detected in all samples, or detected in some samples. These vitamins were all detected in trace amount, except in the case of vitamin C which was found in considerable amount. All the vitamins were significantly ($p<0.05$) higher in var. edulis samples when compared with that of var. parvicarpa, with raw sample in each case recording the highest value, when compared with the processed samples.

4.4 Mineral element composition

Table 4 presented the mineral composition of raw, roasted and boiled var. edulis and var. parvicarpa samples. Boiled var. edulis and var. parvicarpa recorded a significantly ($p<0.05$) high sodium content of 282.60±0.09 ppm and 285.34±0.02 ppm respectively; raw var. edulis and var. parvicarpa recorded a significantly

($p<0.05$) high zinc content of 52.17±0.03 ppm and 50.44±0.04 ppm respectively, while roasted var. edulis and var. parvicarpa recorded a significantly ($p<0.05$) high calcium, potassium, iron and phosphorus contents, when compared with other samples of both Dacryodes edulis varieties.

4.5 Fatty acid methyl ester analysis

Results on the fatty acid methyl ester analysis are presented on Table 5. The two varieties of the raw and processed African pear oil were composed mainly of oleic acid, linoleic acid, palmitic acid and stearic acid. Results for oleic acid was the highest and ranged between 43.59% - 38.98 % in all the samples, while stearic acid was the least (13.27% - 11.95%.) fatty acid analysed. The raw var. edulis pear oil was composed of 33.36% saturated fat and 66.64% unsaturated fat while raw var. parvicarpa pear contained 35.33% saturated fat and 64.67% unsaturated fat.

4.6 Acidic composition of the two varieties of D edulis

The results for the pH values done within 24 hours was significantly ($p<0.05$) higher (4.71±0.06 and 4.64±0.12) in roasted var.edulis and var. parvicarpa, when compare with other samples. The var. parvicarpa pear had a significantly ($p<0.05$) high acidic content compared to the var. edulis samples. The pH done after 7 days was significantly ($p<0.05$) higher (5.85±0.06) in roasted var. edulis, compared to other samples, thoughshowed no significant differences with var. parvicarpa. There was no significant difference in the values obtained for the titratable acidity of unprocessed and processed var. parvicarpa and var. edulis pear. The results of the titratable acidity generally ranged from 0.09±0.02% - 0.12±0.02% (Table 6).

Table 1 Proximate composition of the two varieties of D. edulis

	Moisture (wet weight)		**Moisture (dry weight)**		**Protein**		**Lipid**	
	D.e.e	D.e.p	D.e.e	D.e.p	D.e.e	D.e.p	D.e.e	D.e.p
Raw	58.31±0.02*[a]	54.07±0.01*[a]	22.50±0.20	22.63±0.21	5.45±0.28*	5.50±0.02	35.93±0.24*[a]	35.21±0.04*[a]
Roasted	55.39±0.02*[a]	51.71±0.06*[a]	22.20±0.20*	22.30±0.36	4.60±0.20*	4.87±0.31	33.22±0.04*	33.40±0.35*
Boiled	59.32±0.01*[a]	55.05±0.05*[a]	23.50±0.20*	23.10±0.20	4.35±0.02	4.40±0.02*	34.00±0.02*[a]	34.50±0.02*[a]

	Dietary fiber		Ash		Carbohydrate		Caloric values (kcal/100g)	
	D.e.e	**D.e.p**	**D.e.e**	**D.e.p**	**D.e.e**	**D.e.p**	**D.e.e**	**D.e.p**
Raw	6.30±0.17 *	6.32±0.04 *	4.81±0.17 *a	4.74±0.24 *a	26.40±0.02 *a	27.00±0.02 *a	680.46±0.12 *a	685.60±0.02 *a
Roasted	7.51±0.03 *a	7.20±0.02 *a	4.85±0.02 *	4.81±0.03 *	27.64±0.03 *a	27.20±0.02 *a	712.49±0.01 *a	710.20±0.04 *a

Boiled	6.50±0.02 a	6.81±0.05 *a	4.40±0.02 *a	4.10±0.02 *a	27.25±0.02 *a	27.1±0.02* a	702.40±0.02 *a	695.20±0.04 *a

Values are expressed as Mean ±Standard deviation of triplicate determinations

* Significant (down the column) at $p<0.05$

[a] variety edulis vs variety parvicarpa Significance at $p < 0.05$; D.e.e = D.e.var. edulis; D.e.p = D.e.var. parvicarpa

Table 2Anti-nutrient composition of the two varieties of D. edulis(ppm)

	Phytate (ppm)		**Oxalate (ppm)**		**Hydrogen cyanide (ppm)**	
	D.e.e	D.e.p	D.e.e	D.e.p	D.e.e	D.e.p
Raw	8.37±0.02*[a]	8.47±0.03[a]	36.79±0.01*	39.47±0.01*	0.05±0.01*	0.07±0.02
Roasted	15.85±0.01*[a]	17.25±0.01[a]	86.94±0.02*	94.85±0.01*	0.09±0.00*	0.11±0.01*
Boiled	10.35±0.03*[a]	11.47±0.01[a]	46.06±0.01*	54.39±0.01*	0.07±0.01	0.08±0.02

Values are expressed as Mean ± Standard deviation of triplicate determinations

* Significant (down the column) at $p < 0.05$

[a] variety edulisvs variety parvicarpa Significance at $p < 0.05$; D.e.e = D.e.var. edulis; D.e.p = D.e.var. parvicarpa

Table 3 Vitamin composition of the two varieties of D. edulis (mg/100g)

NAME	**AMOUNT mg/100g**					
	D.e.e raw	D.e.e Roasted	D.e.e Boiled	D.e.p raw	D.e.p roasted	D.e.p boiled
Vitamin A	0.02	0.01	0.01	0.02	0.01	0.01
Vitamin B1	0.70	0.30	0.66	0.67	0.28	0.59
Vitamin B2	0.72	0.25	0.69	0.70	0.24	0.60
Vitamin B3	0.43	0.32	0.40	0.41	0.32	0.34
Vitamin B4	-	-	-	-	-	-
Vitamin B5	0.18	0.16	0.18	0.18	0.15	0.18
Vitamin B6	0.01	-	0.01	0.01	-	-
Vitamin	-	-	-	-	-	-

B9						
Vitamin C	6.32	5.83	6.04	6.17	5.40	5.64
Vitamin D	-	-	-	-	-	-
Vitamin E	0.40	0.33	0.38	0.38	0.32	0.33
Vitamin K	0.01	-	-	0.01	-	-

D.e.e = D.e.var. edulis

D.e.p = D.e.var. parvicarpa

TABLE 4 Elemental Composition of the two varieties of D edulis (ppm)

	Sodium		**Calcium**		**Potassium**	
	D.e.e	D.e.p	D.e.e	D.e.p	D.e.e	D.e.p
Raw	274.26±0.03*[a]	269.84±0.03*[a]	2888.22±0.09*[a]	2816.86±0.03*[a]	6630.31±0.12*[a]	6360.58±0.05*[a]
Roasted	212.55±0.04*[a]	203.18±0.03*[a]	3404.69±0.11*[a]	3193.49±0.09*[a]	7322.34±0.10*[a]	7218.40±0.09*[a]
Boiled	282.60±0.09*[a]	285.34±0.02*[a]	2929.85±0.11*[a]	2868.45±0.10*[a]	6754.35±0.10*[a]	6568.34±0.12*[a]

	Zinc	**Iron**	**Phosphorus**

	D.e.e	D.e.p	D.e.e	D.e.e	D.e.e	D.e.p
Raw	52.17±0.03 *a	50.44±0.04 *a	17.16±0.01 *a	16.96±0.01 *a	3825.56±0.06 *a	3794.74±0.07 *a
Roasted	48.89±0.03 *a	46.50±0.02 *a	18.79±0.01 *a	17.89±0.02 *a	4328.42±0.04 *a	4218.30±0.03 *a
Boiled	49.48±0.02 *a	48.58±0.01 *a	17.31±0.02 *a	16.98±0.02[a]	3942.24±0.05 *a	3811.51±0.07 *a

Values are expressed as Mean ±Standard deviation of triplicate determinations

* Significant (down the column) at $p<0.05$

[a] variety edulisvs variety parvicarpaSignificance at $p<0.05$; D.e.e = D.e.var. edulis; D.e.p = D.e.var. parvicarpa

Table 5 Fatty Acid methyl esters composition of the two varieties of D. edulis (%)

Name						
	D.e.e raw	**D.e.e roasted**	**D.e.e boiled**	**D.e.p raw**	**D.e.p roasted**	**D.e.p boiled**
Caprylic Acid (C8:0)	-	-	-	0.01	0.01	-
Capric Acid (C10:0)	-	-	-	-	-	-
Lauric Acid (C12:0)	0.06	0.09	0.10	0.09	0.16	0.8
Myristic Acid (C14:0)	0.45	0.57	0.66	0.56	0.99	0.51
Palmitic Acid (C16:0)	17.45	14.10	15.01	18.81	14.68	17.19
Palmitoleic Acid (C16:1)	0.43	0.58	0.64	0.53	1.02	0.49
Margaric Acid (C17:0)	0.25	0.33	0.36	0.30	0.58	0.28
Stearic Acid (C18:0)	13.03	11.95	13.27	12.83	12.49	12.78
Oleic Acid (C18:1)	40.67	43.59	40.52	38.98	40.36	40.27
Linoleic Acid (C18:2)	24.40	25.50	24.68	23.77	23.50	24.50
Linolenic Acid (C18:3)	0.53	0.71	0.78	0.65	1.24	0.59
Arachidic Acid (C20:0)	1.63	1.13	2.30	2.13	2.39	2.07
Arachidonic Acid (C20:4)	0.15	0.20	0.22	0.18	0.35	0.17
Behenic Acid (C22:0)	0.11	0.15	0.17	0.14	0.26	0.13
Erucic Acid (C22:1)	0.45	0.61	0.66	0.56	1.06	0.50
Lignoceric Acid (C24:0)	0.38	0.52	0.57	0.46	0.38	0.90

D.e.e = D.e.var. edulis

D.e.p = D.e.var. parvicarpa

Table 6 pH and Titratable Acidity (%) composition of the two varieties of D. edulis

	pH within 24 hours		pH after 7 days		Titratable acidity (%)	
	D.e.e	**D.e.p**	**D.e.e**	**D.e.p**	**D.e.e**	**D.e.p**
Raw	5.27±0.15*[a]	5.11±0.09*[a]	6.21±0.01*	6.24±0.06	0.09±0.00	0.09±0.02
Roasted	4.71±0.06*[a]	4.64±0.12*[a]	5.85±0.06*	5.78±0.33	0.12±0.02	0.11±0.01
Boiled	4.97±0.06*	4.83±0.04*	6.10±0.02*	6.17±0.16	0.10±0.02	0.10±0.02

Values are expressed as Mean ±Standard deviation of triplicate determinations
* Significant (down the column) at $p<0.05$ [a]variety edulisvs variety parvicarpa
Significance at $p<0.05$; D.e.e = D.e.var. edulis; D.e.p = D.e.var. parvicarpa

5. Discussion

This study has revealed that Dacryodes edulis (D.e.var. edulis and D.e.var. parvicarpa), both raw and processed, contained an appreciable amount of nutrients. Proximate parameters analysed were significantly ($p<0.05$) higher in var. edulis samples when compared with that of var. parvicarpa. The moisture contents obtained in this study was higher in processed (boiled) samples and was in agreement with Korotimi et al. (2017) who reported that boiling increased the moisture content in food samples. This increase in moisture content may be attributed to the disruption of cell walls and membranes allowing water to fill spaces in the vegetables. The decrease in the moisture content of the pulp shortly after roasting of the samples agreed with the work done by Ndidi et al. (2014) and can be attributed to the loss of moisture by direct heat application of the roasting method. The roasted samples will thus favor longer shelf-life with less microbial attack.

The protein composition in both varieties was higher in the unprocessed samples, compared to the processed samples and agreed with the study of Olawepo et al. (2014), who reported a decrease crude protein in processed food samples. This may be because the proteins in the raw samples were degraded and then converted into soluble forms during boiling and this may have possibly led to low amount of proteins in the boiled African pear. An appreciable amount of protein in raw samples could indicate that both varieties of Dacryodes edulis

are important and nutritious food for fighting malnutrition, especially severe acute malnutrition in children.

The decrease crude fat contents in the processed samples is in line with the study of Reid et al. (2017) who stated decreased lipid content for processed plants. The decrease in the lipid content might be due to the breakdown of lipid into glycerol and fatty acids. Dietary fats help in the absorption of fat-soluble vitamins, and retention of flavors during cooking and contribute to increase palatability of the diet (Otegbayo et al., 2018). The dietary fats of both varieties of Dacryodes edulis contributed to a caloric value higher than that reported by Otegbayo et al. (2018) on dietary fats contribution of 1%-2% caloric value of food which is sufficient for the diet. The dietary fiber of food reduces the threat of colon cancer and cardiovascular diseases and protects the beneficial microflora of the intestine (Otegbayo et al., 2018). The high fiber in the diet improves the digestion and absorption process of the large intestine, which helps to prevent constipation (Cyril et al., 2022). The decrease fiber content in the unprocessed samples might be due to the non-disruption of the cell wall of the fruit and this finding is in agreement with the work of Abdulrasheed-Adeleke et al.(2021).

The ash content of the Dacryodes edulis determines the presence of important dietary minerals and is useful for the development of the body. Tsado et al. (2015) also reported a decrease in ash content of processed plant samples and the reduction may be a result of minerals leaching out of the leaves during processing. Also, the increased carbohydrate content of Dacryodes edulis fruit pulp as observed in this study is consistent with Etsuyankpa et al. (2019) who recorded higher carbohydrate content for the fruit samples. The increase carbohydrate content in the roasted sample maybe attributed it to a decrease in moisture content, which led to the high concentration of the nutrients.Also, Agiang et al. (2010) reported that processing generally unlocks the carbohydrates in food by converting it into more accessible forms. The high caloric value may be attributed to the high fat and carbohydrate content.

The study revealed thatboth varieties of Dacryodes edulis contains significant levels of anti-nutrients such as oxalate, phytate, and a trace amount of hydrogen cyanide (HCN) which increased by the processing methods used and this was in support of the study of Nwaogu and Oluwamukomi, (2024), who reported increase in bioactive compounds of African pear (Dacryodes edulis) pulp treated with heat. Roasting was found to increase all the chemical anti-nutrients quantified more than boiling and unprocessed. This may be a result of Maillard reaction yielding new desirable products such as flavour and colour. Heating of food has been reported to cause changes in the flavour and colour of food to a great extent due to Maillard reaction (MR) (Liu et al., 2022). Also, processing cause food to lose water and concentrate the level of oxalate since oxalates are heat stable salts. The values for all the anti-nutrient obtained in this study are generally low such that none of them is above the lethal dosage approved by standard bodies like National Agency for Food and Drugs

Administration and Control (NAFDAC) in Nigeria (2002). This also indicates that the samples will not contribute to cyanide toxicity if consumed in a large quantity. Only plants with more than 200 mg of hydrocyanic acid equivalent per 100g fresh weight are considered dangerous(Oboh et al., 2015).

Dietary minerals are very important in human nutrition; the mineral analysis revealed the existence of significant amounts of quite a lot of minerals and the level of most of the minerals were higher in edulis variety than in parvicarpa and this isrelated to the findings of Kadji et al. (2006). Roasting generally increased the concentration of most macro and micro elements of the african pear and this maybe due to the high crude ash content in the roasted samples obtained in this study (Table 1). The considerable concentration of iron in this study implies that, these samples will serve as blood building foods and should be desired for human and animal feed formulations. The intake of phosphorus helps in bone growth, proper kidney function and cell growth. It also plays a role in maintaining the body's acid-alkaline balance. The dietary allowance for phosphorus is 800 mg/100g (Etsuyankpa et al., 2019). Therefore, this sample may not be good source to be solely relied on for this element. Zinc plays a role in gene expression, regulation of cellular growth and participates as a co-factor in enzymes responsible for carbohydrate, protein and nucleic acid metabolism (Adeboye et al., 2007). Potassium plays an important role in the human body and sufficient amounts of it in the diet protect against heart disease, hypoglycaemia, diabetes, obesity and kidney dysfunction; regular intakes of potassium lower blood pressure (Etsuyankpa et al.,2019). Calcium is an essential mineral for bone development. The calcium content of both varieties of African pear pulp obtained was within the 210 - 1200 mg/day21 recommended daily allowance for calcium, hence, these samples could be classified as good sources of calcium.

Our findings further revealed that var. edulis generally contained higher amounts of vitamins than var. parvicarpa. The highest vitamin content of the African pear in both var. edulis pear and the var. parvicarpa pear was Vitamin C (ascorbic acid). Vitamins concentration were higher in the raw (unprocessed) samples, compared to the processed samples and this was in support of the study of Nwaogu and Oluwamukomi, (2024), who reported decrease vitamin content of African pear (Dacryodes edulis) pulp treated with heat. Loss of vitamins during cooking has been reported to be majorly influenced by cooking temperature and time and this might have occurred due to leaching into the water during boiling. The higher roasting time and temperature involved in this study, must have contributed to the greater loss of these vitamins in the roasted pear than in the boiled pear. According to Hou et al. (2018), Vitamins (mostly vitamin C) losses occur mainly by chemical breakdown involving the oxidation of ascorbic acid to dehydroascorbic acid, followed by breakdown to 2, 3-diketogulonic acid and undergoes further changes to form other less bioactive products. Past study has shown that the oxidation pathway of ascorbic acid could be accelerated during

thermal treatment, thus reducing the vitamin C content of heat-treated fruits and vegetables (Hou et al., 2018). All B-vitamins are very sensitive to heat and this might have been the reason for their decrease concentrations in processed samples.

The principal fatty acids revealed in this study were two unsaturated fatty acids, oleic acid (C18:1) and linoleic acid (C18:2) while the two saturated fatty acids were palmitic acid (C16:0) and stearic acid (C18:0). These findings were the same with those reported by Igile et al. (2020) who reported a considerable amount of saturated and unsaturated fatty acids in D. edulis.These fatty acids were high in var. edulis, compared to the var. parvicarpa samples. Both varieties of D. edulis contain a higher percentage of unsaturated fatty acids than saturated fatty acid. Oleic acid was revealed to have the highest value in all the samples. Oleic acid is a monounsaturated omega-9 fatty acid that occurs widely and naturally in animal and vegetable oils. It is the most commonly found fatty acid in human cells which is why it is not considered an "essential fatty acid" like omega-3 and omega-6 oils. Oleic acid was reported to have enormous benefits to the heart, brain, mood, skin cells and waistline. It is an antioxidant which prevents oxidative stress leading to various health benefits including anticancer and anti-ulcer effects (El-Fakharany et al., 2018). This is of very significant importance nutritionally, as dietary fat rich in unsaturated fatty acids, especially, linoleic acid prevents conditions like coronary heart diseases and atherosclerosis (Igile et al., 2020). Processing did not have pronounced effects on the fatty acid composition of the African pear and this might be due to the high fats content of the processed samples recorded in this study (Table 1).

The acidity of the African pear as determined by the pH when determined within 24hours of harvesting showed that var. parvicarpa pear has a significantly ($p<0.05$) higher acidic content than the var. edulis pear. The results of this study are in support of the work Onuegbu et al. (2011). Processing increased titratable acidity level and is in line with the work of Nwosuagwuet al. (2009). Generally, the entire samples recorded low titratable acidity and this could play a great part in the acid: sugar balance and consequently, influence the taste and flavour of the fruit.

6. Conclusion

It can be concluded from this study on the effects of some traditional processing methods on the nutrient content of the two varieties of African pear (D. edulis)fruits: var. edulis and var. parvicarpa, that they were particularly rich in nutrients. However, the var. edulis is more nutritious and contains less anti-nutrients and acidity levels than the var. parvicarpaand the roasting method generally increased the concentration of macro and micro elements of the African pear while boiling and roasting decreased the vitamin contents.

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Conflict of interests: No conflict of interest

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