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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 (92.01 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 (Mojeremane 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. Caulfield *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 Omoro 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, Omel A Parish and Paicho Sub-County, Aswa County. The fresh fruits were collected, sorted and transported in 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, 1SO 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.* (2008).

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. paradoaxa* have relative amounts of both macro and micro nutrients in

Table 1: Macro and micro mineral contents of the fresh and dried pulp cake of *V. paradoxa* on Dry matter (DM basis)

	mg/100 g of minerals					
Edible states	Fe (Iron)	Zn (Zinc)	K (Potassium)	Na (Sodium)	Mg (Magnesium)	Ca (Calcium)
Fresh pulps	2.88 (0.17)	0.56 (0.03)	126.60 (6.70)	24.40 (6.60)	51.20 (1.80)	329.08 (8.80)
Dried pulp cake	8.00 (0.05)	0.67 (0.04)	94.90 (8.40)	42.20 (0.30)	108.10 (5.80)	198.23 (10.94)

Values in brackets are standard deviations (Std. Dev.) of triplicate measurements (n = 3)

Table 2: Macro and micro mineral contents of the fresh and dried pulp cake of *V. paradoxa* on fresh matter (FM basis)

	mg/100 g of minerals					
Edible states	Fe	Zn	K	Na	Mg	Ca
Fresh pulps	0.86 (0.08)	0.40 (0.02)	38.00 (2.00)	7.30 (2.00)	21.90 (0.76)	234.90 (6.30)
Dried pulp cake	6.80 (0.01)	0.09 (0.01)	13.30 (1.20)	5.90 (0.00)	92.10 (5.00)	29.21 (1.60)

Values in brackets are standard deviations (Std. Dev.) of triplicate measurements (n = 3)

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 (Alinnor 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 pulp 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 4.6% 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 pulps cakes of V. paradoxa on dry matter (DM) basis

	Proximate contents										
Edible states	Dry matter (g/100 g)	Fibre (g/100 g)	Fat (g/100 g)	Ash content (g/100 g)	Proteins (g/100 g)	Carb. (g/100 g)	Gross energy (Kcal/100 g)	Vitamin C (mg/100 g)	Phytates (mg/100 g)	Carotenoid (µg/100 g)	Vitamin A (µg/100 g)
Fresh pulps	29.50 (0.87)	13.30 (1.29)	3.30 (1.1)	5.10 (0.26)	6.61 (1.06)	27.50 (12.2)	399.40 (2.62)	83.30 (47)	0	8890 (0.45)	740.80
Dried pulp cake	85.30 (0.02)	12.20 (1.4)	1.60 (0.15)	2.70 (0.86)	4.64 (0.13)	27.90 (16.4)	391.60 (9.62)	72.20 (21.8)	740.80	2810 (0.22)	234.20

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

	Proximate compositions										
Edible states	MC (Moisture content) g/100 g (%)	Fibre g/100 g (%)	Fat g/100 g (%)	Ash g/100 g (%)	Proteins g/100 g (%)	Carbohydrates g/100 g (%)	Energy Kcal	Vitamin C (mg/100 g)	Phytates (mg/100 g)	Carotenoids (µg/100 g)	Vitamin A (µg/100 g)
Fresh pulps	70.50 (0.87)	5.95 (0.14)	0.98 (0.35)	1.53 (0.08)	1.98 (0.32)	8.25 (3.70)	119.90 (0.78)	25.01 (14.1)	0	2740 (0.16)	228.3
Dried Pulp cake	14.70 (0.02)	1.77 (0.41)	1.33 (0.13)	2.33 (0.74)	3.95 (0.11)	23.95 (14.3)	333.85 (8.13)	61.57 (18.61)	0	2420 (0.17)	201.7

Values are expressed as mean (Std) of triplicate measurements (n = 3) except for phytates (n = 2)

important mineral for keeping ones blood healthy and adequate iron intake is important for the development of the brain and its deficiency can result to irreparable damage to the brain cells. The dried cake is notably as a better source of iron but its high iron contents could be agued as resulting from contamination during the time when the cakes were being prepared locally since many conditions might have not been controlled.

The Zn content of the fresh pulps of the Shea fruits on FM basis (Table 2) is similar to its content reported by Maranz *et al*. (2004) and that for mango and guava as reported by Mahapatra and Panda (2012), all values are less than 1 mg/100 g. This very content constitutes 2.6% DV higher than 0.6% DV for the dried pulp cakes (USDA, 2008) for adults and children four or more years of age per day (FAO/WHO, 2005; FNB, 2005). The fresh pulps are thus a better source of Zn, it being important in the body for cell division, protein synthesis and growth and can supplement in case of clear signs of reduced growth rate and impairments of immune defense which demonstrates signs of mild zinc deficiency in humans.

The ash content of the fresh pulps (Table 3) on DM basis is similar to the values reported for the districts of Pader (5.9 g/100 g), Katakwi (5.5 g/100 g) and Arua (4.6 g/100 g) as reported by Okullo *et al*. (2010). The ash content of the fresh pulps on FM basis (Table 4) is slightly lower than that of the dried pulp cakes. When compared with the contents of some introduce fruits, the content of ash for the fresh pulps on FM basis is higher than the contents of all the papaya varieties reported by Nwofia *et al*. (2012). The different ash contents could therefore be one of the reasons for varied mineral contents in the fresh and dried pulps, ash being an indicator of the amount of minerals in foods.

The moisture contents of the fresh pulps on FM basis (Table 4) is comparable to the contents reported by Okullo *et al*. (2010) for the districts of Lira and Katakwi in Northern Uganda. The dried pulp cakes showed lower MC since it was brought to the laboratory when already dried and ready for storage. The disadvantage of the fresh pulps having higher MC, despite it necessity in life, is that makes them very susceptible to infection and decreases their ability for storage hence lowering their life span for preservation.

The crude fibre (CF) content of the fresh pulps on DM basis (Table 3) is similar to the contents for the Shea fruits from the districts of Lira (14.5 g/100 g), Katawi (14.4 g/100 g) and Arua (14.6 g/100 g) in Northern Uganda as reported by Okullo *et al*. (2010). On FM basis, the CF contents (Table 4) is higher than the contents in Apple (1 mg/100 g), pineapple (0.5 mg/100 g), Jack fruits (1.1 mg/100 g), mango (0.7 mg/100 g) and papaya (0.8 mg/100 g) but similar to that of guava (5.5 mg/100 g) (Nazarudeen, 2010). This content on FM basis constitutes 23.8% DV of the 25% crude fibre calculated based on total dietary energy intake of 2000kcal per day;

Fig. 1: (a) Fresh fruits and (b) the dried pulps cake of *V. paradoxa*, respectively

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 *Anannas comosus* (0.2 g/100 g), *Mangnifera 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 Mahaptra *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, both 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 cariotenoids 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 adquate 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. paradoxa* 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/AI 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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