European Journal of Nutrition & Food Safety

Volume 14, Issue 12, Page 74-86, 2022; Article no.EJNFS.95200
ISSN: 2347-5641

Nutritional and Functional Properties of Wheat-Defatted Peanut-Orange Peel Composite Flour

Ndi Betrand Bongjo [a,b++*], Ahemen Samuel Aondoaver [a,c], Joseph Aondoaver Gbertyo [b], Ayong Mary Assumpta Fulai [a,b] and Lorita Nchung [a,b]

[a] Centre for Food Technology and Research (CEFTER), Benue State University Makurdi, Nigeria.
[b] Department of Chemistry, Benue State University Makurdi, Nigeria.
[c] Department of Agricultural Engineering, Akperan Orshi Polytechnic, Yandev, Nigeria.

Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/EJNFS/2022/v14i121283

Open Peer Review History:
This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here: https://www.sdiarticle5.com/review-history/95200

Original Research Article

Received: 14/10/2022
Accepted: 23/12/2022
Published: 28/12/2022

ABSTRACT

The need to improve and enhance the nutritional quality of locally made foods (bakery and confectionaries) cannot be overemphasized. This study set out to meet this need by producing composite flours from wheat, defatted peanut and orange peel flour blends which will serve an even greater issue of reducing the cost of wheat importation and use. The samples were coded as follows: A-100:0:0, B-90:5:5, C-85:10:5, D-80:15:5, E-75:20:5 of wheat flour: Defatted peanut flour: orange peel flour. The flours produced were analyzed for functional, anti-nutrient, proximate, minerals, and phytochemical properties. The functional properties of flours; bulk density, swelling capacity, OAC, WAC, and Foaming capacity ranged from 0.43 to 0.93 g/ml, 0.89 to 5.67%, 0.47 to 2.55 g/L, 1.75 to 4.35ml/g, 0.52 to 10.56% respectively. The anti-nutritional properties: phytates,

[++] *ORCID: 0000-0002-0717-6119*
**Corresponding author: Email: betrandbongjo@gmail.com;*

tannins, and trypsin inhibitor content of flours ranged from 0.0352 to 0.0845%, 0.040 to 0.600%, and 0.011 to 0.048mg/g respectively. The proximate composition of the flour samples, Moisture, Protein, fats, crude fibre, ash, carbohydrates, and energy values ranged from 5.58 to 9.55%, 6.33 to 15.64%, 1.06 to 3.51%, 0.24 to 4.07%, 1.42 to 2.65%, 85.37 to 64.58% and 376.34 to 352.47kcal/100g respectively. The mineral composition in the samples ranged from 232.05 to 394.62mg/100g for Ca, 76.09 to 122.27mg/100g for Mg, 6.71 to 29.42 mg/100g for Fe, 108.78 to 256.47mg/100g for K, 10.09 to 25.75 mg/100g for Zn. The phytochemical composition of the samples was as follows; 0.067-0.153%, for saponins; 0.043-1.457%, for alkaloids; 1.03-13.77mgGAE/g, for Total phenolics; 3.07-29.31mg/QE, for Total Flavonoids respectively. The composite flour herein produced demonstrates great potential for its use in the development of functional foods given its great nutrients and improved functional characteristics. However sample E with 75%wheat: 20%DPF: 5%OPF surpassed all other samples in terms of the quality attributes and therefore was the best of the formulations.

Keywords: Defatted peanut flour; orange peel; composite flours; functional foods.

1. INTRODUCTION

"Composite flour is defined as a mixture of flours obtained from tubers (rich in starch such as cassava, yam, potato, and protein-rich flour) and cereals, with or without wheat flour aimed at satisfying specific functional characteristics and nutrient composition" [1]. It has been used successfully and extensively in the bakery and pastry industry. Economically, composite flour reduces the huge amount of foreign exchange spent by Nigeria, Cameroon and other sub-Saharan countries in the importation of wheat flour. When composite root and tuber-wheat flour is fortified with seeds like peanuts, this can further increase the nutritional quality of the pastry products like chinchin, cookies, breads, muffins etc. Besides, the increase in the protein content of composite flour via legumes, fortification has been reported to improve the baking quality of dough and its products [1,2]. The nutritional quality of the foods produced from composite flours therefore is known to depend on the proportional composition of the concerned flours. The FAO (Food and Agriculture Organization of the United Nations) introduced the Composite Flour Programme in 1964 [3] with a mandate to the development of bakery products from locally available food crops.

Peanut (*Arachis hypogaea*), belongs to the family *Leguminosae*, native to Mexico, South and Central America [4]. China has been reported to be the highest producer of peanut estimated at of 33,309,998 tonnes per year [5], while Niger state tops the scale in terms of peanut production in Nigeria and contributes enormously to the economy through the sales of seeds, cakes, oil, and haulms [6]. Research has shown that when peanuts are added to a high glycemic load meal, they keep the blood sugar stabilized so that it does not rise too high too quickly. They are an important food crop known for their high source of protein and oil and fibers [7]. Consumption of peanuts on daily basis has been linked to the reduction of mortality risk of malnutrition by up to 20% [8]. "The nutritional importance of peanuts is due to the energy and growth supplementing constituents present in them. These include carbohydrates, lipids, proteins, vitamins, minerals, some organic acids, and purines" [7]. Authors report a composition per 100 g of raw peanuts as follows: water-1.55g, carbohydrates-21.51g, Fiber-8.0g, Lipids (Fats)-49.66g, Proteins-23.68g, Energy-585 Kcal [9]. Partially defatted peanut flour is a protein-rich, inexpensive and underutilized product offering the same health and dietary benefits of peanut but with less fat content making its wide applications in diets of nutritionally vulnerable groups [10].

"Orange (*Citrus sinensis* L) is one of the most important fruits in the tropical and sub-tropical regions of the world. Its fruits are usually eaten fresh, used for making canned orange juice, frozen juice concentrates, jams, and jellies and many others" [11]. Orange peels have shown great preservative potentials but unfortunately these peels are not efficiently exploited and made use of in the food industry for product development. Many food processors still resort to using artificial preservatives as a means of extending shelf life of their products. It has been noted that orange processing industries generate huge amounts of orange peel and pulp as by products from the industrial extraction of orange juices [12].

"This is a great cause for concern as it impacts negatively on the environment. In accordance with recently published information by the FAO considering the impacts of the novel coronavirus (COVID-19), the situation of populations with extreme hunger in the world will probably increase, and therefore countries should gain efficiencies and try to reduce trade-related costs, for example, by reducing food waste and losses" [13].

It is known that orange peels contain significant levels of nutritional and phytochemical properties which can contribute to body's nutrition and also medical purposes [14,15]. This study therefore set out to produce and evaluate the quality of flour produced from a blend of wheat, defatted peanut and orange peel flour.

2. MATERIALS AND METHODS

2.1 Sourcing of Materials

Wheat flour, Peanuts and oranges were gotten from Wurukum, Wadata and Railway markets respectively, all in Makurdi-Benue State, Nigeria. Processing and analysis was carried out in the Chemistry lab, Benue State University (BSU) for processing.

2.2 Equipment

The equipment used for the study were mixer, blender, desiccator, furnace, milling machine, oven (Hipman 60), sieves (0.5 mm and 0.7 mm), measuring cylinder and weighing scale. All reagents and chemicals used were of analytical grade.

2.3 Raw Material Preparation and Blend Formulation

Defatted peanut flour was produced as on Fig. 1, while Orange peel flour was produced as shown on Fig. 2. The 3 flours; wheat, defatted peanut flour and orange peel flour were blended in different ratios as on Table 1.

2.4 Analytical Methods

The functional properties of the flours obtained were determined as described by Bukuni et al. [17]**.** The proximate analysis of the composite flours were determined by the official methods of AOAC [18]. Energy was calculated using Attwater factor (fat x 9 + carbohydrate x 4 + protein x 4 kcal/100 g).

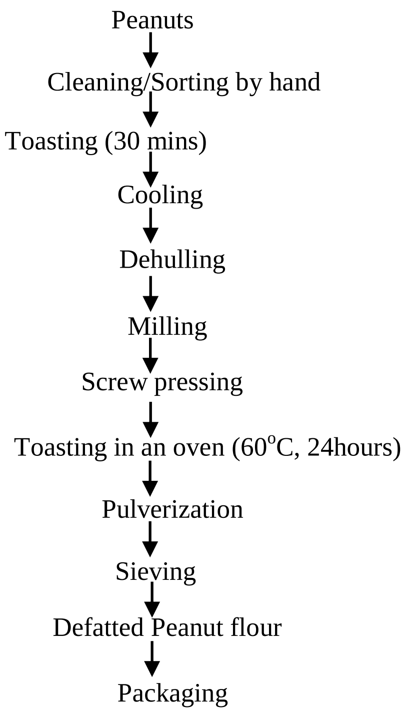

Fig. 1. Flow chart for the production of defatted peanut flour
Source: Modified method of Ikese et al. [16]

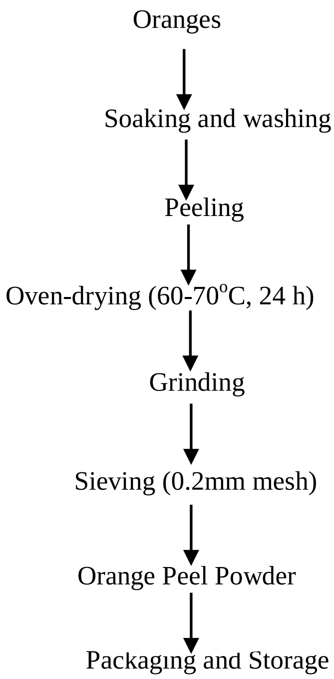

Fig. 2. Flow chart for the production of orange peel flour
Source: Modified method of Belose et al. [62]

Table 1. Flour blend formulation

	Ingredient (%)		
Samples	**Wheat flour**	**Defatted peanut flour**	**Orange peel flour**
A	100	0	0
B	90	5	5
C	85	10	5
D	80	15	5
E	75	20	5

2.5 Determination of Minerals

"The minerals Ca, K, Mg, Fe, and Zn were determined by the Atomic Absorption Spectrophotometer method. The optimum range for each element was prepared and all the operational instruction for setting up the instrument for the analysis of specific element was strictly followed" [18]. "The ash residues were digested with 5 mL of concentrated nitric acid, filtered and the filtrate transferred 100 mL volumetric flask and diluted with distilled water to 100 mL volume. This was done for all the samples, and stored at room temperature pending AAS analysis" [18].

2.6 Anti-nutritional Analysis of Samples

Tannins were determined by the Follins-Dennis titrating method [19]. Phytates were determined by the Young and Greaves methods with slight modification [20]. Trypsin was determined by the method as described by Omoboyowa et al. [21].

2.7 Determination of Phytochemicals

The Folin-Ciocalteu reagent was used to determine the total phenolic content (TPC) of the various sample extracts in terms of Gallic acid equivalent (GAE) [22]. The total flavonoid content was determined, using quercetin as standard, and aluminium chloride as reagent [23]. Alkaloids and saponins were estimated gravimetrically [19].

2.8 Statistical Analysis

Statistical Package for Social Science (SPSS) Version 26 computer software was used to analyze the data. All experiments were conducted in triplicates and reported as mean±standard deviation (SD). Analysis of variance (one way ANOVA) was used to ascertain any significant differences in the treatments; differences were considered at 95% ($p<0.05$) significant level. The Duncan Multiple Range Tests (DMRT) was used to separate means.

3. RESULTS AND DISCUSSION

3.1 Functional Properties of Flours

The functional properties of flours describe the behavior of the flours during preparation and cooking and also predict how they will affect the finished products in terms of appearance, taste and texture [24]. These properties are a function of the organoleptic, physical, and chemical properties of the food such as protein content, carbohydrate content, fibre and fat content [25]. The functional properties of the composite flours are presented on Table 2. Water absorption capacity (WAC) is an important functional property required in food formulations especially those involving dough handling as it determines the extent to which the flour concerned can absorb water. The water absorption capacity increased significantly ($p<0.05$) from 1.75mg/L (sample A) to 4.32mg/L (sample E). The major chemical composition that enhances the water absorption capacities of flours are proteins, fiber and carbohydrates .These constituents contain hydrophilic parts such as polar or charged side chains. Therefore, the increase in the WAC of the flour is due to the increase in the protein and fiber content of the flour as the quantity of the high-protein-dense rich DPF and OPF were added. A similar trend was observed by several authors who used composite flours of wheat, rice flour, green gram and potato flours and noted an increase in WAC with increase in the incorporation of the different flours to wheat flour[26]. This was attributed to the molecular structure of the rice, green gram and potato starch. A similar situation was reported in another study by Kaushal et al. [27].

The bulk density (BD) of the flours ranged from 0.67g/ml (sample A) to 0.98 g/ml (sample E). The bulk density of flour is a measure of the heaviness of a flour sample. It is that parameter of a flour that is used to determine its packaging requirements and is a function of the particle size and moisture content of flours [28]. As observed, the BD of the composite flours increased with increase in the incorporation of DPF. Flours from legumes have been reported to have high BD [29] and this could also be one of the reasons for the significant increase ($p<0.05$) in the BD from sample A to E. A similar trend was observed by Suresh et al. [26]. It is clear that decreased the proportion of wheat flour increased the bulk density of the composite flours. The high bulk density of the flours suggests their suitability for use in food preparations.

The oil absorption capacity (OAC) of the flours ranged from 0.47g/L (sample A) to 1.84g/L (sample E). OAC is the ability of the fat in flour to bind to the non-polar side chain of proteins. It is an essential functional property that contributes to enhancing mouth feel while retaining the food products' flavor [30]. The OAC as observed in this study increased with increase in the addition of DPF. This could be due to the high protein content in DPF. The higher the amount of heat treatment given to a protein, the more hydrophobic the protein becomes, as a result of a higher number of hydrophobic groups exposed through the unfolding of the protein molecules [31]. This could further explain the significant increase ($p<0.05$) in the OAC of the flours with increase substitution of DPF (produced by a series of heat treatment procedures including roasting and screw pressing). The results of this study agree with those of Suresh et al. [26] and Kaush et al. [27].

The swelling capacity (SC) of the flours ranged from 1.08% (sample E) to 1.31% (sample A). Increase incorporation of DPF witnessed a significant decrease ($p<0.05$) from sample A to sample C. However, increase incorporation from sample C to sample E witnessed no significant change ($p>0.05$) in SC. SC is a function of the size of particles, types of variety (like the presence of starch) and types of processing methods or unit operations involved in the flour production. The results show a significant decrease ($p<0.05$) in SC from sample A to sample E. This could be due to a reduction in the flour's ability to absorb water and swell as it reflects the extent of associative forces in the starch granules [32].

The foaming capacity (FC) of the flours ranged from 8.6 (sample A) to 10.56 (sample E). It is a measure of the amount of interfacial area created by the whipping the food or flour. Proteins are mainly responsible for foaming [33]. Foaming capacity and stability generally depend on the interfacial film formed by the proteins, which maintains the suspension of air bubbles and slows down the coalescence rate[34]. This study recorded a significant increase ($p<0.05$) in the foaming capacity as the substitution with DPF increased from sample A to sample E. This could be due to the increase in protein content of the flours as DPF concentration increased. A similar trend was reported by Aburime et al. [24] and Suresh et al. [26].

3.2 Proximate Composition of the Composite Flours

The proximate composition of composite flours of wheat, defatted peanut flour and orange peel flour are presented on Table 3. The moisture content of the flours ranged from 5.58% in sample A to 9.55% in sample E. There was a significant increase ($p<0.05$) from sample A to sample E as the level of DPF incorporation increased; implying the composite flours are different from the control. The increase in moisture content could be attributed to increase in the hydrophilic property of fiber in the DPF and OPF as the level of incorporation increased. Also this was expected as DPF contain a great concentration of protein[35] which is usually associated with high water absorption. This result agree with those of [36] who reported an increase in the moisture content with increase in African yam bean flour on a cassava-African yam bean composite flour. The relatively low moisture content is an indication of storage stability and could produce a more shelf stable product. These also compare favorably with results by other authors who reported a moisture content ranging from 8.89-9.11% [37]. These results fall below the 14% recommended standard as set by Standard Organization of Nigeria (SON) for safe storage of flours in Nigeria. The protein content ranged from 6.33% (sample A) to 15.64% (sample E). Protein content of the blends increased significantly ($p<0.05$) with every level of DPF flour substitution. This increase was expected because of the high protein content of DPF compared with wheat flour hence the observed synergistic effects of protein complementation [35]. A similar result was noted in a study by Iwe et al. [30] but rather disagree with Alexander [38] and Meka et al. [37] who observed a decrease in the protein content as the level of substitution of wheat flour increased. As observed in this study, the significant increase in the protein content of the composite flours is the basis for formulating the blends such that the any food product there from will not only have higher protein content but also higher protein quality.

The fat content of the flours ranged from 1.06% (sample A) to 3.51% (sample E). There was an observed significant fat content increase (p<0.05) in the flour composites as the level of substitution with DPF and OPF increased. This may be due to the fat content of peanut as the level of incorporation in the blends increases. The low fat levels are beneficial as it ensures longer shelf life for the products [39] because all fats and fat containing foods contain some unsaturated fatty acids and hence are potentially susceptible to oxidative rancidity. These results are higher than those observed by Ajibola and Olapade [36] of 0.5%-1.4% but are similar to results by Iwe et al. [40].

The ash content of the flours as shown ranged from 1.42% in sample A (control) to 2.65% in sample E with 20%DPF and 5% OPF. It was observed that the values increased significantly (p<0.05) with increase in the level of DPF and OPF. This could be attributed to the high ash content in peanuts [4], [41] and orange peels[15]. The ash content of a food is essentially its mineral content. Minerals are a group of essential nutrients which serve a variety of important metabolic functions and are parts of molecules such as hemoglobin, adenosine triphosphate (ATP) and deoxyribonucleic acid (DNA). The results herein obtained are higher than those observed by Iwe et al. [40] but are similar to those in a study by Bukuni et al. [17] who reported on the chemical composition of composite flours with increasing incorporation of Bambara groundnut. The fibre content of the flours produced was observed to vary from 0.24% in sample A to 4.07% in Sample with the highest substitution of DPF. There was a significant difference (p<0.05) between the samples as the level of incorporation of DPF and OPF increased. This increase was expected as peanut and orange peel have high fibre contents [35,42]. Consumption of foods appreciably high in fibre contributes to an increase in faecal bulk thus increased rate of intestinal transit. Dietary fibre intake has also been linked with lower risk of coronary heart diseases, stroke, hypertension, diabetes, lowering blood pressure as well as cholesterol levels in the serum [43]. These results are lower than those reported by Ajibola and Olapade [36] and Alexander [40] who incorporated orange-fleshed sweet potato into wheat flour cookie production. These results however are also higher than those reported by Meka et al. [37] who reported 1.10 to 1.58% in a yellow maize-soybean-jackfruit composite flour. The carbohydrate content of the flours decreased significantly (p<0.05) from 85.37% in sample A (control) to 64.58% in sample E. The decrease is due to the increase in other proximate components since carbohydrate is obtained by difference. This agrees with [17,36,40] who reported that increase in other proximate component (protein, ash fibre, moisture) often result to decreased in carbohydrates content of food. The lower carbohydrate content of flour has several health benefits, as it will aid digestion in the colon and reduce constipation often associated with products from refined grain flours. These results disagree with those from other studies [37]. The total calories decreased significantly (p<0.05) with increase substitution of DPF and OPF from 376.34 Kcal in sample A (control) to 352.47Kcal in sample E. This decrease could be attributed to a decrease in the carbohydrate contents of the flours which is the main contributing macromolecule to the energy content of any food product and also due to the fact that peanuts do not have high carbohydrate contents as opposed to wheat flour [4].

3.3 Antinutritional Factors of the Composite Flours

The antinutrients in the composite flours are presented in Table 4. The phytate contents of the flours ranged from 0.035 to 0.085% as the level of incorporation of DPF increased. Sample A had the lowest phytate contents while sample E had the highest concentration. As observed, there was a significant increase (p<0.05) in the phytate contents between sample A and sample B but no significant difference (p>0.05) between sample B and C. This was also noticed between sample C and D. Phytic acid has been known to decrease the availability of especially bivalent mineral ions (calcium, iron, magnesium and zinc) as well as protein. When bound to protein; it is known to induce a decrease in its solubility and functionality [44]. The results obtained here are lower than those obtained by Bukuni et al. [17] who reported 0.06%-0.11% for composite flours from yellow maize, Bambara groundnut and mango powder, but higher than those reported for a wheat-based complementary food by Ikese et al. [16]. The tannin contents ranged from 0.040% to 0.600% for sample A to sample E in flours. As seen, the level of incorporation of DPF didn’t have (p>0.05) any significant effect on the tannin content of both the flour. This could be due to proper processing which reduced the level of tannin contents significantly. Tannins are known to precipitate proteins, inhibit digestive enzymes and affect the utilization of vitamins and minerals, hence consuming large amounts of tannins may result in adverse health effects, such as impaired microbial enzyme activity such by forming irreversible as well as reversible complexes with these enzymes [45,46]. The results in this study are lower than those reported by other studies [17,47]. The trypsin inhibitor contents of the flour samples ranged from 0.011mg/g to 0.048mg/g for sample A to sample E. Increasing levels of incorporation of DPF didn't have a significant effect on the trypsin inhibitors in the flour samples. There was a significant increase in the trypsin inhibitor content between sample A and sample B to E. This could be due to the fact that peanuts are known, just like many legumes to contain high concentrations of trypsin inhibitors [48]. The presence of protease inhibitors in the diet had been reported to form an irreversible trypsin enzyme-trypsin inhibitor complex, causing a trypsin drop in the intestine and a decrease in the diet protein digestibility, leading to slower growth. In this condition, the organism increases the secretory activity of the pancreas, which could cause pancreatic hypertrophy and hyperplasia [49]. The results of this study follow the same trend as those reported by Nwatum et al. [1], Abioye et al. [50] but are lower comparatively.

3.4 Mineral Composition of Composite Flours

The mineral composition of the flour samples are presented on Table 5. The value for the calcium contents in the flours ranged from 232.05-394.62mg/100g. There was a significant difference ($p<0.05$) in the calcium contents of the flours as the values increased with increase in the incorporation of DPF and OPF. Calcium is known to play a major role in muscle contraction, building strong bones and teeth, blood clotting, nerve impulse, transmission, regulating heart beat and fluid balance within cells [51]. The iron content of the samples increased significantly ($p<0.05$) from 6.71 mg/100g (sample A) to 29.41mg/100g in sample E. There was a significant increase in the iron content of the flours as the level of incorporation of DPF and OPF increased. Iron is involved in strengthening the immune system. Iron is the functional component of hemoglobin and other key compounds used in respiration, immune function and cognitive development. It is important in the diet of pregnant women, nursing mothers and infants. Iron prevents anemia [52].

The potassium contents of the samples ranged from 108.78-256.47mg/100g with sample A having the least, while sample E having the highest. There was significant increase ($p<0.05$) in the potassium content as the level of incorporation with DPF and OPF increased. It has been reported that potassium plays vital roles in maintaining fluid balance and proper functioning of the essential organs such as the brain, nerves, heart and muscle [53]. It has also been known to aid nerve impulse transmission and it is a major cation of intracellular fluid [52]. The addition of DPF and OPF increased the magnesium content of the flours such that sample A had the least value of 76.54mg/100g and sample E had the highest value of 122.27mg/100g. There was a significant increase ($p<0.05$) in the magnesium content between the samples. Magnesium is essential to good health as it helps in the maintenance of normal muscle and nerve function, keeping heart rhythm steady, supporting a healthy immune system and keeps bones strong [54].

Table 2. Functional properties of flours

	Bulk density (g/ml)	Water absorption capacity (ml/g)	Oil absorption capacity (%)	Swelling capacity	Foaming capacity (%)
A	0.67^{c}±0.00	1.75^{a}±0.00	0.47^{a}±0.38	1.31^{d}±0.01	8.60^{c}±0.00
B	0.71^{d}±0.00	1.89^{a}±0.01	1.12^{b}±0.00	1.22^{c}±0.00	9.10^{d}±0.10
C	0.73^{d}±0.01	2.37^{b}±0.01	1.37^{b}±0.02	1.13^{b}±0.00	9.50^{e}±0.00
D	0.82^{e}±0.01	3.25^{c}±0.20	1.69^{c}±0.02	1.14^{b}±0.01	9.85^{f}±0.05
E	0.98^{f}±0.00	4.35^{d}±0.15	1.84^{c}±0.00	1.08^{b}±0.00	10.56^{g}±0.06
DPF	0.43^{a}±0.02	2.33^{b} ±0.02	2.55^{d}±0.02	0.89^{a}±0.02	0.93^{b}±0.02
OPF	0.63^{b}±0.02	1.75^{a}±0.11	1.34^{b}±0.03	5.67^{e}±0.11	0.52^{a}±0.03

Key: A-100% Wheat flour, B-90%Wheat: 5%DPF: 5%OPF flour, C-85%Wheat: 10%DPF: 5%OPF flour, D-80%Wheat: 15%DPF: 5%OPF flour, E-75%Wheat: 20%DPF: 5%OPF flour; DPF-Defatted peanut flour, OPF-Orange peel flour

Values represent mean±SD of triplicate determinations. Means in the same column with different superscripts are significantly different at p<0.05

Table 3. Proximate composition of composite flours

Percentage (%)							kcal/100g
Sample code	**moisture**	**Fat**	**Protein**	**Ash**	**Fibre**	**Carbohydrates**	**Total calories**
A	5.58^{a}±0.01	1.06^{a}±0.01	6.33^{a}±0.01	1.42^{a}±0.00	0.24^{a}±0.00	85.37^{e}±0.03	376.34^{e}±0.02
B	7.99^{b}±0.04	1.37^{b}±0.05	8.90^{b}±0.16	1.66^{b}±0.01	0.66^{b}±0.02	79.42^{d}±0.19	365.61^{d}±0.35
C	8.46^{c}±0.01	1.76^{c}±0.04	11.04^{c}±0.07	1.97^{c}±0.01	1.57^{c}±0.21	75.20^{c}±0.03	360.80^{c}±0.21
D	8.72^{d}±0.01	2.66^{e}±0.08	12.48^{d}±0.03	2.27^{d}±0.00	2.79^{d}±0.11	71.08^{b}±0.16	358.18^{b}±0.14
E	9.55^{e}±0.00	3.51^{f}±0.00	15.64^{e}±0.01	2.65^{e}±0.00	4.07^{e}±0.07	64.58^{a}±0.00	352.47^{a}±0.00

Key: A-100% Wheat flour, B-90%Wheat: 5%DPF: 5%OPF flour, C-85%Wheat: 10%DPF: 5%OPF flour, D-80%Wheat: 15%DPF: 5%OPF flour, E-75%Wheat: 20%DPF: 5%OPF flour. Values represent mean±SD of triplicate determinations. Means in the same column with different superscripts are significantly different at p<0.05

Table 4. Antinutritional composition of composite flours

Sample	Phytates (%)	Tannins (%)	Trypsin inhibitors (mg/g)
A	0.0352^{a}±0.000	0.040^{a}±0.000	0.011^{a}±0.000
B	0.0583^{b}±0.000	0.435^{b}±0.005	0.028^{a,b}±0.000
C	0.0596^{b}±0.000	0.475^{b}±0.055	0.014^{a,b}±0.000
D	0.0823^{c}±0.001	0.445^{b}±0.005	0.029^{a,b}±0.000
E	0.0845^{c}±0.000	0.600^{c}±0.000	0.048^{b}±0.001

Key: A-100% Wheat flour, B-90%Wheat: 5%DPF: 5%OPF flour, C-85%Wheat: 10%DPF: 5%OPF flour, D-80%Wheat: 15%DPF: 5%OPF flour, E-75%Wheat: 20%DPF: 5%OPF flour. Values represent mean±SD of triplicate determinations. Means in the same column with different superscripts are significantly different at p<0.05

Table 5. Mineral composition of composite flours

mg/100g					
Sample	**Calcium**	**Iron**	**Potassium**	**Magnesium**	**Zinc**
A	232.05^{a}±0.01	6.71^{a}±0.21	108.78^{a}±1.22	76.09^{a}±0.01	10.09^{a}±0.11
B	237.13^{b}±0.01	13.27^{b}±0.28	159.73^{b}±39.73	88.32^{b}±0.00	13.42^{b}±0.04
C	277.24^{c}±0.12	17.87^{c}±0.02	176.11^{b}±2.35	95.22^{c}±0.01	17.41^{c}±0.05
D	309.08^{d}±1.06	24.84^{d}±0.25	215.29^{c}±0.73	107.78^{d}±0.01	21.88^{d}±0.20
E	394.62^{e}±6.01	29.42^{e}±0.15	256.47^{d}±0.43	122.27^{e}±0.01	25.75^{e}±0.57

Key: A-100% Wheat flour, B-90%Wheat: 5%DPF: 5%OPF flour, C-85%Wheat: 10%DPF: 5%OPF flour, D-80%Wheat: 15%DPF: 5%OPF flour, E-75%Wheat: 20%DPF: 5%OPF flour. Values represent mean±SD of triplicate determinations. Means in the same column with different superscripts are significantly different at p<0.05

Table 6. Phytochemical composition of composite flours

Sample	Saponins (%Dry weight)	Alkaloids (%Dry weight)	Total phenols (mgGAE/g)	Total flavonoids (mgQE/g)
A	0.067^{a}±0.001	0.043^{a}±0.001	1.03^{a}±0.00	3.07^{a}±0.01
B	0.107^{b}±0.000	0.663^{b}±0.000	4.44^{b}±0.08	12.68^{b}±0.01
C	0.125^{c}±0.001	0.811^{c}±0.006	8.80^{c}±0.00	16.22^{c}±0.00
D	0.145^{d}±0.002	0.980^{d}±0.005	10.14^{d}±0.00	24.89^{d}±0.01
E	0.153^{e}±0.003	1.457^{e}±0.000	13.77^{e}±0.02	29.31^{e}±0.00

Key: A-100% Wheat flour, B-90%Wheat: 5%DPF: 5%OPF flour, C-85%Wheat: 10%PDPF: 5%OPF flour, D-80%Wheat: 15%PDPF: 5%OPF flour, E-75%Wheat: 20%DPF: 5%OPF flour. Values represent mean±SD of triplicate determinations. Means in the same column with different superscripts are significantly different at p<0.05

The zinc content of the samples ranged from 10.09-25.74mg/100g. There was a significant increase (p<0.05) in zinc content of the flours as the level of incorporation with DPF and OPF increased. Zinc helps with hormone production, growth and repair; improves immunity and facilitates digestion. Zinc also has a big impact on hormonal balance, so for this reason, zinc deficiency can result to an increased risk for infertility or diabetes. Peanuts are rich in zinc and this increase is justified [41]. Zinc has been recommended for the treatment of diarrhea by the World Health Organization (WHO) and United Nations Children's Fund (UNICEF). Zinc is an effective therapy for diarrhea and will decrease diarrhea morbidity and mortality [55].

3.5 Phytochemical Composition of the Composite Flours

The saponin, alkaloids, Total Phenols and Total Flavonoids of the flour samples are presented on Table 6. The saponin content ranged from 0.067% to 0.153% in the flours as the level of incorporation with DPF increases. Increasing levels of DPF in the samples witnessed a significant increase ($p<0.05$) in the saponin contents. This could be due to the fact that peanuts and orange peel also contain some significant amount of saponins as reported in literature [56]. Saponins are natural compounds present in in foods most especially and they are known to have surface active properties. Saponins have plasma cholesterol lowering effect in humans and are important in reducing the risk of many chronic diseases [56]. On the other hand, saponins are treated as natural antioxidants since it binds to cholesterol and prevents cholesterol oxidation in the colon [57]. The content of alkaloids in the flour samples ranged from 0.04% to 1.46%. There was a significant increase ($p<0.05$) in the alkaloid contents with increase incorporation of DPF and OPF. Alkaloids belong to a class of naturally occurring organic compounds that mostly contain basic nitrogen atoms. These compounds include related compounds with neutral and even weakly acidic properties. Alkaloid is seen as bye-products of plant metabolism, and they also act as protein reservoirs [17]. They generally possess high level of bitterness and thus become universal feeding deterrent in plant-herbivores interactions [58]. The results herein obtained are significantly lower than those reported by Bukuni et al. [17]. The total phenolic content in the flour samples ranged from 1.03-13.77mgGAE/g. There was a significant difference ($p<0.05$) in the total phenolic contents of the flours as it was observed to increase with increase incorporation of DPF and OPF. Sample A had the least with 1.03mgGAE/g while sample E had the highest with 13.77mgGAE/g. Phenols play important roles in the prevention of degenerative diseases, particularly cardiovascular diseases and cancers through the modulation of oxidative stress mediated through their antioxidant properties. These biologically active compounds have been reported to have anti- inflammatory, anti-carcinogenic, and anti-ischemic properties [59]. The observed rise in flavonoid content of formulated flour with attendant rise in DPF(94.4-228.8mgGAE/g) and OPF(5.27-9.40mgGAE/g) substitution is consistent with earlier study that showed peanuts and orange peels are good sources of phenolics with antioxidant activity [23,59]. The total flavonoid contents of the flours increased significantly ($P<0.05$) with increase in the incorporation of DPF and OPF. Sample A had the least (3.07mgQE/g) while sample E had the highest (29.31mgQE/g). This increase was expected as peanuts have been known to contain high amounts of flavonoids than phenols [60]. Flavonoids also possess strong antioxidant properties. They have been used in many countries as medications for blood vessel protection, and are ingredients of numerous multivitamin preparations and herbal remedies. Studies have also reported increasing flavonoid contents for pearl millet-tiger nut flour [61].

4. CONCLUSION

Composite flour was successfully produced from wheat, partially defatted peanut flour and orange peels. Sample E (75%wheat: 20%DPF: 5%OPF) was the best formulation in terms of overall quality of the flours produced. Increased incorporation or substitution with defatted peanut flour and orange peel flour significantly improved the protein, fat, ash and the dietary fibre contents of the composite flour, which could be nutritionally advantageous to the low-income earners who can hardly afford high protein foods because of the costs. The flour also had increased nutrients in minerals, with improved functional properties showing that the flours could be used extensively in the food system. Interestingly, this study demonstrated a significant enhancement in the phytochemical composition of the flours. This makes the flours potential sources of these bioactive compounds and making it versatile for use in functional food development. The use of this composite flour would greatly enhance the utilization of these crops in sub-Saharan African countries like Nigeria where the crops has not been optimally utilized. It would encourage farming activities and value addition to the farmers' crops.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Nwatum IA, Ukeyima MT, Eke MO. "Production and quality evaluation of cookies from wheat, defatted peanut and avocado composite flour." Asian Food Sci. J. 2020;15(4):1–12.
DOI: 10.9734/afsj/2020/v15i430156
2. Otunola E, Sunny-Roberts E. "Effects of addition of partially defatted groundnut paste on some Properties of 'kokoro' (a popular snack made from maize paste)." Agric. Biol. J. North Am. 2012;3(7):280–286.
DOI: 10.5251/abjna.2012.3.7.280.286
3. Jisha S, Padmaja G, Moorthy SN, Rajeshkumar K. "Pre-treatment effect on the nutritional and functional properties of selected cassava-based composite flours." Innov. Food Sci. Emerg. Technol. 2008;9(4):587–592.
DOI: 10.1016/j.ifset.2008.06.003
4. Salve A, Arya S. "Physical, chemical and nutritional evaluation of *Arachis hypogaea* L. Seeds and its oil." J. Microbiol. Biotechnol. Food Sci. 2018;8(2):835–841.
DOI: 10.15414/jmbfs.2018.8.2.835-841
5. UN. Food and Agricultural Organization; 2013. [Online]
Available:http://www.fao.org/countryprofiles/index/en/?lang=en&iso3=CRI
6. Olorunju PE, Alabi O, Tanimu BB. "Priorities, and strategies for groundnut research in Nigeria. A paper presented at the national workshop on groundnut rehabilitation in Nigeria, Kano." Kano, Nigeria; 1999.
7. Toomer OT. "Nutritional chemistry of the peanut (*Arachis hypogaea*)." Crit. Rev. Food Sci. Nutr. 2018;58(17):3042–3053.
DOI: 10.1080/10408398.2017.1339015
8. Cacchiarelli N. "Association of nut consumption with total and cause-specific mortality." Arch. Argent. Pediatr. 2014;112(5)484–485.
DOI: 10.1056/nejmoa1307352
9. Özcan MM. "Some nutritional characteristics of kernel and oil of peanut (*Arachis hypogaea* L.)." J. Oleo Sci. 2010;59(1):1–5.
10. Dhanesh B, Kochhar A. "Development and sensory evaluation of value added products incorporating partially defatted peanut cake flour and powdered greens." Chem Sci Rev Lett. 2018;7(25):25–33.
11. UNIDO. "Small-scale fruit and vegetable processing and products - production methods , equipment and quality assurance practices." Vienna; 2004.
12. Nwosu AN, Akubor PI. "Acceptability and storage stability of biscuits produced with orange peel and pulp flours." IOSR J. Environ. Sci. Toxicol. Food Technol. 2018;12(12):8–15.
DOI: 10.9790/2402-1212010815
13. de Castro LA, Lizi JM, das Chagas EGL, de Carvalho RA, Vanin FM. "From orange juice by-product in the food industry to a functional ingredient: Application in the circular economy." Foods. 2020;9:5.
DOI: 10.3390/foods9050593
14. Romelle FD, Ashwini RP, Manohar RS. "Chemical composition of some selected fruit peels." Eur. J. Food Sci. Technol. 2016;4(4):12–21. [Online]
Available:www.eajournals.org
15. Rani V, Sangwan V, Rani V, Malik P. "Orange peel powder: A potent source of fiber and antioxidants for functional biscuits." Int. J. Curr. Microbiol. Appl. Sci. vol. 2020;9(9):1319–1325.
DOI: 10.20546/ijcmas.2020.909.167
16. Ikese O, et al. "Proximate composition, antinutrients and some functional properties of a potential infant food made from wheat and groundnut." Int. J. Food Sci. Nutr. 2016;1(5):59–63.
17. Bukuni SJ, Kwagh-al Ikya J, Dinnah A, Bongjo NB. "Chemical and functional properties of composite flours made from fermented yellow maize, bambara groundnut, and mango fruit for 'Ogi' production." Asian Food Sci. J. 2022;21(2):22–33.
DOI: 10.9734/afsj/2022/v21i230405
18. AOAC. Official methods of analysis of the association of official analytical chemists, 15th ed., Washington, D.C., USA. 1991;242.
DOI: 10.1016/0003-2670(91)87088-o
19. Umeobika UC, Nwali DC, Ekwueme IJ. "Quantitative evaluation of anti-nutritional factors in mango (*Magnifera indica*) fruit." Int. J. Appl. Sci. Math. 2015;2(5):142–145.
20. Disseka W, Faulet M, Koné F, Gnanwa M, Kouamé L. "Phytochemical composition and functional properties of millet (*Pennisetum glaucum*) flours fortified with sesame (*Sesamum indicum*) and moringa (*Moringa oleifera*) as a weaning food." Adv. Res. 2018;15(6)1–11.
DOI: 10.9734/air/2018/42811
21. Omoboyowa DA. "Evaluation of chemical compositions of *Citrulus lanatus* seed and

Cocos nucifera stem bark." African J. Food Sci. Technol. 2015;06(03):75–83. DOI: 10.14303/ajfst.2015.025

22. Alhakmani F, Kumar S, Khan SA. "Estimation of total phenolic content, *in-vitro* antioxidant and anti-inflammatory activity of flowers of *Moringa oleifera*." Asian Pac. J. Trop. Biomed. 2013;3(8): 623–627. DOI: 10.1016/S2221-1691(13)60126-4
23. Madaan R, Bansal G, Kumar S, Sharma A. "Estimation of total phenols and flavonoids in extracts of *Actaea spicata* roots and antioxidant activity studies." *I*ndian J. Pharm. Sci. 2011;73(6):666–669. DOI: 10.4103/0250-474X.100242
24. Aburime LC, Ene-Obong HN, David-Oku E. "Functional properties and sensory evaluation of 'chinchin' bread and biscuits produced from composite flours from African yam bean, orange fleshed sweet potatoes, plantain, cocoyam, maize and wheat." Eur. J. Food Sci. Technol. 2020;8(4):46–64.
25. Juliana KR, Zhengxing C. "Effects of processing methods on the physico-functional properties of peanut flour (*Arachis hypogaea* L.)." Biotechnology 2008;7(2):168–174. DOI: 10.3923/biotech.2008.168.174
26. Chandra S, Singh S, Kumari D. "Evaluation of functional properties of composite flours and sensorial attributes of composite flour biscuits." J. Food Sci. Technol. 2015;52(6)3681–3688. DOI: 10.1007/s13197-014-1427-2
27. Kaushal P, Kumar V, Sharma HK. "Comparative study of physicochemical, functional, antinutritional and pasting properties of taro (*Colocasia esculenta*), rice (*Oryza sativa*) flour, pigeonpea (*Cajanus cajan*) flour and their blends." LWT - Food Sci. Technol. 2012;48(1):59–68. DOI: 10.1016/j.lwt.2012.02.028
28. Oladele AK, Aina JO. "Chemical composition and functional properties of flour produced from two varieties of tigernut (*Cyperus esculentus*)." African J. Biotechnol. 2007;6(21):2473–2476. DOI: 10.5897/AJB2007.000-2391
29. Kui Du S, Jiang H, Yu X, Lin Jane J. "Physicochemical and functional properties of whole legume flour." LWT - Food Sci. Technol. 2014;55(1):308–313. DOI: 10.1016/j.lwt.2013.06.001
30. Iwe MO, Onyeukwu U, Agiriga AN. "Proximate, functional and pasting properties of FARO 44 rice, African yam bean and brown cowpea seeds composite flour." Cogent Food Agric. 2016;2(1). DOI: 10.1080/23311932.2016.1142409
31. Hasmadi M, Noorfarahzilah M, Noraidah H, Zainol MK, Jahurul MHA. "Functional properties of composite flour: A review." Food Res. 2020;4(6):1820–1831. DOI: 10.26656/fr.2017.4(6).419
32. Godswill C, Somtochukwu V, Kate C. "The functional properties of foods and flours." Int. J. Adv. Acad. Res. | Sci. 2019;5(11):2488–9849.
33. Zhu SM, Lin SL, Ramaswamy HS, Yu Y, Zhang QT. "Enhancement of functional properties of rice bran proteins by high pressure treatment and their correlation with surface hydrophobicity." Food Bioprocess Technol. 2017;10(2):317–327. DOI: 10.1007/s11947-016-1818-7
34. Cousminer J. Culinology: Blending culinary arts & food science. Hoboken NJ, USA: Research Chefs Association, John Wiley and Sons, Inc; 2017.
35. Dharsenda TL, Dabhi M. "The effect of peanut (*Arachis hypogaea* L.) flour on the quality and sensory analysis of cookies." Mod. Technol. Agric. For. Biotechnol. Food Sci. 2020:403–406.
36. Ajibola GO, Olapade AA. "Chemical composition, anti-nutritional factors and pasting properties of cassava-african yam bean flour blends for noodle preparation." Int. J. Food Stud. 2021;10:SI1–SI13. DOI: 10.7455/ijfs/10.SI.2021.a1
37. Meka E, Igbabul BD, Ikya J. "Chemical and functional properties of composite flours made from yellow maize, soybeans, and jackfruit seed." Int. J. Res. Innov. Appl. Sci. 2019;IV(Xi):57–63.
38. Alexander K, Ariahu CC, MO Eke "Effect of incorporating orange flesh sweet potato flour, starch and non-starch residue flour to wheat on the quality characteristics of cookies." Asrjets Journal Org. 2021;77(1):200–219. , [Online] Available:https://asrjetsjournal.org/index.php/American_Scientific_Journal/article/view/6718
39. Beebe S, Gonzalez AV, Rengifo J. "Research on trace minerals in the common bean." Food Nutr. Bull. 2000;21(4):387–391. DOI: 10.1177/156482650002100408

40. Iwe MO, Onyeukwu U, Agiriga AN. “Proximate, functional and pasting properties of FARO 44 rice, African yam bean and brown cowpea seeds composite flour.” Cogent Food Agric. 2016;2(1). DOI: 10.1080/23311932.2016.1142409
41. Arya SS, Salve AR, Chauhan S. “Peanuts as functional food: A review.” J. Food Sci. Technol. 2016;53(1):31–41. DOI: 10.1007/s13197-015-2007-9
42. Dharsenda T, Dabhi M, Jethva M, Kapopara M. “Nutritional and functional characterization of peanut okara (defatted peanut) flour cookies.” J. Grain Process. Storage. 2015;2(2):24–28. [Online] Available: www.jakraya.com/journal/jgps
43. Anderson JW, et al. “Health benefits of dietary fiber.” Nutr. Rev. 2009;67(4):188–205. DOI: 10.1111/j.1753-4887.2009.00189.x
44. Egbuonu A, Omodamiro O, Odo C, Uroko R. “Some antinutritive and antioxidative properties of pulverized *Citrus sinensis* (sweet orange) peels and seeds.” J. Sci. Res. Reports. 2016;10(6):1–9. DOI: 10.9734/jsrr/2016/25930
45. Popova A, Mihaylova D. “Antinutrients in plant-based foods: A review.” Open Biotechnol. J. 2019;13(1):68–76. DOI: 10.2174/1874070701913010068
46. Ram S, Narwal S, Gupta OP, Pandey V, Singh GP. Anti-nutritional factors and bioavailability: Approaches, challenges, and opportunities. Elsevier Inc; 2020. DOI: 10.1016/b978-0-12-818444-8.00004-3
47. Ndife J, Abasiekong KS, Nweke B, Linus-Chibuezeh A, Ezeocha VC. “Production and comparative quality evaluation of chin-chin snacks from maize, soybean and orange fleshed sweet potato flour blends.” Fudma J. Sci. 2020;4(2):300–307. DOI: 10.33003/fjs-202-0401-220
48. Embaby HES. “Effect of heat treatments on certain antinutrients and *in vitro* protein digestibility of peanut and sesame seeds.” Food Sci. Technol. Res. 2011;17(1):31–38. DOI: 10.3136/fstr.17.31
49. Wilhelmi AE. Principles of biochemistry. 4th ed., Upper Saddle River, NJ, USA: Pearson Prentice Hall. 1955;56(4). DOI: 10.1210/endo-56-4-496
50. Abioye VF, Olodude OA, Atiba V, Oyewo IO. “Quality evaluation of chinchin produced from composite flours of wheat and germinated finger millet flour.” Agrosearch. 2020;20(1):13–22. DOI: 10.4314/agrosh.v20i1.2s
51. Grace U, Elijah A, Nicholas A. “Vitamin and mineral evaluation of mixed fruit jam from blends of pineapple, orange and sourplum.” Pakistan J. Food. 2015;25(3)137–143. [Online] Available:http://www.psfst.com/__jpd_fstr/4b5c479a7d874a815a94a4fb0cf987ad.pdf
52. Olayinka BU, Etejere EO. “Proximate and chemical compositions of watermelon (*Citrullus lanatus* (Thunb.) matsum and nakai cv red and cucumber (*Cucumis sativus* L. cv Pipino).” Int. Food Res. J. 2018;25(3):1060–1066.
53. Asouzu NN, Oly-Alawuba AI, Umerah NM. “Functional properties and chemical composition of composite flour made from cooking banana (*Musa Paradisiaca*) and yellow maize (*Zea Mays*).” Res. J. Food Nutr. 2020;4(2):6–12. [Online]. Available:https://www.researchgate.net/profile/Nkemjika-Umerah/publication/341769201_Functional_Properties_and_Chemical_Composition_of_Composite_Flour_Made_from_Cooking_Banana_Musa_Paradisiaca_and_Yellow_Maize_Zea_Mays/links/5ed30d98299bf1c67d2cafa9/Functional-Prop
54. Guyih MD, Dinnah A, Eke MO. “Production and quality evaluation of cookies from wheat, almond seed and carrot flour blends.” Int. J. Food Sci. Biotechnol. 2020;5(4)55. DOI: 10.11648/j.ijfsb.20200504.11
55. Fischer Walker CL, Black RE. “Zinc for the treatment of diarrhoea: Effect on diarrhoea morbidity, mortality and incidence of future episodes.” Int. J. Epidemiol. 2010;39(1):63–69. DOI: 10.1093/ije/dyq023
56. Singh B, Singh JP, Singh N, Kaur A. “Saponins in pulses and their health promoting activities: A review.” Food Chem. 2017;233:540–549. DOI: 10.1016/j.foodchem.2017.04.161
57. Shi J, Arunasalam K, Yeung D, Kakuda Y, Mittal G, Jiang Y. “Saponins from edible legumes: Chemistry, processing, and health benefits.” J. Med. Food. 2004;7(1):67–78. DOI: 10.1089/10966200432298473
58. Ee Wei S. “Isolation and determination of anti-nutritional compounds from root and shells of peanut (*Arachis Hypogaea*),” Universiti Tunku Abdul Rahman; 2011. [Online]

Available:http://dx.doi.org/10.1038/ni.1913%0A

59. Chukwumah Y, Walker LT, Verghese M. "Peanut skin color: A biomarker for total polyphenolic content and antioxidative capacities of peanut cultivars." Int. J. Mol. Sci. 2009;10(11):4941–4952. DOI: 10.3390/ijms10114941
60. Omoba OS, Obafaye RO, Salawu SO, Boligon AA, Athayde ML. "HPLC-DAD phenolic characterization and antioxidant activities of ripe and unripe sweet orange peels." Antioxidants. 2015;4(3):498–512. DOI: 10.3390/antiox4030498
61. Omoba OS, Dada OO, Salawu SO. "Antioxidant properties and consumer acceptability of pearl millet – tiger nut biscuits." Nutr. Food Sci. 2015;45(6):818–828. DOI: 10.1108/NFS-06-2015-0074
62. Belose BB, Kotecha PM, Godase SN, Chavan UD. "Studies on utilization of orange peel powder in the preparation of cookies." Int. J. Chem. Stud. 2021;9(1):1600–1602. DOI: 10.22271/chemi.2021.v9.i1w.11455

Peer-review history:
The peer review history for this paper can be accessed here:
https://www.sdiarticle5.com/review-history/95200