The chemical properties of African pear pulp at different stages of fruit development

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Lack of information on the properties of African pear has led to no processed products from it, as the fruit flesh is greatly appreciated by local people who eat it after boiling or roasting. The results showed that the development of the fruit differed significantly (p < 0.05) on all the chemical parameters evaluated from the fifth week after fruit set. The results at the (17th - 21 wks after fruit set), confirmed the fact of previous reports made at the time of harvest. This period showed the results as thus: fat content (32.62 - 35.05%); moisture (53.11 - 48.52%); crude protein (13.06 - 14.52%); crude fibre (13.19 - 14.50%); ash (2.48 - 2.85%); TTA (2.12 - 1.08%); pH (5.87 - 6.05%); total sugar (5.37 - 5.58%); TSS (4.66 - 4.88%); pectin (5.53 - 6.34%); total solid (46.89 - 51.48%); vitamin C (33.16 - 22.53 mg/100 g); total dietary fibre (2.71 - 3.22%); carbohydrate (38.64 - 32.97%) and energy value (500.43 - 505.43 kcal). It showed that high quantities of these constituents are present in the African pear pulp and could be incorporated in food products. This shows that African pear fruit which is a nutritious food could be harvested at this period for industrial and domestic uses.

Key words: African pear, pulp, chemical properties, fat, protein content, fruit development, energy value.

INTRODUCTION

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Dacryodes edulis (also called African plum, African pear or Safou) is an indigenous fruit tree in the humid low lands and plateau regions of West, Central African and Gulf of Guinea countries. In south-east Nigeria, the trees are grown around homesteads and flowering takes place from January to April. The major fruiting season is between May and October (Emebiri and Nwufo, 1990; Kengue and Nyagatchou, 1990).

Fruits are ellipsoidal and their size varies approximately from 4 - 9 cm long and from 2 - 5 cm wide (Omoti and Okiy, 1987). They could be an important source of pulp oil, seed oil and even whole fruit oil (Awono et al., 2002). The Safou oil should take their place in the food industry, the pharmaceutical and the cosmetics industry (soap, perfume, creams) as well as in other branches of industry where fat raw materials are needed. The cake remaining after the production of pulp oil may be useful in human food industry (bakery, baby foods). Information on the consumption and composition of Safou is far from complete. As the fruit becomes more popular and is increasingly commercialized, such information is indispensable for proper valorization of the fruit.

A major set back in the commercial utilization of African pear fruit is the lack of adequate and consistent data. Most of the published data collected on the physical and chemical properties of the fruit, are at variant from each other. Also, lack of information on the properties of the fruit has led to no processed products from the fruit. Efforts made so far to optimize the economic and to a lesser extent the nutritional value of the fruit have emphasized its oil content (quality and extraction methods) and have largely ignored how other components, especially the proteins could also be utilized to supplement the nutritional needs of the consumer. Most studies aimed at enriching bakery products have made use of legumes as their major protein source. Yet other plant food sources rich in proteins could be used for this purpose. Also, because of the high perishability of the African pear fruit, high percentages of fruit losses are incurred annually.

Therefore, the objective of this study is to: Determine the developmental effects on the chemical properties of
the African pear pulp.

MATERIALS AND METHODS

The three different Trees 1, 2, 3 had their ages ranged from 7, 10 and 12 years with the experience of first, second and third fruiting respectively in Umuahia-Abia state, Nigeria.

Sample collection and preparation

Forty five (45) fruits were collected randomly from the fruit tree at bi-weekly intervals starting from the fifth week after fruit set until senescence. The collected fruits were cleaned with a moist soft cotton-wool then a knife was used to cut through the fruits, to carefully separate the seed. Then part of the separated pulp was immediately used for the moisture analysis while the remaining part was dried at 65°C for 4 h in an oven, crushed with a laboratory hammer mill and kept in a well labeled air tight polythene bags for subsequent chemical analysis.

Sample analysis

The moisture content, total solids, ash, crude fibre, fat and protein content calculated as Nx 6.25 and carbohydrate by difference (AOAC, 1990), while the total soluble solids and total dietary fibre content by AOAC (1976, 1995) respectively.

Total titratable acidity (TTA): This determination was carried out in accordance with the method by Nielsen (2003). One gram of the crushed sample was dissolved after shaking thoroughly in 50 ml distilled water in a conical flask and 5 ml of the sample with 2 drops of phenolphthalein indicator were added to a 100 ml conical flask. The mixture was titrated against 0.1N solution of sodium hydroxide. The end-point was reached when a change of colour was observed after a drop of the sodium hydroxide.

Calculation;

\[
\%\text{TTA} = \frac{N \times V_1 \times 100}{V_2}
\]

Where; \( N \) = Normality of titrant (M Eq/ml), \( V_1 \) = Volume of titrant (ml), \( V_2 \) = Volume of Sample used.

\( pH \): The \( pH \) was measured directly using a \( pH \) meter (Jenway Model) as described by Nielsen (2003). 20 ml of the sample was put in a 50 ml glass beaker. 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.

\( \text{Pectin content} \): The procedure described by Onwuka (2005) was used. The two grams of the sample were heated in 95% alcohol for 10 min at 70°C to inactivate the pectin enzymes. The fruit material was ground using an electric blender and the ground material was placed in a beaker and covered with a solution of 2% sodium EDTA as well as adjusted the \( pH \) to 6.0 and heated the mixture at 95°C. The clear solution was filtered with a white cloth and the pectin precipitated from the solution using acidified alcohol. The precipitate was centrifuged and washed repeatedly using 70% alcohol. The pectin was dried in a hot air oven at 50°C for 4 h and then weighed.

Calculation;

\[
%\text{Pectin} = \frac{\text{weight of pectin} \times 100}{\text{weight of sample}}.
\]

\( \text{Vitamin C determination} \): The titrimetric method by Barakat et al. (1973) was used. Twenty grams of each processed sample was homogenized in 50 ml of 6% trichloro acetic acid EDTA extractant solution. The homogenate was centrifuged at 3000 rpm for 10 min and the supernatant was decanted and its volume needed (\( V_i \)). 20 ml of the extract was dispersed into a conical flask and 10 mls of 10% Potassium iodide and 1% starch were added as indicators.

After mixing well, the mixture was titrated against 0.01N CuSO\(_4\) solution. Titration was done to bluish end point. A reagent blank was carried out using 20mls of the extractant solution for titration. The vitamin C content was calculated as shown below,

\[
\text{Vit C mg/100 g sample} = \frac{100 \times V_i \times 0.88 \times T}{W}
\]

Where; \( W \) = weight of sample used, \( V_i \) = Total extract volume, \( V_a \) = Volume of extract titrated, \( T \) = Titre value less blank.

\( \text{Total sugar content} \): The spectrophotometric method using anthrone reagent as described by Ojiako and Akubugwo (1997) was used. One gram of the crushed sample was dispersed after thorough shaking in 50 ml distilled water in a conical flask and filtered through a Whatman No. 42 filter paper of which 1ml of the filtrate (test sample) was measured into a separate tube. 6 ml of anthrone reagent was run into the tube with the aid of a burette under an ice blocks. The tubes were later transferred into boiling water in a water bath and allowed to boil for 10 min ensuring that the tubes were covered with aluminum foil or stopper to prevent evaporation. The absorbance of the solution was read at 620 nm against a reagent blank. The sugar content of the samples was later determined by extrapolating using the standard curve obtained by standard glucose solution.

The caloric value was obtained by multiplying the values of crude protein, fat and carbohydrate by at water factors of 4, 9 and 4 respectively (Omoti and Okiy, 1987). Also, the colour changes of the fruit were observed by visual evaluation. Different codes were allocated to the fruits based on their colours. The highest code being six (bluish-black) and the lowest one for pink.

Statistical analysis

The mean, standard deviation, Analysis of variance (ANOVA) of the data obtained from the study and separation of means using least significant difference test (LSD) were computed using statistical package for social sciences (SPSS) version 13. Significant difference was judged at p<0.05. The observed colour changes during the fruit development were ascribed codes and represented graphically.

RESULTS AND DISCUSSIONS

Changes observed on the chemical compositions of African pear during development and ripening

The fat content within the (7th - 13th week) had slight variation but increased rapidly afterwards (Table 1). This suggests a slow formation of the chemical constituents during the fruit development (Bezard et al., 1991). An increase in the fat content from (26.73 - 35.05%) showed maturity attribute. The values of the fat content (32.62 -
Table 1. Developmental effect on the chemical properties of African pear pulp.

<table>
<thead>
<tr>
<th>Development Stage (week)</th>
<th>CHO (%)</th>
<th>Fat (%)</th>
<th>Moisture content (%Wm)</th>
<th>Crude fiber (%)</th>
<th>Crude protein (%)</th>
<th>Ash (%)</th>
<th>Vit c (mg/100g)</th>
<th>Total sugar (%)</th>
<th>Pectin (%)</th>
<th>Total soluble solids (%)</th>
<th>pH</th>
<th>TTA (%)</th>
<th>Total Solids (%)</th>
<th>Total dietary fiber (%)</th>
<th>Caloric value (Kcal/100g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Week 5</td>
<td>51.61(^a) ± 1.64</td>
<td>26.73(^h) ± 0.80</td>
<td>66.73(^a) ± 1.37</td>
<td>10.64(^d) ± 0.67</td>
<td>9.69(^i) ± 0.47</td>
<td>1.47(^n) ± 0.14</td>
<td>30.86(^e) ± 0.70</td>
<td>3.32(^k) ± 0.12</td>
<td>2.45(^g) ± 0.18</td>
<td>3.92(^j) ± 0.13</td>
<td>3.29(^a)</td>
<td>33.25(^i)</td>
<td>-</td>
<td>485.76(^d) ± 6.60</td>
<td></td>
</tr>
<tr>
<td>Week 7</td>
<td>46.95(^b) ± 1.22</td>
<td>28.22(^g) ± 0.55</td>
<td>64.70(^b) ± 1.23</td>
<td>11.88(^a) ± 0.70</td>
<td>11.22(^a) ± 0.84</td>
<td>1.71(^g) ± 0.12</td>
<td>34.26(^d) ± 0.87</td>
<td>3.66(^d) ± 0.12</td>
<td>0.68(^g) ± 0.08</td>
<td>4.20(^b) ± 0.13</td>
<td>3.11(^b)</td>
<td>35.30(^h)</td>
<td>-</td>
<td>486.40(^d) ± 2.98</td>
<td></td>
</tr>
<tr>
<td>Week 9</td>
<td>44.68(^c) ± 1.28</td>
<td>28.95(^g) ± 1.00</td>
<td>63.32(^c) ± 0.89</td>
<td>12.14(^a) ± 0.64</td>
<td>12.26(^d) ± 0.62</td>
<td>1.96(^g) ± 0.10</td>
<td>35.13(^d) ± 0.57</td>
<td>3.78(^i) ± 0.09</td>
<td>1.07(^g) ± 0.09</td>
<td>36.87(^d)</td>
<td>36.87(^d)</td>
<td>-</td>
<td>488.34(^c) ± 4.94</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Week 11</td>
<td>43.37(^d) ± 1.24</td>
<td>29.60(^e) ± 0.80</td>
<td>60.25(^d) ± 1.06</td>
<td>12.70(^d) ± 0.68</td>
<td>12.09(^d) ± 0.68</td>
<td>2.24(^g) ± 0.12</td>
<td>38.47(^b) ± 1.80</td>
<td>3.78(^i) ± 0.18</td>
<td>0.99(^j) ± 0.09</td>
<td>39.13(^d)</td>
<td>39.13(^d)</td>
<td>-</td>
<td>488.24(^d) ± 3.59</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Week 13</td>
<td>42.92(^d) ± 1.69</td>
<td>29.79(^g) ± 1.14</td>
<td>58.83(^e) ± 0.90</td>
<td>12.80(^d) ± 0.67</td>
<td>12.13(^cd) ± 0.11</td>
<td>2.35(^i) ± 0.20</td>
<td>39.50(^b) ± 0.17</td>
<td>5.01(^e) ± 0.14</td>
<td>0.99(^j) ± 0.06</td>
<td>39.50(^b)</td>
<td>39.50(^b)</td>
<td>-</td>
<td>488.35(^d) ± 6.14</td>
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<tr>
<td>Week 15</td>
<td>41.26(^e) ± 1.96</td>
<td>30.74(^d) ± 1.60</td>
<td>55.77(^e) ± 0.82</td>
<td>13.00(^d) ± 0.48</td>
<td>12.64(^e) ± 0.11</td>
<td>2.39(^i) ± 0.21</td>
<td>41.80(^b) ± 0.11</td>
<td>5.21(^d) ± 0.13</td>
<td>0.99(^j) ± 0.09</td>
<td>34.13(^d)</td>
<td>34.13(^d)</td>
<td>-</td>
<td>492.12(^d) ± 7.73</td>
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<tr>
<td>Week 17</td>
<td>38.64(^f) ± 0.97</td>
<td>32.62(^e) ± 0.83</td>
<td>53.11(^g) ± 1.30</td>
<td>13.19(^f) ± 0.31</td>
<td>13.06(^f) ± 0.27</td>
<td>2.48(^g) ± 0.10</td>
<td>33.16(^c) ± 0.28</td>
<td>5.37(^i) ± 0.11</td>
<td>0.99(^j) ± 0.09</td>
<td>39.50(^b)</td>
<td>39.50(^b)</td>
<td>-</td>
<td>500.43(^b) ± 6.65</td>
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<tr>
<td>Week 19</td>
<td>36.77(^g) ± 1.31</td>
<td>33.54(^c) ± 1.13</td>
<td>50.73(^h) ± 1.79</td>
<td>13.65(^b) ± 0.42</td>
<td>13.32(^a) ± 0.36</td>
<td>2.72(^g) ± 0.10</td>
<td>26.57(^d) ± 1.99</td>
<td>5.49(^c) ± 0.10</td>
<td>4.92(^b) ± 0.10</td>
<td>4.75(^b) ± 0.10</td>
<td>0.99(^j) ± 0.09</td>
<td>39.50(^b)</td>
<td>502.20(^b) ± 6.19</td>
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<tr>
<td>Week 21</td>
<td>32.97(^h) ± 2.26</td>
<td>48.52(^l) ± 1.82</td>
<td>45.50(^e) ± 1.39</td>
<td>28.22(^c) ± 0.47</td>
<td>14.52(^a) ± 0.77</td>
<td>2.85(^g) ± 0.08</td>
<td>22.53(^a) ± 0.07</td>
<td>5.58(^c) ± 0.07</td>
<td>6.34(^a) ± 0.05</td>
<td>6.05(^a) ± 0.05</td>
<td>51.48(^b) ± 6.05</td>
<td>505.43(^a) ± 8.57</td>
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<tr>
<td>LSD</td>
<td>1.017(^a) ± 0.777</td>
<td>0.797(^a) ± 0.356</td>
<td>0.402(^a) ± 0.067</td>
<td>1.989(^a) ± 0.077</td>
<td>0.343(^a) ± 0.064</td>
<td>0.165(^a) ± 0.112</td>
<td>0.817(^a) ± 0.440</td>
<td>3.900(^a) ± 0.077</td>
<td>0.165(^a) ± 0.112</td>
<td>0.817(^a) ± 0.440</td>
<td>3.900(^a) ± 0.077</td>
<td>0.165(^a) ± 0.112</td>
<td>0.817(^a) ± 0.440</td>
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abc* Means with similar superscripts in the same column are not significantly different (p > 0.05).

35.05%) at the (17th - 21st week) respectively, are similar to those reported at the time of harvest by several authors (Omoti and Okiy, 1987; Kiakouama and Silou, 1990 and Fonteh et al., 2005). This period was indicated by the period of significant external colour changes (bluish-black) as in Figure 1. This result supports the fact that African pear pulp is a relatively richer source of lipid than other conventional sources like soybean which contains between (17 - 20%); oil palm (20 - 22%) and cotton seed (28 - 32%) and as well could replace some in culinary uses (Mbofung et al., 2002).

The moisture content on wet weight basis decreased from (66.73 - 48.52%) as the fruits approached maturity (Table 1). The decrease in the moisture content and the concomitant increase in the fat content demonstrated a close negative trend and showed that the constituents remained relatively constant for fruits widely differing in oil content (Bezard et al., 1991). The moisture content values (53.11 - 48.52%) at the (17th - 21st week) respectively were lower than the values (53.17 - 75.01%) reported at the time of harvest by other researchers on the wet weight basis (Mbofung et al., 2002; Fonteh et al., 2005; Kinkela et al., 2006). This period was indicated by the period of significant external colour changes (bluish-black) as in Figure 1.

The crude protein content (9.69-14.52%) significantly increased (p < 0.05). The crude protein within the (9th - 15th week) had slight variations (Table 1). This suggests the period of slow formation in the constituents as earlier reported by Bezard et al. (1991). The values of the crude protein (13.06 - 14.52%) at the (17th - 21st week)
respective, agreed with the results reported by other recent researchers at the time of harvest (Silou, 1996; Onuegbu, 2004; Anegebah et al., 2005; Kinkela et al., 2006). This period was indicated by the period of significant external colour changes (bluish-black) as in Figure 1. In contrast, lower than the ranged values (24 - 60%) reported by the authors (Omoti and Oky, 1987; Ayuk et al., 1999; Mbofung et al., 2002). The variations in the present study and those reported by earlier studies could be attributed to the differences in the methods of analysis employed, genetic make-up and racial origin of the fruit (Biale and Young, 1971; Silou, 1996). This equally emphasized the rich source of the fruit in plant proteins with a high content of available lysine 27 - 39 mg/100 g protein (Mbofung et al., 2002).

The crude fibre content significantly increased (p < 0.05) with development but had a slight variation within the (7th - 15th week) suggesting a period of slow formation in the constituents (Table 1). The values (13.19 - 14.50%) of the crude fibre at the (17th - 21st week) respectively

Figure 1. Colour changes observed during the fruit Development of African pear.
were lower than the value (17.9%) reported by Omoti and Okiy (1987). This period was indicated by the period of significant external colour changes (bluish-black) as in Figure 1. The state of development at the time of harvest and geographical growth location of the fruit could influence variation (Itoh et al., 1975). Ash content values ranged (1.47 - 2.85%) and significantly increased (p < 0.05) with development (Table 1.0). A slight variation occurred within the (13th - 15th week). The values (2.48 - 2.85%) at the (17th - 21st week) respectively, agreed with the ranged values (2.80 - 3.70%) as reported by the researchers (Mbofung et al., 2002 and Kinkela et al., 2006). This period was indicated by the period of significant external colour changes (bluish-black) as in figure1. In contrast, lower than the values (10.8, 4.6 and 3.88 - 4.67%) as reported by the authors respectively (Omoti and Okiy, 1987; Silou, 1994 and Fonteh et al., 2005). The racial origin of the fruits could influence the variation (Silou, 1996).

The TTA and pH demonstrated a close negative trend as the TTA dropped from (3.29 - 1.08%) while pH increased from (3.92 - 6.05%) with the maturation of the fruit (Table 1.0). This could suggest the fact that the reduction of acidity during ripening plays a great part in the acid: sugar balance and consequently, influence the taste and flavour of the fruit. Rao et al. (1972) attributed a decrease in TTA in Pineapple as a chemical indicator for fixing maturity.

The total soluble solids value (3.92 - 4.88%) increased with the approach of harvest maturity as well as the total sugar value (3.32 - 5.58%), indicating ripening as the fruit colour changed (Figure 1). The ranged values of the Total sugar (5.37 - 5.58%) at the (17th - 21st week) were lower than the 10% reported by Silou (1996). The increase could be attributed to the metabolism of the polysaccharides in the cell-wall accompanied with the significant external colour and taste changes (Biale, 1975). However, in fruits which contain starch, this is hydrolyzed and contributes to the increase in sugars as found in climacteric fruits (Biale and Young, 1962). Lakshminarayana (1975) also reported that fruits harvested at a physiologically mature stage showed higher quantities of sugars during ripening. This suggests that the total sugar and total soluble solids could be used as a chemical parameter to determine the harvest maturity of the fruit. The increase in the TSS of the fruit could have been greatly influenced by the soil and its fertility (Lakshminarayana, 1975).

pectin content ranged (2.45 - 6.34%) and significantly increased (p < 0.05) with development (Table 1.0). The increase suggests that towards physiological maturity, a slight build-up in the flesh due to swelling of the fruit (cell-enlargement) was encountered (Mizuno et al., 1975). He also attributed the increase in pectin as the decrease in the protoplast when the fruit ripens.

The total solids values from (33.25 - 51.48%) also increased with the fruit development (Table 1). Biale and Young (1962) attributed the increase to the synthesis and accumulation of other constituents with the decrease in the water content of the fruit towards maturity.

The total dietary fibre value (2.71 - 3.22%) at the (17th - 21st week) respectively, increased significantly (p < 0.05) with the fruit development (Table 1.0). This period was indicated by the period of significant external colour changes (bluish-black) as in figure1. The values are similar to the results obtained in other fruits like apples (3.2%); pear (3.2%); papaya (2.7%) and peach (3.9%) by Ramulu and Rao (2003). The soil condition and fruit type could influence the variation (Lassoudiere, 1969).

The energy value (485.76 - 505.43 kcal/100 g) significantly increased (p < 0.05) with development (Table 1). This could be attributed to the increase in the other components with maturity (Lakshminarayana, 1975). The energy value had a slight variation within the (5th - 15th week) showing a period of slow formation of other components as earlier reported.

The vitamin C content increased soon after the fruit set (5th week) and reached its peak value during the 15th week, then declined thereafter and remained more or less steady till harvest maturity (22.53mg/100g) as shown in Table 1. Askar et al. (1972) reported a decreased in vitamin C with ripening in some fruits. Lakshminarayana et al. (1970) reported that vitamin C content changes with growth and development in mango fruits. Achinewhu (1983) reported that African pear pulp has a high ascorbic acid content of 24.5 mg/100 g. The fruit flesh could be recognized as a nutritious food. The fruit type and the degree of fruit exposure to sun could influence variation (Askar et al., 1972).

The carbohydrate content significantly decreased (p < 0.05) with development (Table 1). The metabolism of the polysaccharides in the cell wall and the starch hydrolysis which contributes to the increase in the total sugars as occurred in climacteric fruits could have attributed to the decrease (Biale and Young, 1962). He also attributed the decrease to the over all changes in the quantity of cell wall material during ripening.

### Conclusion and Recommendation

The results at the (17th - 21st week after fruit set), confirmed the fact of previous reports made at the time of harvest. Preference towards any of the fruit varieties should be based on the intended function of such a fruit in the overall process. It showed that high quantities of these constituents are present in the African pear pulp and could be incorporated in food products. It could as well be regarded as the physiological mature stage of the fruits that would present the optimum values of the properties. Also, help the harvesters to reduce the collection of fruits that dropped naturally, which results to contamination, pest and disease attacks, over-ripe and under-ripe fruits. This shows that African pear fruit which is a nutritious food could be harvested at this period for indus-
trial and domestic uses. The selection and standardized vegetative propagation methods are the main prerequisites for a breakthrough in high productivity and should help to reduce variations on the chemical parameters.

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