Physicochemical, phytochemical and functional properties of whole and defatted tea (*Camellia sinensis*) seed flour

**Abstract**

Whole and defatted Tea (*Camellia sinensis*) seed flour (TSF) were subjected to physicochemical, phytochemical and functional characterization with a view to harnessing its edibility and industrial applications. The results of the study showed that TSF contains appreciable amount of protein, fat, ash, crude fiber and carbohydrate. Whole flour (WF) of tea seed gave higher percentage than DF for some of the parameters that were examined. The energy value of WF (2075.7 KJ/100g) was higher than for DF (1680.7 KJ/100g). Tea seed flour (TSF) was also a good source of mineral element such as magnesium (155.7mg/100g for WF, 134mg/100g for DF), and potassium (23.44mg/100g for WF and 15.74mg/100g for DF). Phytochemical/antinutritional component analysis showed the presence of saponin, alkaloid, flavanoid, phenols and terpenoid etc. Flavanoid content in WF (0.75mg/g) was higher than DF (0.49 mg/g). A total antioxidant in WF (2.26 mg/g) was also higher than that obtained for DF (1.92 mg/g). Alkaloid in DF was 2.02 mg/g while it was 2.04 mg/g for WF. Bulk density, solubility, swelling capacity, water absorption capacity (WAC), oil absorption capacity (OAC) of DF were significantly higher than for WF, thus indicating their good functional properties, that can be harnessed in foods as well as other industrial applications. These quality characteristics of DF and WF show that great potentials abound for Tea seed.

**Key words:** Tea seed flour, flavanoid, bulk density, phytochemical, carbohydrate.

**Introduction**

Seeds and nuts flours from edible plant materials have over the years, received much attention. This may be due to their increasing utilization in fabricated foods. Most of these materials are inherently endowed with proteins and other nutritive ingredients that make them suitable for this purpose. The ultimate goal of utilizing seed and nut flours from plant material as ingredients depends to a large extent on the benefits they have on foods, which are also a function of their nutrients, functional and physicochemical characteristics (Aluko and Yada, 1995; Shadrach et al., 1999).

Tea has both therapeutic and prophylactic benefits to humans. This includes its anti oxidants properties which helps to improves body resistant to bacterial infection, reduces the incidence of diabetics, inhibits growth of cancer cells, and increases body’s immunity against viral infection. It is a cardio-protective agent; it is an anti-inflammatory and anti-fibrotic agent (Aroyeun et al., 2013). Tea is an important source of caffeine which has mild stimulating effect on the central nervous system. It increases mental alertness and improves heartbeat and breathing rate thus helps to reduce the incidence of hypotension (Sowumi et al., 2009). The health-promoting effects of green tea are mainly attributed to its polyphenol content.

The seed of Tea (*Camellia sinensis*) has been over the years underutilized and unexploited. In Nigeria for example, the seed has received little or no attention. Its origin can be traced back to South-east Asia. Tea cultivation...
in Nigeria is restricted to the upland of the Mambilla plateau and its production figure is great, therefore accounting for the world production figure of 3.6 million tons a year (FAO, 2006). The increased production of Tea invariably results in generation of large quantities of their seeds as by-products. It therefore becomes necessary that the components of these seed be determined to be able to elucidate their potentials for human and/or animal diets. Adequate information on the potentials of these seeds such as their chemical (essential nutrient), phytochemicals and functional properties will create awareness on the possible use of this material in food processes.

Plant foods are embedded with bioactive compounds in addition to those which are traditionally considered as nutrients, such as vitamins and minerals. These physiologically active compounds are simply referred to as ‘phytochemicals’, and these are produced via secondary metabolism in relatively small amounts. Until fairly recently, they have been generally assumed to be irrelevant, sometimes even harmful, to human health (Rodriguez et al., 2006). The number of identified phytochemicals has increased dramatically over the years. Some phytochemicals with known health benefit include carotenoids, phenolics (flavonoids, phytoestrogens, phenolic acids), phytosterols and phytostanols, tocotrienols, organosulfur compounds (allium compounds and glucosinolates) as well as nondigestible carbohydrates (Rodriguez et al., 2006; Hertog et al., 1995; Arts and Hollman, 2005; Kushi et al., 2012). Functional component represents those non-conventional biomolecules present in food which can modulate one or more metabolic processes in the body that result to improved health (Swanson, 2003). Research has shown a positive correlation between functional components in food, health and well-being (Shibamoto et al., 2008). These properties (solubility, foamability and oil absorption capacity etc.) most times are the intrinsic physicochemical characteristics that affect the behavior of food systems during processing and storage. This study reports the Physicochemical, Phytochemical, and functional properties of Tea Seed flour.

**MATERIALS AND METHODS**

**Physicochemical properties**

**Processing of Camellia seed flour**

Tea seeds were collected from a substation of the Cocoa Research Institute of Nigeria. The seeds were well dried and kept until ready for use. The dried seeds were roasted at 105°C after which it was blended. The blended Tea seed, Tea Seed Flour (TSF) was divided into two parts – one part, the whole flour (WF) and the other part, defatted flour (DF) was expressed of its oil. 

**Proximate composition analysis**

**Moisture content:** This was carried out using the methods of Association of Analytical Chemist (AOAC). 1 g of TSF in a previously weighed crucible was introduced in an oven at a heating temperature of 105°C for 24 h. The content was cooled and weighed again. Percentage moisture was determined as follows:

\[ \text{Moisture content} \% = \frac{W2 - W3}{W2 - W1} \times 100 \]

where W1 and W2 represent the weight of the crucible and weight of the crucible after drying at 105°C and sample, respectively while W3 is the weight of the crucible and the sample after cooling.

**Crude protein:** This was estimated using the micro-Kjeldahl method as described by Pearson (1976). To 3 g of TSF was added 10 ml H2SO4 and digested for 1 h, 30 min. Water (40 ml) was added and distilled using a Kjeldahl distillation Unit (Model unit B – 316) that contained 40% NaOH and Millipore water. Ammonia liberated was collected in 20 ml boric acid with bromocresol green and methyl red indicators and titrated against 0.04 N H2SO4. Blank solution was also prepared. Percent crude protein was estimated as:

\[ \text{Crude protein} (\%) = \frac{\text{Sample titer–blank titer } \times 14 \times 6.25}{\text{Sample weight}} \times 100 \]

where 14 is the molecular weight of nitrogen and 6.25 is the nitrogen factor.

**Ash content:** This was carried out according to AOAC (Association of Analytical Chemists) numbers 923.03 and 984.27 (AOAC 2005). 2 g of TSF was placed into a previously weighed crucible. This was incinerated in a muffle furnace at 600°C. Percentage ash content was calculated as follow:

\[ \text{Ash} (\%) = \frac{w2-w3}{w2–w1} \times 100 \]

Where w1 represents the weight of dried, ignited, and cooled crucible, w2 the weight of the crucible and sample after incinerating at 600°C, while w3 the weight of the crucible and sample after cooling.

Crude fiber: 1 g of defatted TSF was placed in pre-weighed crucible and then attached to the extraction unit (Kjeldahl apparatus) and into this was added 150 ml of hot 1.25% H2SO4. This was digested for 30 min, while acid was removed and sample washed with hot distilled water. The crucible was oven dried overnight at 105°C, cooled, weighed, and incinerated at 550°C in a muffle furnace (MF-1-02; PCSIR Labs, Lahore, Pakistan) overnight and weighed.
again after cooling. Percentage extracted fiber was calculated as:

\[
\text{Crude fiber} \% = \frac{\text{wt of digested sample} - \text{wt of ashed sample}}{\text{wt of sample}} \times 100
\]

**Lipid:** Lipid content was estimated using Tecator Soxtec (Model 2043) [2043001]; Hilleroed, Denmark. A mixture of TSF (1.5 g) and anhydrous sulfate (2.3 g) was placed in a thimble and covered with absorbent cotton. 40 ml of n-hexane was added to a pre-weighed cup. Both thimble and cup were attached to the extraction unit. TSF was extracted for 30 min and rinsed severally. The extracted fat was desolvatized and then placed in an oven at 105°C for 1 h, cooled and weighed. Percent fat was calculated as follow:

\[
\text{Lipid} \% = \frac{\text{wt of initial cup} - \text{wt of final cup}}{\text{wt of sample}} \times 100
\]

**Carbohydrate:** The percentage of carbohydrate in TSF was estimated by difference. This is the addition of all the percentages of moisture, fat, crude protein, ash, and crude fiber subtracted from 100%. This gave the amount of nitrogen-free extract called carbohydrate:

\[
\text{Carbohydrate} \% = 100 - (\% \text{Moisture content} + \% \text{Ash} + \% \text{crude protein} + \% \text{crude fiber} + \% \text{fat})
\]

**Mineral determination**

This was carried out according to the methods of AOAC (2005). One gram of TSF was digested with nitric/perchloric/sulfuric acid mixture in the ratio 9:2:1, respectively, and filtered. Filtrate was marked up in a 5-ml volumetric flask. Filtered solution was then introduced into an Atomic Absorption Spectrophotometer. Standard curve for each mineral was made from known standards and the mineral values of TSF were estimated against that of the standard curve. Values of Na and K were determined using a Flame photometer using NaCl and KCl as the standard (AOAC 2005).

**Phytonutrient analysis**

Tannin content of the TSF sample was determined using the methods described by Swain (1979). Into 20 ml of methanol (50%) was added 0.2 g of TSF in a 50-ml volumetric flask. This was covered and placed in a water bath at 80°C for 1 h with constant stirring. The solution was filtered and the content was made up to mark with distilled water. Into the 50-ml volumetric flask was added 1 ml of the extract, 20 ml distilled water, 2.5 ml Folin-Denis reagent, and 10 ml of 17% Na₂CO₃. The mixture was made up to mark with distilled water, and allowed to stand for 20 min until a bluish-green color developed. Standard tannic acid solutions in the range of 0 –10 ppm were treated similarly as the 1 ml sample above. The absorbance of the standard solutions as well as samples was read after colors were developed on a Spectronic 21D spectrophotometer using a wavelength of 760 nm and the percentage tannin was estimated.

The spectrophotometric method was used for saponin analysis as described by Brunner (1984) while total polyphenol was also determined according to the method outlined by Harborne (1973). Phytic acid determination was carried out using the procedure of Wheeler and Ferrel (1971). Oxalate was determined using the AOAC (2005) method. Alkaloids and Flavanoids were determined according to the method outlined by Harborne (1973).

**Functional characteristics**

The determination of the Water absorption capacity was carried out using the procedure described by Sathe et al. (1982). The result was expressed as a percentage of water absorbed by the blends on % g/g basis where density of water was assumed to be 1 g/ml. The method of Leach et al. (1959) was used to determine the swelling capacity, while the solubility was calculated after the determination of swelling capacity as per 100 g of starch on dry basis. 5 ml of aliquot of the supernatant was dried to a constant weight at 120°C. The residue obtained after drying represents the amount of starch solubilized in water using the method of Akpapunam and Markakis (1987). The procedure of Akpapunam and Markakis, (1987) was used in the determination of bulk density of the samples while, Oil absorption capacity was also determined using standard method.

**RESULTS AND DISCUSSION**

**Proximate composition analysis of tea seed flour**

The proximate composition of whole and defatted Tea seed flour is shown in Table 1. The moisture mean value of defatted flour (DF) was higher than for the whole (WF).

The value obtained in the present study is in agreement with those reported for other seeds by other researchers (Ige et al, 1984; Fagbemi and Oshodi, 1991; Oltino et al., 2007). The mean ash value of DF (6.5%) was slightly higher than for WF (5.33%). However, these values are not within the recommended value for animal feed stuff. The ash content of nuts and seeds are expected to be within the range 1.5 -2.5% to be fit for consumption as animal diet (Pomeranz and Clinton, 1981; Aremu et al., 2006). Crude protein mean values for both WF and DF were 9.4 and 9.95%, respectively. These values indicates that Tea flour is not fully laden with protein as compared with other protein rich foods such as soya bean, cowpea, melon, pumpkin,
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Table 1: Proximate composition of whole and defatted tea seed flour (TSF).

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Whole</th>
<th>Defatted</th>
</tr>
</thead>
<tbody>
<tr>
<td>Moisture (%)</td>
<td>3.93</td>
<td>6.6</td>
</tr>
<tr>
<td>Ash (%)</td>
<td>5.33</td>
<td>6.5</td>
</tr>
<tr>
<td>Protein (%)</td>
<td>9.4</td>
<td>9.95</td>
</tr>
<tr>
<td>Crude fiber (%)</td>
<td>2.13</td>
<td>2.6</td>
</tr>
<tr>
<td>Ether Extract (%)</td>
<td>28.13</td>
<td>12.38</td>
</tr>
<tr>
<td>Carbohydrate</td>
<td>51.08</td>
<td>61.97</td>
</tr>
<tr>
<td>Energy (KJ/100g)</td>
<td>2075.26</td>
<td>1680.7</td>
</tr>
</tbody>
</table>

Values are means of triplicate determinations.

Mineral composition of TSF
The mineral composition (mg/100g) of whole and defatted TSF is shown in Table 2. The most abundant minerals in TSF were magnesium (155.7 mg/100g), potassium (23.44 mg/100g), and calcium (16.16 mg/100g) while sodium, zinc and iron were limiting in abundance. Studies showed that magnesium activates many enzymes systems and this helps to maintain the electrical potentials in nerves (Ferrao et al., 1987). The ratio of Na/K and Ca/K are indication of body electrolyte balance as well as bone formation. For example, the molar ratio of Na/K in the body is relevant in the prevention and normalizing high blood pressure. Nieman et al. (1992) recommended a Na/K ratio of less than one in diets particularly for the hypertensive patient. Therefore, the observed molar ratio of Na/K (0.13 and 0.16 mg/100g) for TSF, implied that consumption of this flour or fortifying with other food ingredients will be beneficial for the hypertensives.

Phytochemical/antinutritional components of TSF
Phytochemicals represents those biologically active compounds that are present in very little amount, even though are not established, nutrients contribute significantly to the prevention and protection against degenerative diseases (Dreosti, 2000). They are natural antioxidants that provide health benefits associated with their ability to prevent damages resulting from biological degeneration. The level of phytochemicals in foods do not necessarily reflect their total antioxidant capacity, which could also depend on synergic and redox interactions among the different antioxidant molecule present in the food material. Some phytochemicals posses’ anti-nutritional properties, when ingested in large quantity. Others are minerals binders, for example, cyanide and tannins binds minerals such as calcium, iron, magnesium and zinc in the digestive tract to form insoluble salts, thereby reducing their bioavailability or absorption. Saponins also have haemolytic activity against RBC (Khalil and Eladawy, 1994).

In the present study tea seeds flours examined contained good amount of phytochemicals. Phytochemical components of whole and defatted TSF (mg/g) are shown in Table 3. The mean alkaloid value for WF and DF were 2.04 and 2.02 mg/g, respectively which are appreciable. Alkaloids belong to the heterogeneous group of naturally occurring compounds that can be found in the leaves, bark, roots or seeds of plants. They found uses therapeutically as analgesic, antimicrobial and antibacterial. Flavonoids are also known to have protective effects including anti-inflammatory, anti-oxidants, antiviral, and anti-carcinogenic properties.

Functional properties of TSF
Functional properties of foods are the intrinsic properties which may affect the behavior of food systems in the course of processing and storing food. They are properties
Table 2: Mineral composition of whole and defatted TSF (mg/100g).

<table>
<thead>
<tr>
<th>Minerals</th>
<th>Whole</th>
<th>Defatted</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sodium</td>
<td>3.06</td>
<td>2.59</td>
</tr>
<tr>
<td>Zinc</td>
<td>3.93</td>
<td>2.66</td>
</tr>
<tr>
<td>Magnesium</td>
<td>155.7</td>
<td>134.6</td>
</tr>
<tr>
<td>Iron</td>
<td>0.075</td>
<td>0.062</td>
</tr>
<tr>
<td>Potassium</td>
<td>23.44</td>
<td>15.74</td>
</tr>
<tr>
<td>Calcium</td>
<td>16.16</td>
<td>6.30</td>
</tr>
<tr>
<td>Sodium/K</td>
<td>0.130</td>
<td>0.16</td>
</tr>
<tr>
<td>Calcium/K</td>
<td>0.68</td>
<td>0.40</td>
</tr>
<tr>
<td>Sodium/Mg</td>
<td>0.02</td>
<td>0.019</td>
</tr>
<tr>
<td>Calcium/Mg</td>
<td>0.103</td>
<td>0.05</td>
</tr>
</tbody>
</table>

Values are means of triplicate determinations.

Table 3: Phytochemical/antinutritional factors of whole and defatted TSF (mg/g).

<table>
<thead>
<tr>
<th>Phytochemicals</th>
<th>Whole</th>
<th>Defatted</th>
</tr>
</thead>
<tbody>
<tr>
<td>Saponin</td>
<td>0.112</td>
<td>0.141</td>
</tr>
<tr>
<td>Terpenoids</td>
<td>2.62</td>
<td>2.68</td>
</tr>
<tr>
<td>Phytate</td>
<td>2.93</td>
<td>1.95</td>
</tr>
<tr>
<td>Oxalate</td>
<td>0.17</td>
<td>0.13</td>
</tr>
<tr>
<td>Alkaloids</td>
<td>2.04</td>
<td>2.02</td>
</tr>
<tr>
<td>Phenols</td>
<td>0.61</td>
<td>0.68</td>
</tr>
<tr>
<td>Flavanoids</td>
<td>0.75</td>
<td>0.49</td>
</tr>
<tr>
<td>Tanin</td>
<td>1.16</td>
<td>1.23</td>
</tr>
<tr>
<td>Total antioxidant</td>
<td>2.26</td>
<td>1.92</td>
</tr>
</tbody>
</table>

Values are means of triplicate determinations.

reflecting complex interactions between the composition, structure, conformation and physiochemical properties components. The knowledge of these properties is vital in their usefulness for industrial applications (Kohnhorst et al., 1990; Fasasi et al., 2006). Low bulk density could be an advantage in the digestion of food products and also in transportation cost, while relatively high bulk density could also be an advantage particularly for food products with high dispensability and reduced thickness of paste (Udensi and Eke, 2000). The suitability of flour in food applications is a function of their functional properties such as bulk density, swelling capacity, water absorption capacity, solubility, oil absorption capacity (Hernandez-Diaz et al., 2007). In the present study, the functional properties are as follows: bulk density 0.5-0.58; swelling capacity 5.1-5.14; solubility, 31.3-32.67; water absorption capacity (WAC), 78-89.7%; oil absorption capacity (OAC), 93.3-98.9. The bulk density of DF was a little higher than for WF. These values are higher than soya bean flour (0.38 g/ml) (Edema et al., 2005) and it compares favourably with the value obtained for other seed flour (Samir-El Saty et al., 2012). According to Omueti (2009), low density may sometimes be advantageous because high bulk limit the calorific and nutrient intake per feed per child and infant may not be able to consume enough to meet their energy and nutrient requirement. Bulk density of flour material also affect the amount of strength of materials used for packaging, energy density and mouth feel (Udensi and Okoronkwo, 2006). Solubility is an index of protein functionality such as denaturation and its useful applications. In the present study, WF and DF mean solubility values of 32.67 and 31.3%, respectively were obtained. The flours of tea seed have swelling capacities of 5.11 and 5.14% for WF and DF, respectively. Water absorption capacity, WAC, represents the ability of a product to associate with water under a limiting condition. It is a critical function of protein in many food products. It is also attributed to the presence of high amount of starch and fiber in particular flour. The WAC mean value for WF was 78% while that of DF was 89.7%. Water and oil binding capacity of food protein is a function of the intrinsic factor such as amino acid profile, protein conformation and surface polarity. WF and DF have good OAC as shown in Table 4. The implication of this is that they will be more useful in food systems where optimum oil absorption is desired. OAC also makes the flour suitable while enhancing flavor and mouth feel when applied in food preparation and for this reasons, they can serve as functional ingredients in foods and food applications.
Conclusion

The results of the present study showed that TSF is embedded with essential nutrients which could be beneficial for human consumption and food processing. Proximate analysis of WF and DF shows that they are embedded with appreciable amount of mineral elements. Both flours are rich sources of energy but WF gave the highest value. The presence of phytochemicals is also an indication that the flour could serve a protective and preventive purpose and could therefore be used as such. The functional properties of the flours showed that they can be incorporated into food and for other industrial applications. Flavanol was higher in the whole flour than for the defatted one. The water absorption capacity (WAC) and oil absorption capacity (OAC) of Defatted flour were higher than for whole flour.

REFERENCES

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