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Research Article

Comparative evaluation of the nutritional profile, overall acceptability and microbiological quality of chinchin enriched with peanut and soybean flour

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Abstract

The quest for nutritious food and snacks due to the health benefits they offer has necessitated the addition of various nutrient-rich substances to foods and diets for nutritional fortification. This study was carried out to determine the effect of supplementation of 30% wheat flour with either peanut or soybean flour on the nutritional profile, overall acceptability, and microbiological quality of chinchin samples. Chinchin produced from wheat flour alone served as a control. The results showed a significant ($p < 0.05$) increase in the protein, fiber and ash contents of chinchin supplemented with 30% soybean flour (p-value=0.017, 0.025 and 0.003, respectively), while there was a significant increase in the lipid content and energy value of chinchin supplemented with peanut (p-value=0.031 and 0.003, respectively). There was also an increase in the mineral content of chinchin supplemented with 30% soybean. All chinchin samples showed appreciable sensory attributes with mean score values (average) indicating that they were generally acceptable, with chinchin enriched with 30% peanut having a significant score of 8.72 ± 0.28 (p-value = 0.034) for overall acceptability. Microbial growth was only evident on plate cultures of all samples stored within 7 and 14 days, with bacterial counts ranging from 1.10 x 10 to 4.80 x 10^3 cfu/g and fungal counts ranging from 1.30 x 10^2 to 3.0 x 10^3 cfu/g. This study shows the production of nutritionally fortified and acceptable chinchin from supplementation of 30% wheat flour with either peanut or soybean flour with good microbiological quality within seven days of storage.

1. Introduction

Chinchin is a deep-fried, popular ready-to-eat, cheap and convenient snack that is consumed among all age groups in many countries [1]. It is produced from wheat (*Triticum aestivum*) flour and other ingredients, making it sweet, crunchy and crispy. It is popular in West African countries, especially Nigeria [1], and is widely accepted and commercially produced to meet the increasing demand [2]. Several authors have reported the use of other cereal flours as supplements or alternatives to wheat flour in the production of chinchin [3-8].

Chinchin is mostly cereal-based and hence rich in carbohydrates suggesting the need for nutritional fortification. The use of pulses and legumes to supplement cereals has been reported as an effective approach to combat protein energy malnutrition

(PEM), diabetes, and other deficiency diseases [9]. Enriching chinchin with protein-rich ingredients will enhance its nutritional quality, thereby making it a source of nourishment, body building, and growth for development for consumers, of which children are the most prevalent [10]. Reports have shown that snacks like chinchin, biscuits and cookies, although cereal-based, have the potential to become excellent vehicles for providing nutritional quality foods and snacks when incorporated with less expensive high-quality proteins, vitamins, minerals, dietary fiber, and functional ingredients [11]. Peanuts and soybeans are examples of leguminous plants that serve as inexpensive high-quality protein sources in most developing countries in Africa.

Peanut (*Arachis hypogaea* L.) also known as groundnut is a globally favoured and significant industrial crop, highly valued for its rich nutritional content, diverse health benefits, and distinctive aroma [12]. The nutritional value of peanuts has been reported to be due to the energy and growth-supplementing constituents they possess [13]. Ayoola et al. [14] reported that the protein in groundnut seeds contributes to the growth and repair of worn-out tissues and also improve the nutrition of humans and animals. Incorporation of peanuts into diets has been proven to be desirable because it is a rich source of protein, carbohydrates, lipids, vitamins, minerals, some organic acids, and purines [5, 15].

Soybean (*Glycine max* L.), is an annual leguminous crop, and an excellent source of protein (35-40%), cultivated to provide food for humans, feed for animals and raw materials for industries [16, 17]. Soybean seeds are the richest in food value of all plant foods consumed worldwide and their health benefits have resulted in an increase in demand [18], necessitating increased, production. The world production of soybeans has significantly increased rising from 200 million metric tons in 2005 to 324 million metric tons in 2016 [19]. The production and evaluation of functional pasta developed using soy flour and whole wheat flour showed that incorporating soy flour into pasta significantly improved nutritional and functional properties while maintaining consumer appeal at moderate substitution levels [20].

Several authors have reported the substitution or incorporation of nutrient-rich ingredients in the production of chinchin to enhance its nutritional value. Biscuits and chinchin have been produced by incorporating a mixture of plantain and sorghum flours in varying proportions of different flour blends [3]. Chinchin produced from okra seed and wheat flour blends has been reported to possess an improved nutritional profile and increased fiber content to enhance digestibility [7]. Ndife et al. [21] reported the production of nutrient rich chinchin by substituting wheat flour with a mixture of maize, soybean and defatted groundnut flours. The nutritional composition of chinchin produced from blends of wheat flour and chicken meat flour was studied and the results showed nutritional fortification of the chinchin samples [22]. Another study on chinchin produced from flour blends of wheat, defatted peanut and orange peel showed improved nutritional and organoleptic attributes [5]. This study aimed to evaluate the nutritional profile, overall acceptability and microbiological quality of chinchin samples produced by supplementing 30% of the wheat flour with either peanut or soybean flour.

2. Materials and methods

2.1. Preparation of peanut and soybean for supplementation of wheat flour

The peanuts were sorted to remove dirt and shafts, washed and dried thoroughly. The peanuts were then roasted over low heat for 15 min, allowed to cool and de-hulled before milling. The soybeans were sorted, cleaned, dried and roasted under low heat. After cooling, the roasted soybeans were milled into a fine powder and sieved with a 0.25 mm British standard sieve (Model BS 410) [23].

2.2. Production of chinchin

Three chinchin samples were prepared using wheat flour (100%), wheat with 30% milled groundnut and wheat flour with 30% soybean flour as described by Adewoyin et al. [8]. The dry ingredients (flour 1kg, grated nut-meg 5g, baking powder15g and salt 5g) were mixed together in a bowl, and 125 g of margarine was rubbed in to form a crumb-like mixture before adding well-beaten eggs (2). Milk (30 g), sugar (200 g) and vanilla essence (10 mL) were added to 750 mL of water and stirred properly to dissolve, and mixed

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with the flour mixture to form a smooth and elastic dough. The dough was then rolled out to a uniform thickness (about 1cm), sliced into stripes and further diced into small pieces. The diced pieces were deep-fried in hot vegetable oil until golden brown. The fried chinchin was drained of excess oil using absorbent sheets, allowed to cool for about 30 min and stored in an airtight container until further analysis.

2.3. Determination of proximate composition of chinchin samples

The proximate composition of produced chinchin samples was determined using standard procedures. Moisture, crude protein, fat, crude fiber, ash and carbohydrate contents were determined as described by the Association of Official Analytical Chemists [24]. The gravimetric method was used to determine the moisture content, while the Kjeldahl method was used to determine the protein content and crude protein content was calculated by multiplying the nitrogen content by 6.25. The fat content was determined by the continuous solvent extraction method while the total ash content was determined by using the furnace incineration gravimetric method. The total carbohydrate content was estimated as described by Raghuramulu et al. [25]. Gross energy value (kcal/100g) was calculated using the Attwater factor:

Energy (kcal/100g) =
(2.62 ×% protein) + (4.2 × % Carbohydrate) + (8.37 × % Fat)

2.4. Determination of mineral content of chinchin samples

Atomic Absorption spectrometry (AAS) was used to determine the selected mineral content of the ashed pulverized chinchin samples, as described by James [26] and AOAC [24]. Analyses were carried out in triplicate and the results are presented as mean ± SD in mg/100g. The selected minerals included calcium, potassium, magnesium, phosphorus, iron and zinc.

2.5. Sensory evaluation of chinchin

Sensory evaluation was carried out on the chinchin samples produced after cooling (for about 30 min after production) using a hedonic scale, as described by Larmond [27]. Untrained laboratory taste panelists who were regular chinchin consumers, consisting of 40 students of the Department of Science Laboratory Technology within the age range of 18 and 24, gave their consent to participate in the sensory evaluation of the chinchin samples. The panelists assessed the chinchin samples using a 9-point hedonic scale (9=like extremely, 8=like very much, 7 = like moderately, 6 = like slightly, 5 = neither like nor dislike, 4 = dislike slightly, 3 = dislike moderately, 2 = dislike very much and 1 = dislike extremely). This was used to determine the overall liking of the chinchin samples [28]. The appearance, color, aroma, crunchiness, taste, and overall acceptability of the chinchin samples were evaluated. A mean value of above 5 (indicating neither like nor dislike) was considered acceptable.

2.6. Microbiological analysis of chinchin

Representative quantities of freshly prepared chinchin samples were subjected to microbiological analysis using aseptic techniques. One gram (1 g) of the sample was weighed and homogenized in 0.1% sterile peptone water to produce a stock suspension. The stock suspension was serially diluted using 0.1% peptone water as the diluent. Aliquots were aseptically taken from the appropriate dilutions and transferred to freshly prepared nutrient agar (NA) and potato dextrose agar (PDA) for the isolation of bacteria and fungi, respectively. Pure isolates were derived by streaking colonies on fresh agar plates and distinct colonies were picked and stored on freshly prepared slants, which were maintained at 4°C until further use. Microbiological analyses of chinchin samples stored in airtight containers at room temperature (for 7 and 14 days) were also carried out to determine their keeping quality.

2.7. Identification of the isolates from chinchin

Bacterial isolates were identified based on morphological (shape of colonies, colonial outline, colonial evaluation, color, consistency and size) and biochemical (catalase, endospore stain, and sugar fermentation, etc.) characteristics. Motility test was carried out using the method described by Varghese and Joy [29] and Cheesbrough [30]. Fungal identification was based on macroscopic and microscopic examination of culture isolates and was characterized by the duration of growth, surface morphology and spore color on plate cultures. Microscopic examination of fungal isolates was carried out with lactophenol cotton blue stain. The

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Table 1. Proximate composition (%) and energy value (Kcal/100g) of chinchin samples.

Proximate composition (%)	Chinchin samples		
	WPC	WSC	WFC
Moisture content	5.89±0.33[b]	6.32±0.63[b]	7.58±0.45[a]
Protein	15.54±1.08[b]	19.28±1.15[a]	10.95±0.63[c]
Lipid	11.74±0.72[a]	10.69±0.41[b]	3.22±0.34[c]
Fiber	3.82±0.11[b]	5.55±0.72[a]	3.00±0.25[b]
Ash	2.24±0.00[a]	2.94±0.09[a]	1.51±0.33[b]
Carbohydrate	60.77±0.45[b]	55.22±0.60[c]	73.74±0.40[a]
Energy (Kcal/100g)	388.30±5.61[a]	365.08±3.49[b]	357.20±1.99[c]

Values represent mean ± standard deviation of triplicate determinations and values with the same superscript along the rows are not significantly different (p<0.05). WPC= Chinchin prepared from wheat flour and 30% peanut; WSC=Chinchin prepared from wheat flour and 30% soybean flour; WFC= Chinchin prepared from wheat flour alone (100%).

nature of mycelium and conidia formation was used to differentiate various genera and species

2.8. Data analysis

The data obtained in the study were subjected to analysis of variance (ANOVA) using the statistical package for social sciences (SPSS), version 20.0. Results are presented as mean ± standard deviation of triplicate determinations (except where indicated otherwise). One-way analysis of variance was used to compare the means. Differences between means were considered significant at $p < 0.05$ with a confidence interval 95% using the Duncan multiple range test (DMRT).

3. Results and discussion

The results of the proximate composition and energy value (kcal/100g) of the chinchin samples showed significant differences between the chinchin samples, as shown in Table 1. The moisture and carbohydrate contents were significantly ($p < 0.05$) higher in the chinchin produced using only wheat flour (WFC) than in the other chinchin samples. The moisture content of chinchin produced from wheat flour supplemented with 30% peanut (WPC) and that produced from wheat flour supplemented with 30% soybean flour (WSC) was not significantly different. The highest protein content was observed in the WSC (19.28 ± 1.15%) followed by WPC (15.54 ± 1.08%). However, the lipid content was however significantly higher in WPC (11.74 ± 0.72%), whereas the fiber and ash contents were higher in WSC (5.55 ± 0.72% and 2.94 ± 0.09%, respectively). The highest carbohydrate content (73.74 ± 0.40%) was recorded for WFC, whereas the highest energy value was recorded for WPC (388.30 ± 5.61 kcal/100g). The range of moisture content reported in this study is lower than that reported by Ndife et al. [21] for gluten-free chinchin samples prepared from blends of composite flours of maize flour, soybean and groundnut. However, it is within the range reported by some authors for different composites and blend of flours Ilelaboye and Jesusina [3], Bongjo et al. [5], Owheruo et al. [7] and higher than what has been reported by some authors Arya et al. [31], and Alagbu [22]. This variation could be a result of the proportion of the dry and liquid ingredients used in chinchin production as well as the frying duration. The moisture content of food samples reported to influences their shelf life and storage [32]. The higher the moisture content, the more prone the sample is to microbial spoilage. The higher protein, lipid, fiber and ash contents of the chinchin supplemented with either 30% peanut or soybean flour show that the nutrient profile of these chinchin samples was fortified by the protein-rich, peanut and soybean flours. The fortification of chinchin samples at different levels has also been reported [21, 33, 34]. This suggests an improvement in the nutritional value of chinchin snacks, making them suitable for consumption by individuals of all ages for growth and development.

Significant differences ($p < 0.05$) were observed in the selected mineral (calcium, potassium, magnesium, phosphorus, iron and zinc) content of the chinchin samples as presented in Table 2. The highest calcium, potassium, magnesium, phosphorus, iron and zinc contents were observed in WSC. Phosphorus was the

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Table 2. Mineral composition (mg/100g) of chinchin samples.

Mineral composition (%)	Chinchin samples		
	WPC	WSC	WFC
Calcium	432.20±13.47^{b}	608.83±18.65^{a}	175.28±3.475^{c}
Potassium	355.54±15.25^{b}	379.28±11.15^{a}	141.84±7.74^{c}
Magnesium	150.85±9.62^{b}	195.77±4.00^{a}	88.58±5.51^{c}
Phophorus	168.24±0.00^{a}	171.85±4.09^{a}	105.51±2.33^{b}
Iron	17.25±1.01^{a}	18.69±1.20^{a}	8.56±0.58^{b}
Zinc	8.81±0.75^{b}	9.20±0.96^{a}	4.50±0.33^{c}

Values represent mean ± standard deviation of triplicate determinations and values with the same superscript along the rows are not significantly different ($p<0.05$). WPC= Chinchin prepared from wheat flour and 30% peanut; WSC=Chinchin prepared from wheat flour and 30% soybean flour; WFC= Chinchin prepared from wheat flour alone (100%)

Table 3. Sensory attributes of chinchin samples.

Sensory attribute	Chinchin samples		
	WPC	WSC	WFC
Appearance	8.70±0.47^{a}	6.95±0.17^{b}	6.78±0.20^{c}
Aroma	8.85±0.28^{a}	6.50±0.20^{c}	7.50±0.10^{b}
Texture	8.70±0.25^{a}	7.80±0.67^{a}	8.30±0.21^{a}
Mouthfeel	8.50±0.29^{a}	6.50±0.15^{b}	7.95±0.25^{a}
Crunchiness	7.52±0.18^{a}	7.30±0.15^{a}	6.90±0.25^{a}
Overall acceptability	8.72±0.28^{a}	6.52±0.17^{c}	7.80±0.28^{b}

Values represent mean ± standard deviation of triplicate determinations and values with the same superscript along the rows are not significantly different ($\varrho<0.05$). WPC= Chinchin prepared from wheat flour and 30% peanut; WSC=Chinchin prepared from wheat flour and 30% soybean flour; WFC= Chinchin prepared from wheat flour alone (100%)

most abundant mineral in all the chinchin samples with the highest in WSC (608.83 ± 18.65 mg/100g). There were no significant differences were observed in the phosphorus and iron content of WPC and WSC. The mineral content of WFC was the lowest, indicating that the addition of either 30% peanut or soybean greatly improved the mineral content of chinchin. This finding corroborates the findings of previous studies [5, 22]. The mineral content is directly related to the ash content [35]. The higher mineral content of WPC and WSC indicates mineral enrichment of chinchin [7].

Table 3 showed the summary of results obtained from the sensory evaluation by the panelists. The results showed significant differences ($p < 0.05$) in the mean scores for sensory attributes such as appearance, aroma, texture, mouth-feel, crunchiness and overall acceptability. The highest mean score for appearance (8.70 ± 0.47) was observed for WPC, whereas the lowest mean score of 6.78 ± 0.20 was observed for WFC. The scores for aroma (7.50 ± 0.10) and overall acceptability (7.80 ± 0.28) of WFC were significantly different from those of WSC. There were no significant differences in the mean scores awarded by the panelists for texture, and crunchiness of all the chinchin samples. The chinchin produced with 30% peanut supplementation had the highest score for overall acceptability (8.72 ± 0.28), followed by WFC. The chinchin produced from wheat flour supplemented with 30% soybean flour recorded the lowest value (6.52 ± 0.17) for overall acceptability, suggesting that it compares favourably with WFC. All the mean values for the overall acceptability (combination of all the other sensory parameters) for all the chinchin samples exceeded the average indicating that in regards to all the sensory attributes all the chinchin samples were acceptable. This outcome is consistent with previous reports on the acceptance of nutrient-fortified snacks [3-5, 21].

The microbial counts (CFU/g) of the freshly prepared and stored (for 2 weeks) chinchin samples are summarized in Table 4. All plate cultures of freshly prepared chinchin samples showed no visible growth and there was no visible growth in fungal plate

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Table 4. Microbial count (cfu/g) of freshly prepared and stored chinchin samples.

Storage Time (Days)	WPC		WSC		WFC	
	TVC	TFC	TVC	TFC	TVC	TFC
0	NG	NG	NG	NG	NG	NG
7	1.23×10^2	NG	1.65×10^2	1.50×10^1	1.10×10^2	1.30×10^2
14	1.15×10^3	2.10×10^2	4.80×10^3	3.00×10^2	3.70×10^3	2.60×10^2

WPC –Wheat-pea chinchin, WSC – Wheat-soybean chinchin, WFC- Wheat flour chinchin, TVC –Total viable count, TFC-Total fungal count, NG-No growth.

cultures from chinchin samples prepared by supplementing wheat flour with 30% peanut stored for 7 days. The results showed an increase in bacterial and fungal counts for all the chinchin samples from day 7 to day 14. In all chinchin samples, the bacterial count was higher than the fungal count. The highest bacterial count for chinchin samples stored for 7 days was observed in the chinchin produced from wheat flour supplemented with 30% soybean flour (1.65×10^2 CFU/g) while the highest fungal count was observed in the chinchin produced from wheat flour alone (1.30×10^2 CFU/g). For chinchin samples stored for 14 days, the highest bacterial count of 4.80×10^3 CFU/g and the highest fungal count of 2.60×10^2 CFU/g were observed in the chinchin produced from wheat flour supplemented with 30% soybean flour.

The lack of visible growth on the culture plates of freshly prepared chinchin samples shows that the incidence of microorganisms at the post-production stage could possibly be a result of exposure during cooling, handling, use of contaminated packaging material, or defective storage method. The results of the microbial count indicate that the microbial load may be greatly affected by the nutritional profile and moisture content of the chinchin samples. However, the total bacterial count observed in all the stored chinchin samples was less than the 7 $\log_{10}$CFU/g limit recommended by the International Commission on Microbiological Specification for Food (ICMSF). This suggests that the presence of these microorganisms and their population within 2 weeks of storage of chinchin samples is not sufficient to cause a disease condition in consumers. The microbial counts reported in this study for the chinchin sample were less than the reported different blends of composite flour produced from corn, breadfruit and date flours that was used for the production of chinchin [4]. However, the range of microbial counts reported was close to the findings of Owheruo et al. [7] for chinchin produced from wheat-okra composite flour blends.

The microorganisms isolated and identified from the chinchin samples (Table 5) were *Bacillus cereus, Staphylococcus aureus, Streptococcus* spp., *Pseudomonas* spp., *Lactobacillus* spp., *Candida* spp. and *Aspergillus* spp.

Table 5. Identified microorganisms and their occurrence in the chinchin samples.

Isolates	WPC	WSC	WFC
Bacillus cereus	+	+	+
Staphylococcus aureus	-	+	+
Streptococcus spp.	-	+	-
Pseudomonas spp.	+	-	-
Lactobacillus spp.	+	+	+
Candida spp.	+	+	-
Rhizobium spp.	+	-	-

Key: + = Presence; - = Absence

Among all these isolates, only *Lactobacillus* spp. is beneficial microorganism and its presence in the chinchin samples is not considered a threat to the health of consumers. Other isolates have been implicated in one health condition or the other, while the fungal isolates produce mycotoxins, however, their population in the chinchin samples is not sufficient to cause disease conditions. Of all these microorganisms, *B. cereus and Lactobacillus* spp. were present in all the chinchin samples, whereas *S. aureus* and *Candida* spp. were present in two of the chinchin samples. In total, chinchin produced from wheat flour supplemented with 30% peanut and chinchin produced from wheat flour supplemented with 30% soybean flour were contaminated with five (5) different microorganisms each, while the chinchin produced from wheat flour alone was contaminated with only three (3) microorganisms. This could be due to a lack of additional preservatives that inhibit

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microbial development. The incidence of *Bacillus* sp., *Staphylococcus aureus*, *Streptococcus* sp. and *Candida* sp. has also been reported in blends of composite of corn flour, breadfruit flour and date flour used for production of chinchin by Ihuoma et al. [4]. Similar isolates to those reported in this study have been reported in ready-to-eat food and snacks, corroborating the findings of previous authors Mengistu et al. [36], Okeke et al. [37] and Omoridion [38].

4. Conclusions

This study shows that the supplementation of wheat flour with 30% peanut and 30% soybean flour for chinchin production resulted in an enhanced/fortified nutritional profile of chinchin. The chinchin was generally acceptable to the consumers. Despite the nutritional improvement of chinchin, fortified chinchin has a good keeping quality time of less than 2 weeks as shown by a low microbial load that is within the permissible limit. The acceptance of the fortified chinchin suggests its suitability for commercial production.

Disclaimer (artificial intelligence)

Author(s) hereby state that no generative AI tools such as Large Language Models (ChatGPT, Copilot, etc.) and text-to-image generators were utilized in the preparation or editing of this manuscript.

Authors' contributions

Conceptualization, A.A.G., O.I.C.; methodology, O.G.A., I.Z.O., O.S.B.; writing – original draft preparation, A.A.G.; writing – review & editing, O.I.C.; supervision, A.A.G., O.O.R.

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Conflicts of interest

The authors declare no conflict of interest.

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