Nutrient Composition and Sensory Qualities of *Landolphia Togolana* Used for Traditional Soup Consumed by Post-Partum Mothers in Akoko Region of Ondo State, Nigeria

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Abstract

Landolphia togolana is locally known as jabajaba is an underutilized plant with wide range of applications. This study assessed the nutritional composition and sensory qualities of Landolphia togolana root specie used in soup preparation by post-partum mothers in Ondo State, Nigeria. Landolphia togolana root were harvested, washed, dried at 50 ! and then milled into powder using a domestic blender. Water and methanol were used for the extraction process to form sample A and B respectively. Part of the powdered samples were used as a soup thickener during preparation of traditional soup of five samples at different ratios of 100% (control), 0%, 50%, 30%, and 20%. Laboratory analyses for proximate, mineral, and vitamin compositions were carried using standard analytical procedures, while fifty (50) academics and non-academics staff served as untrained panellists were used for study. Sensory evaluation using a 9-point hedonic scale was adopted by the panellists. Data collected were analysed using means and standard deviations. Results of the proximate analysis showed that sample A had higher contents of crude protein (8.00%), crude fibre (33.67%), carbohydrate (40.17%) than sample B. Moisture (11.62%), ash (17.43%), lipid (9.64%) of sample B was higher than that of sample A. For the mineral, Iron (Fe) had the highest (36.3 mg/kg) composition among the micronutrients. Vitamin E and niacin had the highest (52.98 μg/100 g) and lowest (0.02 μg/100 g) concentrations among the vitamins. For sensory evaluation, acceptability showed soup formulated with 20% of Landolphia togolana root (MLT20) is the most desired. Landolphia togolana root specie could be addressed for proper health management, maintaining of well-being for sustainable family particularly the post-partum mothers living in an unstainable economy.

Keywords: Post-partum mothers, Nutrient composition, Sensory properties, *Landolphia togolana*

Introduction

Plants are good sources of natural products commonly used in traditional soups through communities worldwide (Luo,Li, Ahmad and Long., 2019). The roots, leaves, seeds, and bark of some plants have profound applications in foods and medicines because of their chemical and nutritional properties. In addition, the therapeutic, culinary, and nutritional effects of some plants commonly used in folklore remedies against many diseases may be attributed to the antioxidant properties of their phytoconstituents (Mahomoodally, 2013). Many plants are edible and used as flavour enhancers, spices, sources of fibre and phytochemicals, minerals and vitamins, and food thickeners hence are used in food preparation (Ene-obong *et al*, 2013). The use of plants as a soup thickener among women has increased substantially due to the increasing interests on natural substances. Among these plants is *Landolphia family* which are highly nutritious with antioxidant properties (Kossivi, Amengnona, Messanyi., 2015).

Landolphia, a popular African plant is known locally by various names among Nigerian tribes but commonly called *Jabajaba* among natives of Akoko-South in Ondo State. The most common species in Africa includes *Landolphia oweriensesand Landolphia Togolana* (Persoon *et al.*, 1992; Lykke & Padonou, 2019). *Landolphia togolana* (*Jabajaba*) is locally believed to have some fascinating advantages for post-partum mothers which could be responsible for its wide use for soup preparation during post-partum period. The term "post-partum" period is commonly used to refer to the first six weeks following childbirth. A post-partum period begins immediately after the birth of a child. This period is the most critical and yet the most neglected period in the lives of mothers and their babies. Most maternal and new-born deaths occur during the post-partum period as a result of neglected significant physiological, social, and emotional changes in the nursing mother (Altuntuð, Anik and Egel., 2018). Thus, in many cultures, the post-partum period is considered as a risky period, hence various traditional foods are used to protect the health of the mother and that of the baby (Altuntuð *et al.*, 2018).

Landolphia togolana has continued to be an important plant in western Nigeria where it is widely consumed mainly as "*Jabajaba*" soup. However, little is known about the chemical, functional, nutritional and organoleptic properties of this plant. Aside this, associated physiological stress of pregnancy and excessive blood loss during delivery makes the health status of post-partum mothers a major concern. Iron deficiency may be attacked by blood stasis and bacteria resulting in high fever, dizziness, rapid pulse, pale face, and blood clots. As a result of these envisaged problems, there is need to determine the properties present in *Landolphia togolana* root specie.

Objective of the Study

The major objective of this study is to determine the Nutrients Composition and Sensory Qualities of *Landolphia Togolana* used for Traditional Soup Consumed by Post-Partum Mothers in Akoko Region of Ondo State, Nigeria.

Specific Objectives

1. Determine the nutrients composition of Landolphia togolana (jabajaba) root.
2. Determining the sensory quality of the soup prepare with landolphia togolana root at different ration.

Materials and Methods

Source of Raw Materials

Landolphia togolana plant was obtained from Adelabu Salami's farm in Owo, Owo Local Government Area of Ondo State, Nigeria. The plant and botanical identification were carried out in the Department of Plant Biology and Biotechnology, Faculty of Life Science, University of Benin, Benin City, Nigeria. For soup preparation, ingredients like palm oil, bush meat, beef, chicken, dried fish, melon, Maggi, salt, pepper, onions, tomatoes, and locust beans were purchased from a market in Ilorin metropolis, Kwara State, Nigeria.

Drying, milling, and storage of sample

Landolphia togolana root was detached from the stem and oven dried for 24hrs at 60 ! temperature and ground into flour using Hammer mill (Retsch GmbH 5657). It was later sieved using 40 mesh sieve and sealed tightly in plastic containers. The samples were refrigerated for use in soup preparation and chemical analysis.

Extraction of *Landolphia togolana*

Extraction process of *Landolphia togolana* root was carried out at the Department of plant pharmacy laboratory, University of Benin, Nigeria. The extraction procedure was carried out using water and methanol. For water, root powder of 200 g was soaked with 500 ml. of water for 24hrs, filtering with white cloth or filter paper. The yield was used for qualitative phytochemicals, functional properties, vitamins and minerals analysis. For extraction with methanol, the root powder of 500 g of the *Landolphia togolana* root powder was weighed and soaked with 1500 ml of methanol concentrate for 24hrs under dark cupboard. The sample was filtered and evaporated at 60 ! for 30min. The extract obtained (2.65 ml) was bottled and stored in a refrigerator. This was used for the proximate analysis, and determination of calories (Offia-olua,2014).

Laboratory analysis.

AOAC (2003) was used in the determination of proximate composition. The procedure is detailed as follows:

Moisture content

Moisture was determined by oven drying method. 1 g of root sample was accurately weighed in clean, dried crucible (W1) respectively. The crucible was placed in the oven at 100-105 °C for 6-12 hrs until a constant weight obtained. Then the crucible was placed in the desiccators for 30 min to cool. After cooling it was weighed again ($W2$). The percentage moisture was calculated by following this formula:

% Moisture = $W1 - W2$ ×100 (Weight of sample)

Where: $W1$ = Initial weight of crucible + Sample; = Final weight of crucible + Sample

Moisture free samples was used for further analysis.

Ash

In determining the ash content, clean empty crucible was placed in a muffle furnace at 600 ! for 1 hr, cooled in desiccators. The weight of empty crucible was noted (). 1 gram of each of sample was taken in crucible (). The sample was ignited over a burner with the help of blowpipe, until it is charred. Then the crucible was placed in muffle furnace at 550 ! for 2-4 hrs. The appearance of gray white ash indicates complete oxidation of all organic matter in the sample. After aching furnace was switch off. The crucible was cooled and weighed (). Percent ash was calculated by following formula:

%Ash = Difference in of Ash × 100

= weight of sample; Difference in wt. of ash = ; = Dilution of sample after digestion

Crude fat

Crude fat was determined by ether extract method using Soxhlet apparatus. Approximately 1 g of moisture free sample was wrapped in filter paper, placed in fat free thimble and then introduced in the extraction tube. Weighed, cleaned and dried the receiving beaker was filled with petroleum ether and fitted into the apparatus. Turned on water and heater to start extraction. After 4-6 siphoning, allow ether to evaporate and disconnect beaker before last siphoning. Transferred extract into clean glass dish with ether washing and evaporated ether on water bath. Then place the dish in an oven at 105 ! for 2 hours and cool it in a desiccator. The percent crude fat was determined by using the following formula:

% Crude Fat = of ether extract × 100

= weight of sample

Crude fiber

A moisture free and ether extracted sample of crude fiber made of cellulose was first digested with dilute H_2SO_4 and then with dilute KOH solution. The undigested residue collected after digestion was ignited and loss in weight after registered as crude fiber 0.153 g sample () was weighed and transferred to porous crucible. The crucible was placed into Dosi-fiber unit and the valve was kept in "OFF" position. After that, 150 ml of preheated H_2SO_4 solution was added to some drops of foam-suppresser to each column. Then cooling circuit was opened and heating elements (power at 90%) was turned on. When boiling starts, the power was reduced at 30% and left for 30 min. The valves were opened for drainage of acid and rinsed with distilled water thrice to completely ensure the removal of acid from sample

.Crude protein

Protein in the sample was determined by Kjedahl method. The samples were digested by heating with concentrated Sulphur acid (H_2SO_4) in the presence of digestion mixture. The mixture was then made alkaline. Ammonium sulphate thus formed, released ammonia which was collected in 25 boric acid solution and titrated against standard HCL. Total protein was calculated by multiplying the amount of nitrogen with appropriate factor and the amount of protein was calculated.

Mineral analysis

AOAC (2005) was used for mineral analysis. The sample was ashed at 550 ^{0}C and boiled with 10 ml of 20% hydrochloric acid in a beaker and then filtered into a 100 ml standard flask. This was made up to the mark with deionized water. Thereafter the mineral content was determined form the resulting solution. Phosphorus (P) and calcium (Ca) were determined calorimetrically using the spectronic 20 (Gallenkamp, UK) and Atomic Absorption Spectrophotometer (AAS Model SP9) respectively.

Vitamins

The SPE method was used for the extraction of water-soluble vitamins. The sample was treated by passing through the SPE with Sep-Pak C_{18} (500 mg) cartridges that enable separation of water-soluble vitamins and remove most of the interfering components. Deionised water was added to the sample. The mixture was homogenized using a homogenizer at medium speed for 1 min. The homogenized samples were centrifuged for 10 min at 14 × 10^3 g. The stationary phase was flushed with 10 mL methanol and 10 mL water at a pH 4.2 to activate the stationary phase. The sample was loaded unto the stationary phase and was eluted with 5 mL water (pH 4.2), then 10 mL methanol at a flow rate of 1 mL min^{-1}. The eluent was collected in a bottle and evaporated to dryness and residue dissolved in mobile phase. Before HPLC analysis all samples were filtered through 0.45 ìm pore size FP 30/45 CA-S filters (Schleicher and Schuell, Darmstadt, Germany) at 7 bar max. Samples (20 ìL) of solutions of the water-soluble vitamins were injected into the HPLC column.

DPPH was used to determine the activities of different concentrations of vitamin C in the extract from the root of *Lanolphia togolana*

Determination of Carbohydrates

Carbohydrate is determined by difference. That is, the carbohydrate content of a food can be determined by calculating the percent remaining after all the other components have been measured. This mean % carbohydrate = 100 - %moisture -%protein- %lipid -%mineral.

Tables 1: The Formulated Samples Used for Sensory Quality

Coded samples	Constituents
LTR100	100% *Landolphia togolana* powdered root
MEL100	100% of melon also served as control 100 (MTS 100%).
MLT50	50% of melon and 50% of *Landolphia togolana* root extract
MLT30	70% of melon and 30% of *Landolphia togolana* root extract
MLT20	80% of melon and 20% of *Landolphia togolana* root extract

MLT = Methanol Landolphia togolana; LTR = Landolphia togolana Root

The ingredients for *Landolphia togolana* used in the soup preparation is as follows: *Landolphia togolana* root flour (1000g), Melon/soup (1000 g), Chicken/beef (1000 g), Tomatoes (500 ml); pepper (250 g), locust beans (10 g), salt (5 g), palm oil/ vegetable oil (250 ml), stock (75 ml), onions (20 g), dry fish/bush meat (250 g).

Data Analysis

Data collected was analyzed using SPSS (Version 20). All values were presented using means and standard deviation. Wilcoxon sign test analysis was used for organoleptic testing scores, mean differences and standard deviation for the general acceptability of the soup thickener samples. Data was further subjected to analysis of variance (ANOVA) for significant difference at 0.05 on the products attributes, color/appearance, aroma, taste and texture and general acceptability.

Results and Discussion

Nutrient's composition of *Landolphia togolana* root determined in this study are moisture content, Ash, lipid, Carbohydrate, Fibre and Protein, Minerals, vitamin A, B, E and C using different extraction methods

The nutrients composition of the dried pulverized root powdered (Sample A) and methanol extract (Sample B) of *Landolphia togolana* root is presented in Table 1. The result shows that the moisture content of samples A and B were 2.73 % and 11.62 % respectively. High moisture content promotes susceptibility to microbial activity (Ponnusha *et al.*, 2011). It was reported in insects and plants disease control manual (2018) that plant material with a level of moisture higher than 8% promotes invasion of insects. Therefore, sample A shows minimal risk of spoilage or being contaminated with bacteria and fungi while sample B has faster tendency to acquire microbial growth. Rapid drying of this component is recommended to prevent microbial attack. Ash content of sample A (17.43 %) was found to be higher than sample B (11.05 %). This implies that Sample B had a higher mineral concentration in the root. *Observation from this study* correlates with previous work by Odoh and Agbachi (2020) for ash content of *Landolphia owanriensis.* The level of the ash contents of a plant suggested the availability of inorganic constituents which is subsequently confirmed by the considerably high content of mineral compositions. Lipid in sample B (9.64 %) was twice of sample A (4.52 %). The lipid content of sample B had more fat. Lipids is a source of energy in food substance. It yields over 9 cal/g compared to carbohydrates and proteins that yield about 4 kcal/g. Digestible carbohydrates are another source of energy in the diet. Sample A had higher carbohydrate content of (40.03%) compared to sample B (27.17). One of the metabolic consequences of high carbohydrate food is the increased risk of the development of insulin resistance and diabetes (Schulze and Hu, 2005). Also, *Landolphia togolana* contains very high amounts of fibre 33.25 and 31.51% in samples A and B respectively. The presence of fibre aids digestion and bowel movement. The root can form viscous gels which bind glucose and lipids, retarding their absorption from the intestinal mucosa into the blood (Mazhar *et al.*, 2018). Crude protein was 8.00% and 2.63% in samples A and B respectively. According to the guidelines for dietary protein intake, 0.8 g per kilogram of body weight (g/kg BW/d) daily was recommended for humans regardless of age or gender (Richter *et al.*, 2019)

Table 2: Nutrients Composition of *Landolphia togolana* root

Nutrients Composition	Amount (%)	
	Sample A	Sample B
Moisture Content	2.73±0.01[a]	11.62±0.11[b]
Total Ash	11.05±0.02[a]	17.43±0.05[b]
Crude Fibre	33.67±0.04[a]	31.51±0.21[b]
Lipid	4.52±0.01[a]	9.64±0.12[b]
Carbohydrate	40.03±0.25[a]	27.17±0.32[b]
Protein	8.00±0.01[a]	2.63±0.02[a]

Values are expressed as Mean ± SEM, n=3. Values with different lowercase letters are significantly different between means pÂ0.05.

Mineral contents of *Landophia togolana* root using different extraction methods

Mineral composition of *Landolphia togolana* is presented in Table 2. Iron (Fe) and copper (Cu) had the highest (36.30 mg/kg) and lowest (1.7 mg/kg) mineral content. The value obtained for Iron is higher than that of *Landolphia owariensis* in the report of Igwenyi and Akubugwo (2010). Also, the values obtained for Iron (Fe) is far above the RDA of 8 mg/day for adult male and up to 28 mg/day for pregnant women. Zinc content of *Landolphia togolana* obtained in this study is higher (13.00 mg/kg) when compare with that of *Landolphia owariensis* as reported in the report of Odoh and Agbachi (2020). The recommended daily intake of Zinc and copper is 8 mg/kg and 0.9 mg/day. The value obtained for copper is in this study is quite lower than that reported by Odoh and Agbachi (2020) in mineral composition of *Landolphia owariensis* seed. Also, manganese (Mn) in this study (13.3 mg/kg) was lower when compared to 227.3 mg/kg in melon seed thickener in the report of Jacob *et al*. (2015). The recommended RDA of Mn is 2.3 mg for adult males, 1.8 mg for adult females, 2 mg for pregnant women and 2.6 mg for lactating mothers (Freeland-Graves, 2016).

Macronutrients: The result of macronutrient is presented in Table 3. The values of some macronutrients were 45.51mg/100g (carbon), 0.52 g/100g (Sulphur), 0.98 g/100g (nitrogen), 0.11 g/100g (fluorine), 0.86 g/100g (calcium), 0.79 mg/100g (magnesium), 3.94 g/100g (potassium) and 1.92 mmol/L (sodium). Calcium plays an important role in the formation and function of bones, muscles and prevents high blood pressure and depression. However, the value of calcium in this study is lower when compared with daily Recommended Dietary Allowance (RDA) of 1000 mg/day for males and females aged 19-30 years. More so, the presence of magnesium and sodium shows that *Landolphia togolana* could be crucial in ensuring proper fluid balance, nerve transmission and muscle contraction while the fluoride is essential element in the formation of bones and teeth.

Table 3: Estimation of the Mineral Content of *Landolphia togolana* Root Extract

Element	Amount (%)	Element	Amount (mg/kg)
Carbon	45.51	Sodium	19.24
Sulphur	0.52	Copper	1.7
Nitrogen	0.98	Iron	36.3
Calcium	0.86	Sodium	19.24
Magnesium	0.79	Zinc	13.0
Potassium	3.94	Manganese	13.3
Fluorine	0.11	Aluminum	2.48

Vitamin compositions of *Landophia togolana*

The result of the vitamins composition is presented in Table 4. Vitamin E had the highest concentration of 52.98 µg/100 g. This suggests that the *Landophia togolana* is highly rich in vitamin E. This is in contrast with the report of Odoh and Agbachi (2020) for vitamin composition of *Landolphia owenriensis*. ã-carotenoid showed highest concentration of 16.097 µg/100 g compared to á and â carotenoid. Thus, the extract is also a rich source of vitamin A which compares with standard vitamin A (Axerophtol) with a ratio of 1:4. Among the vitamin (B-Complex), thiamine (39.284 µg/100 g) had the highest concentration, followed by pyridoxine (20.857 µg/100 g), folic acid (15.899 µg/100 g) and cyanocobalamin (10.329 µg/100 g), while the least concentration was niacin (0.0183 µg/100 g). Pyridoxine (vitamin B6), thiamine (vitamin B1), folic acid (vitamin B9),and niacin values are like that of *Landolphia owariensis* seed in the report of Odoh and Agbachi, (2020).

Table 4: Estimation of the Vitamin Content of *Landolphia togolana* Root Extract

Vitamins (μg/100g)					
A		**B**		**E**	
α-carotenoid	0.358	Niacin	0.018	α-tocopherol	52.98
β-carotenoid	0.867	Pyridoxine	20.857		
γ-carotenoid	16.096	Thiamine	39.284		
Axerophtol	0.001	Folic Acid	15.899		
α-carotenoid	0.358	Cyanocobalamin	10.329		
		Niacin	0.018		
		Riboflavin	0.060		

Table 5: DPPH Activity of Different Concentrations of Ascorbic Vitamin —C acid and Extract From the root of *Lanolphia togolana*

Concentration(μg/mL)	% Inhibition of methanol Extract of *Lanolphia togolana*	% Inhibition of Ascorbic acid (Standard)
20	84.8±0.03a	65.59±0.01a
40	97.8±0.04b	96.97±0.07a
60	100.1±0.05b	98.53±0.01b
80	98.7±0.02b	98.82±0.08a
100	101.2±0.25b	99.41±0.01b

Values are expressed as Mean±SEM, n=3. Values with different lowercase letters are significantly different between means pÂ0.05

DPPH was used to determine the activities of different concentrations of vitamin C in the extract from the root of *Landolphia togolana* and it showed that the methanol extract of the root of *L. togolana* demonstrated remarkable and dose dependent increase in radical scavenging activity. The methanol extract of the root of *Landolphia togolana* showed the highest inhibition percentage (100.1%) at 60 μg/ mL concentration compared to standard ascorbic acid with inhibition percentage of 98.53 %.

Sensory Evaluation of *Landolphia togolana* soup

The result of the mean score of the sensory evaluation of the soup is presented in Table 5. Considering the aroma, sample MLT20 ((8.08±1.05) was most preferred and slightly above MEL100 (8.00±1.09). The variations in the preference for aroma of *Landolphia togolana* root powder may be due to some of the panelists' first experience of tasting *Landolphia togolana* root powder. However, the findings agreed with Akubugwo and Ugbogu (2007) who reported an odourless aroma for *Landolphia owariensis* at room temperature. Also, sample MLT20 showed a higher value (7.80±1.21) in texture compared to other samples formulated with Landolphia togolana root. Although, the texture decreased from 7.80 to 7.60 and 7.56 in MLT50 and MLT30 respectively, *Landolphia togolana* soup (MLT20) is still texturally desired because of the closer values. The values were statistically insignificant ($P < 0.05$). More so, taste evaluation shows MEL100 and MLT20 had same values (8.02). Higher composition of *Landolphia togolana* into soup leads to further reduction in the desire for taste. The taste of MLT20 is same as whole melon soup (MEL100). The higher the concentration *Landolphia togolana*, the lower the taste. MEL100 was the most preferred among the samples for colour. Increase in the concentration of *Landolphia togolana* in soup leads to colour changes and this leads to reduction in desirability. The colour decreased in the order of MLT20 > MLT30 > MLT50. Acceptability showed that consumer had preference for whole melon soup (MEL100) without being formulated with *Landolphia togolana*. The higher the

Landolphia togolana content, the lower the acceptability. The results show that 100% melon was the most preferred and accepted sample. Among soup formulated with *Landolphia togolana* sample, the most preferred and acceptable is MLT20.

Table 6: Mean Score of The Sensory Parameters Of Soup

Samples	Aroma	Texture	Taste	Colour	Overall
MEL100	$8.00^{a}\pm1.09$	$7.82^{a}\pm1.14$	$8.02^{a}\pm0.94$	$8.20^{a}\pm1.31$	$8.08^{a}\pm0.99$
LTR100	$7.64^{a}\pm1.74$	$7.38^{a}\pm1.89$	$7.36^{b}\pm2.09$	$6.80^{c}\pm2,51$	$7.40^{b}\pm2.08$
MLT50	$7.66^{a}\pm1.22$	$7.60^{a}\pm1.39$	$7.78^{ab}\pm1.33$	$7.46^{bc}\pm1.52$	$7.54^{ab}\pm1.46$
MLT30	$7.88^{a}\pm1.12$	$7.56^{a}\pm1.26$	$7.60^{ab}\pm1.41$	$7.56^{ab}\pm1.45$	$7.84^{ab}\pm1.11$
MLT20	$8.08^{a}\pm1.05$	$7.80^{a}\pm1.21$	$8.02^{a}\pm1.20$	$7.82^{ab}\pm1.30$	$8.04^{a}\pm1.11$

Values are means ± SD. Means in the same column having different superscript are significantly (< 0.05) different

CONCLUSION

The nutrients compositions of *Landophia togolana* root and sensory qualities of soup formulated with *Landophia togolana* powder for post-partum mothers was carried out in this study. Extraction methods has effect on nutrients qualities of *Landophia togolana* plant root. Methanol-extracted *Landophia togolana* had higher moisture, ash and lipids than dried pulverized root which contains higher contents of crude protein, carbohydrates and fibre. The plant is a good source of iron (Fe), carbon (C), as well as Vitamins A (carotenoid), B (Thiamine), E (tocopherol) and Vitamin C Soups formulated with 20% of *Landophia togolana* was highly desired by panelists. Based on these qualities, it is recommended that consumption of soups formulated with *Landophia togolana* should be encouraged among post-partum mothers.

References

Akubugwo, I.E., & Ugbogu, A.E. (2007). Physicochemical studies on oils from five selected Nigerian plant seeds. *Pakistan Journal of Nutrition*, *6*(1), 75-78.

Altuntuð, K., Anik, Y., & Egel, E. (2018). Traditional practices of mothers in the postpartum period: Evidence from Turkey. *African Journal of Reproductive Health*, *22*(1), 94-102

AOAC (2005). *Official Methods of Analysis of the Association of Official Analytical Chemists International.* USA: Maryland.

AOAC. (2003). *Official Methods of Analysis of the Association of Officials Analytical Chemists.* 17th Edn., Arlington, Virginiall

Ene-Obong, H., Onuoha, N., Aburime, L., & Mbah, O. (2013). Chemical composition and antioxidant activities of some indigenous spices consumed in Nigeria. *Food Chemistry*, 238, 58–64.

Freeland-Graves, J.H., Mousa, T.Y., & Kim, S. (2016). International variability in diet and requirements of manganese: Causes and consequences. *Journal of Trace Elements in Medicine and Biology, 38, 24–32.*

Igwenyi, O., & Akubugwo, E.I. (2010). Analysis of four seeds used as soup thickeners in the Southeastern part of Nigeria. *International Conference on Chemistry and Chemical Engineering*, 2010, pp. 426-430.

Insect and Plant Disease Control Manual (2018). Published by University of Tennessee Institute of Agriculture, PB1690. Retrieved from https://extension.tennessee.edu/publications/documents/pb1690.pdf

Kossivi, D., Amegnona, A., & Messanvi, G. (2015). Antioxidant and toxicological studies of ethanolic root extract of *Byrsocarpus coccineus. Journal of Medicinal Plants Research, 9*(36), 940-949.

Luo, B., Li, F., Ahmed, S., & Long, C. (2019). Diversity and use of medicinal plants for soup making in traditional diets of the Hakka in West Fujian, China. *Journal of Ethnobiology and Ethnomedicine, 15*(1), 1-15.

Lykke, A.M., & Padonou, E.A. (2019). Carbohydrates, proteins, fats and other essential components of food from native trees in West Africa. *Heliyon, 5*(5)..

Mahomoodally, M. F. (2013). Traditional medicines in Africa: An appraisal of ten potent African medicinal plants. *Evidence-Based Complementary and Alternative Medicine, 2013, 1–14.*

Mazhar, M., Ahmad, M., Mumtaz, S.M., & Kumar, Y. (2018). Indian medicinal herbs-useful in diabetes. *Hosp. Pharm*. 2018, 13, 33

Odoh, U.E. & Agbachi, B.C. (2020). Phytochemical, proximate and nutritive composition analyses of the seed of *Landolphia Owariensis P. Beauv*. (*Apocynaceae*). *World Journal of Innovative Research (WJIR), 8*(5), 104-109.

Offia-Olua, B.I. (2014). Chemical, Functional and Pasting Properties of Wheat and Walnut Flour. *Food and Nutrition Sciences, 05*, 1591-1604

Persoon, J.G.M., van Dilst, F.J.H., Kuijpers, R.P., Leeuwenberg, A.J.M., & Vonk, G.J.A. (1992). The African species of *Landolphia P. Beauv*. series of revisions of Apocynaceae XXXIV, Wageningen Agricultural University Papers 92-2 (1992), 1-234.

Ponnusha, B. S., Subramaniyam, S., Pasupathi, S., Subramaniyam, B., & Virumandy, R. (2011). Antioxidant and antimicrobial properties of glycine max-A review. *International Journal of Current Biological and Medical Science, 1*(2), 49–62.

Richter, M., Baerlocher, K., Bauer, J.M., Elmadfa, I., Hesekera, H., Leschik-Bonnet, E., Stangl, G., Volkert, D., & Stehle, P. (2019). Revised reference values for the intake of protein. *Annals of Nutrition Metabolism*, *74*, 242–250.

Schulze, M.B., & Hu, F.B. (2005). Primary prevention of diabetes: what can be done and how much can be prevented? *Annual Review of Public Health*, 26: 445–467 doi: 10.1146/ annurev.publ.health.