Nutrient Contents of the Fresh Pulps and Dried Pulp Cakes of *Vitellaria paradoxa* of Gulu District, Uganda

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**Abstract:** *Vitellaria paradoxa* Gaertn, locally known as 'Yaa' in Acholi is a valuable edible indigenous wild fruit in Gulu District, northern Uganda. It is a multipurpose fruit tree and highly favoured by the inhabitants of this district. Its fruit pulps are eaten when fresh and/or made into cakes and dried. This study determined the nutrient compositions of the fresh pulps and dried pulp cakes of *V. paradoxa*. Laboratory analyses were undertaken to determine the micro and macro nutrients in the samples on fresh (FM) and dry matter (DM) basis following standard procedures and protocols. The potassium, sodium and calcium contents of the fresh pulps on FM basis were, respectively 38, 7.3 and 234 mg/100 g. The contents of zinc (1.00 mg/100 g), Iron (6.8 mg/100 g) and magnesium (82.01 mg/100 g) on FM basis were the highest in the dried pulp cakes compared to the contents in the fresh pulp cakes. The fresh pulps had higher moisture contents (70.50 g/100 g). Fibre (5.95 g/100 g) and Vitamin A (228.30 μg/100 g) contents. Phytates were absent in both fresh and dried pulp cakes on both FM and DM basis. The study revealed appreciable contents of nutrients in both the fresh pulps and dried pulp cakes that can be useful in supplementing nutrition deficiencies. Further studies are recommended to determine availability of the nutrients in the body when consumed.

**Key words:** Edible wild fruits, proximate, macro and micro nutrients compositions

**INTRODUCTION**

Poor dietary quality and inadequate intake of micronutrients are widespread problems (Steward et al., 2010). WHO (2009) reported vitamin A deficiency as a major nutritional concern in poor societies, especially in lower income countries. High mortality and disease burden resulting from nutrition-related factors enhances a compelling case for the urgent implementation of interventions to reduce their occurrence (Black et al., 2008). A more recent attention has been on the utilization of inexpensive and lesser known traditional useful plants as food for man and feeds for animals (Embaby and Mokhtar, 2011). Development of effective interventions to stop critical stunting in children from birth to 24 months is thus crucial (deOnis and Blossner, 2003).

Plants are the major components of human diets with many types and parts eaten (Hamilton and Hamilton, 2006) hence a good source of nutrients. Although undomesticated, indigenous edible wild fruit trees play many important roles in many rural areas (Mojereman and Tshwenyane, 2004). The edible wild fruit species are very common and easily accessible to most rural communities and very important for food and nutritional security. Like introduced fruits, edible wild fruits are important in an adequate diet and serve as food supplements and appetizers (Adepoju, 2009). In Gulu district the fruits of *V. paradoxa* in particular are available during the seasons when there is shortage of food and the communities are in a period of hard manual work such as opening new gardens and weeding which demands a lot of energy.

Besides the importance of these edible wild fruits (Adepoju, 2009), the long period of insurgency in Northern Uganda between 1986 and 2006 greatly interrupted fruit consumptions among the local communities of Gulu District. Malnutrition became rampant especially among the children because the community relied heavily on diets which consisted only of maize flour and beans supplied by humanitarian aids while in the internally displaced persons camps. Caufield et al. (2004) reported that 52.5% of all deaths in young children are attributable to inadequate nutrition. In 2005, the Ministry of Agriculture, Animal Industries and Fisheries (MAAIF) (2005) and Ministry of Health of Uganda noted over 40% of deaths among Ugandan children as being attributed in part to malnutrition. Musinguzi et al. (2007) observed that most foods eaten by the majority of Ugandans lack micro nutrients. Nalwoga et al. (2010) noted a number of cases of chronic childhood diseases in Uganda due to under nutrition. Since fruits are generally acceptable as good

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source of nutrients and supplements for food in a world faced with problem of food scarcity (Adepoju, 2009). Edible wild fruits can be one such solution to the problem of nutrient inadequacies if appropriately eaten. Oryema et al. (2013) documented a number of edible wild fruit species of Gulu District, of which only a few were reportedly most preferred for their fruits by the community. Therefore, in an effort to increasing consumptions of the fruits of some wild fruit species, these researchers planned and investigated the nutrient compositions of V. paradoxa fruit species of Gulu district. This was mainly to unearth the nutritive values of this plant species so as to promote their consumption and conservation. This study investigated the nutrient compositions of both the fresh and dried pulp cakes of V. paradoxa. The information obtained is to be used for awareness creation on the importance of the edible wild fruits to the community and to be used in the development of new products from V. paradoxa pulps.

MATERIALS AND METHODS
Gulu district is one of the districts of Uganda and is bordered by the districts of Lamwo to the northeast, Pader to the east, Nwoya to the southwest and Amuru to the west and northwest. It also shares a border with Southern Sudan. The district comprises of Omooro and Aswa Counties and has a total of 12 Sub counties and 294 villages (RIC-NET 2012-2013). Both the fresh pulps and dried cakes which were made from the fruit pulps of V. paradoxa were collected from Ngom-lac Village, Omej A Parish and Paicho Sub-County, Aswa County. The fresh fruits were collected, sorted and transported into a coolant to the laboratory and refrigerated at -4°C (Okullo et al., 2010). The edible parts of the refrigerated fruits were then manually separated from the kernel using a stainless steel knife, packed in a polythene bag and re-stored in the refrigerator. The dried pulp cakes on the other hand were brought already in their original dry state as made by the local community and also tied in a polythene bag then stored in the refrigerator. Composite and analytical portions were prepared from these samples, respectively. The nutrients compositions under investigation included: crude fats, crude fibre, moisture content, ash, carbohydrates, gross energy, phytates, crude proteins, vitamin C, Carotenoids, iron, zinc, manganese, copper, sodium, potassium, magnesium and calcium. The analyses were done in the laboratories of Food and Nutrition Department, Makerere University, Uganda and the Department of Human nutrition, Faculty of Life Science, University of Copenhagen, Denmark.

Moisture contents: The moisture content was determined according to a force draft-air oven method (AOAC, 1990).

Minerals and proteins analysis: Samples for minerals and proteins were digested under a Fume hood (Selecta Block Digest µ40, ISO 9001-2000 CERTIFIED Co).

Crude proteins: These were determined using the Micro-Kjeldahl method No. 960 (AOAC, 1990). The digested sample was distilled using an auto-distillation machine (2200 Kjeltec, Foss-Tecator, Sweden). The crude protein contents were then obtained by determining the organic nitrogen content of the sample using a factor of nitrogen by a constant multiple 6.25N (Amarteifio and Mosase, 2006; Nnamani et al., 2009; Effiong and Udo, 2010).

Minerals: All minerals were determined using Atomic Absorption Spectrophotometer (AAS).

Vitamin C contents: These were determined following the procedures outlined by Rodriguez-Amaya and Meiko Kimura (2004). The contents in the pulps were determined by titration with 2,6-dichlorophenol-indophenol solution (Adepoju, 2009).

Crude fat: Crude fat was analyzed using Swedish made Soxtec system HT-1043 extraction unit following the procedures by AOAC (1990).

Total carbohydrates: These were estimated using the method of Knowles and Watkins (1950) called the hot water extraction method.

Ash contents: These were determined by incineration of the samples in a muffle furnace (Ugese et al., 2010).

Crude fibre: This was determined by the procedures outlined by Kirk and Sawyer (1998) whereby the samples were extracted sequentially with concentrated sulphuric acid and sodium hydroxide.

Energy contents: This was determined using a bomb calorimeter (Miller and Payne, 1959).

Phytates: These were analyzed on a high-performance liquid chromatography systems and the details of the methods were described by Bohn et al. (2006).

Data analysis: Data were analyzed using STATA 12 (Stata Corp LP, College Station and Texa, USA). Analysis of Variance (ANOVA) was used in the determination of means and standard deviations. All results are presented in different Tables for proximate and minerals on dry (DM) and fresh matter (FM) basis, respectively.

RESULTS
Both the fresh and the dried pulps of V. paradoxa have relative amounts of both macro and micro nutrients in
varying concentrations. The fresh pulps have higher moisture contents compared to that of the dried pulp cakes. Both states of the pulps showed negative test for phytates. The nutrient compositions are shown in Table 1 to 4.

The fresh pulps have higher contents of potassium (126.60 mg/100 g) and calcium (329 mg/100 g) while the dry pulp is higher in iron, sodium and magnesium. The composition of Zn (0.40 g/100 g) on FM basis is less than 1.00 g/100 g in both the edible forms although the Fe content (6.8 g/100 g) is higher in the dried cakes (Table 2). The dried pulp cakes have higher K and Ca contents.

The fibres contents (13.30 g/100 g) and carbohydrates contents (27.50 g/100 g and 27.90 g/100 g) contents are similar in both the fresh and the dried pulps respectively (Table 3). The fresh pulps however on DM basis contain higher contents of vitamin A (740.80 μg/100 g) and vitamin C (83.20 mg/100 g) compared to the dried pulps.

The moisture contents (70.50 g/100 g), Crude fiber (5.95 g/100 g) and Vitamin A (228.3 μg/100 g) contents are higher in the fresh pulps on FM basis than in the dried pulp cake (Table 4). Crude fats, ash and proteins compositions are all lower than 2 g/100 g.

**DISCUSSION**

The K contents of the fresh pulps of *V. paradoxa* on DM basis (Table 1) is higher than the reported values by Okullo et al. (2010) for the districts of Lira (47.9±0.2 mg/100 g), Katakwi (52.0±0.3 mg/100 g), Pader (63.6±0.3 mg/100 g) and Arua (42.0±0.3 mg/100 g). The daily value (1.3%) for the fresh pulps on FM basis, is slightly higher than the daily value (0.35%) for the dried pulp (FAO/WHO, 2005; FNB, 2005). The K content of the fresh pulps on FM basis is similar to that of the pineapple (37 mg/100 g) (Nazarudeen, 2010) while its sodium content (Table 2) is lower than for pineapple (34.7 mg/100 g) (Nazarudeen, 2010), making it even more appropriate. The same content of K on FM basis constitutes only 0.3% DV calculations (FNB, 1997, 2000, 2001, 2004), a percentage similar to that of the dried pulp cakes (0.24%) of the 3800 mg/d total dietary energy based on 2000Kcal per day; for adults and children four or more years. The low ratio of K: Na concentrations in these pulps enhances their consumptions and roles in regulating high blood pressure (Alnimor and Akalezi, 2010) just like the introduced fruits.

The Mg content of the fresh pulps on DM basis (Table 1) is much higher compared to the reported values by Okullo et al. (2010) and Mbaiguinam et al. (2007). The Mg content on FM basis (Table 2) constitutes 5.6% DV compared to the 23.4% DV for the dried pulps cakes in reference to the Mg values calculated using the standard values by USDA (2008) for adults or children aged 4 or older based on the 2,000 Kcalories reference (USDA, 2008), making the dried pulps a better source of Mg than the fresh pulps. Ca contents in both the fresh pulps (Table 3) on DM basis and FM basis (Table 4) are higher compared to the contents reported for some districts in Northern Uganda (Okullo et al., 2010). Ca contents in the fresh pulps on FM basis (Table 2) are also higher than for the contents of the Dodo mango and Viringe mango (Othman, 2009). This same value constitutes 23.5% daily nutritional requirements higher than the 2.9% DV for the dried pulps for adults or children aged 4 or older based on a 2,000 Kcal reference per day (FAO/WHO, 2005). The fresh pulp is then a good source of calcium, Ca being very important for aiding the development of strong bones, improving nerve impulses and blood clotting and muscle contractions (Agatemor and Ukhun, 2006).

The iron content of the fresh pulps on DM basis (Table 1) is comparable to the values reported by Okullo et al. (2010) for northern Uganda districts and Mbaiguinam et al. (2007) from Southern Chad. On FM basis the Fe contents is similar to that of papaya (0.10 mg/100 g), banana (0.26 mg/100 g) and mango (0.13 mg/100 g) (Mahapatra and Panda, 2012), all values are less than 1.00 mg/100 g. This content accounts for only 0.6% DV compared to the daily values in the dried pulp cakes (USDA, 2008) needed for adults or children aged 4 or older based on a 2,000 Kcalories reference. Iron is an
Table 3: Proximate contents of the fresh and dried pulp cakes of V. paradoxa on dry matter (DM) basis

<table>
<thead>
<tr>
<th>Edible states</th>
<th>Dry matter (g/100 g)</th>
<th>Fibre (g/100 g)</th>
<th>Fat (g/100 g)</th>
<th>Ash content (g/100 g)</th>
<th>Proteins (g/100 g)</th>
<th>Carbohydrates (g/100 g)</th>
<th>Gross energy (Kcal/100 g)</th>
<th>Vitamin C (mg/100 g)</th>
<th>Phytates (mg/100 g)</th>
<th>Carotenoids (µg/100 g)</th>
<th>Vitamin A (µg/100 g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fresh pulp cake</td>
<td>29.50 (0.87)</td>
<td>13.30 (1.29)</td>
<td>3.30 (1.1)</td>
<td>5.10 (0.26)</td>
<td>6.61 (1.06)</td>
<td>27.50 (12.2)</td>
<td>399.40 (2.62)</td>
<td>83.30 (47)</td>
<td>0</td>
<td>8890 (0.45)</td>
<td>740.80</td>
</tr>
<tr>
<td>Dried pulp cake</td>
<td>68.30 (0.02)</td>
<td>12.20 (1.4)</td>
<td>1.80 (0.15)</td>
<td>2.70 (0.86)</td>
<td>4.84 (0.13)</td>
<td>27.90 (16.4)</td>
<td>391.60 (0.92)</td>
<td>72.20 (21.8)</td>
<td>740.80</td>
<td>2610 (0.22)</td>
<td>234.20</td>
</tr>
</tbody>
</table>

Values are expressed as mean (Std. Dev.) of triplicate measurements (n = 3) except for phytates (n = 2) in respective SI units. Carb.: Carbohydrates

Table 4: Proximate compositions of the fresh and dried pulp cakes of V. paradoxa on fresh matter (FM) basis

<table>
<thead>
<tr>
<th>Edible states</th>
<th>MC (Moisture content) g/100 (%)</th>
<th>Fibre g/100 (%)</th>
<th>Fat g/100 (%)</th>
<th>Ash g/100 (%)</th>
<th>Proteins g/100 (%)</th>
<th>Carbohydrates g/100 (%)</th>
<th>Energy Kcal</th>
<th>Vitamin C mg/100 g</th>
<th>Phytates mg/100 g</th>
<th>Carotenoids µg/100 g</th>
<th>Vitamin A µg/100 g</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fresh pulp cake</td>
<td>70.50 (0.37)</td>
<td>6.66 (0.14)</td>
<td>0.68 (0.35)</td>
<td>1.53 (0.08)</td>
<td>1.98 (0.32)</td>
<td>8.25 (3.70)</td>
<td>159.60 (0.76)</td>
<td>25.01 (14.1)</td>
<td>0</td>
<td>2740 (0.15)</td>
<td>228.3</td>
</tr>
<tr>
<td>Dried Pulp cake</td>
<td>13.70 (0.02)</td>
<td>1.77 (0.41)</td>
<td>1.33 (0.13)</td>
<td>2.33 (0.74)</td>
<td>3.96 (0.11)</td>
<td>23.96 (14.3)</td>
<td>333.86 (8.13)</td>
<td>61.57 (18.91)</td>
<td>0</td>
<td>2420 (0.17)</td>
<td>201.7</td>
</tr>
</tbody>
</table>

Values are expressed as mean (Std. Dev.) of triplicate measurements (n = 3) except for phytates (n = 2)
for adults and children four or more years of age per day compared to only 7.08% DV for the dried pulp cakes (FAO/WHO, 2005). These put the fresh pulps in a better position as a good source of fibre than its dried pulp and some introduced fruits.

The crude fat contents in the fresh pulps on DM basis (Table 3) is similar to the lipid contents reported for the Shea pulps from the districts of Pader (3.5 g/100 g) and Arua (2.5 g/100 g) by Okullo et al. (2010). Its content in these fresh pulps on FM basis (Table 4) is also similar to the contents of the papaya varieties reported by Nwofia et al. (2012). This very content constitutes 1.5% DV compared to 2.05% of the DV for the dried pulp cakes (FAO/WHO, 2005) for adults and children four or more years of age per day. These percentage daily values are comparable making both pulp states potential sources of crude fats that could contribute to the energy that is required for this farming community.

The crude protein contents of the fresh pulps on DM basis (Table 3) fall within the ranges of values reported by Maranz et al. (2004) and Mbaiguinam et al. (2007). On FM basis, its contents (Table 4) are higher than that of Ananass comosus (0.2 g/100 g), Mangifera indica (0.6 g/100 g) and Carica papaya (0.6 g/100 g) (Nazarudeen, 2010) and also for banana, orange, lemon (Mahapatra and Panda, 2012). Its values for the fresh pulps on FM basis constitutes 3.7% DV of the 50% crude proteins based on total dietary energy intake of 2000 kcal/day, for adults and children four or more years of age per day lower than the 7.9% DV for the dried pulp cakes (FAO/WHO, 2005). This adds value to the dried pulp cakes hence the need to encourage its preparation and storage for future use especially in times when the fresh fruits are out of seasons and or when there is food shortage.

The carbohydrate contents of the fresh pulps on DM basis (Table 3) are higher compared to the values reported for Shea Parkland area of Northern Uganda by Okullo et al. (2010). Its contents on FM basis (Table 4) are similar to the mean values of Shea pulps reported by Maranz et al. (2004) and the contents of banana, orange and lemon reported by Mahapatra and Panda (2012).

The Vitamin C contents in the fresh pulps on DM basis (Table 3) are much higher than the contents reported for all the districts of northern Uganda (Okullo et al., 2010; Mbaiguinam et al., 2007). Similar on FM basis, its contents (Table 4) are higher than the contents of banana (22.84 g/100 g), mango (17 g/100 g) and orange (11.54 g/100 g) as reported by Mahapatra et al. (2012). The same content on FM basis however constitutes only 2.8% DV of the 300 g/d carbohydrates based on the 2000Kcal/d, a value lower than 8% DV for the dried pulp cakes (FAO/WHO, 2005). Being a powerful antioxidant and important in reducing the risk of chronic diseases such as coronary heart disease, the pulps of V. paradoxa are potential source of Vitamin C.

The carotenoids/Vitamin A contents of the fresh pulps on both DM basis (Table 3) and FM basis (Table 4) are higher than the contents in the dried pulp cakes. The differences observed could be due to the effect of sunlight on carotenoids while the dried pulp cakes were being made. The importance of carotenoid has been over emphasized in many studies in treatment of sight problems among others.

The energy content of the fresh pulps on DM basis (Table 3) is higher than that of the dried cakes. On FM basis, the content of the dried pulps was much higher than that of the fresh pulps. This coresponds to the contents of the crude fat, Protein and carbohydrates of the dried pulps as reported in this study. This indicates that the dried pulps are in a better position to providing adequate energy when consumed therefore the need to preserve them for later usage when the community are busy with field work.

The absence of phytates in both the fresh and dried pulp cakes (Table 3 and 4) means enhanced availability of
the minerals in the fruits themselves, because phytate is one of the anti-nutrients which when available in foods can interfere with the availability of minerals. Phytates have also been implicated in decreasing protein digestibility by forming complexes and also by interacting with enzymes such as trypsin and pepsin (Reddy and Pierson, 1994) in Embaby and Mokhtar (2011).

**Conclusion:** Both the edible states of the pulps of *V. paradoxus* contain appreciable contents of the nutrients although with variable contents. The fresh pulps however have higher contents of most nutrients compared to the dried pulps. The daily value percentages of all the nutrients for both the fresh and dried pulps on both FM and DM basis are less than the RDA/RAI and the tolerable upper limits for all age groups and categories of persons hence making these pulps suitable for consumption by all categories of persons in the community.

**Recommendations:** There is need for sensitization of the community on the nutritive values of these edible parts so as to enhance consumptions of the fruits, sustainable utilization and conservation of the wild fruits. An alternative way of obtaining the kernel from the fruits ought to be sought so as to save the fresh pulps, which could be made into dried pulp cakes. There is also need to carryout nutritional study to assess the availability of these nutrients in the body after consumption. More members of the communities are encouraged to prepare the dry pulp cakes for use in periods of shortages other than leaving the fresh fruits to rot in the wild.

**Conflict of interest:** There is no conflict of interest in this paper. This manuscript is one of the objectives of my PhD studies.

**Authors contributions:** Christine Oryema is the candidate and main researcher, while, Prof. Hannington Oryem-Origa was the main supervisor for the research and Associate Prof. Nanna, Roos was a Co-supervisor.

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