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Functional and Pasting Properties, Mineral and Antinutrient Contents of *Telfairia Occidentalis(Cucurbitaceae) Seed* Flours Commonly Used in Cameroon

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Abstract As part of the valorization of the seeds of *Telfairia occidentalis* (fluted pumpkin) from the Centre region of Cameroon, their functional and rheological properties, mineral and antinutrient compositions were determined using standard methods. The results showed that the functional properties of this defatted seed flours had 100% emulsifying capacity, 12.5% foaming capacity, 543.3% water absorption capacity and 30% oil absorption capacity. The solubility was 2.58 and the swelling capacity was 83.39. The pasting properties of the sample revealed a pasting time of 12.33 min and temperature of 49,97°C. The values of the breakdown, final, setback and maximum viscosities are greater than 40 cP with the maximum value of 187.5 cP. *T. occidentallis* seed flour was found to be rich in K, Fe, Zn, Cu and Mn, for 100g of the flour can cover the recommended daily allowances for these minerals for most age groups of people. The Antinutrient composition of the seed flours revealed 11.12 for phytate, 250.50 for oxalate, 14.10 for trypsin inhibitor and 15.07 mg/100g dry weight for cyanide. These values are far below the toxic levels for these antinutrients. *Telfairia occidentalis* seed flour can therefore be used as thickener, emulsifier and mineral supplements in food formulations, in order to help fight against hidden hunger.

Keywords: *Telfairia occidentalis seeds, defatted flours, functional properties, pasting properties, minerals, antinutrients*

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1. Introduction

Plants of the Cucurbitaceae family, are a family of broadleaf plants with about 800 species divided into 130 genera [1]. They are cultivated mainly for their nutritional, industrial and medicinal importance [2]. The marketing of Cucurbit fruits is a significant source of income for the farmers. Their seeds are good sources of proteins, fats, carbohydrates, minerals and vitamins [3,4]. These seeds can be used to prepare a number of foods including flours and sauces [5].

*Telfairia occidentalis (*the fluted pumpkin) is a tropical and subtropical plant that belongs to the Cucurbitaceae family, *T. occidentalis* is an annual plant, produced in the forest areas of West and Central Africa [6]. It is a very important plant for food and health and is widely cultivated for its palatable and nutritious leaves. It contains significantly higher amount of vitamin C, total flavonoid and phenolic compounds and inhibits more free radicals than *Psidium guajava* stem bark [7]. The leaves of *T. occidentallis* when compared with other tropical vegetables have high nutritive value. Its protein content (21 %) is higher than those of other commonly used leafy vegetables. The leaves are rich in vitamins and minerals such as calcium, potassium and iron. They are also rich in proteins (29%), minerals and vitamins (20%) and contain some amount of fats (8%) [8]. The seeds are also eaten as food. The oil obtained from the seed is used in cooking. Its seeds are natural sources of proteins, phytosterols, polyunsaturated fatty acids, phytochemicals, sterols, antioxidant vitamins such as carotenoids and tocopherol and trace elements such as zinc and selenium [9]. Due to Africa's rapidly growing population and the increasing demand for agricultural by-products, the search for local health promoting, readily available, cheaper metabolite-rich plant sources are needed.

T. occidentalis seeds have been shows to have a good nutritional potential (rich in lipids, proteins and carbohydrates) [10]. Very little research has been conducted on the functional, pasting properties, mineral and antinutrient content of these seeds use in Cameroun. The exploitation of the multiple uses of this plant seeds and their industrial applications therefore depends on the knowledge of these parameters. This work was conducted with the objective to promote the utilization and consumption of *T. occidentallis* seeds specifically in food supplementation.

2. Materials and Methods

Collection of Sample

Telfairia occidentalis fruits were harvested from farmer fields on the outskirts of the city of Yaoundé and identified by comparison with the specimen of the National Herbarium of Cameroon and then quickly transported to the laboratory. The fruits were identified in comparison with the Westphal material, 9285 of the specimen in the National Herbarium collection number 424721 HNC.

Sample preparation

The fruits of *T. occidentalis* were washed with clean tap water, rinsed with distilled water and allowed to air dry at room temperature. The fruits were opened with a clean knife, the seeds extracted and washed with distilled water. After drying in the air at room temperature for one week, the seeds were decorticated, crushed. The powders obtained were divided into two batches. One batch of powder was defatted in a solvent mixture of dichloromethane and methanol (70/30 v/v) [11] for functional and pasting analysis. The other one (undefatted) was used for mineral and antinutrient composition. The whole and defatted powders of the seed were stored in air-tight plastic bags at 4 °C for further analysis.

2.1 Technological Properties of Defatted Powders of *T. occidentalis*

Water absorption (WAC) and oil absorption capacity (OAC).

These parameters were determined using the method described by [12] modified by [13]. One gram of each sample was respectively mixed with 10 ml of sunflower for the oil absorption capacity (OAC) or distilled water for the water absorption capacity and incubated in a water bath at 30° C for 30 min. The mixture was centrifuged at 4500 g for 15 min. The volume of water or oil absorbed was measured. The WAC and OAC were calculated as follows:

$$\mathbf{WAC/OAC}(\%)=\frac{\left[\left(\mathbf{V_i}-\mathbf{V_f}\right)*100\right]}{V_i}$$

where: Vi = Initial volume of water/oil, Vf = volume of water/oil after centrifugation.

Solubility

The solubility of *T. occidentallis* defatted seed flour were determined by heating a flour-water slurry (0.35 g of flour in 12.5 mL of distilled water) in a water bath at 60 °C for 30 min, with constant stirring [14]. The slurries were centrifuged at 168 g for 15 min, the supernatant was decanted into a weighed evaporating dish and dried at 100 °C for 20 min. The difference in weight of the evaporating dish was used to calculate flour solubility.

$$\%\text{solubility}=\frac{\text{weight of the soluble sample}}{\text{weight of the sample}\left(\text{dry basis}\right)}*2*100$$

Whit 2 like dilution factor.

Swelling capacity (SC).

The swelling capacity of the flour was determined according to the method described by [15] modified by [13]. Flour solution (10%) (w/v) was prepared and incubated in a water bath for 30 min at 30°C. The mixture was centrifuged at 4500 g for 15 min. The swelling capacity (SC) was estimated as the difference between the weight of the sample that has retained water (W_1) and that of the initial sample (W_0). The SC was calculated using the following formula:

$$\mathbf{SC}(\%)=\frac{\left[\left(\mathbf{W_1}-\mathbf{W_0}\right)*100\right]}{W_1}$$

Emulsion activity (EA) and stability (ES).

The emulsion activity (EA) was determined according to the method of Beuchat [16] while its stability was evaluated as described by Kinsella [17]. 1g of flour was mixed with 3 ml of distilled water and 3 ml of refined palm olein in a graduated centrifuge tube. After stirring for 10 min using a vortex, the mixture was centrifuged at 3500g for 30 min and the emulsion's height measured. For emulsion stability (ES), the tubes were first heated at 80°C for 30 min before centrifugation.

EA and ES were calculated as follows:

EA (%) = He/Hw x 100
ES (%) = Hes/Hws x 100

Where: He = Height of the emulsified layer in cm; Hw = Total height of the liquid in the tube in cm; Hes = Height (in cm) of the emulsified layer after stirring and centrifugation); Hws = Total height (in cm) of the liquid in the tube after heating

Loose and packed bulk density

Some 20 g of sample was poured into a 100 ml measuring cylinder, and the volume occupied by the sample was noted. After that, the sample in the measuring cylinder was beaten 100 times, and the volume recorded. The loose and packed densities were calculated according to [18] as follows:

Loose density = Weight of Sample/Volume occupied by the sample.

Packed density = Weight of Sample/Volume occupied by the sample after beating.

Hausner ratio and porosity.

Hausner ratio was calculated as the proportion of loose and packed bulk densities. Hausner ratio = Packed density/Loose density Whereas the porosity was determined using the formula: porosity in percentage = (Loose density - Packed density)/Loose density multiply by 100.

Foaming Capacity and Stability

The foaming capacity (FC) and stability (FS) of the flour was estimated by the method of [19]. 5 g of flour sample were put into clean, dry and graduated 250 mL cylinders. The samples were gently leveled and the volumes noted. 100 mL of distilled water was added. The cylinder was swirled and foam volumes were recorded after 30 s.

The FC was expressed as percentage increase in foam volume measured after homogeneisation, and FS was determined by measuring the FC after standing for 10, 30 and 60 min.

$$\mathrm{FC}(\%)=\frac{\left[\left(\mathrm{V}_1-\mathrm{V}_0\right)*100\right]}{V_0}$$

$$\mathrm{FS}(\%)=\frac{\left[\left(\mathrm{V}_t\right)*100\right]}{V_0}$$

$V_{1:}$ volume after homogeneisation, V_0: initial volume of foam, V_t: foam volume after time t

Pasting properties

Flour gelation is applied in many industrial food applications. For some polysaccharides and protein-rich materials, the Rapid Visco Analyser (RVA) is emerging as such a tool which may provide fundamental information about application potential of a raw material through pasting characteristics of the flour**.**

The evaluation of the apparent viscosity of the defatted powder of the seeds was done using a Rapid Visco Analyser device (RVA-4 model 4D, New Port Scientific, Sydney, Australia). By definition, the RVA is a heating and cooling viscometer that measures the viscosity of a sample over a period of time while it is agitated [20]. This device subjects the sample in solution in excess water, to constant agitation and records the evolution of the viscosity of the paste during different phases of heating, temperature maintenance or cooling. RVA uses two scales (time and/or temperature) on the abscissa and viscosity on the ordinate.

Procedure:

A suspension of 12.5% (3.5 g of dry matter in distilled water for a total weight of 28g) of flour sample contained in an aluminum bottle, was maintained for 1 minute at 50°C. then heated to 95°C for 5 minutes at 9°C / min. The suspension was maintained at this temperature for 2 minutes, then cooled to 50°C for 5 minutes at the rate of 9°C / min and then maintained again at 50°C for 1 min. Data were collected on pasting temperature, pasting time, maximum viscosity, breakdown viscosity, final viscosity and Setback viscosity.

2.2. Mineral Content of the Whole Seeds of *Telfairia Occidentallis*

The powder sample was incinerated at 550°C for the determination of minerals. The ash was dissolved with 10 ml HCl 20% and filtered for the quantification of minerals. Magnesium, calcium, sodium, zinc, manganese, copper, iron, potassium were quantified using an atomic absorption spectrophotometer (Varian 220FS Spectra AA, Les Ulis, France). The colorimetric method of vanadomolybdate was used for the determination of phosphorus according to AOAC procedure 965.17 [21]. The mineral content of each sample was obtained from the calibration curve of the standard minerals.

2.3. Antinutrients in the Whole Seeds of *Telfairia Occidentallis*

Phytate

Phytate content was determined according to the method described by [5]. Briefly, 2 g of the sample was soaked in 100 ml of 2% HCL for 3 hr and filtered with Whatman no 1 filter paper. 25 ml of the filtrate was transferred into another conical flask and into it; 5 ml of 0.3% ammonium thiocyanate solution plus 53.3 ml of distilled water was added. The solution was titrated against standard iron III chloride solution (0.001 95 g of iron per mL) until a reddish brown colour which persisted for 5 min was obtained. Phytate content was calculated as:

Phytate (%) = Titre value × 0.001 95 × 1.19 × 100.

Oxalate

The oxalate content was determined as described by [22]. Briefly, 1 g of sample was weighed into a conical flask containing 75 ml of 3 M H_2SO_4. The solution was properly mixed and filtered. 5 ml of the filtrate was heated to 90°C and then titrated against 0.05 M of KMnO4 until there was a colour change which persisted for about 30 s. The oxalate content was calculated by taking 1 ml of 0.05 M of KMnO4 as equivalent to 2.2 mg oxalate.

Cyanogen

The cyanide content of the sample was determined according to the spectrophotometeric method of [23]. 3g of sample were extracted with 15 ml of 0.1M orthophosphoric acid. The extract was put in a tight closed vessel and placed in a refrigerator until required for analysis.

Trypsin inhibitor

The trypsin inhibitor activity was measured by inhibiting the activity of trysin. A synthetic substrate (BAPNA) was subjected to hydrolysis by trypsin to produce yellow-coloured p-nitroanilide. The degree of inhibition by the extract of the yellow colour production was measured at 410 nm using a spectrophotometer [24].

Statistical Analyses

The variable distribution was assessed using the Shapiro-wilk test. The results were expressed as mean ± standard deviation and data obtained were analyzed using one-way analysis of variance (ANOVA) with the help of IBM SPSS package, version 22.0.

3. Results and Discussion

3.1. Functional and Pasting Properties of Defatted Seed Flours of *T. occidentalis*

The functional properties of food matrices are mainly due to their constituents and predict their behaviour during the processing and preservation of the food [25]. The functional properties of the defatted seed flours of *T. occidentalis* are presented in Table 1.

Table 1. Functional properties of defatted seed flours of *Telfairia occidentalis*

Parameters	Values
Emulsion (%)	100 ± 0.00
Emulsion stability (%)	100 ± 0.00
Foaming capacity (%)	12.49 ± 1.47
Foaming stability (%)	3.89 ± 0.96
Water Absorption Capacity	543.30 ± 13.32
Oil Absorption Capacity (%)	29.67 ± 4.041
Solubility index (%)	2.58 ± 0.35
Swelling capacity (%)	83.39 ± 0.85
Loose Buck density (g/ml)	0.26 ± 0.001
Packed density (g/ml)	0.30 ± 0.01
Hausner ratio	1.19 ± 0.01
Porosity (%)	16.2 ± 0.67

Values are means ± standard deviations (SD)

The emulsion activity (EA) and stability (ES) of the defatted seed flours of *T. occidentalis* are 100% (Table 1). These values are higher than 29.99% and 14.67% reported for *Citrullus lanatus* seeds [25]. The differences in the emulsifying properties of flours are related to the protein contents (soluble and insoluble) and other components such as starch and fat [26], the differences in the emulsifying properties of flours are related to the protein contents (soluble and insoluble) and other components (starch, fat…). The emulsifying properties are usually attributed to the flexibility of solutes and exposure of the hydrophobic portions. Food emulsions are thermodynamically unstable mixtures of immiscible liquids. The formation and stability of emulsions is very important in food systems such as salad dressing [27]. The capacity of these seed flours to enhance the formation of emulsions and their stability is important for many applications such as in cakes, coffee whiteners and frozen desserts.

The Foaming capacity of *T. occidentalis* seed flours (Table 1) is 12.49%. The ability of the flours to form foam depends on the presence of flexible molecules like proteins and carbohydrates which may decrease the surface tension of water and the solubility [28].

The foam stability of defatted *T. occidentallis* seed flours (Table 1) is 3.89%. The success of a whipping agent depends on its ability in maintaining the whip as long as possible.

Foaming capacity (FC) is the volume of foams relative to the total volume. Foam formation and stability involve the diffusion of soluble molecules to the air/water interface. **Foam stability (FS)** is measured as the percentage of stable foams (remaining) to the percentage of initial foams. According to the results in Table 1, *T. occidentalis* seeds form foams and this ability to form stable and consistent foams is important in the preparation of cakes, fillings, desserts such as puffed products. These seeds would find their importance in bakery, pastry and dairy.

The Water absorption capacity of *T. occidentalis* seed flours is 543.30% (Table 1). This indicates that *T. occidentalis* flour has hydrophilic compounds such as polysaccharides and proteins. The functional properties of food matrices depend on their chemical composition [29]. Water absorption capacity plays a major role in the texture of various foods including ground meats and bakery doughs. Water imbibition without flour dissolution leads to an increase in properties such as consistency, thickening, viscosity and adhesion [30]. The value obtained with *T. occidentalis* seed flours in this study is higher than 125.0% [31] obtained with the defatted seeds of *Cucumeropsis mannii* from Nigeria. The results of this study show that this defatted seeds can lead to an increase of the water content of the products in which they are incorporated and can also limit the water losses during cooking.

The oil absorption capacity (OAC) of defatted *T. occidentalis* seed flour is 29.67% (Table 1). This value is lower than 184.0% and 195.38% for the defatted seed flours of *Cucurbita maxima* and flutted pumpkin respectively [31,32]. These variations in the OAC might be partially due to the different proportions of non-polar side chains of the amino acids on the surfaces of their protein molecules. OAC is defined as the difference in the flour weight before and after its oil absorption [33]**.** It is of great importance, since oil acts as a flavour retainer and also increases the soft texture to mouth feel in foods, especially bread and other baked foods [34]. It is also important because of its storage stability, especially in relation to the development of rancidity [35]. The ability of this *T. occidentalis* flour to bind oil makes it very useful in Food Technology for oil retention and therefore could to be suitable for retaining food flavours.

Solubility index

The solubility index of the defatted seed flours of *T. occidentalis* is 2.58 g/g (Table 1). The functional properties of foods such as emulsions, foams and gels depend on their solubility [30]. Flour solubility is one of the functional properties usually determined during the development and testing of a new flour or flour composite. Solubility in foods is a chemical and functional property referring to the ability of a given food substance to dissolve in a solvent, usually water or oil. This characteristic is measured and determined in terms of the maximum quantity of solute dissolved in a given solvent at equilibrium. It is due to the chemical composition of the matrice or to the quality of flour particles [36]. Solubility is a property used in brewing. The sample studied in this work can be easily incorporated in some beverages and food preparations.

Swelling capacity (SC)

The swelling capacity of the defatted seed flours of *T. occidentalis* seed is 83.39%. (Table 1). The swelling capacity is considered as a quality parameter in some food formulations such as bakery products. It is a clear evidence of the presence of low energy bonding between molecules within the food product. The consistency of a food product is associated to its swelling and water absorption capacities [37]. The SC is due to the presence of substrates like proteins and polysaccharides that capture water. The swelling capacity has been shown to be affected by the source, size, temperature, pH and ionic strength [37].

The packed and loose bulk densities (BD)

The loose bulk and packed densities of *T. occidentalis* seed flour are 0.26 g/ml and 0.30g/ml respectively (Table 1). These values are lower than 0.68–8.88 g/ml and 0.50–0.58 g/ml for *Citrullus lanatus* and maize powders respectively [25,38]. A lower loose BD implies that less quantity of the food samples would be packaged in constant volume, thereby ensuring an economical packaging. However, the packed BD would ensure more quantities of the food samples being packaged, but less economical [39]. However, the packed BD would ensure more quantities of the food samples being packaged, but less economical. The loose bulk and packed densities are very important parameters for packaging requirement [40]. From a technological point of view, these two parameters depend on the size of the particles of the powder. When the particle size is very low, both packed and loose bulk densities increase. This is because the increase in contact surface is correlated to the cohesive and frictional forces that help in resisting flowability and compaction capacity and shape of particles [41]. However, high bulk densities of flours generally reflect their suitability to be used in food_preparation. In this light, the values obtained in this study suggest that the flours from this sample can be used as thickening agents which are important factors taken into consideration while feeding children or convalescent peoples, since it reduces paste thickness [42].

Porosity

The porosity of the defatted flour of *T. occidentalis* seed is 16.20 (Table 1). Porosity and bulk densities are important parameters for the determination of the storage, transportation and packaging conditions of foods [43]. Porosity measures the voids between solid particles of a substance. The pores can be filled with liquids such as gas or water. In Food Technology, pores should be continuous [44]. A high porosity is the ability of these samples to form more pores and therefore render them lighter and more suitable for storage, transportation and packaging.

Hausner ratio

The Hausner ratio of defatted *T. occidentallis* seed flour is 1.19 (Table 1). Hausner ratio of 1–1.25 identify powders with excellent and near free flowing [37]. The Hausner ratio generally measures the compaction and compression related to inter particle friction. The sample in this study had hausner ratio between 1 and 1.25 hence, are excellent or near free flowing. Hausner ratio greater than 1.25 generally indicates a fair to free-flowing powder [42].

Pasting properties of the sample

The Rapid Visco Analyser (RVA) test, gives the mashing process of a flour and water slurry subjected to agitation and heat. Pasting properties are greatly influenced by the plant source, starch content, interaction among the components, and testing conditions [45].

T. occidentalis defatted seed flour showed 187.5, 43 and 181 cP respectively for peak, setback and final viscosities (Table 2). These values are lower than (2803, 217 and 1223 cP) obtained with *Cucumeropsis mannii* defatted seed flour [46]. The low peak viscosity indicates the high shear stability of the sample. The parameter, setback, is a range where retrogradation occurs. The low set back value of the flour in this study indicates that their pastes would have a high stability against retrogradation and syneresis. Setback, defined as the difference between the breakdown viscosity and the viscosity at 50 °C, determines the tendency of starch to retrograde.

Table 2. Pasting properties of *T. occidentalis* defatted seed flour

Parameters	values
Time (min)	12.33 ± 0.28
Final viscosity (cP)	181 ± 0.00
Pasting temperature (°C)	49.97 ± 0.03
Setback viscosity (cP)	43 ± 9.90
Breakdown viscosity (cP)	41.5 ± 2.12
Maximal viscosity (cP)	187.5 ± 0.71

Values are means ± standard deviations (SD)

The higher the setback value, the lower the retrogradation during cooling and the lower the staling rate of the products made from the flour.

Breakdown viscosity of the sample is 41.5 cP. It measures the ability of the paste to withstand and disrupt during cooling and an estimation of the resistance of the paste to disintegration in response to heat and shear. Lower breakdown viscosity showed greater resistance which would be expected of flours with lower peak viscosities. Final viscosity indicates the ability of the material to form a viscous paste or gel after cooking and cooling.

The pasting temperature of flour varied in the same direction as the peak and final viscosities and this value is 49.97°C (Table 2). Pasting temperature depends on the size of the starch granules in the flour. Small starch granules are more resistant to rupture and loss of molecular order [47]. High pasting temperature indicates more resistance to swelling.

The peak time that measures the cooking time of *T. occidentalis* defatted seed flour is 12.33 min (Table 2). The higher peak time obtained with our sample than 7.20 min obtained with *Cucumeropsis mannii* defatted seed flour [46] indicates a greater structural rigidity of *T. occidentalis* defatted seed flour.

3.2. Mineral Composition of Whole Seeds of *T. occidentalis*

Minerals are inorganic substances needed in small amounts for normal growth and functioning of the body. They are involved in the synthesis reactions of various metabolic pathways of compounds like vitamins, enzymes and hormones. They are involved in water regulation, acid-base balance, nerve transmission and muscle contraction in the body.

Depending on the proportions needed in the body, minerals are generally divided into 2 groups: The main elements or macrominerals, whose daily intake is in grams, (calcium, phosphorus, chlorine, potassium, sodium, magnesium) and trace elements, whose contributions are less than a 100mg such as zinc, copper, iodine and manganese.

The calcium level of *T. occidentalis* seeds is 128 mg/100g. This value is higher than (63.73 mg/100g [48]. obtained with musk melon seeds. Calcium is necessary for the development of teeth, bones and the release of hormones [49]. The daily requirement of calcium is 200 - 1300 mg for children and 1000 - 1300 mg for adults [50], therefore these seeds should be prepared and consumed with calcium-rich foods for a good nutritional balance.

Table 3. Mineral composition of whole seeds of *T. occidentalis*

Minerals	Values (mg/100g dry weight)
Calcium	128.0 ± 1.00
Magnesium	160.38 ± 0.60
Phosphorus	397.60 ± 1.78
Potassium	1057.23 ± 2.02
Sodium	74.32 ± 0.87
Iron	4.82 ± 0.00
Zinc	6.88 ± 0.76
Copper	11.81 ± 0.11
Manganese	14.45 ± 0.09

Values are means ± standard deviations (SD)

The magnesium content of our sample is 160.38 mg/100g. This value is higher than 20.46 mg/100g obtained for melon seeds [51]. Magnesium is very important for cellular function. It is closely related to calcium and phosphorus with about 70% found in the skeleton. It is an essential enzyme activator. It also facilitates the transmission of nerve impulses in humans [52]. Daily magnesium requirements range from 30 - 130 mg for children and 240 to 420 mg for adults [50]. The results of this study show that *T. occidentalis* seeds can be considered a source of magnesium for children.

The phosphorus content of *T. occidentalis* seeds flour is 397.60 mg/100g (Table 3). This value is lower than 1364 mg/100g [10] obtained with fresh *Telfairia occidentalis* seeds. Phosphorus has more functions than many other minerals in the human body. It forms complexes with calcium that helps strengthen bones. 80% of this mineral is found in skeletal tissue. Phosphorus acts as a cofactor for many enzymes and activates many B-complex vitamins. It also influences the production of protein and adenosine triphosphate, which is essential for energy storage [53]. The phosphorus level found in these seeds is below the RDA for phosphorus which is 1200 mg/100g [54]. Thus 100 g of *T. occidentalis* seeds from this study can cover about 1/4 the recommended daily phosphorus requirements for humans.

The Potassium content in *T. occidentalis* seeds is 1057.23 ± 2.02mg/100g. Potassium is the main intercellular cation and, together with sodium, plays a very important role in regulating water, electrolyte and acid-base balance in the body [55]. In addition, potassium lowers blood pressure, influences the contractility of skeletal and cardiac smooth muscles, and affects the excitability of nervous tissue [56]. The value obtained with these seeds is within the RDA range for potassium (300 to 4700 mg/100g) [57]. The seeds of *T. occidentalis* can be considered as a source of potassium, for the consumption of 100g of these seeds can cover the daily needs for potassium.

The sodium content of *T. occidentalis* seeds is 74.32 mg/100g. (Table 3). This value is higher than (16.10mg/100g) [25] obtained with *Citrullus lanatus* seeds but lower than (82.200mg/100g) [48] found in *pumpkin* seeds. Excessive consumption of sodium in food promotes high blood pressure or oedema in some people. The daily sodium needs range from 1000-1500 mg/day for children, men and women. These seeds have low sodium level, hence their consumption can play a role in controlling blood pressure.

The iron content of the seeds of *T. occidentalis* is 4.82 mg/100g (Table 3). This is lower than 10.22 and 20.25mg/100g for watermelon and pumpkin seeds respectively [48]. Iron is an essential mineral for the production and proper functioning of hemoglobin, a protein responsible for oxygen transport in the body. Iron deficiency leads to anemia. Therefore, iron can prevent some iron deficiency anemias [58] because it is a member of the heme group whose function is to transport oxygen in the body. It also plays a very important role in oxidation and reduction reactions [59]. The values obtained in this study are within the RDA for iron (0.27 - 27 mg/ 100g) [57]. Nevertheless, these seeds should be consumed with iron-rich foods for better nutritional balance.

The zinc content of *T. occidentalis* seeds (Table 3) is 6.88 mg/100g. This value is lower than 21.05 mg/100g for melon seeds [51], but much higher than 0.05 mg/100g obtained with fresh *T. occidentalis* seeds [10]. More than 80 enzymes in the body require zinc as a prosthetic group [50]. Along with vitamin A, zinc plays a role in dark adaptation and night vision. It is involved in nucleic acid and protein metabolism and is a good antioxidant [60]. It is also necessary for the body's defenses (immune system). It plays a role in cell division, growth and wound healing. The zinc levels in our sample are within the RDA ranges of 3mg/day for children but lower than 8 and 13 mg/day for men and women respectively [50].

The Copper level of *T. Occidentalis* seed flour is 11,81 mg/100g (Table 3). Copper helps the body to use iron and sugar properly. It is also necessary for bone growth and nerve function. Deficiency in this mineral can lead to anemia or osteoporosis. This value is higher than the RDA for copper of 1.5-3 mg per day for adult men and women. These seeds are therefore potential sources of copper.

The manganese level of *T. occidentalis* seed flour used in this study is 14.45 mg/100g. This value is two times that obtained with *pumpkin* seeds (7 mg/100g) [48], but is lower than 22.73 mg/100g for melon seeds [51]. Manganese plays a role in enzyme activation, contributes to digestion, amino acid and protein utilization. It also maintains the health of bones, blood vessels and nerves, prevents cardiovascular diseases and osteoporosis. The RDA values of manganese are 1.2, 1.9, 2 mg/day for children, men and women, pregnant women respectively [50]. The manganese content of *T. occidentalis* seeds is higher than these RDA values so the consumption of 100g of this seed flour will largely cover the daily manganese needs of individuals of all age groups.

3.3. Antinutrients Contents in the Whole Seeds of *T. occidentallis*

Antinutrients are natural constituents of foods that inhibit digestion and absorption of nutrients in the digestive tract. These compounds reduce the nutritional value of foods and the bioavailability of certain compounds or inhibit enzymes necessary for digestion [61]. The results of the antinutrients analysed in mg/100g of dry weight for *T. occidentalis* whole seed flour are represented in Table 4.

Table 4. Antinutrient contents in *Telfairia occidentalis* seed flour

Antinutrient	Value (mg/100g)
Phytates	11.12 ± 3.50
Oxalates	250.50 ± 10.39
Trypsin inhibitor	14.10 ± 0.50
Cyanide	15.07 ± 0.29

Values are means ± standard deviations (SD) of three determinations

The Phytate level in *T. occidentalis* seeds flour is 11.12 mg/100g. This value is higher than that of watermelon seeds (0.63mg/100g) [62] but lower than 30 mg/100g for watermelon seeds [63]. Phytic acid is widespread in the plant kingdom. When present in food, it can form complexes with proteins and divalent cations. Phytates bind and form complexes with proteins and minerals which affect digestibility, solubility, protein function, and absorption of certain minerals such as iron and calcium [64]. An intake of 4-9mg/100g of phytate is said to decrease iron absorption by 4-5 folds in humans [65]. So the low content of phytate in the sample is beneficial.

The seeds of *T. occidentalis* contain a significant amount of **oxalates** (250.5 mg/100g (Table 4). This result is higher than 26. 40 mg/100g [51] and 48 mg/100g [63] for watermelon seeds. Oxalic acid is an organic diacid whose structure has only two carbon atoms. It is present in the free state and mainly in the form of salts, both in the plant and animal kingdom. The harmful aspects of oxalic acid are at two levels: it limits the biological use of calcium, proteins and can lead to the formation of kidney stones. Protein-oxalate interactions are formed via divalent ions like calcium ions. Under suitable conditions, oxalic acid is negatively charged, electrostatically attracting the calcium ions which carry positive charges. This leads to the formation of the oxalate - calcium complex. Oxalic acid in solution can react directly with proteins and thus prevent their hydrolysis by peptide enzymes. The lethal level of oxalate in man is 3-5g [66]. The value obtained with *T. occidentalis* seeds is much lower (250.5 mg or 0.25g) than toxic levels. Also these seeds are consumed cooked and the processing steps also help to further significantly reduce the content of oxalate [62].

The trypsin inhibitor level in *T. occidentalis* seeds is 14.10 ± 0.50 mg/100g (Table 4). This value is lower than 74 mg/100g [67] obtained with *tofu* prepared from 6 days sprouted soybean. Trypsin inhibitors are plant proteins that reduce the biological activity of trypsins by controlling the activation and catalytic reactions of proteins [68]. Trypsin is an enzyme involved in the degradation of many proteins mainly during digestion in humans and animals. However, the processing steps for *T. occidentalis* seeds will significantly reduce this antinutrient in these seeds before consumption.

The Cyanide content in *T. occidentalis* seeds is 15.07mg/100g (Table 4). This result is higher than 0.79mg/100g [62] for watermelon seeds but lower than the recommended safety limit for cyanide in food (20mg/100g) [50]. Variations in HCN content may be due to genotype, cultivar and environmental conditions such as soil type, moisture, temperature, maturity level, nutritional status of the plant, weather conditions at harvest, application of inorganic fertilizers and environmental pollution. Cyanide is a toxic compound derived from the decomposition of cyanogenic glycosides that limit the use of certain substances in foods. Endemic goiter and tropical ataxic neuropathy are neurodegenerative diseases associated with the consumption of cyanide-containing foods. The levels obtained with *T. occidentallis* seeds are below the WHO recommended toxicity limits, indicating that it can be directly used in food applications.

4. Conclusion

This study which was aimed at determining the functional and pasting properties of the defatted seed flour, the mineral and antinutrient contents of the whole seed flours of *T. occidentalis* revealed that: *T. occidentalis* defatted seed flours have good emulsifying capacity (100%), good water absorption capacity (543.33%) and good swelling capacity (83.39%).The seed flour showed a pasting time of 12.33 min, at a temperature of 49,97°C and maximum viscosity of 187.5 cP, indicating that *T. occidentalis* seed flour has good rheological properties, thus has potential for use as a functional ingredient in soups, frozen dessert and bakery and pastry applications.

The whole seed flour has high levels of potassium and phosphorus, but low sodium level. This is important in regulating blood pressure. The seeds are also good sources of trace elements such as iron, zinc, copper and manganese, which could aid in blood building, body defense, bone growth and nerve function respectively, and also to prevent these mineral deficiencies. The antinutrient contents (phytate, cyanide, trypsin inhibitor and oxalate) are below the levels for them to be toxic. Based on these results, *T. occidentallis* seed flour has a good potential to be used as an ingredient in the formulation of many food products. It can greatly contribute to cover the recommended daily allowances for K, Fe, Zn (for children), Cu and Mn, hence, helping to fight against hidden hunger

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References

[1] Najafi, N.S., Sanadgol, B.S., Nejad, M.A., Beiragi E., Phytochemical screening and antibacterial activity of *Citrullus colocynthis* (Linn.) Schrad against *Staphylococcus aureus*, *Journal of Medical Plants Research*, 4. 2321-2325. 2010.

[2] Mogotlane, E.A., Phatlane, W.M., Phetole, M., Comparative analysis of the chemical compositions of indigenous watermelon (*Citrullus lanatus*) seeds from two districts in Limpopo Province, South Africa, *African Journal of Biotechnology*, 17. 1001-1006. 2018.

[3] Akuamoah, F., Odamtten, G.T., Kortei, N.K., Influence of gamma irradiation on the colour parameters of dry smoked shrimps (*Penaeus notialis*), *Food Research*, 2. 350-355. 2018.

[4] Falade, O.S., Otemuyiwa, I.O., Adekunle, A.S., Adewusi, S.A., Oluwasefunmi, O., Nutrient composition of watermelon (*Citrullus lanatus* (Thunb.) Matsum. &Nakai) and egusi melon (*Citrullus colocynthis* (L.) Schrad.) seeds, *Agricuture Consp Science*, 85. 43–

49. 2020.

[5] Talabi, J.Y., Olukemi, A.O., Ajayi, O.O., Adegoke, G.O., Nutritional and antinutritional compositions of processed Avocado (*Persea americana Mill*) seeds, *Asian Journal of Plant Sciences and Research,* 6. 6-12. 2016

[6] Oyeleke, G.O., Olagunju, E.O., Ojo, A., Functional and Physicochemical Properties of Watermelon (*Citrullus Lanatus*) Seed and Seed-Oil, *Journal of Applied Chemistry,* 2. 29-30. 2012.

[7] Aminu, M., Mada, S.B., Olagunju, A., Muhammad, A., Bala, S.M., Garba, A., Abdullahi, M., Mustafa, S., Nasir, N.H., Ahmadu, H., Aliyu, S., Comparative in vitro Antioxidant Studies of Ethanolic Extracts of *Psidium guajava* Stem Bark and *Telfairia occidentalis* Leaf, *International Journal of Modern Biochemistry*, 1. 18-26. 2012.

[8] Ndor, E., Dauda, S.N., Garba, M.N., Performances de croissance et de rendement de la citrouille cannelée (*Telfairia occidentalis* Hook F.) sous engrais organique et inorganique sur les ultisols du centre –nord du Nigeria, *Journal International des sciences des plantes et des sols,* 2. 212-221. 2013.

[9] Aghaei, S., Nikzad, H., Taghizadeh, M., Azami, T.A., Taherian, A., Protective effect of Pumpkin seed extract on sperm characteristics, biochemical parameters and epididymal histology in adult male rats treated with Cy clophosphamide, *Andrologia*, 46. 927-935. 2014.

[10] Achu, M.B.L., Djuikwo, R.V., Tamo, S.G., Fotso, C.L.M., Fowe, M.C.D., Fokou, E., Physical Characteristics and the effect of Boilling and Fermentation on the Nutritional Value of *Telfairia occidentalis* Seeds, *Jounal of Agricultural Chemistry and Environment*, 10. 389-401. 2021.

[11] Xanthopoulou, M.N., Nomikos, T., Fragopoulou, E., Antonopoulou, S., Antioxidant and lipoxygenase inhibitory activities of *pumpkin* seed extracts, *Journal of Food Research International*, 42. 641-646. 2009.

[12] Lin, M.J.Y., Humbert, E.S., Sosulski, F.W., Certain functional properties of sunflower meal products. *Journal of Food Science*, 39. 368–370. 1974.

[13] Tambo, T.S., Klang, J.M., Ndomou, H.S.C., Teboukeu, B.G., Womeni, H.M., Characterization of corn, cassava and commercial flours: use of amylases rich flours of germinated corn and sweet potato in the reduction of the consistency of the gruels made from these flours-influences on the nutritional and energy value, *Food Science and Nutrition*, 7. 1190–1206. 2019.

[14] Crosbie, G.B., The relationship between starch swelling properties, past viscosity and boiled noodle quality in wheat flours, *Journal of Cereal Science*, 13. 145–150. 1991.

[15] Okezie, O., Bello, A., Physicochemical and functional properties of winged beans flour and isolate compared with soy isolate, *Journal of Food Science*, 53. 450–454. 1988.

[16] Ubbor, S.C., Akobundu, E.N.T., Quality characteristics of cookies from composite flours of watermelon seed, cassava and wheat, *Pakistan Journal of Nutrition*, 8. 1097-1102. 2009.

[17] Siddiq, M., Ravi, R., Harte, J.B., Dolan, K.D., Physical and functional characteristics of selected dry bean (*Phaseolus vulgaris L.*) flours, *LWT-Food Science and Technology*, 43. 232-237. 2010.

[18] Okaka, J., Okorie, P., Ozo, O., Quality evaluation of sun dried yam chips, *Tropical Science,*31: 265–275. 1991.

[19] Narayana, K., Rao, M.S.N., Effect of partial proteolysis on the functional properties of Winged Bean (*Psophocarpus tetragonolobus*) flour, *Journal of Food Science*, 49. 944-947. 1984.

[20] Gamel, T.H., Abdel-Aal, E.S.M., Wood, P.J., Ames, N.P., Tosh, S.M., Application of the Rapid Visco Analyzer (RVA) as an effective rheological tool for measurement of ß-glucan viscosity, *Cereal Chemistry*, 89. 52–58. 2012.

[21] A.O.A.C., Official methods of analysis 14th Edition, Association of Official Analytical Chemists, Washington D.C., U.S.A., 2005.

[22] Ohikhena, F.U., Olubunmi, A.W., Afolayan, A.J., Proximate Composition and Mineral Analysis of *Phragmanthera capitata* (Sprengel) Balle, a Mistletoe Growing on Rubber Tree, *Research Journal of Botany, 12. 23-31.* 2017.

[23] Esser, A.J.A., Bosveld, M., VanderGift, R.M., Voragen, A.G.J., Studies on the quantification of specific cyanogens in cassava products and introduction of a new chromogens, *Journal of Science and Food Agricuture*, 63. 287 – 296. 1993.

[24] Sadasivam, S., Manickam, A., Phenolics. In: *Biochemical methods for agricultural sciences, Wiley Eastern Ltd, New Delhi, India,* 187-188. 1992.

[25] Niangoran, A.M., Dué, E.A., Koné, F.M.T., Kouamé, L.P., Functional Properties of Seed Flours from Differents Cultivars of *Citrullus lanatus* (*Cucurbitaceae*) cultivated in Côte d'Ivoire, *International Journal of Research Studies in Agricultural Sciences*, 1. 32-48. 2015.

[26] Jiang, H., Du, S-k., Yu, X., Jane, J-l., Physicochemical and functional properties of whole legume flour, *LWT-Food Science and Technology*, 55. 308-313. 2014.

[27] Fekria, A.M., Isam, A.M.A., Suha, O.A., Elfadil, E.B., Nutritional and functional characterization of defatted seed cake flour of two Sudanese groundnut (*Arachis hypogaea*) cultivars, *International Food Research Journal*, 19. 629-637. 2012.

[28] Tijani, A.O., Bakare, H.A., Babajide, J.M., Adebukunola, M.O., The effect of processing parameters on the functional and pasting properties of breadfruit (*Artocarpus Altilis*) "elubo" flour *Croatia Journal of Food Sciences and Technology*, 9. 31–39. 2017.

[29] Harijono, T.E., Saputri, D.S., Kusnadi, J., Effect of blanching on properties of water yam (*Dioscorea alata*) flour, *LWT-Food Science and Technology*, 40. 1723–1731. 2013.

[30] Moure, A., Sineiro, J., Domínguez, H., Parajó, J.C., Functionality of oilseed protein products: A review, *Food Research International*, 38. 945–963. 2006.

[31] Ogunbusola, M.E., Fagbemi, T.N., Osundahunsi, O.F., Chemical and functional properties of full fat and defatted white melon (*Cucumeropsis mannii*) seed flours, *Journal of Food Science and Engineering,* 2. 691–696. 2012.

[32] Noumo, N.T., Pierre, D.M., Atsadjieu, N.L.T., Carl, M.F.M., Functional properties of *Cucurbita maxima Duchense*, *Cucumeropsis mannii Naudin* and *Lagenaria sciceraria* (***Molina***) Standley defatted seed flours, *Food Measure*, 2017.

[33] Giami, S.Y., Okonkwo, V.I., Akusu, M.O., Chemical composition and functional properties of raw, heat-treated and partially proteolysed wild mango (*Irvingia gabonensis*) seed flour, *Food Chemistry*, 49. 237-243. 1994.

[34] Eke-Ejiofor, J., Physico-chemical and pasting properties of starches from cassava, sweet potato and three leaf yam and their application in salad cream production, *International Journal of Biotechnology and Food Science*, 3. 23–30. 2015.

[35] Siddiq, M., Ravi, R., Harte, J.B., Dolan, K.D., Physical and functional characteristics of selected dry bean (*Phaseolus vulgaris L.*) flours, *LWT-Food Science and Technology*, 43. 232-237. 2010.

[36] Asmeda, R., Noorlaila, A., Norziah, M.H., Effects of different grinding methods on chemical and functional properties of MR211 rice flour, *International Journal of Food Engineering,* 1. 111–114. 2015.

[37] Tonfack, D.F., Cecile Mazarine, M.N., Eric, S.N., Bernard, T., Stephano, T.T., Aduni, U.A., Hilaire, M.W., Effect of different processing methods on the proximate composition, mineral content and functional properties of snail (*Archachatina marginata*) meat, J*ournal of Agriculture and Food Research, 8. (100298).* 2022.

[38] Adedeji, O.E., Oyinloye, O.D., Ocheme, O.B., "Effects of germination time on the functional properties of maize flour and the degree of gelatinization of its cookies," *African Journal of Food Science,* 8. 42-47. 2014.

[39] Steve, I.O., Influence of germination and fermentation on chemical composition, protein quality and physical properties of wheat flour (*Triticum aestivum*), *Journal of Cereals and Oil seeds*, 3. 35-40. 2012.

[40] Oppong, D., Arthur, E., Kwadwo, S.O., Badu, E., Sakyi, P., Proximate composition & some functional properties of soft wheat flour. *International Journal of Innovative Research, Technological Science and Engineering*, 4. 753–758.

[41] Perea-Flores, M., Fabela-Moron, M.F., Rayas-Amor, A.A., P´ erez-Ruíz, R.V., Ruíz-Hern´ andez, R., Linares-Violante, B., Ortega-Avil´es, M., Barba-Bellettini, M., P´erezAlonso, C., Physical-chemical properties and microstructural characterization of traditional mexican chili (*Capsicum annuum L.*) powders, *Agropastoral Productividad*, 14. 47–58. 2021.

[42] Eltayeb, Ali A.O., Abou-Arab, A.S., Chemical composition and functional properties of flour and protein isolate extracted from Bambara ground nut (*Vigna subterranean*), *African Journal of Food Science,* 5. 82–90. 2011.

[43] Drakos, A., Andrioti-Petropoulou, L., Evageliou, V., Mandala, I., Physical and textural properties of biscuits containing jet milledrye and barley flour, *Journal of Food Science and Technology*, 56. 367–375. 2019.

[44] Kumar, M., Saini, R., Reflection and refraction of waves at the boundary of nonviscous porous solid saturated with single fluid and a porous solid saturated with immiscible fluids, *Latin American Journal of Solid Structure*, 13. 1299–1324. 2016.

[45] Liu, Q., Donner, E., Yin, Y., Huang, R.L., Fan, M.Z., The physicochemical properties and in vitro digestibility of selected cereals, tubers and legumes grown in China, *Food Chemistry,* 99. 470–477. 2006.

[46] Noumo, N.T., Pierre, D.M., Tatsadjieu, N.L., Carl, M.F.M., Functional properties of *Cucurbita maxima Duchense*, *Cucumeropsis mannii* Naudin and *Lagenaria sciceraria* (*Molina*) Standley defatted seed flours, *Food Measure,* 2017.

[47] Zeng, F., Liu, H., Liu, G., Physicochemical properties of starch extracted from *Colocasia esculenta* (L.) Schott (*Bun-long taro*) grown in Hunan, *China Starch/Stärke*, 65. 1–7. 2013.

[48] Gade, S.R., Meghwal, M., Prabhakar, P.K., Giuffrè, A.M., A Comparative Study on the Nutritional, Antioxidant, Thermal, Morphological and Diffraction Properties of Selected *Cucurbit* Seeds, *Agronomy*, 12. 2242. 2022.

[49] Beto, J.A., Le rôle du calcium dans le vieillissement humain. *Clinical Nutrition Research,* 4. 1-8. 2015.

[50] FAO-OMS., Human vitamin and mineral requirements. Report of a joint FAO/OMS expert consultation Bangkok, Thailand, 2001, 281.

[51] Jacob, A.G., Etong, D.I., Tijjani, A., Proximate, mineral and anti-nutritional compositions of melon (*Citrullus lanatus*) seeds. *Britich Journal of Research*, 2. 142–151. 2015.

[52] Steinberg, F.M., Bearden, M.M., Keen, C.L., Cocoa and chocolate flavonoids: implications for cardiovascular health. *Journal Am Diet Association*, 103. 215–223. 2003.

[53] Food and Nutrition Board. Phosphorus: Dietary Reference Intakes: Calcium, Phosphorus, Magnesium, Vitamin D, and Fluoride, *National Academy Press, Washington D.C*., 1997, 146–189.

[54] Idris, S., Compositional Studies of *Telfairia Occidentalis* Leaves, *American Journal of Chemistry,* 2. 56-59. 2011.

[55] Otten, J.J., Hellwig, J.P., Meyers, L.D., Dietary Reference Intakes: the Essential Guide to Nutrient Requirements. *National Academies*

[56] Institute of medicine. Reference Intakes for Water, Potassium, Sodium, Chloride, and Sulfate, The National Academies Press, Washington, DC., 2005.

[57] Danso, J., Francis, A., Reindorf, B., John, B., David, B.K., Effect of drying on the nutrient and antinutrient composition of *bombax buonopozense* sepals, *African Journal of Food Science,* 13. 21-29. 2019.

[58] Djikeng, F.T., Womeni, H.M., Edem, V., Morfor, T.A., Tiencheu, B., Hako, T.A.B., Boungo, G.T., Houketchang, S.N., Karuna, M.S.L., Ngoufack, F.Z., Effect of Boiling and roasting on lipid quality, proximate composition, and mineral content of walnut seeds (*Tetracarpidium conophorum*) produced and commercialized in Kumba, South-West Region Cameroon, *Food Science and Nutrition*, 6. 417–423. 2017.

[59] Lukaski, H.C., Vitamin and mineral status: effects on physical performance. *Nutrition*, 20. 632–644. 2004.
[60] Viteri, F.E., Berger, J., Importance of pre-pregnancy and pregnancy iron status: can long-term weekly preventive iron and folic acid supplementation achieve desirable and safe status, *Nutritional Review*, 63. 65–76. 2005.

[60] Farah, B.S., Caractérisation du comportement des micronutriments d'intérêt et des composés antinutritionnels des pois chiches et du niébé au cour des procédés de transformation. Informations et ressources scientifiques sur le développement des zones arides et semi-arides, Institut des régions chaudes (IRC) *SupAgro Montpellier*, 2015.

[61] Egbuonu, A.C.C., Nzewi, D.C., Effect of soaking prior to oven-drying on some nutrient and anti-nutrient properties of bitter yam (*Dioscorea dumetorum*). *Journal of Nutrition and Food Science*, 4. 2014.

[62] Addo, P.W., Agbenorhevi, J.K., Adu-Poku, D., Antinutrient contents of watermelon seeds. *MOJ Food Process Technology,* 6. 237−239. 2018.

[63] Montesano, D., Blasi, F., Simonetti, M.S., Santini A., Cossignani, L., Chemical and nutritional characterization of seed oil from *Cucurbita maxima L.* (var. Berrettina) pumpkin, *Foods*, 7. 30. 2018

[64] Hurrell, R.F., Juillerat, M.A., Reddy, M.B., Lynch, S.R., Dassenko, S.A., Cook, J.D., Soy protein, phytate and iron absorption in man, *American Journal of Clinical Nutrition*, 56. 573–578. 1992.

[65] Munro, A.D., Bassir, D.N., Oxalate in Nigerian vegetables, *African Journal of Biological and Applied Chemistry*, 12. 14 – 18. 1969.

[66] Sumaiya, A.Z., Asmaul, H.N., Poly, K., Abir, H., Fahad, J., Delara, A., Anisur, R.M., Effects of sprouting of soybean on the anti-nutritional, nutritional, textural and sensory quality of tofu. *Heliyon*. 8. 2405-8440. 2022.

[67] Aviles-Gaxiola, S., Chuck-Hernandez, C., Serna Saldivar, S.O., Inactivation methods of trypsin inhibitor in legumes: a review. *Journal of Food Science*. 3. 17-29. 2018.

[68] Alipour, H.J., Shabanpoor, B., Shabani, A., Mahoonak, A.S., Effects of cooking methods on physico-chemical and nutritional properties of *Persian sturgeon Acipenser persicus* fillet, *International Aquatique Research*, 2. 15–23. 2010.