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Quality Attributes and Consumer Acceptability of *Chinchin* Produced from Blends of Rice, Cowpea, and Sweet Potato Flours

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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

This study investigated the proximate composition, mineral content, vitamin content, amino acid profile and sensory attributes of *chinchin* produced from blends of rice flour (RF), cowpea flour (CPF), and sweet potato flour (SPF). All analyses were carried out using standard methods. Proximate analysis revealed moisture content ranging from 5.11 % to 7.15 %, with the highest in the

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60:35:5 blend. Protein content increased significantly (9.76 to 16.25 %) with increase in CPF, while fat content ranged from 12.35 to 16.21 %, ash content from 1.60 % to 5.11 %, and fiber content from 1.87 % to 5.02 %. Carbohydrate content varied from 50.26 % to 68.67 %, and energy content from 411.90 to 427.43 kcal/100g. Addition of CPF and SPF significantly altered the mineral content of the *chinchin* samples as follows; Potassium (95.82 to 139.29 mg/100 g), Calcium (89.00 to 158.57 mg/100 g), Magnesium (59.06 to 93.59 mg/100 g), Phosphorous (100.14 to 162.90 mg/100 g), Iron (65.14 to 82.13 mg/100 g), Zinc (10.40 to 34.76 mg/100 g). Analysis of vitamins (A, B1, B2, B3) showed significant differences among *chinchin* samples. Amino acid composition improved with increased CPF and SPF. Sensory evaluation rated 90:5:5 and 80:15:5 blends favorably compared to control.

Keywords: Chinchin, composite flours; nutritional composition; sensory evaluation; amino acids; consumer acceptability.

1. INTRODUCTION

Chinchin just like many other snacks is traditionally prepared from cereal flours which have been known to be deficient in some vital nutrients like Sulphur-containing amino acids. There is therefore need to complement their nutrient content by incorporating other food sources. The majority of snacks are made using low-nutrient cereal flour most especially wheat flour one of the reasons being its unique content of gluten. It is necessary to supplement these snacks' nutritious value with various food sources. Most of the time, wheat has only been utilized to make *chinchin* and other pastries. However, there have been advancements recently in what the food processing industry refers to as composite flour technology—the addition of additional flours derived from fruits, vegetables, legumes, or tubers (Abioye et al., 2020; Akubor, 2004).

Rice flour is a valuable ingredient with significant nutritional benefits and economic importance. Research has shown that rice flour is a gluten-free alternative with high nutritional value, containing a balanced complex of proteins, lipids, minerals, and vitamins (Marques et al*.,* 2023). It is particularly rich in high-grade protein with a good balance of amino acids, making it a suitable dietary option for various populations, including the elderly, who may be at risk of protein-energy malnutrition (Tumenova & Myktabayeva, 2023). Additionally, rice flour has functional and technological properties that make it a versatile ingredient for food processing, allowing for the development of products that cater to specific nutritional needs while maintaining taste and quality (Matsuda, 2019). Economically, rice flour plays a crucial role in reducing wheat flour imports in non-producing countries and is increasingly used in gluten-free bakery products, contributing to the growth of the healthy food market (Cristina et al*.,* 2021). Moreover, the protein composition of rice flour makes it a valuable component in enhancing the nutritional quality of bakery products, especially in the context of dietary restrictions or health conditions that require specific protein intake adjustments (Andrey, 2023). With its complete amino acid profile and low dietary fiber content, rice flour offers a promising solution for increasing the nutritional value of food products while addressing dietary limitations, such as the need for complete proteins with minimal fiber for patients with gastrointestinal issues. Overall, the nutritional richness and functional properties of rice flour make it a versatile and economically significant ingredient in the food industry, supporting the development of diverse and nutritious food products for various consumer needs and preferences.

Cowpeas are major sources of proteins, some vital amino acids, minerals, vitamins, and dietary fibre, being a significant legume in West African diets. They give diversity to meals in the tropics, especially ones that consist mostly of starchy staples like plantains, grains, and tubers. They are readily available sources of protein due to their high yield and drought tolerance, which allow them to flourish even in areas unsuitable for other legumes. Cowpeas have a high protein content, which is utilised to improve the nutritional value of food. Cowpea has therefore been added to *chinchin* and other similar products to supplement foods and make them more nutritious (Alamu et al*.,* 2020).

Sweet potatoes are a nutrient-dense root vegetable renowned for their rich nutritional composition. Packed with complex carbohydrates, they serve as an excellent energy source, while their high dietary fibre content supports digestive health and helps regulate blood sugar levels. Sweet potatoes are abundant in essential vitamins, particularly vitamin A in the form of beta-carotene, which is crucial for vision, immune function, and skin health (Aburime et al., 2021). Additionally, sweet potatoes provide a spectrum of B vitamins, including B6, necessary for metabolism and neurological function. These tubers also offer minerals like potassium, manganese, and copper, contributing to cardiovascular health, bone density, and antioxidant defence. With a low glycemic index and various antioxidants, sweet potatoes are a versatile and nutritious food that can be a valuable part of a well-balanced diet (Ndife et al., 2020).

2. MATERIALS AND METHODS

2.1 Sample Preparation and Flour Blend Formulation

Rice flour, sweet potato flour and cowpea flour were produced as in Figs. 1, 2 and 3. These flours were then blended in different ratios as in Table 1. *Chinchin* was prepared from different blends of rice flour, sweet potato and cowpea flours. Refined wheat flour was used as Control (reference) standard.

2.2 *Chinchin* Preparation

Chinchin was prepared using the method outlined by Bongjo et al. (2023). Hundred grams (100 g) of the composite flour was weighed and sieved (250-micron particle size). The recipe is as shown in Table 2. All other ingredients (sugar, salt, and baking powder) were also added. Margarine, eggs, and milk was turned in and mixed to form dough. The dough was briefly kneaded, rolled out (2 cm thick) and cut into small squares (2 cm by 2 cm). It was deep fried till it turns golden brown. It was then drained, cooled, packaged (in Low Density Polyethylene-LDPE) and stored at room temperature.

2.3 Analyses

2.3.1 Proximate analysis

The proximate analysis of the composite flours were determined by the official methods of AOAC (2012). Energy was calculated using Attwater factor (fat x 9 + carbohydrate x 4 + protein x 4 kcal/100 g).

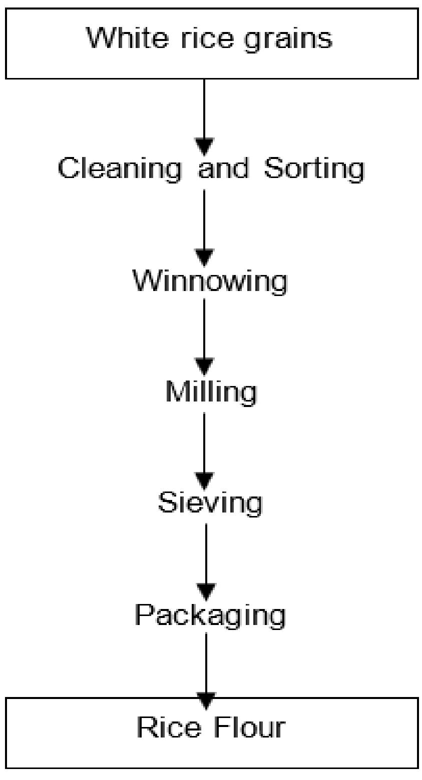

Fig. 1. Flow Chart for rice flour Production

Source: (Osuji et al.*, 2020)*

Table 1. Flour based formulation for *chinchin*

	Ingredient (%)		
Samples	**Rice flour**	**Cowpea flour**	**Sweet potato flour**
100:0:0	100	0	0
90:5:5	90	5	5
80:15:5	80	15	5
70:25:5	70	25	5
60:35:5	60	35	5
CTRL	100 % Wheat flour		

Table 2. Recipe used for the preparation of *chinchin*

Ingredient	Composition (g)
Composite flour	100
Margarine	25
Sugar	25
Egg	1 egg
Milk	10
Baking Powder	5.6

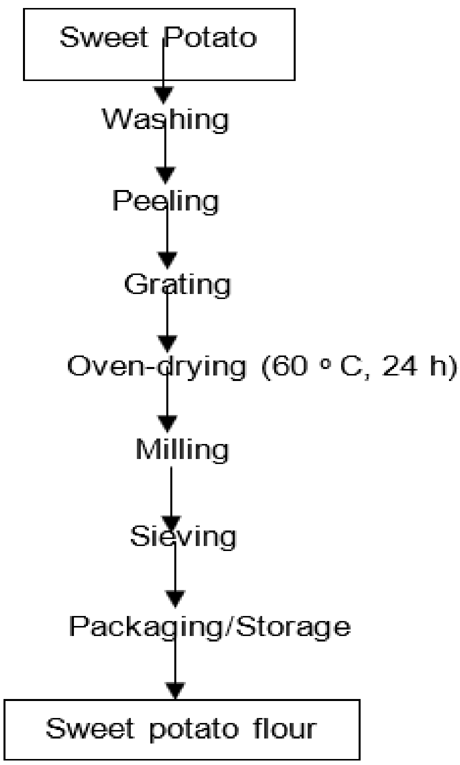

Fig. 2. Flow chart for sweet potato flour production
Source: (Ndife et al.*, 2020)*

2.3.2 Determination of Minerals

The minerals Ca, K, Mg, Fe, P and Zn were determined. 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. The ash residues were digested with 5 mL of concentrated nitric acid, filtered and the filtrate was 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 Atomic absorption spectroscopy (AAS) analysis (AOAC, 2012).

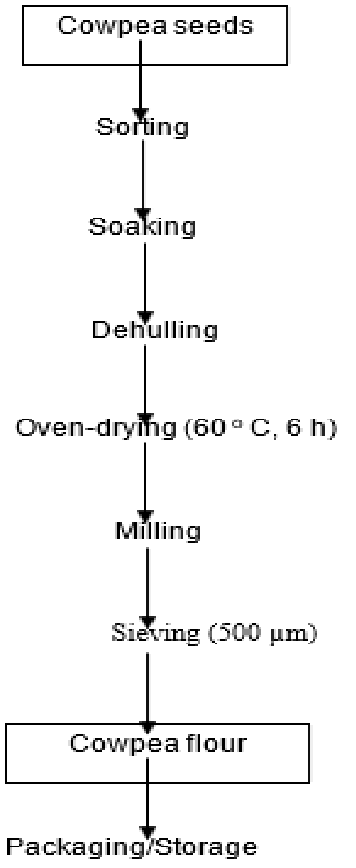

Fig. 3. Flow Chart for the Production of cowpea flour
Source: (Ibidapo et al*., 2017)*

2.3.3 Determination of vitamin content

The method of AOAC (2012) using the colourimeter was adopted. Vitamins A, B1, B2 and B3 were determined.

2.3.4 Amino acid analysis of the *chinchin*

Amino acids composition was quantified after hydrolysis using model 120A PTH amino acid analyzer (HPLC) in the reversed-phase column, after derivatization with 9-fluorentylmethyl chloroformate and a fluorescence detector (AOAC, 2015). The sample was dried at 70 °C to constant weight, defatted, hydrolyzed, evaporated in a rotary evaporator and loaded into the biosystem PTH Amino Acid Analyzer. The concentration of the individual amino acids was calculated in relation to the protein content.

2.4 Evaluation of Sensory Quality Attributes of Chinchin Samples

A panel of 30 individuals were employed for this study, where a 9-point hedonic scale was used; with 9 representing like extremely and 1 representing dislike extremely.

3. RESULTS AND DISCUSSION

3.1 Proximate Composition of *chinchin* from Rice, Cowpeas and Sweet Potato

The proximate composition of the *chinchin* samples is presented in Table 3. The moisture content significantly increased ($p<0.05$) with the increasing incorporation of CPF and SPF. This increase in moisture content could be attributed to the increased hydrophilic properties of the fiber in CPF and SPF as their levels of incorporation rose. Moisture content is a critical indicator of a product's shelf stability; the lower the moisture content, the better the shelf stability (Ayogu et al*.,* 2016). Bongjo et al. (2023) reported similar results for wheat-defatted peanut-orange peel based *chinchin*. These results are similar those reported by (Ayogu et al*.,* 2016) (7.82–9.76%) who evaluated the potential of two local cowpea varieties for wheat-based cookies and higher than reported by

Adegunwa et al., (2014) (3.98-5.05%) who produced *chinchin* from a millet-wheat composite flour. The trend in results also agree with other studies (Akindele et al*.,* 2017).

The protein content varied significantly across all samples. This significant increase (p<0.05) in protein content was observed as the incorporation of CPF and SPF increased. These results are higher than those of Adegunwa et al*.* (2014), who produced *chinchin* from millet and wheat. Adebayo-Oyetoro et al*.* (2017) reported protein contents ranging from 11.1% to 14.9%, and similar ranges were reported by another study with 10.51% to 14.58%. This indicates that the *chinchin* produced in this study is rich in protein. Additionally, the protein content observed in this study was higher than those Badau et al. (2013) reported for Garabia (a Nigerian snack produced from different rice varieties), ranging from 10.72 % to 12.86 %.

The substitution with CPF and SPF in the *chinchin* samples increased fat content. This increase in fat content differed significantly among all the samples and could be attributed to the fat content in the CPF as well as due to the recipe. This finding aligns with a study by Dharsenda et al*.* (2015) on the substitution of defatted peanut flour in peanut flour-based cookies. However, the fat content results in this study are lower than those reported by Badau et al*.* (2013) for Garabia-a Nigerian traditional snack who reported 28 to 42.30 % for fat content. The high fat content in the *chinchin* samples was expected, given the significant increase in the OAC of the flours with higher CPF incorporation. Additionally, this high fat content could be attributed to oil absorption during frying and variations in the recipes.

The ash content of the *chinchin* samples increased significantly, an increase in the ash content of the *chinchin* samples was seen as substitution with CPF increased. All samples were significantly different (*p*<0.05) from each other. The increase in ash content could be attributed to the high ash content of CPF of 3.43 % and SPF of 3.12% (Table 4). Bongjo et al*.* 2023) also reported an increase in the ash content of *chinchin* produced from defatted peanut flour and orange peel flour. The ash content in this study was higher than those reported by several studies on the production of *chinchin* and other snacks (Badau et al*.*, 2013; Deedam et al*.,* 2020; Ugwuanyi et al., 2020). However, the trend in results are comparable to those reported by (Ajibola et al*.,* 2015) in biscuits incorporated with Moringa flour and cocoa powder. The ash content of a product indicates a rough estimate of its mineral content. (Adelekan et al*.,* 2019). This study therefore indicates that the *chinchin* samples would contribute enormous mineral elements to the body.

There was a significant increase (p<0.05) in fiber content as the substitution with CPF increased. This increase can be attributed to the high fiber content (2.12 %) in CPF, as noted in Table 4, and also reported by Ayogu et al*.* (2016) to contain fibre contents ranging from 4.91 to 5.49 %. The crude fiber content in this study was lower than that reported by Singh and Arivuchudar (2018) for peanut-based cookies. However, the fiber content in this study was comparatively higher than those reported by Adebayo-Oyetoro et al*.* (2017), Deedam et al*.* (2020b, 2020a), and Ndife et al*.* (2020), who produced *chinchin* from different composite flours. The results were also comparable to those by Adegunwa et al*.* (2014) in their wheat-millet *chinchin*.

A significant decrease (p<0.05) was observed in the carbohydrate content with increase in CPF and SPF incorporation. This outcome is consistent with research by Shakpo and Osundahunsi, (2016) and Nwafor et al*.* (2020), who produced *Ipekere Agbado* (cowpea-enriched maize snack) and Yam-cowpea flour, respectively, and reported a decrease in carbohydrate content (65-30 %) and (81-63 %). This study's carbohydrate content is higher than that of (Badau et al*.,* 2013) but greater than that of Nwafor et al*.* (2020)'s study.

The *chinchin* samples' energy contents increased. As the percentage of CPF grew, there was some significant decrease (p<0.05) across the samples as substitution with CPF increased. These findings are in tandem with other authors who produced *chinchin* from different composite flours (Bongjo et al*.*, 2023; Ubbor et al*.*, 2022; Ubbor and Akobundu, 2009).

3.2 Mineral Content of *chinchin* from Rice, Cowpea and Sweet Potato Flour Blends

The mineral composition of the *chinchin* produced is presented in Table 4. A significant increase in Calcium contents (p<0.05) was observed across all the samples with increase in the incorporation of CPF and SPF. 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 (Grace et al*.,* 2015). It has also been identified to play major role in managing blood pressure, and preventing breast cancer. These results are lower than those reported by Bongjo et al*.* (2023) for defatted peanut-based *chinchin* who revealed calcium contents ranging from 153.23 to 415.69 mg/100g. Yilma and Admassu, (2019) also reported lower calcium contents of 0.22 to 0.38 mg/100g for biscuits from cowpea-wheat flour blends. Akubor et al*.* (2023) in a study to produce noodles from wheat, unripe banana and cowpea flour blends, the calcium content was observed to range between 84.40 to 126.0 mg/100g which is far lower than results obtained in the present study.

The iron content of the samples increased significantly ($p<0.05$). The increase in iron content was observed as the level of incorporation of CPF and SPF in the flours increased. Iron plays a crucial role in strengthening the immune system. It is a functional component of hemoglobin and other essential compounds involved in respiration, immune function, and cognitive development. Ensuring an adequate iron intake is especially important in the diets of pregnant women, nursing mothers, and infants to prevent anemia (Olayinka and Etejere, 2018). Results in this study are higher than those reported by for cookies incorporated with different varieties of cowpeas ranging from 6.49 to 8.62 mg/100g. This is also consistent with reports for *Garabia* produced from varieties of rice (Badau et al*.,* 2013). Also, authors have reported iron contents ranging from 0.06 to 0.149 mg/100g for a cowpea enriched maize snack (*Ipekere Agbado*).

There was a significant increase ($p<0.05$) in potassium content as the level of CPF and SPF incorporation increased. Potassium is known to play vital roles in maintaining fluid balance and ensuring the proper functioning of essential organs such as the brain, nerves, heart, and muscles (Asouzu et al*.,* 2020). Additionally, potassium aids in nerve impulse transmission and is a major cation in intracellular fluid (Olayinka and Etejere, 2018). Bongjo et al*.* (2023) witnessed a similar increasing trend with increase in defatted peanut flour and orange peel for the production of *chinchin*. Other reports have reported lower values (6.29-7.8 mg/100g) for cowpea-wheat flour snacks Yilma & Admassu, (2019) and 25.73 to 30.65 mg/100g for wheat-based cookies supplemented with cowpea flours.

Magnesium contents increased with significant difference ($p<0.05$) across samples. Combining RF, CPF, and SPF flour increased the magnesium content of the snacks, as seen by the higher values obtained for the composite flour chinchin samples when compared to CTRL (wheat flour chinchin). The value found in this investigation exceeded the 5.60–13.60 mg/100g range previously reported for maize–wheat chin–chin (Dong et al., 2016).

Comparable ranges of 88.62–178.05 mg/100g were reported by Ndife et al*.* (2020) for *chinchin* prepared from maize, soybean and sweet potato flour blends. Because it maintains a healthy immune system, stabilizes heart rhythm, helps to maintain normal muscle and nerve function, and keeps bones strong, magnesium is necessary for optimal health.Akubor et al*.* (2023) reported lower magnesium contents (35.63 to 53.26 mg/100g) for cowpea-based noodles.

The results for zinc indicate a significant increase ($p<0.05$) in zinc content with the increased incorporation of CPF and SPF into *chinchin*. This trend aligns with findings by Adeleke et al*.* (2021), who reported an increase in zinc content from 2.37 mg/100g to 3.50 mg/100g in *chinchin* enriched with polyphenol extracted from *Amaranthus viridis*. Additionally, Guyih et al*.* (2020) found zinc content values ranging from 5.75 mg/100g to 7.12 mg/100g for wheat-almond-carrot-based cookies, while Akindele et al*.* (2017) reported zinc values from 11.07 mg/100g to 17.93 mg/100g for *chinchin* enriched with *Ugu* and Indian spinach leaves. However, these results differ from those reported by Singh and Arivuchudar, (2018) for peanut-incorporated cookies. Zinc is an essential micronutrient involved in protein formation, blood formation, wound healing, taste perception, growth, and the maintenance of all tissues. It also plays a vital role in the immune system and is a component of many enzymes (Adenike, 2013).

Phosphorous content of the *chinchin* samples increased significantly ($p<0.05$) with addition of CPF and SPF. Phosphorus deficiency leads to decreased growth, poor tooth development, and rickets (Ayogu et al*.,* 2016). Some reports have reported phosphorus contents ranging from 13.35 to 18.26 mg/100g in cookies. Another parallel study on noodles produced from cowpea-wheat flour reported phosphorus contents of between 35.75 to 148.75 mg/100g. Ndife et al. (2020) got similar results ranging from 78.23 to 139.17 mg/100g for *chinchin* from maize, soybean and sweet potato flour blends.

3.3 Vitamin Content of *chinchin* from Rice, Cowpea and Sweet Potato Flour Blends

The vitamin content of the *chinchin* made from rice, cowpea and sweet potato flour blends as shown in Table 5, indicates that the inclusion of CPF and SPF flour in rice flour significantly ($p<0.05$) increased across the samples. The values ranged from 3.14 to 8.12 µg/100g. (Ndife et al*.,* 2020) observed a similar trend in pro-vitamin A contents and recorded 0.3 to 2.1 µg/100g of *chinchin*. These are higher than those reported in this study. These findings are consistent with those of Makanjuola and Adebowale, (2020), who reported an increase in vitamin A content (0.45–5.67 mg/100 g) with the inclusion of cocoyam flour in wheat-cocoyam flour-based biscuits. Vitamin A is crucial for proper and clear vision, and consuming foods rich in this vitamin is essential for improving the body's vitamin A levels. However, all the values for vitamin A in this study were below the recommended daily intake of 300 µg/day (Tadesse et al*.,* 2015).

Thiamine (Vitamin B1) functions as the coenzyme thiamine pyrophosphate (TPP) in the metabolism of carbohydrates and branched-chain amino acids. The inclusion of CPF and SPF flour in the blends resulted in a significant ($p<0.05$) increase in thiamine content. The increase in thiamine content is likely due to the inclusion of CPF and SPF. This finding aligns with the report by Dinnah et al*.* (2020), who observed an increase in thiamine content (1.52–2.45 mg/100 g) with the addition of almond seed and carrot flour in blends. Ndife et al*.* (2020) reported higher values of 0.02 to 0.14 mg/100g for *chinchin* from maize-soybean-orange fleshed sweet potato composite flour.

No significant difference ($p>0.05$) observed in the B2 samples. The B vitamins are needed for carbohydrate and protein metabolism, and are essential for growth, well structuring and functioning of the cells (Dinnah et al*.,* 2020).Dinnah et al*.* (2020) reported higher vitamin contents in vitamin B2 (0.65 – 0.92 mg/100 g) for cookies incorporated with carrot flour and almond seed flour. Ndife et al*.* (2020) reported similar results ranging from 0.03 to 0.09 mg/100g.

Vitamin B3 contents significant increase as the level of CPF and SPF inclusion increased. These results are higher than those reported by Badau et al*.* (2013) for *Garabia* produced from different rice varieties and cowpea flour. They reported vitamin B3 contents ranging from 0.05 to 0.23 mg/100g. Ndife et al*.* (2020) also reported higher vitamin B2 contents ranging from 0.41 to 1.31 mg/100g.

3.4 Amino Acid Composition of *chinchin* from Rice, Cowpea and Sweet Potato Flour Blends

The essential amino acids of the *chinchin* produced are presented in Table 6. Essential amino acids are very important for the body, yet little or none of them is synthesized by the human body. As such, essential amino acids are supplied to the body by the diet (Michael and Shamim, 2023). As variations were made in the formulation by addition of CPF and SPF, the amounts of essential amino acids in all *chinchin* increased significantly ($p<0.05$). The high essential amino acid content of *chinchin* could be as a result of the high protein content of the CPF (Tables 3). The relationship between amino acids and proteins has been established by prominent researchers. Mosse and Huet, (2010) explained that amino acids are the building blocks of proteins, thus high values of proteins in a food indicate high amino acid content and vice versa. Comparing the essential amino acid content of the fortified *chinchin* in this study, the result shows that the *chinchin* made from rice flour/cowpea/sweet potato were richer in amino acids, indicating the availability of more essential amino acids in the *chinchin* from the blends than the CTRL sample. Several studies have also profiled the amino acid content of cowpea (Elharadallou et al*.,* 2015).

The non-essential amino acids of the *chinchin* produced are presented in Table 7. Non-essential amino acids are synthesized in the human body, and the amount obtained from food acts only as supplements. The high non-essential amino acid content of *chinchin* suggests that it is not only essential amino acids but also non-essential amino acids.

Table 3. Proximate Composition (%) of *chinchin* produced from flour blends of rice, cowpea and sweet potato

RF: CPF: SPF	Moisture content	Crude protein	Crude fat	Fibre	Ash	CHO	Calories (kcal)
100:0:0	$5.23^{b}\pm0.01$	$10.12^{b}\pm0.02$	$12.55^{b}\pm0.03$	$1.87^{a}\pm0.02$	$1.73^{b}\pm0.01$	$68.51^{e}\pm0.03$	$427.43^{e}\pm0.22$
90:5:5	$5.59^{c}\pm0.02$	$12.05^{c}\pm0.05$	$13.63^{c}\pm0.16$	$3.09^{c}\pm0.04$	$2.62^{c}\pm0.00$	$63.01^{d}\pm0.20$	$422.97^{c}\pm0.73$
80:15:5	$5.95^{d}\pm0.07$	$14.11^{d}\pm0.01$	$15.18^{d}\pm0.03$	$3.55^{d}\pm0.02$	$3.20^{d}\pm0.01$	$58.00^{c}\pm0.09$	$425.09^{d}\pm0.20$
70:25:5	$6.24^{e}\pm0.02$	$15.20^{e}\pm0.03$	$15.82^{e}\pm0.04$	$4.81^{e}\pm0.02$	$4.18^{e}\pm0.01$	$53.74^{b}\pm0.05$	$418.20^{b}\pm0.32$
60:35:5	$7.15^{f}\pm0.05$	$16.25^{f}\pm0.02$	$16.21^{f}\pm0.03$	$5.02^{f}\pm0.01$	$5.11^{f}\pm0.02$	$50.26^{a}\pm0.09$	$411.90^{a}\pm0.13$
CTRL	$5.11^{a}\pm0.02$	$9.76^{a}\pm0.06$	$12.35^{a}\pm0.01$	$2.52^{b}\pm0.02$	$1.60^{a}\pm0.01$	$68.67^{e}\pm0.06$	$424.84^{d}\pm0.09$

Values are presented as means±standard deviation of triplicate determinations.
Means within the same column with different superscripts are significantly different at p<0.05
RF-Rice Flour, CPF-Cowpea Flour, SPF-Sweet potato flour, CTRL-Wheat flour, CHO-carbohydrate

Table 4. Mineral content (mg/100 g) of *chinchin* from rice, cowpea and sweet potato flour blends

RF: CPF: SPF	Potassium	Calcium	Magnesium	Phosphorus	Iron	Zinc
100:0:0	$101.65^{b}\pm1.33$	$89.00^{a}\pm0.77$	$63.06^{b}\pm0.61$	$121.98^{d}\pm0.09$	$67.90^{b}\pm0.04$	$10.40^{a}\pm0.08$
90:5:5	$95.82^{a}\pm0.58$	$99.56^{b}\pm0.11$	$59.06^{a}\pm0.39$	$100.14^{a}\pm0.02$	$65.14^{a}\pm0.02$	$13.19^{b}\pm0.07$
80:15:5	$112.28^{c}\pm0.61$	$107.09^{c}\pm0.33$	$65.67^{c}\pm0.37$	$112.21^{b}\pm0.24$	$71.31^{d}\pm1.15$	$21.23^{d}\pm1.11$
70:25:5	$120.80^{d}\pm0.34$	$113.77^{d}\pm0.79$	$78.91^{e}\pm0.16$	$141.09^{e}\pm1.03$	$78.38^{c}\pm0.54$	$31.26^{e}\pm0.94$
60:35:5	$131.51^{e}\pm2.26$	$120.62^{e}\pm0.84$	$93.59^{f}\pm0.25$	$162.90^{f}\pm0.16$	$82.13^{f}\pm0.65$	$34.76^{f}\pm0.43$
CTRL	$139.21^{f}\pm1.33$	$158.57^{f}\pm1.34$	$68.02^{d}\pm0.16$	$113.27^{c}\pm0.94$	$76.78^{e}\pm0.42$	$14.74^{c}\pm0.06$

Values are presented as means±standard deviation of triplicate determinations.
Means within the same column with different superscripts are significantly different at p<0.05
RF-Rice Flour, CPF-Cowpea Flour, SPF-Sweet potato flour, CTRL-Wheat flour

Table 5. Vitamin content of mg/100 g) *chinchin* from rice, cowpea and sweet potato flour blends

RF: CPF: SPF	Provitamin A	Thiamine	Riboflavin	Niacin
100:0:0	$3.43^{b}\pm0.01$	$0.05^{d}\pm0.00$	$0.04^{a}\pm0.00$	$0.49^{b}\pm0.01$
90:5:5	$5.04^{c}\pm0.04$	$0.03^{b}\pm0.00$	$0.04^{a}\pm0.00$	$0.60^{c}\pm0.02$
80:15:5	$6.10^{d}\pm0.02$	$0.05^{c}\pm0.00$	$0.05^{a}\pm0.00$	$0.64^{d}\pm0.02$
70:25:5	$7.54^{e}\pm0.02$	$0.06^{e}\pm0.00$	$0.08^{a}\pm0.01$	$0.80^{e}\pm0.01$
60:35:5	$8.12^{f}\pm0.02$	$0.07^{f}\pm0.00$	$0.09^{a}\pm0.00$	$0.90^{f}\pm0.03$
CTRL	$3.14^{a}\pm0.02$	$0.02^{a}\pm0.00$	$0.04^{a}\pm0.00$	$0.42^{a}\pm0.02$

Values are presented as means±standard deviation of triplicate determinations.
Means within the same column with different superscripts are significantly different at p<0.05
RF-Rice Flour, CPF-Cowpea Flour, SPF-Sweet potato flour, CTRL-Wheat flour

Table 6. Essential amino acid composition (g/100g) of *chinchin* from rice, cowpea and sweet potato flour blends

RF: CPF: SPF	Lys	Met	Thr	Ile	Leu	Phe	Val	Trp	His	TEAA
100:0:0	2.84^{a}±0.02	0.87^{b}±0.01	1.24^{a}±0.01	0.91^{a}±0.01	3.26^{a}±0.01	2.96^{a}±0.01	1.97^{a}±0.02	3.06^{a}±0.02	2.19^{a}±0.01	19.27^{a}±0.06
90:5:5	3.56^{c}±0.01	1.24^{c}±0.00	2.31^{c}±0.01	2.67^{c}±0.02	7.03^{c}±0.05	4.14^{c}±0.01	4.02^{c}±0.02	4.03^{c}±0.01	3.63^{c}±0.01	32.61^{b}±0.04
80:15:5	4.04^{d}±0.01	1.41^{d}±0.01	2.66^{d}±0.02	3.06^{d}±0.02	8.01^{d}±0.01	4.95^{d}±0.01	4.72^{d}±0.02	4.33^{d}±0.02	3.84^{d}±0.01	37.00^{d}±0.07
70:25:5	4.14^{e}±0.01	1.64^{e}±0.01	2.81^{e}±0.01	3.26^{e}±0.02	8.21^{e}±0.01	5.20^{e}±0.01	5.02^{e}±0.01	4.76^{e}±0.01	3.98^{e}±0.02	38.99^{e}±0.01
60:35:5	4.85^{f}±0.01	1.86^{f}±0.01	2.88^{f}±0.00	4.03^{f}±0.01	8.78^{f}±0.02	5.47^{f}±0.02	5.14^{f}±0.00	4.83^{f}±0.01	4.21^{f}±0.01	42.04^{f}±0.01
CTRL	3.22^{b}±0.01	0.77^{a}±0.01	1.55^{b}±0.02	1.05^{b}±0.01	3.92^{b}±0.02	3.84^{b}±0.02	2.26^{b}±0.01	3.26^{b}±0.00	2.84^{b}±0.02	22.68^{b}±0.03

Values are presented as means±standard deviation of triplicate determinations.
Means within the same column with different superscripts are significantly different at p<0.05
RF-Rice Flour, CPF-Cowpea Flour, SPF-Sweet potato flour, CTRL-Wheat flour, TEAA-Total Essential AminoAcid

Table 7. Non-essential amino acid composition (g/100g) of *chinchin* from rice, cowpea and sweet potato flour blends

RF: CPF: SPF	Ser	Cys	Tyr	Ala	Asp	Glu	Gly	Pro	Arg	TNEAA
100:0:0	2.35^{a}±0.02	1.76^{a}±0.00	3.91^{a}±0.02	0.65^{a}±0.02	3.25^{a}±0.01	6.97^{a}±0.02	1.56^{a}±0.01	1.02^{a}±0.05	1.14^{a}±0.02	22.59^{a}±0.09
90:5:5	3.14^{c}±0.02	2.05^{c}±0.05	5.59^{c}±0.04	1.73^{c}±0.01	5.53^{c}±0.01	9.13^{c}±0.01	3.43^{c}±0.01	1.86^{c}±0.02	2.47^{b}±0.23	34.91^{c}±0.28
80:15:5	3.37^{d}±0.04	2.20^{d}±0.04	5.84^{d}±0.02	2.19^{d}±0.04	7.36^{d}±0.01	11.05^{d}±0.08	3.65^{d}±0.01	2.28^{d}±0.01	2.33^{b}±0.00	40.25^{d}±0.06
70:25:5	3.47^{e}±0.02	2.33^{e}±0.01	5.91^{e}±0.04	2.24^{e}±0.03	7.96^{e}±0.02	13.23^{e}±0.01	3.97^{e}±0.02	2.91^{e}±0.04	3.09^{c}±0.04	45.09^{e}±0.10
60:35:5	3.76^{f}±0.02	2.58^{f}±0.00	6.12^{f}±0.02	2.53^{f}±0.01	8.14^{f}±0.02	15.27^{f}±0.29	4.27^{f}±0.01	3.34^{f}±0.02	3.22^{c}±0.03	49.21^{f}±0.33
CTRL	2.46^{b}±0.01	1.98^{b}±0.02	4.84^{b}±0.02	0.76^{b}±0.01	4.34^{b}±0.02	8.11^{b}±0.01	2.08^{b}±0.02	1.30^{b}±0.01	1.27^{a}±0.01	27.12^{b}±0.03

Values are presented as means±standard deviation of triplicate determinations.
Means within the same column with different superscripts are significantly different at p<0.05
RF-Rice Flour, CPF-Cowpea Flour, SPF-Sweet potato flour, CTRL-Wheat flour, TNEAA-Total Non-Essential Amino Acid

Table 8. Sensory attributes of *chinchin* from rice, cowpea and sweet potato flour blends

RF: CPF: SPF	Appearance	Aroma	Taste	Crunchiness	Overall acceptability
100:0:0	$6.68^{a}\pm1.25$	$6.00^{a}\pm1.20$	$5.68^{a}\pm1.29$	$5.84^{a}\pm1.77$	$6.58^{ab}\pm1.54$
90:5:5	$7.30^{ab}\pm0.92$	$6.85^{ab}\pm1.50$	$6.70^{b}\pm1.26$	5.70 ± 1.03	$7.20^{b}\pm1.11$
80:15:5	$7.25^{ab}\pm1.02$	$6.60^{ab}\pm1.35$	$6.90^{b}\pm1.07$	$7.25^{b}\pm1.07$	$7.15^{b}\pm1.46$
70:25:5	$6.70^{a}\pm1.22$	$6.05^{a}\pm1.19$	$5.80^{a}\pm1.36$	$6.00^{a}\pm1.86$	$6.70^{ab}\pm1.59$
60:35:5	$6.60^{a}\pm1.43$	$6.00^{a}\pm1.45$	$5.50^{a}\pm1.40$	$5.70^{a}\pm1.53$	$5.95^{a}\pm1.79$
CTRL	$7.80^{c}\pm1.06$	$7.15^{c}\pm1.04$	$7.95^{c}\pm0.83$	$7.05^{b}\pm1.10$	$8.10^{c}\pm0.55$

Values are presented as means±standard deviation of triplicate determinations.
Means within the same column with different superscripts are significantly different at p<0.05
RF-Rice Flour, CPF-Cowpea Flour, SPF-Sweet potato flour, CTRL-Wheat flour

The incorporation of CPF and SPF into the formulation caused a significant increase (p<0.05) in the non-essential amino acid content of the samples. It is reported that the addition of a raw material with high amount of nutrients to a material that is lower in nutrients brings about a rise in concentration of nutrients in the latter (Chen et al*.,* 2018). The results in this study follow the same trend but were lower than those reported by Ajoke et al*.* (2018) for extruded snacks from pearl millet and germinated pigeon pea. This goes further to support the study which profiled the amino acids in cowpea flour (Elharadallou et al*.,* 2015).

3.5 Sensory Attributes of *chinchin* from Rice, Cowpea and Sweet Potato Flour Blends

Sensory attributes such as appearance, aroma, taste, crunchiness and overall acceptability are useful in determining the quality of *chinchin*. The sensory quality attributes as presented in Table 8 showed that the inclusion of CPF and SPF led to a significant difference (p<0.05) between CTRL and the test samples. All samples were generally acceptable but as expected, the CTRL sample was rated significantly higher than the other samples containing rice flour and sweet potato. This therefore affirms the potential of using these flours in food product development. Several studies affirming the use of CPF and SPF for the production of acceptable snacks and other related food products have been reported (Badau et al*.,* 2013; Ayogu, et al*.,* 2016; Ndife et al*.,* 2020; Ubbor et al*.,* 2022).

4. CONCLUSION

Chinchin produced from rice, cowpea, and sweet potato composite flours offers a nutritionally superior and consumer-acceptable alternative to wheat-based products. These findings support the potential of these locally available crops for use in the commercial production of healthier snacks.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that generative AI technologies such as Large Language Models, etc. have been used during the writing or editing of manuscripts. This explanation will include the name, version, model, and source of the generative AI technology and as well as all input prompts provided to the generative AI technology.

Details of the AI usage are given below:

1. Claude 3.5 Sonnet
2. Consensus.app

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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