Open Access

SCHOLARENA

Journal of Food Technology and Food Chemistry

RESEARCH ARTICLE

ISSN: 2641-8118

Proximate and Functional Properties of Water Lily (*Nymphaea Lotus*), Coconut (*Cocos Nicifera*) and Wheat (*Titricum Aestivum*) Flour Blends

John Adanse[1*], Kate Bigson[2], Nyefene Joe Dare[2], Patricia Glago[2]

[1]Department of Hospitality Management, Bolgatanga Technical University, P. O. Box 767, Bolgatanga-Ghana

[2]Department of Hotel, Catering and Institutional Management, Dr. Hilla Limann Technical University, P. O. Box 553, WA – Ghana

[*]**Corresponding author:** John Adanse, Department of Hospitality Management, Bolgatanga Technical University, P. O. Box 767, Bolgatanga-Ghana, Tel: +233-20-939-3838, E-mail: johnadanse@bolgatu.edu.gh

Citation: John Adanse, Kate Bigson, Nyefene Joe Dare, Patricia Glago (2021) Proximate and Functional Properties of Water Lily (*Nymphaea Lotus*), Coconut (*Cocos Nicifera*) and Wheat (*Titricum Aestivum*) Flour Blends. J Food Tech Food Chem 3: 104

Abstract

The proximate compositions and functional properties of water lily tubers (*Nymphaea lotus*), coconut (*Cocos nicifera*) and wheat (*Titricum aestivum*) were determined using Association of Official Analytical Chemists (AOAC) standard methods. Values were obtained in duplicate and results tabulated using mean ± standard deviation. Data were subjected to the analysis of variance (ANOVA) and Tukey-Test was used to determine the significant difference among the various samples. Data were analyzed using the software, Statistical Package for Social Science (SPSS) version 22.00 at the 0.05 level of significance. The results of proximate composition of the various flours indicated increasing level of protein, fat and crude fibre; 4.41 ± 0.22 to 16.73 ± 0.76, 6.47 ± 0.16 to 19.16 ± 0.16 and 12.54 ±0.07 to 13.52 ± 0.04, while there was decrease in levels of moisture, ash and carbohydrate as the proportion of the composite flour increased; 7.91 ± 0.03 to 10.30 ± 0.21, 0.90 ± 0.10 to 4.28 ± 0.24 and 40.89 ± 1.22 to 61.99 ± 0.35. Functional properties results indicated a decrease in the level of water and oil absorption capacity and emulsion ability; ABC (134.87 ± 0.66), RBD (87.97 ± 0.88), XYZ (91.64 ± 1.50), DIO (105.00 ± 1.69) and ERY (128.81 ± 2.29) but decreased level in the bulk density; 0.56 ± 0.03 to 0.68 ± 0.01 and stable foaming capacity, 12.44 ± 1.27 to 17.16 ± 0.69. With the addition of other flours to wheat flour, the functional properties such as water absorption capacity, oil absorption capacity, emulsion stability and foam capacity decreased while the bulk density increased. Incorporating other flours with wheat flour increased the protein, fat and fibre contents, making it a viable materials for the preparation of pastries and other flour products.

Keywords: Functional Properties; Water Absorption Capacity; Bulk Density; Foaming Capacity, Composite Flour, Ghana

Introduction

For the past decade, there has been so much pressure on cereals and grains as food and feed due to population growth. Cereals are generally acknowledged for their importance in the nourishment of millions of people around the world. It is an excellent source of energy and traces of protein. It is also widely acknowledged that some cereals and grains have poor protein content and that, their protein quality is hampered by deficits in certain key amino acids, particularly lysine but if used as composite flour, the nutrients complement each other [1]. Composite flour is well-defined as a mixture of flours obtained from starch-rich tubers such as cassava, yam, and potato, as well as protein-rich flour made from beans, coconut, leave, and cereals, with or without wheat flour, made to meet specific functional characteristics and nutrient composition [2]. In terms of minerals, vitamins, fibers, and proteins, composite flour offers a higher nutritional value than flour milled from a single cereal. According to author [3], the composite flour mixture can give a balanced nutrition. Composite flour has been the focus of various studies in the last few years. There has been a growing interest in using functional gluten-free flours to partially replace the traditional wheat flour formulations [4, 5]. The use of composite flour has several advantages in underdeveloped nations such as Africa and other parts of the world. Furthermore, [6, 7] claimed that using composite flour will promote better overall usage of domestic agriculture products.

Nymphaea lotus is a shallow-rooted aquatic plant with vegetative parts that emerge above the water surface. It is one of the most prominent aquatic macrophytes found in Ghana freshwater bodies. Many authors have emphasized the impact of various macrophytes on water bodies. Despite its prevalence on many of our country’s fresh water bodies and its utility among anglers, there is a scarcity of knowledge about its usage [8]. It is commonly known that the majority of people in impoverished nations rely on famine foods such as Nymphaea Lotus tuber. It is an herbaceous aquatic plant that can be found in rivers, streams, and ponds. It is a hydrophyte with pink, white, or yellow flowers that float or submerge in water [9]. The nymphaea lotus tubers contain seeds that are used to produce food delicacies by the Hausa people of Ghana, Nigeria, the people of Southern Sudan, and some parts of America. The seeds are locally referred to as ‘gunsi’ in Ghana by the people of Upper East Region. The seeds can be milled into flour and has the potential to be used to partially replace wheat or millet flour in meal preparation, due to the relatively high water binding capacity. Author [10] advocated for the use of Nymphaea lotus as a supplement to fish and livestock feeds. Authors [11-16] have all cited composite flour as unique flour that gotten a lot of interest in research and food products development.

Coconut as fruit is common in West Africa particularly Ghana. It is used in making coconut oil apart from eating it as fruit. Therefore, little research has been done about how it can be processed into flour and used to partially replace traditional wheat flour. According to author [17], the mature coconut endosperm is abundant in nutrients and hence used in the application of products in other countries. In the production of food products, the functional qualities of composite flours are critical; as it indicates whether the blends are suitable for use in products that require moisture to facilitate handling [18]. In practicality, the use of composite flour in baked goods would help to reduce total reliance on imported wheat as well as saving hard currency and promoting high yielding native plant species. The aim of this research was to undertake proximate compositions and functional properties of composite flour made from water lily tubers (*Nymphaea lotu*s), coconut (*Cocos nicifera*) and wheat (*titricum aestivum*).

Materials and Methods

Raw Materials and Equipment

Wheat flour, semi dried coconuts and *Nymphaea lotus* tubers were purchased from the Bolgatanga market. Equipment such as blender, bowl, knife, digital weighing scale, measuring cup, baking sheets, and oven were got from the food practical laboratory of Bolgatanga Technical University, Ghana for the samples preparation.

Sample Preparation

Coconut

Semi-dried coconut was cracked, washed and then subjected to grating. Through the grating process, coconut milk was extracted by putting the residue in a clean muslin cloth and squeezed out. The residue was then weighed and dried at 60°C in an Apex Hot Air Oven Dryer (Royce Ross Ltd) until it reached a consistent weight. A plate mill (Quaker City Grinding Co, Model 4-E, Phoenixville, PA) was used to grind the dried coconut into flour. A 100 mesh sieve was used to sieve the coconut flour. The flour was stored in plastic bags at room temperature before being utilized to make the composite flour.

Nymphaea

Nymphaea lotus tubers were collected from the central market of Bolgatanga. The seeds were removed and allowed to dry in hot air oven at 60^{o}C for 12 hours to a desirable moisture content of 12%. Once dried, the *Nymphaea* seeds were placed inside a food processor and pulsed for 2 to 3 minutes until finely textured flour was attained. It was sifted, packaged and stored in air tight container for further analysis.

Formulation of composite flour

The primary formulations for the flour samples are mentioned in Table 1. The samples were prepared with the combination of coconut flour (CF) in 0, 6, 8, 12 and 15%; wheat flour 100, 90,80,70,60 while the *nymphaea* flour (NF) was also prepared in different percentages of 0, 4, 12, 18 and 25% concentration in combination with wheat flour (WF). Five (5) different samples were produced and coded as ABC, RBD, XYZ, DIO and ERY. Sample ABC served as control, containing 100% wheat flour. Samples RBD, XYZ, DIO and ERY consisted of wheat, coconuts and *Nymphaea* flours. Sample (RBD) was produced using 90% wheat flour, 4% coconut flour and 6% *Nymphaea* flour. Sample (XYZ) was prepared using 80% wheat flour, 12% coconuts flour and 8% *Nymphaea* flour whereas sample (DIO) was made up of 70% wheat flour, 18% coconuts and 12% *nymphaea* flour. The last sample (ERY), was comprised of 60% wheat flour, 25% coconuts and 15% *nymphaea* flour.

INGREDIENTS	ABC	RBD	XYZ	DIO	ERY
Wheat flour (soft) (%)	100	90	80	70	60
Nymphaea flour (%)	0	6	12	18	25
Coconut flour (%)	0	4	8	12	15

Table 1: Formulation of Composite Flour

Proximate composition of flours

The proximate composition of the Raw Wheat Flour (ABC, 100%) and their flour blends (RBD 90%, Wheat flour, 6% *Nymphaea flour*, 4% Coconut flour), XYZ (80% Wheat flour, 12% Nymphaea flour, 8% Coconut flour), DIO (70%Wheat flour, 18%, *Nymphaea flour* 12%, Coconut flour), ERY (60%, Wheat flour, *Nymphaea flour*, 25%, 15% Coconut flour) were determined using [19] method.

Moisture content and total solids: Oven Drying Method

Five grams (5g) of sample was transferred to the previously dried and weighed dish. Dish was placed in an oven and thermostatically controlled at 105 degrees for 5 hours. Dish was removed and placed in a desiccator to cool to room temperature and weighed. It was then dried again for 30 minutes, cooled down again and weighed. Drying, cooling and weighing were repeated until a constant weight was reached. (Alternatively, sample could be dried in a thermostatically controlled oven for at least 8 hours where a constant weight would be achieved). The determinations were duplicated and the average found.

Calculations

$$\%\text{moisture (wt/wt)} = \frac{\text{wt } H_2O \text{ in sample}}{\text{Wt of wet sample}} \times 100$$

$$\%\text{moisture (wt/wt)} = \frac{\text{wt of wet sample-wt of dry sample}}{\text{Wt of wet sample}} \times 100$$

$$\%\text{total solids (wt/wt)} = \frac{\text{wt of dried sample}}{\text{Wt of wet sample}} \times 100$$

Ash content

Five grams (5g) sample was weighed into a tarred crucible and was pre-dried. Crucible was placed in cool muffle furnace using tongs, gloves and protective eyewear. The crucibles Ignited for 2 hours at about 600 degrees Celsius. Muffle furnace was turned off and opened when temperature dropped to at least 250 degrees preferably lower. The door was carefully opened to avoid losing ash that may be fluffy. Safety tongs was used to transfer crucibles to a desiccator with a porcelain plate and desiccant. Desiccator was closed and allowed crucibles to cool prior to weighing.

Calculations

$$\%\text{Ash} = \frac{\text{wt of ash}}{\text{Wt of sample}} \times 100$$

$$\%\text{Ash} = \frac{\text{(wt of crucible+ ash) – wt of empty crucible}}{\text{(wt of crucible+ sample) – wt of empty crucible}} \times 100$$

Fat content: Soxhlet Extraction

Previously dried (air oven at 100°C) 250 ml round bottom flask was weighed accurately. Five grams (5.0g) of dried sample to 22 ×80mm paper thimble or a folded filter paper was weighed. A small of cotton or glass wool was placed into the thimble to prevent loss of the sample. 150ml of petroleum spirit B.P 40-60°C was added to the round bottom flask and assembled the apparatus. A condenser was connected to the soxhlet extractor and reflux for 4 - 6 hours on the heating mantle. After extraction, thimble was removed and recovered solvent by distillation. The flask and fat/oil was heated in an oven at about 103°C to evaporate the solvent. The flask and contents were cooled to room temperature in a desiccator. The flask was weighed to determine weight of fat/oil collected.

$$\%\text{FAT (dry basis)} = \frac{\text{fat/oil collected} \times 100}{\text{Weight of sample}}$$

$$\%\text{ FAT (dry basis)} = \frac{\text{(wt of flask + oil) – wt. of flask} \times 100}{\text{Weight of sample}}$$

Crude Fibre Determination

Two grams (2g) sample from crude fat determination was weighed into a 750ml Erlenmeyer flask. 200ml of 1.25% H_2SO_4 was added and immediately flask was set on hot plate and connected to the condenser. The contents were boiled within 1 minute of contact with solution. At the end of 30 minutes, flask was removed and immediately filtered through linen cloth in funnel and washed with a large volume of water. Filtrate (containing sample from acid hydrolysis) was washed and returned into the flask with 200ml 1.25% NaOH solutions. Flask was connected to the condenser and was boiled for exactly 30 minutes. It was then filtered through Fischer's crucible and washed thoroughly with water and added 15ml 96% alcohol. Crucible and contents was dried for 2 hour at 105 °C and cooled in desiccator and it was weighed. Crucible was ignited in a furnace for 30 minutes and after that it was cooled and reweighed.

$$\%\text{Crude fibre} = \frac{\text{weight of crude fibre} \times 100}{\text{Weight of sample}}$$

$$\%\text{ Crude fibre} = \frac{\text{wt of crucible + sample (before – after) ashing} \times 100}{\text{Weight of sample}}$$

Protein Determination

Digestion

Two grams (2g) of sample and a half of selenium –based catalyst tablets and a few anti-bumping agents were added to the digestion flask. 25ml of concentrated H_2SO_4 was added and the flask was shook for the entire sample to become thoroughly wet. Flask was placed on digestion burner and heated slowly until boiling ceases and the resulting solution is clear. The sample was then cooled to room temperature and digested sample solution was transferred into a 100ml volumetric flask and made up to the mark.

Distillation

To flush out the apparatus before use, distilled water was boiled in a steam generator of the distillation apparatus with the connections arranged to circulate through the condenser, for at least 10 minutes. The receiving flask was lowered and continued to heat for 30 seconds in order to carry over all liquid in the condenser. 25 ml of 2% boric acid was pipetted into 250ml conical flask and 2 drops of mixed indicator added. The conical flask and its contents was placed under the condenser in such a position that the tip of the condenser is completely immersed in solution. 10ml of the digested sample solution was measured into the decomposition flask of the Kejdahl unit, fixed it and add excess of 40% NaOH (about 15-20ml) to it. The ammonia produced was distilled into the collection flask with the condenser tip immersed in the receiving flask till a volume of about 150ml- 200ml is collected. Before distilling another sample and on completion of all distillations, the apparatus was flushed as in step 1 above. Steam was allowed to pass only until 5ml of distillate is obtained.

Titration

Distillate with 0.1N HCL solution was titrated. The acid was added until the solution became colorless. If additional acid is added the solution becomes pink. The nitrogen content was determined in duplicate, and run a blank determination using the same amount of all reagents as used for the sample. The blank will correct for traces of nitrogen in the reagents and should include digestion as well as distillation.

Calculation

$$\% \text{ total nitrogen} = \frac{100 \times (Va-Vb) \times NA \times 0.01401 \times 100}{W \times 10}$$

Va- volume in ml of standard acid used in titration

Vb- volume in ml of standard acid used in blank

NA- normality of acid

W- Weight of sample taken

Carbohydrate Content

The calculation of available carbohydrate (nitrogen-free extract-NFE) was made after completing the analysis for ash, crude fibre, ether extract and crude protein. The calculation was made by adding the percentage values on dry matter basis of these analysed contents and subtracting them from 100%.

Calculation

Carbohydrate (%) = % crude fibre + % NFE

OR

Carbohydrate (%) =100 - (% moisture +% fat +% protein +% ash)

x. Calculation for dry basis = $\frac{(100-\% \text{ moisture}) \times \text{wet basis}}{100}$

Functional properties of the flour blends

Water and oil absorption capacity

The water and oil absorption capacities were determined by the method of [20]. One gram (1g) of the flour sample was dispersed in 10ml of oil and vortex the suspension for 5 minutes. The suspension obtained was centrifuged at 3500 rpm for 30min. it was then decanted and measured with supernatant in a 10ml graduated cylinder. The density of the oil, and calculated oil absorption capacity were determined using the formula:

$$\text{Oil absorption capacity (\% OAC)} \ \frac{(y-z)\times d}{x} \times 100$$

Where y= initial volume of oil added

Z= volume of supernatant collected

X= initial weight of (dried) sample taken

d= density of oil

y-z =volume of water retained by the sample after centrifugation

Water Absorption Capacity

The water absorption capacity of the flours was determined by the method of [20]. One (gram) of the sample in 10ml distilled water was dispersed and vortex the suspension for 5 minutes. The suspension obtained at 3500 rpm for 30min was centrifuged. It was then decanted and measured with supernatant in a 10ml graduated cylinder. Density of water was taken as 1.0gcm^{-3}, and calculates water absorption capacity as:

$$\text{Water absorption capacity (\%WAC)} = \frac{y-z}{x} \times 100$$

Where y = initial volume of water added

Z = volume of supernatant collected

X = initial weight of (dried) sample taken

y-z = volume of water retained by the sample after centrifugation

Bulk Density

The bulk density was determined according to the method described by [21]. An amount of 100g of the sample was weighed directly into 250ml capacity graduated cylinder and tap the measuring cylinder 10 to 15 times until no change in volume is observed.

$$\text{Bulk density} = \frac{\text{weight of sample (g)}}{\text{Volume of sample after tapping (ml)}}$$

Foaming capacity and foaming stability

Foaming capacity and foaming stability were determined as described by [22] with slight modifications. Five milligram (5ml) of sample was weighed and mixed in 40ml distilled water and homogenized for 5min at high speed using a homogenizer with a suitable stirrer. The volume of foam separated was noted. For stability, the collapse in foam if any at the end of a specific time was measured (e.g. 1 minute, 2 minutes, 4 minutes and 5 minutes).

Calculate the capacity and stability as follows:

$$\%\text{foaming capacity} = \frac{(vol after homogenization) - (vol before homogenization)}{vol before homogenization} \times 100$$

$$\%\text{foam stability} = \frac{foam volume after time(t)}{initial foam volume} \times 100$$

Statistical analysis

Data were analyzed using analysis of variance (ANOVA). Tukey Test was used to determine significant difference among the various samples in duplicate. Data were analyzed using the software, Statistical Package for Social Science (SPSS) version 22.00 (SPSS Inc., Chicago), IL, USA at the 0.05 level of significance.

Results and Discussion

Proximate Analysis

Table 2 presents the proximate composition of the various flour samples. The moisture content of the flour ranges from 7.91 ± 0.03 to 10.30 ± 0.21 for the flour compositions. There were significant differences between the whole wheat flour and the various flours compositions. The highest moisture content was recorded by Sample ABC (100% wheat flour) and the lowest recorded by DIO (70% wheat flour). Thus sample ABC differed ($p<0.05$) significantly from the other samples. The moisture content of all samples were similar to that produced by [23] from whole wheat flour and full fat soya bean flour (ranged from 7.24-9.85%) except sample ABC. These differences observed could be attributed to the different ingredients (*Nymphaea* flour and Coconut flour) used for the various flours. The flour sample DIO had the lowest moisture content (7.91%) and this shows that it will have a long shelf-life since lower moisture content is critical for prolonging the shelf life [24]. Similar observations were made by [25] in wheat-sweet potato composite flours. The findings disagree with the study of [26] who recorded an increase in moisture content on wheat flour, soybean flour and cocoyam flour blends. The other samples may however have a shorter shelf-life as compared to sample DIO since high moisture content has been associated with short shelf life of baked products, as they encourage microbial proliferation that lead to spoilage [24], [27]. The ash content ranged from 0.90 ± 0.10 to 4.28 ± 0.24 for the flour compositions. Sample ABC (100% whole wheat flour) had the highest ash content with a value of 4.28. The ash content of the remaining four samples namely RBD, XYZ, DIO and ERY had ash contents (1.21 to 1.58) lower than what was recorded by [23]. They reported ash contents of 2.20 to 2.57%. From the results, there was no significant ($p>0.05$) difference between the ash contents. The presence of ash is an indication of minerals present in the sample [28]. The ash content of the samples decreased as substitution of wheat flour increased. This trend shows a reduction in the ash content of the samples with *Nymphaea* flour and Coconut flour.

The protein content ranges from 4.41 ± 0.22 to 16.73 ± 0.76 for the formulation of flour with sample ABC (100% wheat) having the lowest and ERY (60% *Wheat flour*, 25% *Nymphaea flour*, 15% *Coconut flour*) having the highest. There was significant ($p<0.05$) difference between all the flour formulations. Increasing the *Nymphaea* flour and Coconut flour content resulted in the corresponding increase in the protein content due to higher presence in protein in both *Nymphaea* flour and Coconut flour (about 17.5% of protein, [29]. Contrary to this study however, [29] reported a much higher protein content (17.65-21.65%) for their samples produced from sweet potato flour and soybean flour. The protein content increased as the percentage of soybean flour increased. The higher protein content of the samples by [29] may be attributed to the high percentage of soybean flour present in the biscuit. Protein in food is very essential as is responsible for body building and repair of worn out tissues. Proteins are important food components, especially for children since they are needed as building blocks for the body, necessary for growth and for the repair of damaged tissues [30]. Children consuming these products will therefore benefit immensely.

The fat content ranges from 6.47 ± 0.16 to 19.16 ± 0.16 with sample ABC (100% wheat) having the lowest and ERY (60% *Wheat flour*, 25% *Nymphaea flour*, 15% *Coconut flour*) having the highest. There was significant ($p<0.05$) differences in the fat content. This finding is similar to work of [31] whose work was in coconut flour and wheat flour biscuit respectively. They recorded higher levels of fat in their samples. The fat content of all samples were higher than that of a flour (5.25%) with 70% sweet potato flour and 30% soybean flour produced by [31]. These differences could be attributed to the different ingredients (*Wheat flour, Nymphaea flour, Coconut flour*) used for the biscuits in this study. The finding agrees with [31] and [32] on their reports for the increasing trend in the fat content of the flour produced from wheat-defatted cashew nut and wheat-brewers grain (2.52–4.80%) flour blends respectively. The presence of high fat content in the flour means high calorific value and also serves as a lubricating agent that improves the quality of the product, in terms of flavor and texture. In addition, fat is a rich source of energy and is essential as carriers of fat soluble vitamins; A, D, E and K. However, high levels of fat in food products should be ≤25%, since this could lead to rancidity in foods and development of unpleasant and odorous compounds [32]. Fat is very important in food as it helps in the absorption of vitamins and it also fills fat cells and insulates the body to keep it warm.

The Crude fibre content ranges from 12.54 ± 0.07 to 13.52 ± 0.04 for the flour formulations. Sample ABC (100% wheat) had the lowest (12.54) and ERY (60% *Wheat flour,* 25% *Nymphaea flour,* 15% *Coconut flour*) had the highest (13.52) fibre content. Increasing the content of the *Nymphaea* flour and Coconut flour resulted in the corresponding increase in the fibre content as coconut is known to have higher content of fibre. Statistical analysis showed that there was no significant ($p<0.05$) differences between the fat content of the samples. The crude fibre content of all samples were however higher than (12.54-13.52%) than those produced by [33] and [34] which ranged from and 3.29-5.73%. Fibre in food facilitates easy digestion in the colon and reduces constipation [25]; [35]. The finding conforms to the observation of [36] for the increasing trend in the crude fibre (1.32-10.82%) contents of cookies made from wheat-brewers spent grain flour blends. In contrast, the result was higher than the crude fibre (1.05- 1.65%) of cookies produced from wheat-defatted cashew nut flour blends as reported by [29]. The presence of high fibre in food products is essential owing to its ability to facilitate bowel movement (peristalsis), bulk addition to food and prevention of many gastrointestinal diseases in man [36]. Fibre in food is involved in the enhancement of gastrointestinal tract and cardiovascular health [37]. It also aid in lowering the blood cholesterol level and slows down the process of absorption of glucose thereby assisting in keeping the blood sugar level in control [38]. Additionally, it ensures smooth bowel movement leading to easy flushing out of waste product from the body.

The carbohydrate content ranges from 40.89 ± 1.22 to 61.99 ± 0.35 for the flour formulation. The carbohydrate content decreases as the level of the *Nymphaea* flour and Coconut flour increases. Sample ABC (100% wheat) had the highest (61.99%) and the lowest was recorded by ERY (60% *Wheat flour,* 25% *Nymphaea flour,* 15% *Coconut flour*) with a content of 40.89%. There was statistical ($p<0.05$) differences among the samples. The carbohydrate content of all samples were lower than that reported (ranges 64.52-70.32%) by [24]. They were however similar to those reported (49.3-59.5%) by [26]. The high carbohydrate content of the sample ABC suggests a high energy content of the flour and high-energy foods tend to have a protective effect in the optimal utilization of other nutrients [28]. Similar trend was observed by [39]. Carbohydrates are sources of essential energy for the body and are good source of vitamins and minerals.

Sample	Moisture	Ash	Protein	Fat	Fibre	CHO
ABC	10.30 ± 0.21^{a}	4.28 ±0.24^{a}	4.41 ± 0.22^{a}	6.47 ± 0.16^{a}	12.54 ± 0.07^{a}	61.99 ± 0.35^{a}
RBD	8.31 ± 0.19^{b}	1.21 ±0.21^{b}	12.01 ±0.20^{b}	8.60 ± 0.07^{b}	12.72 ± 0.03^{a}	57.01 ± 0.72^{b}
XYZ	8.34 ± 0.17^{b}	1.34 ±0.77^{b}	15.76 ±0.08^{c}	11.01 ± 0.03^{c}	12.98 ±0.04^{ab}	50.70 ± 1.00^{c}
DIO	7.91 ± 0.03^{b}	1.45 ±0.10^{b}	16.11 ±0.08^{c}	15.18 ±0.03^{d}	13.41 ±0.25^{bc}	46.48 ± 0.36^{d}
ERY	8.12 ± 0.37^{b}	1.58 ±0.71^{b}	16.73 ±0.76^{c}	19.16 ± 0.16^{e}	13.52 ± 0.04^{c}	40.89 ± 1.22^{e}

Table 2: Proximate Composition of Flour blends

Values represent means and standard deviation replicate readings for various parameters. Values in the same column with different superscripts are significantly different ($p>0.05$). Keys: ABC = 100% (Wheat flour), RBD = 90, 6, 4 (Wheat flour, Nymphaea flour, Coconut flour), XYZ = 80, 12, 8 (Wheat flour, Nymphaea flour, Coconut flour), DIO = 70, 18, 12 (Wheat flour, Nymphaea flour, Coconut flour), ERY = 60, 25, 15 (Wheat flour, Nymphaea flour, Coconut flour)

Functional properties of flour blends

Table 3 shows the functional properties of the various flour samples. Water Absorption Capacity represents the ability of a product to associate with water under conditions where water is limited [40]. The water absorption capacity of the samples ranged from 87.97 to 134.87. Results obtained reveal that formulation ABC (100% wheat flour) had the highest (134.87 ± 0.66) water absorption capacity followed by ERY, DIO, XYZ and RBD with the least of 87.97 ± 0.88. The highest WAC of the sample AF (whole wheat flour) could be attributed to the presence of higher amount of carbohydrate (starch) in the flour which is supported by the carbohydrate content on the various formulated flour in Table 1. There were significant ($p<0.05$) differences among the WAC of the samples. Results obtained are different from that of [41] who reported WAC of 2.65 to 5.74. They worked on refined wheat flour, elephant foot yam flour and flour blend. The variance of WAC in flours may be due to the difference in particle size, shape and also the presence of different hydrophilic carbohydrates, lipids and proteins [42]. The findings support that of [43] whose work was assessing the functional qualities of composite flours made by combining wheat flour, rice flour, green gram flour, and potato flour in the ratios: 100:0:0:0, 85:5:5:5, 70:10:10:10, and 55:15:15:15. They discovered that adding rice, green gram, and potato flour to wheat flour reduced water absorption because the rice, green gram, and potato starch have a molecular structure that inhibits water absorption. In general, functional characteristic of flour plays a major role in the accomplishment of ready to eat food products and high water absorption capacity may facilitate in the cohesiveness of the product [44]. It is vital to assess these intrinsic functional properties as they can maintain the behaviour of food constituents in a complex food system, either during food processing, manufacturing or storage [45].

The Oil absorption capacity of the samples ranged from 70.63 to 96.43. The highest value of OAC was observed in formulation ABC (96.43 ± 3.01^{a}) followed by ERY, DIO, XYZ and RBD with the least of 68.00 ± 1.48. This capacity also depends on intrinsic factors like amino acid composition, protein conformation and surface polarity or hydrophobicity. The study showed that the oil absorption capacity of sample ABC was significantly ($p>0.05$) different from the other samples. Results obtained are different from that of [41] who reported WAC of 1.86 to 2.73. They worked on refined wheat flour, elephant foot yam flour and flour blend. OAC of flour plays a significant role in improvement of shelf life and palatability especially in bakery product where fat absorption is desirable. OAC also reflects in flavour retention and enhanced mouth feel [46]. The variance in the existence of non-polar groups in flours and binding capacity with flour might be responsible for difference in OAC of flours; the content of protein with hydrophilic and hydrophobic groups plays a significant role in determining OAC of flours [42]. The OAC makes flour to be suitable in facilitating enhancement in flavor and mouth feel when used in food preparation. It is also a useful factor in food system where optimum oil absorption is desired. This result is similar to [47], they tested batters containing rice flour and wheat flour and discovered that rice flour resisted oil absorption better than wheat flour but was less effective as a thickening agent. Again, the results confirmed the studies of [48] on micronized cowpea flour, [49] roasted peanut flour and [50] low-fat soy flour. They found that the oil absorption capacity of defatted macadamia cultivar flours were significantly higher than that of partially defatted flours.

Bulk density is a measurement of how heavy a flour sample is [51]. The bulk density of flour is used to calculate the amount of packaging required. The particle size and moisture concentration of flours play a role. The bulk density of composite flour grew as the percentage of other flours added to wheat flour increased. Flour's high bulk density signifies that it is suitable for use in food preparations (liquids, semisolids or solids). Low bulk density, on the other hand, might be advantageous in the formulation of weaning foods [52]. The bulk density of the flour samples ranged from 0.56 to 0.68. The highest bulk density was observed in Sample RBD (90% Wheat flour, 6% Nymphaea flour, 4% Coconut flour) and the least in sample ABC (100% wheat). Increasing the composite flours resulted in a corresponding decrease in the bulk density with no significant differences between them. The study showed that the bulk density of sample ABC was significantly ($p>0.05$) different from the other samples. Results obtained are similar from those of [41] who reported bulk density of 0.51 to 0.55. They worked on refined wheat flour, elephant foot yam flour and flour blend. Bulk density is a functionality that depends on the particle size and moisture content. High bulk density of flour suggest their suitability for use in food preparations and on the contrast, low bulk density would be an advantage in the formulation of complementary foods [47]. The bulk density of whole flours from pinto bean, lima bean, red kidney bean, black bean, and navy bean was examined by [54]. They found that the bulk density of legume flours ranged from 0.543 g/mL to 0.816 g/mL, with lentil flour and black bean flour having the highest and lowest values, respectively. The results are consistent with those reported by [55], who recorded the bulk densities of various chickpea cultivars and had 0.536 g/mL to 0.571 g/mL. The study had different results from that of [55] whose work was determination of functional properties of potato, taro, corn, and soya flour and recorded the bulk density of potato flour (0.998 g/mL) having the highest bulk density and soya flour having the lowest (Potato>Taro>Corn>Soya). Author [56] reported a similar result for bulk density of flour blend especially wheat flour blended with amaranth flour.

The emulsion ability of the samples ranged from 10.57 to 61.25. Sample ABC (100% wheat flour) had the highest emulsion ability (61.25 ± 1.77). Analysis of variance showed that there were statistical ($p<0.05$) differences between the emulsion ability of the flour samples. It was observed that introducing the coconut and *nymphaea* flour resulted in a sudden decrease in the emulsion ability but increased as the composite flour content increased. This is so probably because of the type of protein presence in the two composite flours is different from that in the whole wheat flour. It is also influenced by factors such as solubility, pH and concentration of the protein. According to [57], adding 20% soy flour to the wheat had a substantial favourable influence on the emulsifying activity of the samples. Author [58], in their findings observed that the addition of 5% pea or soybean protein isolates to rice flour, on the other hand, had no effect on the emulsifying activity of rice flour dough. These findings confirmed with that of [59] whose work was the emulsion stability of mucana bean flour and jack bean flour and recorded decreased in emulsion ability as the concentration of flour in the solution rose. However, [60] observed an improvement in emulsifying stability of Bambara groundnut flour with increasing concentration until it started to diminish with rising flour concentration from 6% w/v upward. Author [61] on the emulsifying capabilities of sunflower and soybean flours and protein concentrates came to the same conclusion. Emulsion ability plays a significant role in much food system where the proteins have the ability to bind with fat to meet products batter, dough and salad dressing [62]. Author [63] also stated that the hydrophobicity of protein has an influence on their emulsifying properties hence the trend that was observed.

The amount of interfacial area generated by protein during foaming is measured by the foaming capacity [64]. Oilseed proteins' foaming characteristics are significant for the domestic market since they are employed in the manufacturing of a variety of culinary products. Flours can form foams due to surface-active proteins [59]. The foaming capacity of all samples ranged from 2.44 to 13.04. There was a significant difference between sample ABC and the remaining samples. Sample ABC (whole wheat flour) had a higher 13.04 ± 0.00 FC while the others had the same results of 2.44 ± 0.00. This trend could be due to the fact that there is a component of one of the composite flours which could possess antifoaming ability hence what was observed. The study showed that the foaming capacity of sample ABC was significantly ($p>0.05$) different from the other samples. The changes in the foaming capacity of flour blends are comparable with earlier studies stated by [65]. Studies by [66] revealed a Foaming capacity of 7.21 to 33.38. The FC is accredited to the existence of proteins, which form a continuous cohesive film around the air bubbles in the foam. In their study the FC of refined flour (33.38%) was found to be significantly higher than that of elephant foot yam flour (7.21%) and flour blend (11.88%). The findings disagree with the study of [67] who found out that the foaming capacity of kidney bean flours ranged from 82.1 to 132.0 percent depending on the pH (2, 4, 6, 8, and 10). Again the results were not in line with [68] who investigated the foaming capacities of wheat flour, rice flour, green gram flour, and potato flour and recorded green gram flour with the maximum foam capacity (24.23 percent), followed by wheat flour (12.92 percent), potato flour (6.84 percent), and rice flour (6.84 percent) (3.52 percent). The foaming capacity of field pea flour (FPF) and pigeon pea flour (PPF) was investigated by [55]. They found that the foams formed by legume flours were thick, with a low foam volume but a high foaming capability. They observed that foaming capacity of FPF was found to be higher (39.5-42.3%) than that of PPF (34.5-37.3%). The results were similar to those previously published by [69], but were lower than those reported by [70] for PPF (68 percent). This could be related to protein and carbohydrate composition discrepancies.

Sample	WAC	OAC	BD	EA	FC
ABC	134.87 ± 0.66^{a}	96.43 ± 3.01^{a}	0.56 ± 0.03^{a}	61.25 ± 1.77^{a}	13.04 ± 0.00^{a}
RBD	87.97 ± 0.88^{b}	68.00 ± 1.48^{b}	0.68 ± 0.01^{b}	10.57 ± 1.69^{c}	2.44 ± 0.00^{b}
XYZ	91.64 ± 1.50^{b}	70.63 ± 0.29^{b}	0.67 ± 0.00^{b}	12.44 ± 1.27^{bc}	2.44 ± 0.00^{b}
DIO	105.00 ± 1.69^{c}	72.21 ± 1.90^{b}	0.66 ± 0.00^{b}	15.83 ± 1.18^{bc}	2.44 ± 0.00^{b}
ERY	128.81 ± 2.29^{a}	72.21 ± 1.52^{b}	0.64 ± 0.05^{b}	17.16 ± 0.69^{b}	2.44 ± 0.00^{b}

Table 3: Functional Properties of Flours

Values represent means and standard deviation replicate readings for various parameters. Values in the same column with different superscripts are significantly different ($p>0.05$). WAC = Water Absorption Capacity, OAC = Oil Absorption Capacity, BD = Bulk Density, EA = Emulsion Ability, FC = Foaming Capacity

Conclusion

Composite flours have been utilized in the making of pastries and other flour products for a long time with great success. The functional qualities of composite flours are a critical parameter for producing high-quality food items in terms of appearance, sensory attributes, and consumer acceptance. With the addition of other flours to wheat flour, the functional properties such as water absorption capacity, oil absorption capacity, emulsion stability and foam capacity decreased while the bulk density increased. Incorporating other flours with wheat flour increased the protein, fat and fibre contents making it a viable material for the preparation of baked and other flour products. Integrating the foregoing flours into wheat flour would thus be a cost-effective technique of lowering the costs of bakery product while also addressing malnutrition issues among Ghanaian children. This study concluded that composite flour had both positive and negative impacts, and can be used to improve food quality in the future. Further, composite flour is likely to operate as a product that provides a future source of locally grown agricultural items.

References

1. FAO (2010) Wheat importation in Nigeria in 2010. FAO Statistics 1999-2010. Food and Agriculture Organization of the United Nations, Rome.

2. Noorfarahzilah M, Jau-Shya L, Md Shaarani S, Abu Bakar MF, Mamat H (2014) Applications of composite flour in development of food products: A review. Int Food Res J 21: 2061-74.

3. Shanthi P, Johnkennedy Z, Parvathi K, Malathi D, Thangavel K, et al. (2005) Studies on wheat based composite flour for pasta products. Indian J Nutr Diet 42: 503-8.

4. Traynham TL, Myers DJ, Carriquiry AL, Johnson LA (2007) Evaluation of water holding capacity for wheat-soy flour blends. Journal of American Oil Chemists' Society 84: 151-5.

5. Alvarez-Jubete L, Arendt EK, Gallagher E (2010) Nutritive value of pseudocereals and their increasing use as functional gluten-free ingredients. Trends in Food Sci and Technol 21: 106–13.

6. Bergh Berghofer E (2000) Bread as a functional food. Grain Meal Bread 54: 175-9.

7. Bugusu BA, Campanella O, Hamaker BR (2001) Improvement of sorghum-wheat composite dough rheological properties and bread making quality through zein addition. Cereal Chemistry 78: 3135.

8. Mohamed S, Hamid NA, Hamid MA (1998) Food components affecting the oil absorption and crispness of fried batter. J Sci and Food Agric 78: 39-45.

9. Fayed ES, Abdel-shafy IH (1985) Accumulation of Cu, Zn, Cd and Pb by Aquatic Microphytes, Environ Int 11: 77-87.

10. Mohammed Nour AA, Mohamed AR, Adiamo OQ, Babiker EE (2018) Changes in protein nutritional quality as affected by processing of millet supplemented with Moringa seed flour. J of the Saudi Society of Agric Sci 17: 275-81.

11. Hasmadi M, Siti Faridah A, Salwa I, Patricia M, Mansoor AH, et al. (2014) The effect of seaweed composite flour on the textural properties of dough and bread. J Appl Phycol 26: 1057-62.

12. Suresh C, Samsher S, Durvesh K (2015) Evaluation of functional properties of composite flours and sensorial attributes of composite flour biscuits. J of Food Sci and Technol 52: 3681-88.

13. Gbenga-Fabusiwa FJ, Oladele EP, Oboh G, Adefegha SA, Oshodi AA (2018) Nutritional properties, sensory qualities and glycaemic response of biscuits produced from pigeon pea-wheat composite flour. J Food Biochem 42: e12505.

14. Hasmadi M, Jahurul MHA, Mohamad Khairi Z, Yu AL (2018) The influence of seaweed composite flour on the quality of muffin. J Aquatic Food Product Technol 27: 635-42.

15. Nyembwe PM, de Kock HL, Taylor JRN (2018) Potential of defatted marama flour-cassava starch composites to produce functional gluten -free bread-type dough. LWT 92: 429-34.

16. Emmanuel KO, Michael AI, Olajide PS, Bakare HA (2019) Quality attributes and storage stability of bread from wheat-tigernut composite flour. J Culinary Sci & Technol 17: 1-14.

17. Sonia D, De Leon Y and Milagros I (2006) Coconut, Processing Fruit: Science and Technology, CRC press, New York, USA, pp 707.3

18. Mepba H, Eboh L and Nwaojigwa SU (2007) Chemical composition, functional and baking properties of wheat-plantain composite flours. Afr J Food Agric Nutrition and Develop 7: 1-22.

19. AOAC (2015) Official Methods of Analysis. Association of Official Analytical Chemists. 18th Edition, AOAC, Arlington 806-14.

20. Moorthy SN, Rickard J, Blanshard JMV (1996) Influence of gelatinization characteristics of cassava starch and flour on the textural properties of some food products In: Dufour O'Brien editor. Cassava flour and starch: Progress in research and development, Best ed. Colombia: CIAT Publications.

21. Okaka JC, Potter NN (1977) Functional and storage properties of cowpea powder-wheat flour blends in bread making. J Food Sci 42: 828-33.

22. Narayana K, Narsinga Rao MS (1982) Functional properties of war and heat processed winged bean (*Psophocarpus tetragonolobus*) flour. J Food Sci 42:534-8.

23. Abayomi HT, Oresanya TO, Opeifa AO, Rasheed TR (2013) Quality Evaluation of Cookies Produced from Blends of Sweet Potato and Fermented Soybean Flour. Int J of Biol Biomol Agric Food and Biotechnol Eng 7: 642-3.

24. Akhtar S, Anjum F, Rehman SSM and Farzena K (2008) Effect offortification on the physico-chemical and microbiological stability of whole wheat flour. Food Chem 112: 156-63.

25. Julianti E, Rusmarilin H, Ridwansyah and Yusraini E (2017) Functional and rheological properties of composite flour from sweet potato, maize, soybean and xanthan gum. J Saudi Society of Agric Sci 16: 171-7.

26. Apotiola ZA, Fashakin JF (2013) Evaluation of Cookies from Wheat, Yam and Soybean Flour Blends. Food Sci and Quality Manag 14: 11-6.

27. Elleuch M, Bedigian D, Roiseux O, Besbes S, Blecker C, et al. (2011) Dietary fibre and fibre-rich by-products of food processing: Characterisation, technological functionality and commercial applications: Review on Food Chemistry 124: 411-21.

28. Owiredu I, Laryea D and Barimah J (2013) Evaluation of cashew nut flour in the production of biscuit. Nutr and Food Sci 44: 204-11.

29. Arancon RN (1999): Coconut flour. Coco info Int l6: 1–8.

30. Wardlaw GM (2004) Perspectives in Nutrition. ((6th ed.). McGram Hill Companies, New York, U.S.A Yadav, DN, Thakur N and Sunooj KV (2012). Effect of partially de-oiled peanut meal flour (DPMF) on the nutritional, textural, organoleptic and physicochemical properties of biscuits. Food and Nutr Sci 3: 471-6.

31. Omeire GC, Ohambele FI (2010) Production and evaluation of biscuits from composite wheat/deffated cashew nut flours. Niger Food J 28: 401-6.

32. Gernah DI, Senger IA, Audu JO (2010) Physico-chemical and sensory evaluation of cookies produced from wheat and brewers spent grain composite flour. Niger Food J 28: 440-7. Ihekoronye AI, Ngoddy PO (1985). Integrated food science and technology for the Tropics. London: Macmillan.

33. Ihekoronye AI and Uzomah A (2011) Manual on small scale food processing; a guide to opportunities for enterprise development in small scale food processing. Springfield publishers Ltd, Owerri. Pp 61-2.

34. Sravanthi L (2012) Essential Minerals Required for Human Body to Survive - Healthy & Fit. Retrieved from The FIt Indian: www.thefitindia.com/essential_minerals_required_for_Human_body_to_survive.html (Accessed 19th October, 2019)

35. Ndife J, Kida F, Fagbemi S (2014) Production and quality assessment of enriched cookies from whole wheat and full fat soya. Eur J of Food Sci and Technol 2: 19 -29.

36. Slavin JL (2005) Dietary fiber and body weight. Nutr 21: 411-8.

37. Gernah DI, Senger IA, Audu JO (2010) Physico-chemical and sensory evaluation of cookies produced from wheat and brewers spent grain composite flour. Niger Food J 28: 440-7. Ihekoronye AI, Ngoddy PO (1985). Integrated food science and technology for the Tropics. London: Macmillan

38. Satinder K, Sativa S, Nagi HPS (2011) Functional properties and anti-nutritritional factors in cereal bran. *Asian* Journal of Food and Agro- industry 4: 122-31.

39. Bibiana G, Grace N, Julius A (2014) Quality Evaluation of Composite Bread Produced from Wheat, Maize and Orange Fleshed Sweet Potato Flours. Am J of Food Sci and Technol 2: 109-15.

40. Anderson JW, Baird P, Davis Jr RH, Ferreri S, Knudtson M, et al. (2009) Health benefits of dietary fiber. Nutr. 67: 188-205.

41. Iwe MO, van Zuilichem, Ngoddy PO (2000) Colour of single-screw extruded blends of soy-sweet potato flour — A response surface analysis

42. Sinha SC (2001) Medicinal plants of Manipur. In: MASS and Sinha, Manipur cultural integration conference, Palace compound, Imphal: 125.

43. Suriya M, Baranwal G, Bashir M, Reddy CK, Haripriya S (2017) Influence of blanching and drying methods on molecular structure and functional properties of elephant foot yam

44. Kaur A, Kaur S, Singh M, Singh N, Shevkani K, et al. (2015) Effect of banana flour, screw speed and temperature on extrusion behaviour of corn extrudates. J Food Sci Technol. 52: 4276-85.

45. Shobha D, Kumar HVD, Sreeramasetty TA, Gowda KTP, Puttaramanaik, et al. (2014) Storage influence on the functional, sensory and keeping quality of quality protein maize flour. J Food Sci Technol 51: 3154-62.

46. Cheng YF, Bha R (2016) Functional, physicochemical and sensory properties of novel cookies produced by utilizing underutilized jering (Pithecellobium jiringa Jack.) legume flour”. Food Biosci 14: 54-61.

47. Aremu M, Olaofe O, Akintayo E (2007) Functional properties of some Nigerian varieties of legume seed flours and flour concentration effect on foaming and gelation properties. J Food Technol 5: 109-13.

48. Akpata MI, Akubor PI (1999) Chemical composition and selected functional properties of sweet orange (Citrus sinensis) seed flour. Plant Food Hum Nutr 54: 353-62.

49. Giami SY (1993) Effect of processing on the proximate composition and functional properties of cowpea (Vigna unguiculata) flour. Food Chem 47: 153-8.

50. Mwangwela AM, Waniska RD and Minnaar A (2007) Effect of micronisation temperature (130oC and 170°C) on functional properties of cowpea flour. Food Chem 104: 650-7.

51. Oladele AK and Aina JO (2007) Chemical composition and functional properties of flour produced from two varieties of tigernut (Cyperus esculentus). Afr J of Biotechnol 6: 2473-6.

52. Shih F and Daigle K (1999) Oil uptake properties of fried batters from rice flour. J of Agric and Food Chem 47: 1611-5.

53. Ugwu and Ukpabi UJ (2002) Potential of soy cassava flour processing to sustain increasing cassava production in Nigeria. Outlook on Agric 31: 129-133.

54. Du S, Jiang H, Yu X and Jane J (2014) Physicochemical and functional properties of whole legume flour. LWT-Food Sci and Technol 55: 308-13.

55. Kaur M, Kaushal P and Sandhu KS (2011) Studies on physicochemical and pasting properties of Taro (Colocasia esculenta L.) flour in comparison with a cereal, tuber and legume flour. J of Food Sci and Technol 50: 94-100.

56. Kaur M and Singh N (2005) Studies on functional, thermal and pasting properties of flours from different chickpea (Cicer arietinum L.) cultivars. Food Chem 91: 403-11.

57. Chauhan A, Saxena D, Singh S (2015) Total dietary fibre and antioxidant activity of gluten free cookies made from raw and germinated amaranth (*Amaranthus* spp.) flour. LWT Food Sci Technol 63: 939-45.

58. Ahn HJ, Kim JH and Ng PKW (2005) Functional and thermal properties of wheat, barley, and soy flours and their blends treated with a microbial transglutaminase. J Food Sci 70: c380-6.

59. Marco C and Rosell CM (2008) Functional and rheological properties of protein enriched gluten free composite flours. J Food Eng 88: 94-103.

60. Adebowale KO and Lawal OS (2003) Foaming, gelation and electrophoretic concentrate. Food Chem 83: 237-46.

61. Sathe SK, Deshpande SS and Salunkhe DK (1981) Functional properties of black gram (Phaseolus mango, L) proteins. Lebensmittel-Wissenschaft und –Technol 16: 69-74.

62. Lin MJ, Humbert ES and Sosulski FW (1974) Certain functional properties of sunflower meals. J of Food Sci 39: 368-70.

63. Kathe SK, Salunkhe DK (1981) Functional properties of the Great Northern bean (*Phasceolus vulgaris* L.) protein: Emulsion, foaming, viscosity, and gelation properties. J Food Sci 46: 71-4.

64. Ahmad M, Wani TA, Wani SM, Masoodi FA, Gani A (2016). Incorporation of carrot pomace powder in wheat flour: effect on flour, dough and cookie characteristics. J Food Sci Technol 53: 3715-24.

65. Zhu SM, Lin SL, Ramaswamy HS, Yu Y and Zhang QT (2017) Enhancement of functional properties of rice bran proteins by high pressure treatment and their correlation with surface hydrophobicity. Food Bioprocess Technol 10: 317-27.

66. Baljeet S, Ritika B, Roshan L (2010) Studies on functional properties and incorporation of buckwheat flour for biscuit making. Int Food Res J 17: 1067-76.

67. Wani IA, Sogi DS, Wani AA and Gill BS (2013) Physico-chemical and functional properties of flours from Indian kidney bean (Phaseolus vulgaris L.) cultivars. LWT - Food Sci and Technol 53: 278-84.

68. Suresh C and Samsher S (2013) Assessment of functional properties of different flours. Afr J of Agric Res 8: 4849-52.

69. Oshodi AA and Ekperigin MM (1989) Functional properties of pigeon pea (Cajanus cajan) flour. Food Chem 34: 187-91.

70. Mizubuti IY, Júnior OB, De-Oliveira-Souza LW, Dos Santos Ferreira da Silva RS and Ida EI (2000) Functional properties of pigeon pea (Cajanus cajan (L.) flour and protein concentrate. Records. Latin Am Nutr 50: 274-80