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Composition of Seed Flour of Selected Nigerian Tea (*Camellia sinensis*) Clones – A Comparative Study

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ABSTRACT: In the present article, six clones of Nigerian Tea (*Camellia sinensis*) were selected for comparative study. Proximate, phytochemical and functional characterization of the whole Tea seed flour (TSF) was examined. The characteristics of the expressed oil from the seed of the different clones were also carried out. Results shows that oil content ranged between 22.9% (C318) to 28.9% (C228); saponification value are in the range of 182.5 -189.2mgKOH/g. DPPH values of the resulting oils were indication of their antioxidant properties with C318 (39.17%) been the highest. The proximate analysis of TSF from the various clones revealed the presence of ash, crude fibre, protein, moisture which was within recommended limit for edible seed flour. The energy value of TSF from the entire clones were remarkable with C68 (2108.3KJ/100g) having the highest. Mineral analysis also showed that TSF contained predominantly Mg, K, and Zn. C236 gave 163.1mg/100g of Mg while C228 gave 23.6 mg/100g of K and 4.1mg/100g of Zn. The result also showed the presence of phytochemicals (Terpenoids, alkaloids, flavanoids etc) in the seed flour across the selected clones. The water absorption capacity of C228 (83.6%) and oil absorption capacity of C318 (96.6%) were remarkable. There is an indication that TSF from the clones stand better chance for potential industrial applications.

Keywords: *Clones, Mineral Elements, Oil Absorption Capacity, Protein, Tea Seed*.

Introduction

Tea (*Camellia sinensis* (L) Kuntze) is an evergreen shrub tree that produces more young shoots for tea leaves harvest which are processed as tea beverage. It is the lowest cost beverages in the world and consumed by a large number of people as one of the major components of world beverage market (Sowunmi *et al*., 2009). Commercial scale tea production started in 1982 on the Mambilla Plateau of Taraba State in Nigeria and the output is being used to feed the Nigerian Beverages Production Company (NBPC). Tea consumption has a lot of health benefits to man; some of these include its antioxidants properties which help to improve body resistant to bacterial infection, reduces the incidence of diabetics, inhibits growth of cancer cells, increases body's immunity against viral infection. It is a cardio protective agent, an anti-inflammatory and antifibriotic agent (Aroyeun *et al*., 2013).

Beside the leaves, tea also produces seeds Figure 1 which have not been fully harnessed. Previous studies shows that the seed is oil - laden which is predominantly saturated fatty acid (Yahaya *et al*., 2011).The use of seed and nuts oils as sources of vegetable oil has received wide attention over the years. Many countries including Nigeria has depended on imported oil as a major source of vegetable oil for domestic use and this exercise is rather exorbitant and uneconomical (George *et al*., 2013). Tea seed oil represents one of such oil

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which has not fully been tapped in Nigeria. It is said to be acceptable as edible oil in countries where it is abundantly cultivated (Sahari *et al*., 2004; Fazel *et al*., 2008). Plants that are rich source of oil are very important for economic growth of the agricultural sector. The oilseeds containing unusual fatty acids serves as industrial raw material, as they are used in protective coatings, plastics, plasticizers, dispersants, pharmaceuticals, cosmetics, detergents, soaps, textiles, surfactants, lubricant additives, organic pesticides, urethane derivatives and a variety of synthetic intermediates as stabilizers in plastic formulations (Hosamani *et al*., 2000).

Tea seed oil is reported to lower blood pressure and cholesterol level; it also have high content of antioxidants (polyphenols, carotenoids and vitamin E), and a rich source of emollients for skin care which help to minimize signs of aging (Fazel *et al*., 2008; Fattahi-far *et al*., 2006). The linoleic acid is an essential component of human diet (Chunhua *et al*., 1986). Fatty acid composition of oil is very important from nutritional and medical viewpoints. Previous studies (Table 1) revealed that the Tea seed oil comprises 25% saturated fatty acids and 75% unsaturated fatty acids (Yahaya *et al*., 2011).

The flour of whole tea seed has not been equally harnessed; in fact no report has shown its utilization, hence there is dearth of information on the composition of tea seed flour. Several tea clones are available in Nigeria and the need to evaluate the seeds from the nutritional stand point becomes relevant. Additionally, vegetable oils remain ideal alternatives to petroleum oil products because they are renewable and eco – friendly (Xua *et al*., 2007). The increase in oil prices coupled with environmental pollution problems occasioned by limited and nonrenewable petroleum resources has led researchers to develop and utilize renewable energy resources like tea seed especially its oil in order to diversify the energy supply. This effort will no doubt help in value addition and product diversification of tea cultivation in Nigeria.

In this work, the variability in the compositional analysis of some selected clones of tea seed in Nigeria were studied particular attention has been given to the phytonutrients and the functional characteristics of the seed flour as no such report exist. The results from the study will no doubt provide data for diverse potentials utilization of tea seed from these clones.

Table 1. Fatty acids composition of tea seed oil (Yahaya *et al*., 2011)

Fatty Acid	%
Saturated	
Palmitic (C16.0)	21.88
Stearic (C18.0)	03.76
Total	25.64
Unsaturated	
Oleic (C18.1)	60.05
Linoleiec (C18.2)	13.01
Linolenic C18.3)	00.20
Total	73.26
Others	01.07

Results are mean standard deviation of triplicate determinations.

Fig. 1. Picture of tea (*Camellia sinensis*) Seed

Materials and Methods

- *Sample preparation*

Tea seed clones (C236, C288, C143, C68, C357, C318) used for this study were obtained from the Mambilla station of the Cocoa Research Institute of Nigeria. All chemicals used in this study were of analytical grade and the reagents used were standardized. Dried tea seeds were de-husked and the husks were

carefully separated from the kernels. The desired tea seed kernels were roasted and finely ground using a kitchen blender and this constituted the tea seed flour (TSF). The ground portion for oil expression was separated and subjected to solvent extraction employing a standard soxhlet apparatus using n- hexane. Employed solid-solvent ratio was 1:20 with an extraction time of 8 h. After extraction, the hexane extract was desolvetized by rotary evaporation at 60°C using a rotor evaporator (Model R-3000, Buchi, Switzerland) and then oven dried for an hour to remove any residual solvent and to obtain the crude. The oil yield was calculated based on weight difference as follow:

Oil yield (%) = weight of oil/weight of sample × 100

- *Characterization of Tea seed oil*

Iodine value (IV): This was determined using Wijs solution as described by AOCS Official Methods of Analysis (1988), Cd 1-25 using the formula $12.69(T)(V2-V1)/W$ and the results were expressed as $gI_2/100$ g of oil, where; *W* is the weight (g) of oil, *V1* the volume (ml) of thiosulphate solution (test solution), *V2* the volume (ml) of thiosulphate solution (blank), *T* is the titre (conc.) of thiosulphate solution ($Na_2S_2O_3$)] and 126.9 being the atomic mass of iodine.

Saponification value (SV): This was determined according to AOCS method Cd 3-25 (AOCS, 1978) with slight modifications. In a a typical experiment, about 5 g of oil was weighed into a 250 ml round bottom flask. Using a volumetric flask, 50 ml of 0.5 M ethanolic KOH was added to the sample. The mixture was boiled under reflux for 1 h. The hot soap solution was then titrated with 0.5 M HCl using phenolphthalein indicator. A blank was also run in the same manner. The saponification values were calculated using the formula $56.1T (V2-V1)/W$ and reported in mgKOH/g oil. Where, 56.1 is the molecular weight of KOH, *W* is the weight (g) of fat, *V1* is the volume (ml) of HCl used in the sample, *V2* is the volume (ml) of HCl used in the blank and *T* is the concentration (mol/litre) of HCl.

Peroxide value (PV): This was carried out according to the IUPAC method 2.501 (Paquot 1979) with slight modifications. Approximately 2 g of oil was weighed into a flask. 20 ml of solvent (2:1 v/v, glacial acetic acid: chloroform) was added to the sample followed by 1 ml of freshly prepared saturated KI solution resulting to a homogenous solution. After a few minutes, 30 ml of water was added and the mixture titrated with sodium thiosulphate solution (0.01 M) using starch solution as the indicator. A blank solution was carried out in the same manner simultaneously.

The peroxide values were calculated using the equation $1000T (V1-V2)/W$ and reported in $meqO_2/kg$ oil, where: *W* is the weight (g) of oil, *V1* is the volume (ml) of $Na_2S_2O_3$ used in the test, *V2* is the volume (ml) of $Na_2S_2O_3$ used in the blank and *T* is the concentration of $Na_2S_2O_3$ (mol/l).

Free fatty acids (FFA): Free fatty acid was determined according to AOCS Ca. 5a-40 (AOCS, 1978). In this study, approximately 2 g of oil was weighed and dissolved gently in 25 ml of solvent system (96% ethanol and ethoxyethane: 1:1 v/v) neutralized just before use by titration with NaOH solution. The mixture was heated in a water bath at 60°C for 10 min. The hot fat solution was then titrated while stirring with 0.1 M NaOH using phenolphthalein indicator. Free fatty acids was calculated and expressed as percentage oleic acid using the formula $MVT/10W$, where *M* is the mean molecular weight of fatty acids, *W* is the weight of oil (g), *V* is the volume of NaOH (ml) used in titration and *T* is the concentration of NaOH.

Antioxidant capacity: The scavenging effect of the different solvent extracts of tea seed oil on DPPH radical was estimated according to the method of Duh *et al*., (2001). The extracts were added to a methanolic solution (0.5 mL) of DPPH radical (final concentration of DPPH was 0.2 mmol/L). The

mixture was shaken vigorously and kept at room temperature for 30 min; the absorbance of the resulting solution was then measured spectrophotometrically at 517 nm.

- *Characterization of Tea seed Flour (TSF)*

Moisture content: This was determined according to the methods of Association of Analytical Chemist (AOAC). One gram of sample in pre-weighed crucible was placed in an oven (105°C) for 24 h, cooled, and reweighed. The percentage moisture was calculated as follows:

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

where W1 is the weight of the crucible, W2 is the weight of the crucible after drying at 105°C and sample, and W3 is the weight of the crucible and the sample after cooling in airtight desiccators.

Crude protein: Crude protein content was determined using the micro-Kjeldahl method as described by Pearson (1976). In a typical experiment, 10 mL H_2SO_4 was added to 3 g of sample and digested with a Kjeldahl digestor (Model Bauchi 430) for 1 hr. 30 min. A volume of 40 mL water was added and distilled using a Kjeldahl distillation Unit (Model unit B – 316) containing 40% concentrated sodium hydroxide and Millipore water. Liberated ammonia was collected in 20 mL boric acid with bromocresol green and methyl red indicators and titrated against 0.04 N H_2SO_4. A blank was likewise prepared. Percent protein was calculated as:

$$\text{Crude protein (\%)} = \frac{Sampler\ titer - blank\ titer \times 14 \times 6.25}{Sample\ weight} \times 100$$

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

Ash: Ash contents were determined according to AOAC (Association of Analytical Chemists) numbers 923.03 and 984.27 (AOAC, 2005). 2 g of sample was added into a pre-weighed crucible and incinerated in muffle furnace at 600°C. The ash content was calculated as follow:

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

where W1 is the weight of cleaned, dried, ignited, and cooled crucible, W2 the weight of the crucible and sample after incinerating at 600°C, and W3 the weight of the crucible and sample after cooling in an airtight vessel.

Crude fiber: A weighed crucible containing 1 g of defatted sample was attached to the extraction unit (in Kjeldahl, D-40599; Behr Labor-Technik GmbH, Dusseldorf, Germany) and into this 150 mL of hot 1.25% H_2SO_4 was added and digested for 30 min, the acid was drained and sample washed with hot distilled water for 1.5h. The crucible was removed and 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 reweighed after cooling. Percentage extracted fiber was calculated as:

$$\text{Crude fiber (\%)} = \frac{wt\ of\ digested\ sample - wt\ of\ ashed\ sample}{wt\ of\ sample} \times 100$$

Ether Extract: This was estimated using TecatorSoxtec (Model 2043[20430001]; Hilleroed, Denmark). A quantity of 1.5 g sample mixed with 2.3 g anhydrous sulfate was weighed into a thimble and covered with absorbent cotton, while 40 ml of n-hexane was added to a pre-weighed cup. Both thimble and cup were attached to the extraction unit. The sample was extracted using ethanol for 30 min and rinsed for 1.5 h. Thereafter, the solvent was evaporated from the cup to the condensing column. Extracted fat in the cup was then placed in an oven at 105°C for 1 h, cooled and weighed. Percent fat was calculated as follow:

$$\text{Ether Extract (\%)} = \frac{wt\ of\ initial\ cup - wt\ of\ final\ cup}{wt\ of\ sample} \times 100$$

Carbohydrate: The carbohydrate content was determined by difference, that is, addition of all the percentages of moisture, fat, crude protein, ash, and crude fiber was subtracted from 100%. This gave the amount of nitrogen-free extract otherwise known as carbohydrate.

Carbohydrate (%) =100 – (% Moisture content + %Ash+ %crude protein + % crude fiber + % fat)

- *Mineral Determination*

Mineral elements determination of TSF was carried out using the methods of AOAC (2005). One gram of sample was digested with nitric/perchloric/sulfuric acid mixture in the ratio 9:2:1, respectively, and filtered. The filtrate was made up to mark in a 5-mL volumetric flask. The filtered solution was placed in an Atomic Absorption Spectrophotometer (model 703; Perkin Elmes, Norwalk, CT). The standard curve for each mineral was prepared from known standards and the mineral value of samples estimated against that of the standard curve. Values of sodium and potassium were determined using a Flame photometer (Sherwood Flame Photometer 410; Sherwood Scientific Ltd., Cambridge, U.K.) using NaCl and KCl as the standard (AOAC, 2005).

- *Phytochemical analysis*

Tannin content of TSF was determined using the methods described by Swain (1979). The sample (0.2 g) was weighed into a 50-mL beaker; 20 mL of 50% methanol was added, covered with homogenizer, placed in a water bath at 80°C for 1 h, and the contents stirred with a glass rod to prevent lumping. The mixture was filtered using a double-layered Whatman No. 1 filter paper into a 100-mL volumetric flask using 50% methanol to rinse. This was made up to mark with distilled water and thoroughly mixed. One milliliter of the sample extract was homogenized into a 50-mL volumetric flask, and 20 mL distilled water, 2.5 mL Folin-Denis reagent, and 10 mL of 17% Na_2CO_3 were added and mixed. The mixture was made up to mark with distilled water, thoroughly mixed, and allowed to stand for 20 min when a bluish-green coloration 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 tannic acid standard solutions as well as samples was read after color development on a Spectronic 21D spectrophotometer at a wavelength of 760 nm while the percentage tannin was calculated.

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 Harbone (1973). Phytic acid determination was carried out using the procedure of Wheeler and Ferrel (1971). Oxalate was determined by AOAC (2005) method. Alkaloids and Flavanoids were determined according to the method outlined by (Brunner, 198).

- *Functional characteristics*

The Water absorption capacity was determined according to the method of Sathe *et al.*, (1982). The result was expressed as a percentage of water absorbed by the blends on % g/g basis. (Density of water was assumed to be 1 g/ml). The method described by Leach *et al.*, (1959) was used to determine the swelling capacity while the solubility was calculated after the determination of swelling capacity as per 100g of starch on dry basis. 5 ml of aliquot of the supernatant was dried to a constant weight at 120^{o}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 to determine the bulk density. Oil absorption capacity was also determined using standard method.

Results and Discussion

- *Characterization of TSO*

Table 2 presents some properties of oil

from selected clones of Nigerian tea seed. The yield values show that C228 had the highest value of 28.9% while, C143 had the lowest value (22.5%) even though it was not significantly different. The values are similar to that obtained by George *et al*. (2013) for some selected Kenyan tea seed oil. Iodine value (IV) measures the degree of unsaturation of oil or; the amount of iodine, in grams, that is taken up by 100 grams of the oil. Saturated oils take up no iodine; therefore their iodine value is zero; but unsaturated oils take up iodine. (Unsaturated compounds contain molecules with double or triple bonds, which are very reactive toward iodine.) The more iodine is attached, the higher is the iodine value, and the more reactive, less stable, softer, and more susceptible to oxidation and rancidification is the oil. In this study, C68 has IV of 89.7g/I_2/100g been the highest while C236 (74.23 g/I_2/100g) was the lowest even though all the clones were relatively low in IV. The implication of this is that the oils from these clones are considered non-drying and therefore can be employed in soap production and other surface active agents. This result is also comparable to values obtained for Kenyan tea clones (George *et al.*, 2013).

Saponification value is a measure of the total free and combined acids especially in a fat expressed as the number of milligrams of potassium hydroxide required for the complete saponification of one gram of substance. It gives information concerning the character of the fatty acids of the fat- the longer the carbon chain; the less acid is liberated per gram of fat hydrolysed. It is also considered as a measure of the average molecular weight (or chain length) of all the fatty acids present. The long chain fatty acids found in fats have low saponification value because they have a relatively fewer number of carboxylic functional groups per unit mass of the fat and therefore high molecular weight. The saponification value (SV) from the study showed that all the oils from the selected tea clones had high SV and the values were not statistically different. It therefore implies that oils from all the tea clones are useful feedstock for soap production. Peroxide detection gives the initial evidence of rancidity in unsaturated fats and oils. It is a chemical indication of how much of the oil is in the early stage of oxidation, and it reflects the degree of oxidation (Madhavi *et al.*, 1996; Pokonery *et al.*, 2001). Other methods may be used, but peroxide value (PV) is the most widely used. It gives a measure of the extent to which an oil sample has undergone primary oxidation, extent of secondary oxidation may be determined from p-anisidine test. The double bond found in fats and oils play a role in autoxidation. Oils with a high degree of unsaturation are most susceptible to autoxidation. The best test for autoxidation (oxidative rancidity) is determination of the peroxide value. Peroxides are intermediates in the autoxidation reaction. This value may vary in different seed oils depending on the extraction method employed, the condition of storage and even the sample varieties. The values (3.1 – 3.6 meqO_2/kg) obtained for the oil from the different clones are within allowable limit (Pearson, 1970). This indicates good measure of stability of the oils and good shelf life (Attai *et al.*, 2003). Polyphenols are one type of antioxidant that fights oxidative stress and other aging-related diseases like heart disease, high blood pressure and cholesterol. It also contains anti-inflammatory properties. The total polyphenol obtained for the samples under study indicates that the oil from the different clones have good antioxidant properties. Cl318 (2.56 mgKOH/g) showed the highest tendency while C228 and 143 (1.22) had the least even though there were no significant differences in the values.

- *Characterization of TSF of Selected clones*

Proximate composition of TSF: The proximate composition of TSF from selected tea clone is presented in Figure 2. The moisture content of the various clones are

within allowable limit for seed with expected long shelf life. Values obtained in this study are in agreement with those reported for other seeds by other workers (Ige *et al.*, 1984; Fagbemi and Oshodi 1991; Olitino *et al.*, 2007). C357 showed the highest value of 4.1% while C318 (3.1%) was the least. There were no significant differences in the values obtained for the ash content of the various clone, however they are not within the recommended value for animal feed which are expected to be within the range 1.5 -2.5 % to be fit for consumption as animal diet (Pomeranz and Clifton 1981; Aremu *et al.*, 2006).

Crude protein for the various clones ranges between 8.5 -9.6 %. C236 showed high protein content and can therefore partly meet the recommended daily protein requirement of 23 -36g to 44-56g for children and adults respectively (NRC, 1989). All the clones showed the presence of carbohydrate which are remarkable with C236 (53%) been the highest. However, energy content of C68 (2108.3KJ/100g) was greater than others. Figure 3 presents the functional characteristics of tea seed flour from selected clones.

The result of the mineral composition of TSF from the various clones is shown in Table 3. The most abundant minerals in TSF were magnesium (163.1mg/100g in C236), potassium (23.61mg/100g in C228), and calcium (18.41mg/100g) while sodium, zinc and iron were limiting in abundance. The molar ratio of Na/K in the body is relevant in the prevention and control of high blood pressure. Nieman *et al*, 1992, recommended a Na/K ratio of less than one in diets particularly for the hypertensive patient. For this study, all the clones had good molar ratios; implying that consumption of flour from these clones or fortifying them with other food ingredients will be beneficial for the hypertensives.

Phytochemicals are natural antioxidants that provide health benefits associated with their ability to prevent damages resulting from biological degeneration. The level of

Table 2. Characteristics of tea seed oil from selected clones in Nigeria.

	Clones					
Parameter	**236**	**228**	**143**	**68**	**357**	**318**
DPPH (%)	27.03	34.14	35.79	32.66	31.57	39.17
Iodine value ($g/I_2/100g$)	74.23	76.44	76.81	89.7	88.9	76.5
Peroxide value ($MeqO_2/kg$)	3.51	3.10	3.62	3.79	3.41	3.33
Saponification value (mgKOH/g)	186.5	189.2	182.5	186.0	182.8	186.8
Total polyphenol (mgKOH/g)	1.48	1.22	1.22	1.85	1.87	2.56
Oil content (%)	26.1	28.9	22.5	25.1	26.4	22.9

Results are mean standard deviation of triplicate determinations.

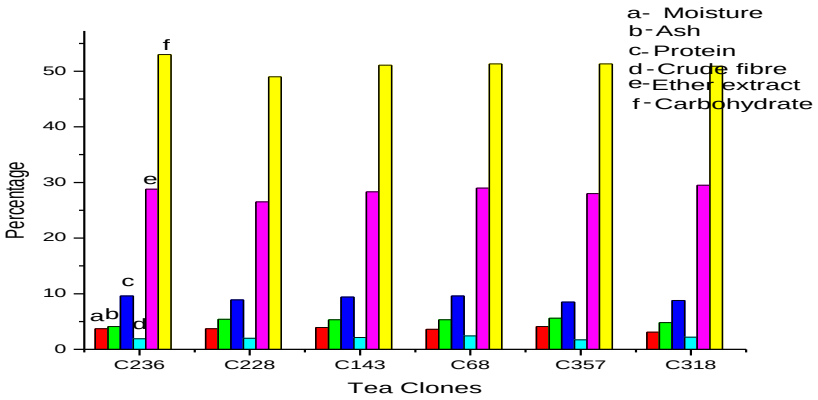

Fig. 2. Proximate composition of TSF from selected clones.

phytochemicals in foods donot 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. Phytohemicals in the present study are presented in Table 4. The result revealed the presence of some phytochemicals across the selected clones examined. Prominent among them are alkaloids, saponins, phytates, flavanoids, tannin etc. Alkaloids for example, are heterogeneous group of naturally occurring compounds found in the leaves, bark, roots or seeds of plants. They are the most effective plant substance used therapeutically as analgesic, antimicrobial and bacterial properties. They are widely including anti-inflammatory, anti-oxidants, antiviral, and anti-carcinogenic properties. All the clones showed appreciable amount of this phytochemicals even though there were not significant differences.

Functional properties of foods are the intrinsic physicochemical characteristics which may affect the behavior of food systems during processing and storage. They are properties 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

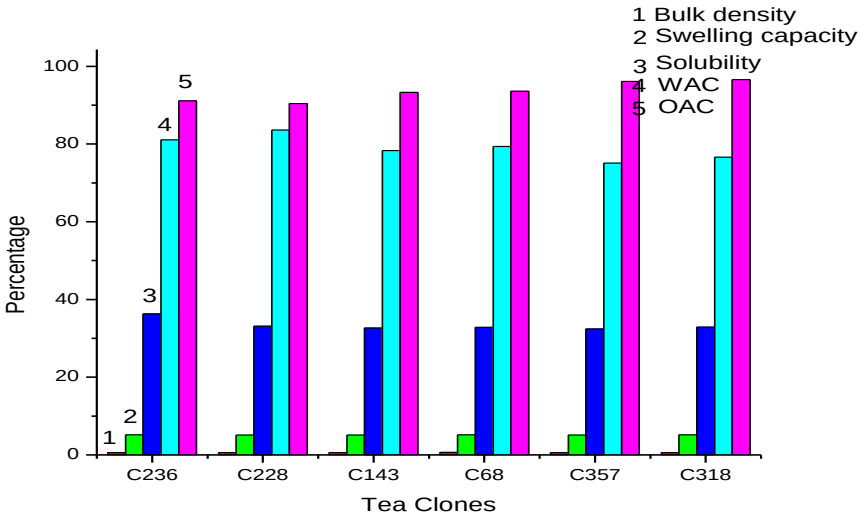

Fig. 3. Functional characteristics of TSF from selected clones

Table 3. Mineral composition of tea seed flour (TSF) from selected clones (mg/100g)

	Clones					
Parameter	**236**	**228**	**143**	**68**	**357**	**318**
Sodium	2.91	3.02	3.06	2.98	3.20	3.19
Zinc	3.99	4.1	3.93	3.81	3.85	3.99
Magnesium	163.1	145.9	155.7	150.1	158.1	155.0
Iron	0.091	0.063	0.075	0.083	0.095	0.088
Potassium	21.94	23.61	23.44	23.65	22.9	23.4
Calcium	16.57	18.41	16.16	17.63	16.9	16.4
Na/K	0.132	0.127	0.130	0.126	0.139	0.136
Ca/K	0.755	0.779	0.680	0.745	0.730	0.700
Na/Mg	0.017	0.02	0.02	0.019	0.020	0.020
Ca/Mg	0.101	0.126	0.103	0.117	0.106	0.105

Results are mean standard deviation of triplicate determinations.

Table 4. Phytochemicals of tea seed flour (TSF) from selected clones (mg/g)

	Clones					
Phytochemicals	**236**	**228**	**143**	**68**	**357**	**318**
Saponin	0.109	0.099	0.112	0.116	0.107	0.111
Terpenoid	2.65	2.71	2.62	2.68	2.90	2.88
Phytate	2.66	2.88	2.93	3.01	3.01	2.91
Oxalate	0.16	0.12	0.17	0.16	0.18	0.17
Alkaloid	2.01	1.98	2.04	2.03	2.04	2.04
Phenol	0.65	0.73	0.61	0.66	0.63	0.69
Flavanoids	0.79	0.77	0.75	0.79	0.81	0.85
Tannin	1.19	1.20	1.16	1.12	1.11	1.18
Total antioxidant	2.51	2.71	2.26	2.23	2.16	2.28

Results are mean standard deviation of triplicate determinations.

particularly for food products with high dispensability and reduced paste thickness (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 (Hermandez-Diaz *et al.*, 2007). Figure 3 shows the functional characteristics of TSF across the selected tea clones. It is interesting to note that TSF across the clones had good functional characteristics. For example, the bulk density ranges between 0.56 -0.63

Conclusion

In the present study, compositional analysis of tea seed flour from different clones were examined. The results indicated the presence of oil in the seed. The chemical analysis of the oil suggests its antioxidant property. The seed flour from the different clones is laden with minerals elements which are beneficial to human health. The seed flour also contains some phytochemicals which are also relevant to human and animal diets. The functional behavior of the flours is an indication that they can be fortified with other food ingredient to achieve better and good food composition for human health.

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