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Environmental Waste Management: Effect of Debittered-defatted Orange Seed Flour on the Proximate, Anti-nutritional and Sensory Properties of Biscuit

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Authors' contributions

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

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ABSTRACT

Orange seeds were extracted from orange fruits and sundried at 30 ± 2˚C for 8 hours. The orange seeds (20kg) were steeped in water for 12 hours and cooked for 120 minutes. The boiling seeds were dehulled, oven dried at 60°C for 14 hours, ground and defatted with 100% ethanol, milled, and sieved. Debittered orange seed flour was used to substitute 10, 20, 30, 40, and 100% in biscuits to test its proximate composition, physical, and sensory qualities. The results revealed that the proximate composition of the biscuits ranged from 12.49% to 17.17% protein, 9.38% - 12.14% fat, 1.55 - 9.84% crude fiber, 1.07% - 4.01% ash, 6.37% - 11.00% moisture content, and 45.83% - 64.46% carbohydrate. With increased orange seed flour content, the biscuits' weight, volume, break strength, and thickness reduced, while their spread ratio and density increased. The anti-nutrient composition of the biscuits revealed oxalate (20.06 – 77.21 mg/100g), phytate (61.03 – 99.91 mg/100g), and tannin (0.07 – 2.09 mg/100g). Biscuits made with up to 30% orange seed flour were generally acceptable throughout sensory evaluation. Orange seeds are commonly disposed improperly during the manufacturing of juice along with other orange fruit products, causing a severe environmental impact and posing a health risk. Orange seed flour production would not only provide a novel source of flour for food manufacturing, but would also serve as an environmentally friendly recycling option.

Keywords: Biscuit; debittered; orange seed flour; physical properties; proximate.

1. INTRODUCTION

Sweet orange has become one of the most important citrus fruit crops grown globally, representing 71% of total citrus fruit production [1]. Because the edible section of oranges is limited, processing generates enormous amounts of leftovers such as peels and seeds having a severe impact on the environment [2]. Citrus fruits are mostly utilized for juice and pectin manufacture. However, a large amount of leftovers (seeds, peels, and pulp) are generated as trash during juice and pectin synthesis. These byproducts, however, have potential in the food business given their nutritious and technological properties [3]. In Nigeria, orange seed waste is recklessly discarded in the environment. This result in the release of odors, which act as an ideal habitat for insects and, in overall, generates an unpleasant atmosphere with low aesthetic appeal [3].

Composite flour can be defined as wheat and other flour blends for the creation of baked goods, or non-wheat blends for the same purpose. There are two reasons for combining wheat and other flours: economic and nutritional [4]. However, raw materials for composites are chosen depending on their compatibility, availability, and cost at the point of usage. Dietary fibers, which are the indigestible, fibrous components of foods, are an important part of the diet. Fibers have a laxative effect because they retain water and help food flow through the colon more quickly [5]. Fibers give bulk to the diet and help you feel full, making you less prone to nibble on greasy foods. As a result, fiber is required daily as part of a well-balanced diet [6].

A high fiber diet reduces the risk of developing stroke, hypertension, diabetes, and several gastrointestinal issues [7,8]. Consuming more dietary fiber raises serum cholesterol levels, lowers blood pressure, promotes regularity, supports weight loss, and appears to stimulate immune function [9]. Nigeria, as a tropical country, cannot cultivate wheat commercially due to its weather conditions. Only 3% of the country's wheat grain consumption can be generated domestically. As a result, the food sector can only survive by utilizing available indigenous commodities such as orange seeds, which can partially substitute wheat in baked goods without compromising product quality. Dibittered orange seed flour is a good source of fiber and protein. Biscuits are manufactured from ingredients including wheat flour, water, oil, and sugar. Biscuits can be classified according to their degree of enriching and processing, as well as the technique used to shape them. Depending on the enrichment criteria, biscuits can be formed from hard dough, soft dough, or batters [10]. However, the nutritional composition of biscuits varies depending on the flour used. If possible, using debittered orange seed flour in the preparation of baked goods such as biscuits will assist to reduce reliance on wheat flour while also delivering nutritional fiber and important phytochemicals. As a result, this study examined the influence of including debittered orange seed

flour on the proximate composition, physical, and sensory qualities of biscuits. This study would secure the conversion of orange seed waste into a usable product.

2. MATERIALS AND METHODS

2.1 Materials

Oranges got purchased from a local market in Nsukka, Enugu State. Wheat flour, baking fat, sugar, powdered milk, eggs, baking powder, and table salt were obtained from the Ogige main market in Nsukka.

2.2 Preparation of Debittered Orange Seed Flour

The orange seed flour was produced according to the method of Emojorho and Akubor, [1] Fig. 1 depicts a flow chart for preparing debittered orange seed flour.

2.3 Preparation of Biscuits

The best acceptable debittered orange seed flour was used to substitute 10, 20, 30, and 40% wheat flour in a food blender that was run at full speed (120 rpm) for 10 minutes. The biscuits were made using the procedure described by Emojorho et al. [3]. The oil and sugar were mixed together using a mixer before adding the remaining dry ingredients. The eggs were then added. This was followed by the addition of water (5 mL). The doughs were combined in a dough mixer for 30 minutes. The doughs were cut into shapes with a manual biscuit cutter. Cut out doughs were placed on oiled trays and baked at 200°C for 20 minutes. The hot baked biscuits were cooled for 15 minutes before being wrapped in HDPE bags. The 100% wheat flour biscuit was used as a control. Fig. 2 depicts the flow chart for producing biscuits.

2.4 Determination of Proximate Composition

The moisture content was determined using the oven method, as described in AOAC [11]. The crude protein was measured using the Kjedahl technique [11]. The fat content, ash, and crude fiber were determined using the procedures described in AOAC [11]. Carbohydrate was determined using the difference AOAC [11] formula: 100 - (% Moisture +% Crude protein +% Crude fiber +% Ash +% Crude Fat).

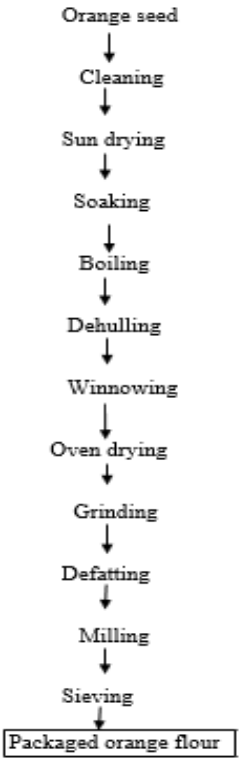

Fig. 1. Processing of debittered orange seed flour

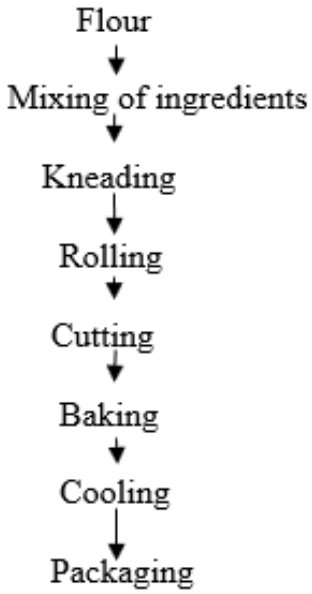

Fig. 2. The production of biscuit
Source: Emojorho et al., [3]

2.5 Analysis of Antinutrients

Phytate content was assessed using the technique described in Pearson [12]. The amount of oxalic acid in the sample was determined using the titration procedure described in AOAC [11]. Tannin was detected using the Folin-Denis spectrophotometric approach, as described in Pearson [12].

2.6 Sensory Evaluation

Twenty trained panelists from the University of Nigeria, Nsukka, evaluated the biscuit samples for taste, color, flavor, texture, and overall acceptability. In a sensory evaluation laboratory, the items were served at room temperature on clean coded white plastic plates in individual booths with enough fluorescent lighting. The sample presentation to the panelists was randomized. The panelists rated the biscuit sample on a 9-point Hedonic scale, with 1 indicating extreme dislike and 9 indicating extreme like.

3. RESULTS AND DISCUSSION

3.1 Chemical Composition of Biscuits

The proximate composition of biscuits prepared from blends of debittered orange seed flour and wheat flour are shown in Table 1.

Table 1. Chemical composition (%) of biscuits prepared from blends of debittered orange seed flour and wheat flour

Wheat: debittered orange seed Flour	Moisture	Protein	Fat	Ash	Crude fiber	Carbohydrate
100:00	8.72^{b}±0.51	12.49^{f}±0.26	11.70^{ab}±0.44	1.07^{c}±0.07	1.55^{d}±0.55	64.46^{a}±0.99
90:10	8.15^{b}±0.74	13.30^{e}±0.33	11.28^{ab}±0,22	1.86^{b}±0.87	2.76^{cd}±0.64	62.68^{ab}±0.57
80:20	7.90^{bc}±0.90	14.35^{d}±0.13	10.06^{bc}±0.84	2.47^{b}±0.66	4.02^{c}±0.41	61.18^{b}±0.32
70:30	7.20^{cd}±0.21	15.74^{c}±0.36	10.74^{bc}±0.74	3.66^{a}±0.86	7.11^{b}±0.25	55.96^{c}±1.75
60:40	6.37^{d}±0.30	16.21^{b}±0.25	9.38^{c}±0.12	3.87^{a}±0.03	8.21^{b}±0.44	55.54^{c}±0.14
00:100	11.00^{a}±0.46	17.17^{a}±0.80	12.14^{a}±0.62	4.01^{a}±0.90	9.84^{a}±0.40	45.83^{d}±1.84

Means within a column with the same superscript were not significantly different (P>0.05). Means ± S.D of 3 replications

Table 1 shows the approximate composition of biscuits made from blended debittered orange seed flour and wheat flour. The moisture values of the biscuits ranged from 6.37% to 11.00%, with the 100% orange seed biscuit having the greatest moisture content (11.00%), which was higher than the 8.72% for the 100% wheat flour. However, enriched biscuits exhibited reduced moisture content, ranging from 6.37 to 8.15%. Low moisture content improves shelf stability of biscuits when placed in moisture-proof containers [13]. Biscuits are often more resistant to microbial deterioration than cakes and bread [14]. A high moisture content suggests high water activity (aw) and a greater risk of degradation caused by mould formation [15].

The protein content of the biscuits ranged from 12.49% to 17.17%, with significant differences ($p<0.05$) between them. The protein level was lower than the 13.27% to 54.58% reported by Emojorho and Okonkwo [2] most likely due to the added effect of processing, but comparable to the 14.79 to 19.24% reported by Emojorho et al. [3] for biscuits made from orange seed flours. The 100% wheat flour biscuit has the lowest protein level at 12.49%. Adding more orange seed flour considerably enhanced the protein content of the biscuit ($p<0.05$). The debittered orange seed flour contained more protein than wheat flour. The protein composition of the biscuit containing 40% debittered orange seed flour was 16.21%, equivalent to the orange seed biscuit's 17.17%. Proteins are a broad class of substances that serve critical structural and functional roles in biological systems [13]. Protein supplies energy and is the only source of vital amino acids required for survival and growth [13]. The fat percentage of the biscuits varied from 9.38% to 12.14%. Significant disparities existed in the fat content of the biscuits. The 100% wheat and 100% orange seed flour biscuits had more fat than the enhanced biscuits. However, the 100% orange seed biscuit contained more fat (12.14%) than the 100% wheat biscuit (11.70%). Fat softens texture, aids moisture retention, and enhances taste in baked goods [13]. Fat improves the mouthfeel and palatability of biscuits.

The ash percentage of the biscuits varied from 1.07% to 4.01The control biscuit had the least amount of ash (1.07%), most likely because wheat flour had less ash than orange seed flour, whereas the 100% orange seed biscuit had the maximum ash (4.01%). The ash level of all supplemented biscuits rose dramatically as the proportion of orange seed flour raised. The biscuits had a large amount of ash, signifying high mineral content [16]. This implied that debittered orange seed flour could include the mineral content of biscuits. Ash content is a measure of mineral content [17]. Minerals are inorganic elements that originate in the ground and cannot be synthesized in the body.

They play crucial roles in different bodily activities and are required for life and optimal health, making them essential nutrients (Wardlaw and Gordom, 1999). The majority of minerals in the human diet are derived either directly from plants and water or indirectly via animal meals. Minerals support bone and tooth structure, as well as energy production, protein synthesis, blood creation, and a variety of other metabolic activities (Wardlaw and Gordom, 1999). Based on its ash content, orange seed flour, when utilized in composite flour, would increase the mineral content of food products.

The crude fiber levels of the biscuits ranged from 1.55 to 9.84%. The biscuit made entirely of wheat flour had the lowest crude fiber content, measuring 1.55%. The crude fiber content of the biscuit mixtures differed significantly ($p<0.05$). The 100% orange seed biscuit has the greatest crude fiber level, 9.84%. With the addition of orange seed flour to the biscuits, the crude fiber content rose. The ability of fiber to take up oil is an important feature in food formulation since oil serves as a flour retainer and optimizes mouthfeel. The carbohydrate content of the biscuits fluctuated between 45.83% to 64.46%. The control sample had the greatest percentage, 64.46%. The values were slightly similar to 48.18 to 54.60% carbohydrate reported by Emojorho et al., [4] for noodles made with wheat and African bean flour mixes.

The inclusion of orange seed flour, which has a lower carbohydrate content than wheat flour (64.46%), could account for the lower carbohydrate level in the formed samples. Carbohydrates provide a rapid supply of metabolizable energy and aid in fat metabolism [18].

3.2 Antinutritional Composition of Biscuit

Table 2 displays the antinutrient content of biscuit.

When compared to the supplemented biscuits, the biscuit made entirely of wheat flour had fewer

oxalate, phytate and tannins. Adding more orange seed flour to the mixes resulted in a substantial increase ($p<0.05$) in antinutrient levels in the biscuits. The biscuits' oxalate concentrations ranged from 20.06 to 77.21 mg/100g, with the wheat (100%) biscuit having the lowest amount (20.06 mg/100g). The highest oxalate level was found in 100% orange seed biscuit (77.21 mg/100g). The oxalate concentration was nearly identical to the 23.82 to 85.87 mg/100g reported by Emojorho et al., [19] for biscuits made from orange seed flour. The increasing level of orange seed flour in the biscuits increased the biscuits' oxalate content. In contrast, modifying their diets is essential for kidney stone prevention in individuals who are susceptible to kidney stone formation. Regular ingest of high-oxalate foods by healthy individuals as part of a balanced and expanded diet is not believed to cause health issues if daily consumption is between 50 and 200 mg/day. It is advised that for these people, the daily intake of foods high in oxalate be restricted to no more than 40–50 mg as these foods may provide a health risk [20].

The biscuits with 100% orange seed flour biscuit had the greatest phytate content of 99.91 mg/100g, while wheat flour had the lowest mean phytate content of 61.03 mg/100g, which was lower than the biscuits supplemented with debittered orange seed flour which ranged from 69.95 to 99.91 mg/100g. Significant differences ($p<0.05$) were observed in the phytate content of the biscuits. The increased quantity of phytate in the biscuits could be attributable to the addition of orange seed flour, which contains more phytate than wheat flour. Phytate intake was predicted to be 150–1,400 mg for mixed diets and 2,000–2,600 mg for vegetarian diets and the diets of people living in rural underdeveloped nations [21].

The tannin content of the biscuits went from 0.07 mg/100g to 2.09 mg/100g, as shown in Table 2. The tannin concentration varied substantially within biscuit samples ($p<0.05$). The tannin concentration in 100% wheat cookies was the lowest (0.07), while entirely orange seed flour biscuits had the most tannin amount (2.09 mg/100g). The findings were fewer than the previously reported 4.21 to 5.29 mg/100g for composite flour paste [22]. The tannin level of the biscuits increased proportionally with the volume of orange seed flour utilized. According to Duguma et al., [21] a man's daily permissible intake of tannins is 560 mg. Based on the results, it was determined that the composite flour's condensed tannin concentrations were not harmful.The levels of phytate and c tannin found in this study are less than what is considered to be a tolerable daily intake .

3.3 Sensory Properties of Biscuits

Table 3 summarizes the biscuits' sensory qualities. There were no significant variations in all of the sensory qualities of the biscuits tested between those made entirely of wheat flour (control) and those made with up to 10% orange seed flour. The evaluations for the biscuits' look, flavor, taste, aftertaste, texture, and crispiness declined as the amount of orange seed flour in the biscuits increased. There were no significant differences ($p>0.05$) in flavor, taste, aftertaste, texture, or overall acceptability between the control and the biscuits enhanced with 20% orange seed flour. However, there were significant differences ($p<0.05$) in the color, aftertaste, and crispiness of the biscuits. This could be linked to orange seed flour's low gluten content, as gluten is important for dough extensibility. Flour for biscuit production should be more extensible but less elastic, so that when masticated, the biscuits are crisp [23].

Table 2. Antinutritinal composition of biscuits prepared from debittered orange seed flour and wheat flour blends

Ratio	Oxalate mg/100g	Phytate mg/100g	Tannins mg/100g
100:00	20.06 ± 0.02^{f}	61.03 ± 0.01^{f}	0.07 ± 0.03^{e}
90:10	24.05 ± 0.01^{e}	69.95 ± 0.03^{e}	0.09 ± 0.01^{d}
80:20	38.16 ± 0.01^{d}	75.12 ± 0.01^{d}	1.02 ± 0.06^{c}
70:30	51.87 ± 0.01^{c}	84.77 ± 0.01^{c}	1.25 ± 0.08^{c}
60:40	65.28 ± 0.03^{b}	92.08 ± 0.02^{b}	1.95 ± 0.03^{b}
00:100	77.21 ± 0.01^{a}	99.91 ± 0.1^{a}	2.09 ± 0.02^{a}

Means within a column with the same superscript were not significantly different (P>0.05)

Table 3. Sensory properties of biscuits prepared from blends of debittered orange seed flour and wheat flour

WF: OSF120	Appearance	Flavour	Taste	Aftertaste	Texture	Crispiness	General Acceptability
100 : 00	8.4^{a}±0.84	8.0^{a}±0.66	8.2^{a}±0.63	7.8^{a}±0.78	7.7^{a}±0.82	8.1^{a}±0.87	8.3^{a}±0.84
90 : 10	8.5^{a}±0.84	8.1^{a}±0.87	7.5^{a}±1.42	7.3^{a}±1.56	7.4^{a}±1.56	7.4^{a}±1.17	7.9^{a}±0.79
80 : 20	6.7b±1.63	7.3^{ab}±1.1	7.1^{a}±1.37	5.8^{b}±1.54	6.7^{ab}±1.1	6.6^{b}±1.58	7.8^{ab}±0.78
70 : 30	4.9^{c}±1.59	6.3^{b}±1.25	4.9^{b}±0.99	4.1^{c}±1.59	6.6^{ab}±1.3	4.4^{c}±2.01	5.0^{c}±1.15
60 : 40	4.4^{cd}±1.83	6.6^{b}±1.34	5.0^{b}±1.24	3.7^{c}±1.33	5.7^{b}±1.7	4.3^{c}±2.01	3.5^{d}±1.26
00 : 100	3.2^{d}±2.34	6.2^{b}±1.54	3.6^{b}±2.54	3.3^{c}±2.31	6.0^{b}±1.15	4.3^{c}±1.94	2.6^{d}±1.87

Means within a column with the same superscript were not significantly different (p>0.05). The biscuits were evaluated on 9-point Hedonic scale (1 = dislike extremely and 9 = like extremely)

4. CONCLUSION

The findings of this study demonstrated that debittered orange seed flour could be used to replace wheat flour in biscuits up to 20% without changing the chemical composition, physical qualities, or sensory attributes of the biscuits. The use of debittered orange seed flour in biscuit production will not only increase the value of orange seed, but it will also reduce the cost of importing wheat flour for the production of food products such as biscuits with improved nutritional value, reducing dependence on wheat importation, conserving foreign exchange, and productively engaging the youth.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of manuscripts.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Emojorho EE, Akubor PI. Effect of Debittering methods on the proximate composition sensory and functional properties of orange (*Citrus sinensis*) Seed Flour/IOSR Journal of Environmental Science,Toxicology and Technology (IOSR-JESTFT). 2016;10(9)134-139. DOI: 10.9790/2402-1009010916
2. Emojorho EE, Okonkwo TM. Effect of debittering methods on the chemical and physiochemical properties of defatted and undefatted sweet orange seed flours. Fruits. 2022;77(6):1-10
3. Emojorho EE, Okonkwo TM, Eze JI. Chemical physical shelf-life and sensory properties of biscuits produced from defatted and undefatted debittered orange seed flours. Fruits. Art. 02 Fruits.2023;78(1):1-10.
4. Emojorho EE, Reuben-Okoye M, Aphiar A, Nwosu AN, Anene MN, Avbundiogba E, Ochimana TO, Ekpekpo LD. Assessing the quality and potential of fried noodles: an analysis of wheat and afzelia africana flour blends in chemical, functional, physical, and sensory dimensions. Asian J. Adv. Res. Rep. 2024;18(6):41–53. Available:https://doi.org/10.9734/ajarr/2024/v18i6652
5. Youssef HM, Mousa MA. Nutritional assessment of wheat biscuits and fortified wheat biscuits with citrus peel powders. Food and Public Health. 2012;2(1):55-60.
6. Youssef MK. Foods that fight cancer. Paper presented at the sixth Conference of Woman and Scientific Research and Development at Assiut University, Upper Egypt; 2007.
7. Marangoni F, Poli A. The glycemic index of bread and biscuits is markedly reduced by the addition of a proprietary fiber mixture to the ingredients. Nutrition Metabolism and Cardiovascular Diseases. 2008;18:602-605.
8. Karhunen LJ, Juvonen KR, Flander SM. A psyllium fiber-enriched meal strongly attenuates postprandial gastrointestinal peptide release in healthy young adults. Journal of Nutrition. 2010;140:737-744.
9. Sharma S, Rana S, Katare C, Pendharkar T, Prasad GB. Evaluation of fiber enriched biscuits as a healthy snack. International Journal of Scientific and Research Publications. 2013;3:1-4.
10. Fayemi, P. O. Home Economics Teacher Guide, (Macmillian Publisher Ltd. Ibadan, Nigeria. 1981;201.
11. AOAC. Official methods of analysis 18th Edition, (Association of Official Analytical Chemists, Washington, D.C. USA; 2010.
12. Pearson D. Chemical and analysis of foods. 9thedition. livingstone London, Churchhill. 1979;33
13. Macrae R, Robinson RK, Sadler MJ. Encyclopaedia of food science food technology and nutrition, (Academic Press inc., San Diego, CA,). 1993;5:3126–3131.
14. Wade P. Biscuits cookies and crackers: the principles of craft, (Elservier Applied Science Publisher, London. 1988;1:1–4.
15. Akintayo ET, Oshodi AA, Esuoso KO. Effects of NaCl, ionic strength and pH on the foaming and gelation of pigeon pea (Cajaninscajan) protein concentrates, Food Chemistry. 1999;66:51–56.
16. Bunde MC, Osundahunsi FO, Akinoso R. Supplementation of biscuit using rice bran and soyabean flour, African Journal of Food Agriculture Nutrition and Development. 2010;10(9):47–59.
17. Ajala L. The effect of boiling on the nutrients and anti-nutrients in two

non conventional vegetables, Pakistan Journal of Nutrition. 2009;8(9):1430-1433.
18. Ogunlakin GO, Oke MO, Babarinde GO, Olatunbosun DG. Effect of drying methods on proximate composition and physicochemical properties of cocoyam flour, American Journal of Food Technology. 2012;7:245–250.
19. Emojorho EE, Anene MN, Udeh CC. Minerals vitamins and anti-nutritional properties of biscuits produced from defatted and undefatted debittered orange seed flours. American Journal of Food Sciences and Nutrition. 2023;5 (2):67–82.
20. Salgado N, Silva MA, Figueira ME, Costa HS, Albuquerque TG. Oxalate in foods: Extraction conditions, analytical methods, occurrence, and health implications. Foods. 2023;12(17):3201. Available:https://doi.org/10.3390/foods12173201
21. Duguma HT, Forsido SF, Belachew T, Hensel O. Changes in antinutritional factors and functional properties of extruded composite flour. Front. Sustain. Food syst. 2021;5:1-11.
22. Chiedu UC, Abiodun MS, Steve IO, Eguono EE, Joy AT. Physicochemical, nutritional and functional properties of composite flour blends from whole wheat, sweet potato, defatted peanut and rice bran. Eur. J. Nutr. Food. Saf. 2023;15 (12):41-55.
23. Kent NL. Technology for cereals, 2nd edition, (Pergamon Press, Oxford). 1985;166.

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