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Potentials of Neglected Wild Foods: Nutritional Composition of a 'Plant Meat' (*Nyam Ngub*) Prepared From Wild Edible Orchid Tubers

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Abstract
The powders of a traditional food (*Nyam ngub*) and two wild varieties of orchid tubers (*Ateehteu* and *Lamsie*) were studied for the chemical composition (proximate and mineral composition) and functional properties (water, oil, ethanol absorption capacities, solubility index and swelling power). The tubers were collected from Kedjom Ketingoh (5^o 58'N and 10^o 19E) in the Northwest Region of Cameroon from July to September 2017. The *Nyam ngub* was prepared following the traditional method used by local processors in the field. *Nyam ngub* and tubers were separately sliced, dried for 96 h at 45 °C, ground and sieved to obtain powders used for the analysis. For 100g DW, the mean crude protein, starch, total sugars, soluble sugars, total lipid, crude fibre, vitamin C, calcium, iron contents and energy values for *Ateehteu*, *Lamsie* and *Nyam ngub* were (1.93; 3.50; 2.59)mg, (6.51; 4.48; 4.26)g, (14.34; 15.07;13.08)g, (1.07; 1.06; 1.05)g, (2.45; 2.93; 2.41)g, (4.02; 5.22; 4.88)g, (8.38; 5.69; 5.93)mg, (58.02; 181.86; 693.03)mg, (2.78; 24.65; 16.02)mg and (60.58; 63.09; 53.73) Kcal. The mean water, oil and ethanol absorption capacities for *Ateehteu* and *Lamsie* were (7.29; 9.10) g/g, (2.60; 3.21) g/g and (1.91; 2.28) g/g and solubility index was (44.38; 59.63) %. The results showed that *Nyam ngub* could therefore represent a rich traditional food that can provide nutrient diversity in diets, served as food for diabetics and had a promising potential as nutraceuticals and functional foods.
Keywords: Wild orchid tubers; Chemical composition; Functional properties; Wild foods.

1. Introduction
Wild foods have gained much research interest in the last decades because they play an important role in the food security of many households especially in forest and grassland areas [1-4]. These foods include forests plants, fungi and animals which have not yet been domesticated but have the potentials to play an essential role in revenue generation [1, 2]. Wild foods bring variety and flavour to diet as well as augment the level of vitamins and minerals necessary for the maintenance of good health and strong growth especially in times of famine when regular crops usually considered staples fail [3, 4]. Approximately one in every nine persons of the world's population is malnourished [1]. Majority of the malnourished persons are found in the developing world who coincidentally harbours a plethora of wild foods with high nutritional potentials. One handicap related to the use of these wild foods is the limited knowledge on their nutritional values which when available encourage the inclusion of these foods in major diets without fear of intoxication and other complications that might arise from the consumption of such foods. There is need to identify and develop food composition data for such foods to enable these disadvantaged populations otherwise endowed with under exploited wild foods to derive the maximum possible benefits that can accrue from their processing and sales.

One such wild and underexploited foods is a jelly-like food prepared from wild orchid tubers usually referred to as *Nyam ngub* or *Nyam nguv* or *Chengnie* by some major tribes of the North West Region of Cameroon where the plant grows abundantly. Orchids belong to the family of Orchidaceae representing the most advanced family in the Monocotyledoneae and are mostly adapted to the tropics [5]. They are considered as one of the largest and most diversified families of Angiosperms represented by 25,000 to 35,000 species belonging to 600-800 genera distributed in all parts of the world except, in the Antarctica [6-8]. It has been processed and eaten as meat snack, meat sausage, meat substitute and/ or traditional meat for decades. Just like the *Napsie* of the Bagam people of Galim-Western Region of Cameroon [9] and the *Chikanda* and *Kinaka* of the people of Southern African countries [8, 10, 11], *Nyam ngub* is obtained from the tubers of some wild orchid plants through a wide range of unit

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operations that requires scientific mastery. *Nyam ngub* and the tubers although wild can represent a source of vital, cheap, and lucrative nutrients [12] to offer variety in diets as well as a possible source of nutraceuticals or a functional food [13]. But like other wild foods, it is undervalued, under estimated in the diet due to lack of food composition data [13] and not considered as a staple of the people concerned, though it is a delicacy in periods of affluence. Moreover, *Nyam ngub* production and consumption is gradually being abandoned due to the adoption of policies and industrialization that has killed traditional survival strategies despite the nutritional, health and cultural benefits of wild foods [14, 15]. There is a gap in information concerning the nutritional value of the tubers and *Nyam ngub* which can significantly contribute to valorise and orientate its consumption. The aim of this study was therefore to evaluate the chemical composition and functional properties of the powders of the two commonly used tubers for the food processing of an underutilised food (*Nyam ngub)* derived from wild tubers.

2. Material and Methods

2.1. Sample Collection

The tubers of *Ateehteu* and *Lamsie* plants were collected from the cold hills of Abong-Phen in Kedjom Ketingoh in Tubah subdivision of the North West Region, from July to September 2017.

2.2. Sample Preparation

The tubers were separately washed with running tap water and portion of *Lamsie* was kept to produce *Nyam ngub*. *Nyam ngub* was then prepared by pounding 10 kg of the tubers in a mortar with a pestle. The resulting marsh was mixed with 5L of distilled water and 3L of wood ash extract added and properly homogenized. It was then allowed to rest for about 25 min and packaged in flamed plantain leaves, and cooked in boiling water for 90 min and then allowed to cool. *Nyam ngub* and each tuber variety were then separately sliced into thin lamellas and dried for four days at 45 °C. The dried pieces were ground with a hand grinding machine and sieved to obtain powders of 75-150 µm diameter which were stored in Ziplock papers and used for the chemical composition and functional properties analysis.

2.3. Chemical Analysis

2.3.1. Proximate Analysis

Dry matter was determined by the method of Association Francaise de Normalisation AFNOR [16], in triplicates using a laboratory oven (DHG-9101 1SA, Dengfeng Haonan, China) at 105^{o}C. The total ash content was determined by the method of Association Francaise de Normalisation AFNOR [17], as follows: The powders of the samples were separately dried overnight at 105 ^{o}C in an oven (DHG-9101 1SA, Dengfeng Haonan, China) and 10 g of each dried sample ignited in porcelain crucibles overnight at 550 ℃ in muffle furnace (model LF 3, Chesterfield, UK). Experiments were carried out in triplicates and ash content was obtained by difference. Sugar content was determined by the dinitrosalicylic (DNS) colorimetric method as described by Fischer and Stein [18], while total starch content was determined by the method of Dubois, *et al.* [19]. The total nitrogen (crude protein) content was determined by the Kjeldahl method [20] and the quantification by the colorimetric technique as described by Devani, *et al.* [21]. The total lipid and crude fibre contents were quantified by the Russian method [22] using hexane as extraction solvent and the Weende filter bag method respectively [23]. Total phenolic compounds were quantified by the Folin-Ciocalteu method as described Marigo, [24]. Vitamin A was determined via β-carotene method; β-carotene content was determined by the method of Wolf [23] and the vitamin A content was then deduced from conventional conversion factor given that 12 µg of carotenoid correspond to 1 µg of Provitamin A. The 2, 6 dichlorophenol indophenol titrimetric method of Haris and Ray [25] was used to quantify the vitamin C content.

2.3.2. Mineral Analysis

The iron content of the samples was determined by orthophenanthroline colorimetry as described by Rodier [26] while Calcium and magnesium quantification was done by the Association Française de Normalisation AFNOR [27] titrimetric method.

2.4. Functional Properties

2.4.1. Determination of Water Oil and Ethanol Absorption Capacities

Water absorption capacity (WAC), oil absorption capacity (OAC) and ethanol absorption capacity (EAC) were determined by slightly modifying the methods described by Sosulski [28], Lin, *et al.* [29] and Sofi, *et al.* [30] respectively. Briefly**,** 1g of powdered samples was added unto 8 ml of distilled water, soybean oil (Kirkland signature) and 40 % ethanol respectively in pre-weighed centrifuge tubes, stirred with a spatula and vortexed (TMT XH-D, Erding Germany) for 2 min. The tubes were centrifuged at 4000 rpm at 25 $^{\circ}$C for 25 min, the supernatant decanted and excess water aspired by a dropper and the samples were allowed to drain for 30 min and the drying completed in in an oven (DHG-9101 1SA, Dengfeng Haonan, China) at 50 $^{\circ}$C. Each tube together with its content was then reweighed and the gains in mass of triplicate analysis of the powder of each tuber species were the WAC, OAC and EAC respectively.

2.4.2. Determination of Solubility and Swelling Index (Power)

Solubility and swelling indices were determined by a modification of the method of Nwokocha, *et al.* [31] and Brou, *et al.* [32] respectively. 2 g of powder samples were suspended in 15 ml distilled water in pre-weight centrifuge tubes. The mixtures were placed in a hot water tank (B Brand scientific, England) at 90 °C with constant stirring for 1. The tubes were then cooled at 25 °C followed by centrifugation at 4000 rpm for 15 min. The supernatant was then decanted and poured into aluminium dishes and the weight of the swollen granules obtained by difference. The aluminium dishes and content were then dried for 12 h at 110 °C in an air oven (DHG-9101 1SA, Dengfeng Haonan, China) and the weight of the dried solid determined. The gain in weight of triplicate analysis of the powder of each species was recorded and the solubility and swelling index calculated as follows:

$$Solubility(S_o) = \frac{Weight\ of\ dried\ supernatant}{weight\ of\ fresh\ sample} \times 100 \ \ldots\ldots\ldots\ldots\ldots \quad [1]$$

$$Swelling\ power\ (S_p) = \frac{weight\ of\ sediments}{weight\ of\ fresh\ sample\ \times(100-S_0)} \ \ldots\ldots\ldots\ldots\ldots \quad [2]$$

2.5. Statistical Analysis

The results obtained were analyzed on Statgraphics, [(Centurion XVI, 2011). The means of triplicate analysis were subjected to a one way ANOVA at $p \leq 0.05$ and where there were significant differences, the means were separated by the Duncan Multiple Range test.

3. Results and Discussion

3.1. Proximate Composition and Chemical Analysis

3.1.1. Proximate Composition

The results of the proximate composition of *Ateehteu, Lamsie* and *Nyam ngub* are shown on table 1. The dry matter showed significant difference at ($p \leq 0.05$) and were respectively 87.06 %, 89.43 % and 85.19 % for *Ateehteu, Lamsie* and *Nyam ngub*. These values were relatively higher than those reported for aroids (22-27) %, cassava (30 - 40) %, potato (20 %), sweet potato (19 – 35) % and yams (20 – 42) % [33].

The ash content varied significantly ($p \leq 0.05$) between *Ateehteu, Lamsie* and *Nyam ngub* which had values of 2.38 g/100gDW, 2.45 g/100gDW and 8.98 g/100gDW respectively. These values were higher than those reported for cassava, yam, sweet potato and taro and the edible orchids of Southern Tanzania which were 0.6 g/100gDW, 1.1 g/100gDW, 1.0 g/100gDW, 0.9 g/100gDW, 1.2 g/100gDW [34] and 0.022 g/100gDW [5] respectively. The particularly higher value of the ash content of *Nyam ngub* could be explained by the minerals present in the wood ash extract added during preparation. The ash content indicated that these tubers and *Nyam ngub* could be reliable sources of minerals.

Although the crude fibre content showed no significant difference at ($p \leq 0.05$), *Ateehteu, Lamsie and Nyam ngub* had crude fiber contents of 4.02 g/100gDW, 5.22 g/100gDW and 4.88 g/100gDW respectively. However, these values were greater than those reported for cassava, yam, sweet potato, potato and the edible orchid of Southern Tanzania which had fibre contents of 1.8 g/100gDW, 4.1 g/100gDW, 3.0 g/100gDW and 2.4 g/100gDW [34] and 0.3 g/100gDW [5] respectively. Chandrasekara and Kumar [35], also reported lower crude fibre contents of 2.4 g/100gDW for white flesh potato, 1.7 g/100gDW for red flesh, 3 g/100gDW for sweet potato, and 1.8 g/100gDW for cassava and 4.1 g/100gDW for yam. The British Nutrition Foundation in 2017 recommended 30 g as the estimated average requirement (EAR) for persons 17 years and above. However, the dietary reference intake report of 200/2005 recommends 38 g/100gDW and 25 g/day for males and females between 19 – 50 years respectively as EAR.

The protein content of *Ateehteu* (1.93 mg/100g DW), *Lamsie* (3.50 mg/100 gDW) and *Nyam ngub* (2.59 mg/100gDW) were significantly different ($p \leq 0.05$). Kasulo, *et al.* [5], reported a significantly lower value for the edible orchids of Tanzania (0.054 mg/100g DW). Though the trend was different in the conventional tubers with cassava, yam, sweet potato, potato and taro having crude protein contents of 1.4 g/100gDW, 1.5 g/100gDW, 1.6 g/100gDW, (1.7-1.9) g/100gDW and 1.9 g/100gDW [5, 36], these value were lower than those obtained for the studied samples. The tubers and *Nyam ngub* could therefore constitute a non-negligible source of proteins. The total sugar content of 14.34 g/100gDW, 15.07 g/100gDW and 13.08 g/100gDW respectively for *Ateehteu, Lamsie* and *Nyam ngub* were significantly different ($p \leq 0.05$). White flesh potato, red flesh potato, sweet potato, cassava and yam were reported to have 1.2 g/g, 1.3 g/g, 4.2 g/g, 1.7 g/g and 0.5 g/g respectively which were comparatively lower. The 2015 British Nutrition Foundation RNI recommends not more that 5% of free sugars of the total energy intake. The total lipid content of *Ateehteu, Lamsie* and *Nyam Ngub* were 2.45 g/100 gDW, 2.39 g/100 gDW and 2.41 g/100 gDW respectively. USDA [34] reported 0.1 g/100gDW, 0.1 g/100gDW, 0.1 g/100gDW, 0.3 g/100gDW and 0.2 g/100gDW for white flesh potato, red flesh potato, sweet potato, cassava and yam respectively while Opara, [37] reported 0.08 g/100gDW and 0.1 g/100gDW for taro and tania respectively.

The energy values were respectively 60.58 Kcal/100gDW, 63.09 Kcal/100gDW and 53.73 Kcal/100gDW for *Ateehteu, Lamsie* and *Nyam ngub* and showed no significant difference between the treatments ($p \leq 0.05$). These values are relatively lower than those of some of the major tubers. Chandrasekara and Kumar [35], reported energy value of 69 Kcal for white flesh potato, 70 Kcal for red flesh potato, 86 Kcal for sweet potato, 160 Kcal for cassava and 118 Kcal for yam. *Nyam ngub.* The low energy value of this wild food indicates that it could constitute or be a source of a food for diabetics as well as those doing body weight control

The vitamin A content of *Ateehteu, Lamsie* and *Nyam ngub* were 2.14µg, 2.45 µg, and 1.27 µg. respectively and were significantly different at ($p \leq 0.05$). Sanjeet, *et al.* [33] reported on a fresh weight basis values of (0 - 42) µg for aroids, 17 µg for cassava, trace for potato, 900 µg for sweet potato and 117 µg for yam. The values on a dry weight basis were 8 international units (IU), 7 IU, 14187 IU, 13 IU and 138 IU for white flesh potato, red flesh potato, sweet potato, cassava and yam respectively. The recommended daily allowance (RDA) specified by the 2001 and 2000 DRI report was 900 µg and 700µg for males and females from 19 to 30 years while the estimate average intake

(EAI) for adults between 19 and 50 established in 2017 by the British Nutrition Foundation was 700 µg/d and 600 µg/d for male and female respectively.

Table-1. Proximate analysis of the samples

Component	Ateehteu	Lamsie	Nyam ngub
Dry weight, DW (%)	87.06±0.57[a]	89.43±0.50[b]	85.19±0.88[c]
Water content (%)	12.94±0.57[a]	10.57±0.50[b]	14.81±0.88[c]
Ash (g/100gDW)	2.38±0.43[a]	2.45±0.27[b]	8.98±0.04[c]
Total sugars (g/100gDW)	14.34±0.33[a]	15.07±0.36[b]	13.08±0.33[c]
R S (g/100gDW)	1.07±0.16[a]	1.06±0.10[a]	1.05±0.03[a]
Starch (g/100gDW)	6.51±0.12[a]	4.48±0.12[b]	4.26±0.44[c]
AC (g/100gDW)	3.13±0.17[a]	3.09±0.06[a]	3.02±0.09[a]
Fibre (g/100gDW)	4.02±0.50[a]	5.22±0.58[a]	4.88±0.17[a]
Total Lipides (g/100gDW)	2.45±0.34[a]	2.93±0.40[a]	2.41±0.31[a]
Protein (mg/100gDW)	1.93±0.26[a]	3.50±0.34[b]	2.59±0.35[c]
EV (Kcal/100gDW)	60.58±5.05[a]	63.09±4.32[a]	53.73±4.67[a]
TPC (mg/100gDW)	362.89±0.62[a]	459.41±29.54[b]	333.01±3.32[c]

Mean ± standard deviation of triplicate determination
Values on horizontal rows with different superscripts are significantly different at p≤ 0.05
RS: Reducing sugars; TPC: Total phenolics compound; EV: energy value: AC: amylocellulose

3.1.2. Mineral Analysis

Table 2 presents the results of the mineral analysis. The Calcium content on a dry weight basis was 58.02 mg, 181.85 mg and 693.03 mg for *Ateehteu, Lamsie and Nyam ngub* respectively significantly different at (p ≤ 0.05). [35] reported 9 mg, 10 mg, 30 mg, 16 mg, and 17 mg for white flesh skin potato, red flesh skin potato, sweet potato, cassava and yam respectively. The 2011 dietary reference intake (DRI) report recommends 1000 mg/day for both men and women between 19 and 30 years. While the British Nutrition Foundation in 2017 recommended 700 mg/d for both men and women between 19 and 50 years as RDA. The tubers and *Nyam ngub* can therefore represent reliable sources of calcium.

The iron content on and dry weight basis was significantly different (p ≤ 0.05) between the treatments with values of 2.78 mg, 24.64 mg and 16.02 mg for *Ateehteu*, *Lamsie* and *Nyam ngub* respectively. Cassava, yam, sweet potato, potato and taro were 0.6 mg, 0.7 mg, 0.6 mg and 1.0 mg/100 respectively [38] which was lower. The 2001 DRI report recommends 8 mg/day and 18 mg/day for men and women respectively between the age of 19 and 30 while the 2017 British Nutrition Foundation EAI is 8.7 and 14.8 for men and women between 19 and 50 years of age respectively.

Table-2. Some mineral and vitamin content of the samples studied

Component	Ateehteu	Lamsie	Nyam ngub
Calcium (mg/100gDW)	58.02±9.67[a]	181.85±20.04[b]	693.03±72.95[c]
Magnesium (mg/100gDW)	70.27±11.82[a]	70.35±12.80[b]	26.75±4.21[c]
Iron (mg/100gDW)	2.78±0.51[a]	24.64±4.22[b]	16.02±0.84[c]
Vitamin A (µg/g)	2.14±0.35[a]	2.45±0.14[b]	1.27±0.12[c]
Vitamin C (mg/100gDW)	8.38±2.80[a]	5.69±0.87[a]	5.93±0.77[a]

Mean ± standard deviation of triplicate determination
Values on horizontal rows with different superscripts are significantly different at p≤0.05
RS: Reducing sugars; TPC: Total phenolics compound; EV: energy value: AC: amylocellulose

3.1.3. Functional Properties

The results of the evaluation of the functional properties of the powders of the tubers of *Ateehteu* and *Lamsie* are shown on table 3. Water absorption capacity for *Ateehteu* (7.29g/g) was significantly lower (p ≤ 0.05) than that of *Lamsie* (9.10 g/g). These values were relatively higher than those reported for some of the conventional tubers as cassava powder possesses water binding capacity of 1.06 g/g [37] while white yam, water yam and cocoyam had respectively 1.23g/g, 0.96g/g and 0.89g/g [39].

There was no significant difference (p ≤ 0.05) between the oil absorption capacities of *Ateehteu* (2.61 g/g) and *Lamsie* (3.32 g/g). But while *Lamsie* could absorb more water and oil than *Ateehteu*, *Ateehteu* absorbed (2.42 g/g) significantly more (p ≤ 0.05) ethanol than *Lamsie* (2.01 g/g). The solubility and swelling power showed no significant difference (p ≤ 0.05) with values ranging from (0.26 – 0.63) g/g and (0.38 – 0.81) g/g respectively for *Ateehteu* and (0.016 - 0.02) g/g and (0.016 – 0.02) g/g respectively for *Lamsie*. The solubility and swelling power of *Ateehteu* and *Lamsie* was lower than those reported for potato (10.13 g/g and 0.83 g/g) [40], white yam (6.10 g/g and 7.00 g/g), water yam (6.92 g/g and 6.39 g/g) and cocoyam (6.31 g/g and 5.36 g/g) [40] respectively.

Table-3. Results of the evaluation of functional properties

Property	Ateehteu	Lamsie
Water absorption capacity (g/g)	7.29± 0.16[a]	9.10±0.47[b]
Oil absorption capacity(g/g)	2.61±0.52[a]	3.21±0.18[a]
Ethanol absorption capacity (g/g)	1.91±0.10[a]	0.14±0.06[b]
Solubility index (%)	44.38± 0.19[a]	59.63±0.21[a]
Swelling power (g/g)	0.02±0.00[a]	0.02±0.00[a]

Values expressed are mean ± standard deviation.
Means in the rows with different superscript are significantly different at ($p \leq 0.05$)

4. Conclusion

The chemical composition of two wild orchid plant (*Ateehteu* and *Lamsie*) tubers and a traditional food (*Nyam ngub*) produced from the tubers and the functional properties of the powders of the tubers were evaluated. The powders of the tubers of *Lamsie* exhibited higher absorption capacities and solubility than those of *Ateehteu*. As these values were relatively higher than those of the powders of the major root and tuber crops, the powders of *Ateehteu* and *Lamsie* could be possible food texturizers and absorbents.

Lamsie was relatively richer in some major nutrients (total sugars, total lipids, crude protein, iron, vitamin A and energy) than *Ateehteu. Nyam ngub* was significantly richer in calcium than the tubers though all three were relative richer in minerals than the major root crops and tubers.

Nyam ngub was therefore a rich traditional food which if processed respecting standard recommendations can provide nutrient diversity in diets thereby contributing to food security. It showed a promising food for diabetics considering the low energy and sugar contents while its orchid, might confer some nutraceutics and/ or functional food potentials.

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References

[1] Asprilla-Perea, J. and Díaz-Puente, J. M., 2019. "Importance of wild foods to household food security in tropical forest areas." *Food Secur,* vol. 11, pp. 15-22.

[2] De Merode, E., Homewood, K., and Cowlishaw, G., 2004. "The value of bushmeat and other wild foods to rural households living in extreme poverty in Democratic Republic of Congo." *Biol. Conserv.,* vol. 118, pp. 573-581.

[3] Bharucha, Z. and Pretty, J., 2010. "The roles and values of wild foods in agricultural systems." *Philos. Trans. R. Soc. B.,* vol. 365, pp. 2913-2926.

[4] Harris, F. M. and Mohammed, S., 2003. "Relying on nature: wild foods in northern Nigeria." *AMBIO: A. J. Hum. Environ. Stud.,* vol. 32, pp. 24-29.

[5] Kasulo, V., Mwabumba, L., and Cry, M., 2009. "A review of edible orchids in Malawi." *J. Hortic. Sci. Biotech.,* vol. 1, pp. 133-139.

[6] Chase, M. W., Cameron, K. M., Barrett, R. L., and Freudenstein, J. V., 2003. "DNA data and Orchidaceae systematics: A new phylogenetic classification." *Orchid Conserv,* vol. 69, p. 32.

[7] Chase, M. W., 2005. "Classification of Orchidaceae in the age of DNA data." *Curtis's Botanical Magazine,* vol. 22, pp. 2-7.

[8] Pillon, Y. and Chase, M. W., 2007. "Taxonomic exaggeration and its effects on orchid conservation." *Conserv Biol.,* vol. 21, pp. 263-265.

[9] Menzepoh, S. B., 2011. "Les orchidées comestibles chez le peuple Bagam, au Cameroun." *Biotechnol. Agro. Soc. Env.,* vol. 15, pp. 509-514.

[10] Challe, J. F. X. and Struik, P. C., 2008. "The impact on orchid species abundance of gathering their edible tubers by HIV/AIDS orphans: a case of three villages in the Southern Highlands of Tanzania." *Nat. J. African. Sci.,* pp. 56-3.

[11] Veldman, S., Otieno, J., van-Andel, T., Gravendeel, B., and de Boer, H., 2014. "Efforts urged to tackle thriving illegal orchid trade in Tanzania and Zambia for chikanda production." *Traffic Bulletin,* vol. 26, pp. 47-50.

[12] FAO/WHO, 2016. "Joint FAO/WHO expert committee on food additives, JECFA." Available: https://www.who.int/foodsafety/areas_work/chemical-risks/jecfa/en/

[13] Shad, A. A., Shah, H. U., and Bakht, J., 2013. "Ethnobotanical assessment and nutritive potential of wild food plants." *J. Anim. Plant. Sci.,* vol. 23, pp. 92-97.

[14] DeClerck, F., Fanzo, J., Palm, C., and Remans, R., 2011. "Ecological approaches to human nutrition." *Food and Nutr. Bull.,* vol. 32, pp. S41-S50.

[15] Daudet, A., 2019. "“Wild” foods and their potential for undernutrition prevention." Available: https://www.actionagainsthunger.org/sites/default/files/publications/Wild_foods_and_their_potential_for_undernutrition_prevention_06.2012.pdf

[16] Association Francaise de Normalisation AFNOR, 1982. *Recueil des normes fracaises des prodiuts derives des fruits et legumes*. Paris: Jus de fruits. p. 327.

[17] Association Francaise de Normalisation AFNOR, 1981. *Recueil des normes françaises, corps, graines oléagineuses et produits dérivés*. Paris, p. 327.

[18] Fischer, E. H. and Stein, E. A., 1961. "a- amylase from human saliva." *Biochem Prep*, vol. 8, pp. 27-33.

[19] Dubois, M., Gilles, A., Hamilthon, J. J., Rebers, P. A., and Smith, F., 1956. "Colorimétric method for determination of sugars and related substances." *Anal. Chem.*, vol. 28, pp. 350-356.

[20] AFNOR, 1984. *Recueil des normes Françaises. Produits agricoles alimentaires. Directives générales pour le dosage de l’azote avec minéralisation selon la méthode de Kjedahl*. Paris: AFNOR.

[21] Devani, M. B., Shishoo, C. J., Shah, S. A., and Suhagia, B. N., 1989. "Microchemical methods: Spectrophotometric methods for micro-determination of nitrogen in Kjedahl digest." *J. Assoc. Anal. Chem.*, vol. 72, pp. 953-956.

[22] Bourely, J., 1982. "Observation sur le dosage de l’huile des grains du cotonier." *Cot. Fib, Trop.*, vol. 27, pp. 183-196.

[23] Wolf, J. P., 1968. *Manuel d’analyse des corps gras*. Paris: Azoulaye edn. p. 519.

[24] Marigo, G., 1973. "Sur une méthode du fractionnement et estimation des composes phénolique chez les végétaux." *Analysis*, vol. 2, pp. 106-110.

[25] Haris, L. J. and Ray, S. N., 1935. "Diagnosis of vitamin C sub nutrition by urine analysis." *Lancet*, vol. 228, pp. 71-77.

[26] Rodier, J., 1978. *Analysis of water. Natural water, waste water, sea water*. 6th ed. Dunod Paris.

[27] Association Française de Normalisation AFNOR, 1986. "Recueil des normes Française, Eaux Methodes D’Essai."

[28] Sosulski, F. W., 1962. *La méthode de centrifugation pour la détermination de l'absorption de la farine de blé de force roux de printemps* vol. 39. Cereal Chem, pp. 344-350.

[29] Lin, M. J. Y., Humbert, E. S., and Sosulski, F. W., 1974. "Certain functional properties of sunflower meal products." *J. Food Sci.*, vol. 39, pp. 368-370.

[30] Sofi, B. A., Wani, I. A., Masoodi, F. A., and Saba, I., 2013. "Muzaffar S, Effect of gamma irradiation on physicochemical properties of broad bean (Vicia faba L.) starch." *LWT Food Sci. Technol.*, vol. 54, pp. 63-72.

[31] Nwokocha, L. M., Aviara, N. A., Senan, C., and Williams, P. A., 2009. "A comparative study of some properties of cassava (Manihot esculenta, Crantz) and cocoyam (Colocasia esculenta, Linn) starches." *Carbohydrate Polymers*, vol. 76, pp. 362-367.

[32] Brou, K., N'Da-Kouassi, A. M., Kouadio, J. H., Guehi, T., and N'Guessan, K. F., 2012. "Gnakri D Biochemical characterization and functional properties of weaning food made from cereals (Millet, Maize) dnd Legumes (Beans, Soybeans)." *J. Food Chem. Nutr.*, vol. 1, pp. 22-32.

[33] Sanjeet, K., Gitishree, D., Han-Seung, S., and Jayanta, K. P., 2017. *Dioscorea spp. (A Wild Edible Tuber): A study on its ethno pharmacological potential and traditional use by the local people of Similipal Biosphere Reserve, India*: Frontiers in Pharmacology. pp. 1-17.

[34] USDA, 2009. *Inspection handbook for the sampling, inspection, grading, and certification of rice HB9*. Washington, DC: Agricultural Marketing Service. pp. 18-11.

[35] Chandrasekara, A. and Kumar, T. J., 2016. "Roots and tuber crops as functional foods: A review on phytochemical constituents and their potential health benefits." *Intl. J. Food Sci.*, pp. 1-14. Available: http://dx.doi.org/10.1155/2016/3631647

[36] USDA, 2015. *Inspection handbook for the sampling, inspection, grading, and certification of rice HB9*. Washington, DC: Agricultural Marketing Service. pp. 18-11.

[37] Opar, L. U., 1999. *Cigr handbook of agricultural engineering, volume iv agro processing engineering, chapter 2 root crops, part 2.6* Storage of Edible Aroids.

[38] Jyothi, A., Kiran, K., Wilson, B., Moorthy, S., and Nambisan, B., 2007. "Wet storage of cassava starch: Use of sodium metabisulphite and acetic acid and the effect on starch properties, starch/stärke." vol. 59, pp. 141-148. Available: https://onlinelibrary.wiley.com/doi/abs/10.1002/star.200600583

[39] Adegunwa, M. O., Alamu, E. O., and Omitogun, L. A., 2011. "Effect of processing on the nutritional contents of yam and cocoyam tubers." *J. Appl. Biosci.*, vol. 46, pp. 3086-3092.

[40] Bouman, A., 1995. *Mechanical damage in potato tubers – enquiry of the EAPR engineering section*. Wageningen: Institute of Agricultural and Environmental Engineering. p. ±0.0035.