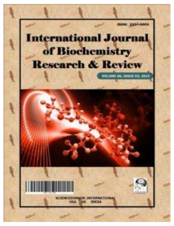

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Proximate, Mineral, Sensory Evaluations and Shelf Stability of *Chinchin* Enriched with *Ugu* and Indian Spinach Vegetables

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Authors' contributions

This work was carried out in collaboration between all authors. Author OA designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Authors OG and KT supervised and managed the analyses of the study. Author CA managed the literature searches. All authors read and approved the final manuscript.

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ABSTRACT

The utilization of Indian spinach and *ugu* vegetables in the enrichment of *chinchin* was investigated with a view to providing information on the nutritional value of enriched *chinchin.* The vegetables (dried and crushed) were incorporated into wheat flour at 1.5%, 3% and 5% levels to produce enriched *chinchin* fried in canola oil at 170°C for 6 min. The enriched *chinchin* were evaluated for proximate and mineral composition, shelf stability as well as sensory characteristics. The result showed that ash, fibre, protein and fat increased from 0.92 to 1.72% and 1.76%, 1.80 to 2.17% and 2.12%, 10.51 to 12.37% and 14.58%, 11.67 to 17.34% and 13.91% while the moisture and carbohydrate decreased from 5.30 to 4.17% and 4.78%, 69.67 to 62.23% and 62.79% for *chinchin* enriched with *ugu* and Indian spinach vegetables, respectively. Potassium, magnesium, calcium, iron and zinc in the enriched *chinchin* increased from; 261.30 to 425 mg/100 g, 76.18 to 176.23

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mg/100 g, 643.91 to 1684.27 mg/100g, 34.54 to 49.69 mg/100 g and 11.07 to 17.93 mg/100 g, respectively. Peroxide value (PV) of stored *chinchin* showed that PV of enriched *chinchin* increased from 28.26 to 32.19% during 4 weeks of storage at ambient temperature. The level of rancidity was within acceptable literature level for human consumption. Consumer acceptability of enriched sample was influenced by its color and taste which was impacted by the green color of the vegetables added. In conclusion, the addition of vegetables to *chinchin* enhanced its nutritional value of the *chinchin.*

Keywords: Perioxide value; nutritional value; ugu; canola oil.

1. INTRODUCTION

Snacks are important for small children and a few adults with very high calorie needs, who do not eat enough food at meals to grow, heal or perform. But for most of us, snacks are often a source of extra calories usually from foods that we eat too much of already [1].

[2] defined snack foods as being something consumed primarily for pleasure rather than for social or nutritive purpose and not ordinarily used in a regular meal. Healthy snacks provide people with vitamins and nutrients needed to keep one healthy and full of energy [3]. *Chinchin* is a traditional Nigerian snack prepared using wheat flour, butter, milk and eggs to form a stiff paste and then deep fried until golden brown [4]. *Chinchin* may at times be prepared by baking instead of frying [5]. Long shelf life of *chinchin* makes large-scale production and distribution possible. Also, good eating quality makes *chinchin* attractive for fortification and other nutritional improvements. The rapid urbanization and increase in population in recent years have resulted in an increase in the consumption of wheat-based product especially *chinchin* in Africa and mostly in Nigeria. Most of bakery products are used for their diversification using different nutritionally rich ingredients for incorporation into products [6,7]. This approach not only promotes development of diversified and nutrient rich bakery products but also reduces over exploitation and excessive use of wheat for making bakery products.

Sources of dietary fibre include fruits, cereals and vegetables. Over one million tonnes of vegetable trimmings from the vegetable processing industry are produced every year which can be used for value addition. Green leafy vegetables constitute an indispensable constituent of human diet [8]. Vegetables are so common in human diet that a meal without a vegetable is regarded as incomplete in many part of the world. Vegetables are valued mainly for their high fibre, vitamin, and mineral content [9]. Green leafy vegetables are one of the most abundant and cheapest potential sources of minor nutrients like vitamins, minerals and fibres [10,11].

Ugwu (Telfairia occidentalis) is a creeping vegetable commonly grown in West Africa as a leafy vegetable and for its edible seeds. *Telfairia occidentalis* contains nutrients such as proteins, carbohydrates, vitamins, minerals and fiber [12]. The leaves have been reported to be rich sources of copper, potassium and manganese, moderate source of zinc and good source of iron [11].

Indian spinach (Basellaceae) is a fast growing perennial climber found in almost every compound. Basella leaves are also very rich sources of minerals like potassium, manganese, calcium and copper [13]. It is very good as laxative; its high water content and fiber provide roughage for human diet. Hence, effective strategies are needed to increase vegetable intake in accordance with health recommendations [14]. The incorporation of vegetables into extruded products create a major opportunity for food processors to provide healthy dietary fiber-enriched products [15]. Thus, the objective of this study was to incorporate dried *ugu* and Indian Spinach vegetable in the preparation of *chinchin* to improve the nutritional qualities and to assess their quality characteristics.

2. MATERIALS AND METHODS

2.1 Collection of Materials

Wheat flour, vegetable (*ugu* and Indian spinach leaves), sugar, margarine, baking powder, egg, nutmeg and vegetable oil were obtained from Ile-Ife central market, Ile- Ife, Osun State, Nigeria. All chemicals used were of analytical grades and were obtained from Sigma Aldrich chemical company (St. Louis, MO), USA.

2.2 Preparation of Vegetable Flour

Vegetable flours were prepared according to the method of [16]. The Indian spinach and *ugu* vegetables were washed separately in a bowl of water and wash and stirred gently with hands. The leaves were then removed to let the sand and grit settle. This step was repeated until the vegetable was clean and free from dirt and sand. After washing, the vegetables were cut into small pieces to remove large stems. The vegetables were blanched in a water bath (Julado 150, England) at 70°C for 3 min. It was then drained and spread thinly and evenly in a hot air oven to ensure even drying. The vegetables were dried at 60°C for 8 h. After drying, the dried vegetable was crushed into coarse particles using a mortar and pestle. The crushed vegetable was passed through a 315 microns- sieve aperture to obtain uniform particle sizes. The coarse vegetable was stored in an airtight plastic container for further analysis.

2.3 *Chinchin* Production

Wheat flour was mixed with Indian spinach and *ugu* vegetable flour separately at 0, 1.5, 3, and 5%. The blended flour, sugar, butter, egg, baking powder, water, and milk were thoroughly mixed together appropriately in a large bowl. The dough was placed on a floured surface and kneaded until smooth and elastic. The kneaded dough was rolled out to approximately 1 cm thickness and then cut into small squares 1 cm by 1 cm in size. About 1.5 litres of vegetable oil was poured inside a deep fryer (Magic fryer MC1800) and allowed to heat up to 170°C. The dough cubes were placed in the hot oil and the *chinchin* was deep fried for 5 min until golden brown. The fried *chinchin* was removed, drained of excess oil and left to cool before being packaged [5]. The *chinchin* samples were pounded in a mortar to powder for further analysis. The recipe formulation for *chinchin* production is shown in Table 1.

2.4 Proximate Analysis of *Chinchin* Samples

Proximate compositions of the fresh enriched *chinchin* samples were determined based on the method of analysis of the Association of Official Analytical Chemists [17].

2.5 Moisture Content Determination

The moisture content of the samples was determined by weighing 5 g of each sample into a porcelain dish of known weight and was heated in a hot air oven (Uniscope SM9053, England) at 105°C until constant weight was obtained. The samples were cooled in a desiccator and weighed. The results were expressed as percentage of dry matter as shown in the equation below:

$$Moisture\ content\ (\%) = \frac{W1 - W2}{W1} \times 100$$

W_1 = weight of flour before drying, W_2 = weight of flour after drying.

2.6 Ash Content Determination

Ash content was determined by the official [17] method using muffle furnace (Carbolite AAF1100, United Kingdom). Five grams (5.0g) of each sample was weighed into already weighed ashing crucible. The samples were charred in an oven at 200°C. The crucibles were transferred into a muffle furnace chambers set at 600°C until the samples turned into ashes within 3 h. The crucibles were removed from furnace, cooled in a desiccator and weighed. Ash content was expressed as the percentage of the original sample. The experiment was carried out in triplicate and the mean calculated for each sample.

$$Ash\ content\ (\%) = \frac{W1 - W2}{W3} \times 100$$

W_1 = weight of crucible + ash
W_2 = weight of empty crucible
W_3 = weight of sample

2.7 Crude Fibre Determination

About 200 ml of 1.25% (*v/v*) sulphuric acid was added to 2 g sample (W_3) in a flask. The flask was placed on a hot plate and boiled for 30 min. The content was filtered using Whatman No.1 filter paper and the residue on the filter paper was washed with 50 to 70 ml distilled water. The washed residue was transferred back into the flask and about 200 ml 1.25% (w/v) NaOH was added and boiled for 30 min. The content was filtered as described earlier and the residue obtained was washed with distilled water. The residue was transferred to an ashing dish, dried at 130ºC for 2 h, cooled in a desiccator and weighed (W_1). This was ashed at 550ºC inside the muffle furnace chamber (Carbolite AAF1100, United Kingdom) for 3 h, cooled and reweighed (W_2). The ash obtained was subtracted from the residue and the difference expressed as percentage of the starting material.

$$Crude\ fibre = \frac{W1 - W2}{W3} \times 100$$

W_1= initial weight
W_2= final weight
W_3= weight of sample

2.8 Crude Protein Content Determination

Ground sample (0.2 g) was weighed into a Kjeldahl flask. About 10 ml of concentrated sulphuric acid was added followed by one Kjeltec tablet (Kjeltec-Auto 1030 Analyzer, USA). The mixture was digested on heating racket placed in a fume cupboard until a clear solution was obtained. The digest was cooled, transferred into Kjeldahl distillation setup and 75 ml distilled water was added followed by the addition of 50 ml of 40% sodium hydroxide solution, the ammonia formed in the mixture was subsequently distilled into 25 ml of 2% boric acid solution containing 0.5 ml of the mixture of 100 ml of bromocresol green solution (100 mg of bromocresol green in 100 ml of methanol) and 70 ml of methyl red solution (100 mg of methyl red in 100 ml methanol) indicators. The distillate collected was titrated with 0.1 M hydrochloric acid. Blank determination was carried out by excluding the sample from the above procedure. The nitrogen content was multiplied by 6.25 to obtain crude protein content.

$$(\%)protein = \frac{1.401\ x\ M\ x\ F\ (ml\ titrant - titrant\ blank)}{Weight\ of\ sample\ x\ 100}$$

M = molarity of acid used
F= kjeldahl factor = 6.25

2.9 Crude Fat Determination

Crude fat was determined using Soxhlet apparatus (Sunbim, India). About 5 g (W_3) of the ground sample was placed into a thimble placed inside Soxhlet extractor and n-hexane was poured into a pre-weighed round bottom flask (W_2) that was used to extract the oil from the sample. The extraction was carried out for 6 h. The solvent was removed from the extracted oil by distillation. The oil in the flask was further dried in a hot-air oven at 90ºC for 30 min to remove residual organic solvent and moisture. This was cooled in a desiccator after which the flask and its content were weighed (W_1).

$$Ether\ extract\ (\%) = \frac{W1 - W2}{W3} \times 100$$

W_1 = weight of flask + oil
W_2 = weight of empty flask
W_3 = weight of sample

2.10 Carbohydrate Determination

The % carbohydrates content was calculated by difference;

$$Carbohydrate\ content\ (\%) = 100 - (moisture + ash + crude + protein + fat + fibre)$$

2.11 Minerals Determination of Enriched *Chinchin*

The determination of selected elements or selected mineral constituents was investigated using Atomic Absorption Spectrometry method [18]. About 0.5 g of samples was digested in 100 mL micro- kjeldahl flask with 10 mL of HNO_3 until the solution became colourless. The sample was cooled and diluted to volume in a 25 mL volumetric flask with 0.1 M HCl solution. The digest was used to determine the elements (calcium, magnesium, iron and zinc) on the atomic Absorption Spectrophotometer (Perkin Elmer, model 402) while potassium was determined by flame photometry.

2.12 Shelf Stability Determination

The products were stored for four weeks on a shelf at ambient temperature and were analyzed for moisture content and peroxide value at interval of a week.

2.13 Peroxide Value of *Chinchin*

One gramme (1 g) of sample was placed into a 250 ml glass stopper Erlenmeyer flask and 20 ml of acetic acid-chloroform solution added (ratio 2 to 1). The tube was placed in boiling water so that the liquid boiled within 30 s. The solution was allowed to stand with occasional shaking for one min and then 30 ml distil water added. 20 ml of 5% saturated potassium iodide (KI) was added. The mixture was titrated with 0.02 N sodium thiosulphate solution using 0.5 ml of 1% starch as indicator. The sodium thiosulphate was added drop- wise until the blue color disappeared. A blank solution was performed at the same time [17].

Note; when titration value was less than 0.5 ml, the experiment was repeated using 0.01 $Na_2S_2O_3$ solution. The peroxide value was calculated as shown in equation

$$Peroxide\ value\ (milliequivalent)kg$$

$$= \frac{(S - B)\ X\ N\ thiosulphate \times 1000}{Weight\ of\ sample}$$

S = volume of titration for sample;
B= titration of blank (ml)
W= weight of the sample (g)

2.14 Sensory Evaluation

The 9-point hedonic scale assessment as described by [19] was used. Students from the Department of Food Science and Technology were selected based on their familiarity with *chinchin*. The panelists scored the coded snacks in terms of degree of likeness for taste, color, texture and aroma. The 9-point hedonic scale used by the panelists for the evaluation ranged from 1 to 9 representing “extremely dislike” to “extremely like”. The coded samples were served in clean plates at room temperature (35°C). The panelists were isolated from each other in a room that was illuminated with fluorescent light and the coded snacks were tasted one at a time. Water was given to each panelist for oral rinsing in between tasting of the samples.

2.15 Statistical Analysis

All experiments were conducted in triplicate. Data reported were averages of three determinations. Analysis of variance (ANOVA) was performed on each of the variables and the least significant difference (LSD) test at a significant level $P < 0.05$ was performed using SPSS/16 software to compare the differences between treatment means. Results were expressed as the means ± standard deviation of three separate determinations.

3. RESULTS AND DISCUSSION

3.1 Proximate Composition of Vegetable Enriched *Chinchin*

The proximate composition of the enriched *chinchin* samples is shown in Table 2. The moisture content (M.C) of the enriched *chinchin* samples ranged from 4.17% in sample DUV (5% *ugu chinchin*) to 5.30% in sample ACV (100% laboratory prepared *chinchin*). Generally, there was a reduction in moisture content as the quantity of vegetable incorporation increased. The decrease in moisture content obtained was similar to the trend and values reported by [20] for cookies produced from Sweet Potato-Maize Flour Blends (5.0-6.1%). [21] also reported similar results for soybean fortified Tapioca. The values gotten were within the range reported to have no adverse effect on quality attributes of the product [22]. A decrease of 21.32% to 4.53% was observed for moisture content of *chinchin* enriched with *ugu* vegetable while a decrease of 9.81% to 2.51% was observed for *chinchin* enriched with Indian spinach. [23] reported that the lower the moisture content of a product to be stored the better the shelf stability of such products. Hence, low moisture ensures higher shelf stability of dried product.

The protein content of the enriched *chinchin* samples ranged between 10.51 and 14.58%. Sample GAV (5% Indian spinach) had the highest value of 14.58% followed by DUV (5% *ugu*) and sample ACF (100% wheat) had the least value of 10.51%.There was a significant difference ($p > 0.05$) in the protein value of all samples. This result shows that there was an increase in protein (5.23 to 38.73%) as the level of vegetable incorporation increased. A similar observation was made in a research study by [24] that showed an increase in the protein content with corresponding increase in the proportion of bambara flour supplementation in biscuit production from cassava-wheat-bambara flour blends. A similar result was also reported by [25], that increase in soybean from 0 to 30% in the composite flour of cassava and soybean gave increase in protein content of flour, while increase in wheat and soybean gave increase in percentage of protein content of food product. Protein content increased from 5.23 to 17.70% for *chinchin* enriched with *ugu* vegetable while an increase of 7.32 to 38.73% was observed for *chinchin* enriched with Indian spinach. This result showed that enrichment of *chinchin* with Indian spinach increased the percentage of protein content than products enriched with *ugu*. The high protein content of the GAV (wheat flour/Indian spinach vegetable; 95:5) might be due to the level of vegetable, which contains high protein content compared with *ugu*.

The fat content of the enriched *chinchin* samples and commercial *chinchin* ranged from 11.49 to 17.4%. There was a significant difference (p > 0.05) in the fat value of all samples. Sample DUV (5% *ugu*) had the highest value of 17.4% while sample CCC (commercial *chinchin*) had the least value of 11.49%. This result showed that there was an increase in fat content of samples (9.60 to 48.59%) as the level of incorporated vegetable increased. The increase may be due to high oil absorption capacity of vegetable enriched flour. An increase of 18.51 to 48.59% was observed for fat content of *chinchin* enriched with *ugu* vegetable while an increase of 9.60 to 19.19 % was observed for *chinchin* enriched with Indian spinach (Table 2). This showed that dried *ugu* vegetable increased the fat content of *chinchin* enriched with than Indian spinach. This might be due to the high oil absorption capacity of *ugu* compared with Indian spinach. [26] reported that low fat content in a dry product will help in increasing the shelf life of the sample by decreasing the chances of rancidity and also contribute to low energy value of the food product while high fat content product will have high energy value and promotes lipid oxidation.

The ash content of all the *chinchin* samples ranged from 0.92 to 1.92%. Sample GAV (5% Indian spinach) had the highest value of 1.92% and sample ACV (100% wheat) had the least value of 0.92%. There was slight variation but no significant difference (p<0.05) in ash content of enriched samples. This result showed that there was an increase in ash content of samples from (43.48 to 108.70%) as the amount of vegetable incorporation into *chinchin* was increased. The ash content of enriched *chinchin* was noted to assume the same trend as that of protein content. This result is in agreement in values with the observation of [27] on incorporation of carrot pomace powder and germinated chickpea flour into biscuit (0.8-1.2%). [28] also reported an increase in the ash content of enriched *chinchin* as the proportion of modified starch substitution increased. Increase in ash content of enriched samples might be attributed to the high value of mineral content of the dried vegetables [11]. An increase of 43.48 to 86.96% was observed for ash content of *chinchin* enriched with *ugu* vegetable while an increase of 65.22 to108.70% was observed for *chinchin* enriched with Indian spinach when vegetable content increased from 1.5 to 5%. Ash content is an index of inorganic mineral elements in the food [29].

Table 1. *Chinchin* formulation

Ingredient	Quantity
Flour	200 g
Sugar	40 g
Baking powder	2 g
Nutmeg	1 g
Salt	0.5 g
Margarine	25 g
Water	15 ml
Powdered milk	15 g
Egg	1 whole egg
Ugu vegetable	3% / 97% of wheat
Indian spinach vegetable	3% / 97% of wheat

Source: [30]

Crude fibre content of all the vegetable *chinchin* samples ranged from 1.80 to 2.17%. Sample DUV (5% ugu) had the highest value of 2.17% and sample CCC (commercial *chinchin*) had the least value of 1.80%.There was an increase in the crude fibre content of samples from 9.44 to 20.56% as the amount of vegetable incorporation into *chinchin* was increased. This result is similar to the report by [27] who observed an increase in crude fiber content of biscuit incorporated with carrot pomace powder and chickpea flour. An increase of 12.78 to 20.56% was observed for ash content of *chinchin* enriched with *ugu* vegetable while an increase of 9.44 to 17.78% was observed for *chinchin* enriched with Indian spinach with concentration of 1.5 to 5% vegetable. This suggested that *ugu* contributed more fibre to the samples than Indian spinach. Green leafy-vegetables contain fibre which helps to reduce cancer risks and normalize digestion time [31]. Dietary fibre helps to prevent constipation, bowel problems and piles, so the richer the food is in fiber, the better for the consumer.

Carbohydrate content of the *chinchin* samples ranged from 62.23 to 69.67% for enriched and commercial *chinchin,* respectively. The 100% wheat based *chinchin* had the highest value of 69.67% followed by CCC (commercial *chinchin*) with the value of 69.27% while sample DUV (5% *ugu*) had the least value of 62.23%. There were significant differences (p > 0.05) among the samples except samples ACV (100% wheat) and CCC (commercial *chinchin*) which exhibited no significant difference ($p < 0.05$). It was observed that there was a decrease from 4.26 to 10.02 % in carbohydrate content of the enriched *chinchin* with increase in amount of vegetable added. All the *chinchin* samples were high in carbohydrate content but the carbohydrate content decreased with increase in proportion of vegetable added. The decrease in value of carbohydrate content may be attributed to the low carbohydrate content of the vegetables added. This result is in agreement with the report of [25] that carbohydrate content of cookies decreased with increase proportion of the cucurbita seed flour added. A decrease of 4.26 to 10.68% was observed in the carbohydrate content of *chinchin* enriched with *ugu* vegetable while a decrease of 3.44 to 10.02% was observed for *chinchin* enriched with Indian spinach. High percentage of carbohydrate content in all the flour blends would suggest that the blends could be good source of energy.

3.2 Mineral Compositions of Enriched *Chinchin*

The mineral composition of the enriched *chinchin* samples is shown in Table 3.

Potassium content for all samples ranged from 261.30 to 425.89 mg/100 g. Sample DUV (5% *ugu*) had the highest value of 425.89 mg/100 g while sample ACF (100% wheat) had the lowest value of 261.30 mg/100 g. This result showed increase in potassium content of the samples by 32.57 to 62.99% as the amount of vegetable incorporated into *chinchin* is increased. [32] reported that green vegetables are rich sources of minerals such as iron, copper, potassium and manganese, calcium etc. An increase of 32.57 to 56.58% was observed in the potassium content of samples enriched with *ugu* vegetable while an increase of 36.52 to 62.99% was observed in the potassium content of samples enriched with Indian spinach. The difference in value of percentage obtained for the samples might be due to the different vegetable used which have potassium composition that differs. The potassium content of *ugu* is 1581.21 mg/100 g while that of Indian spinach is 2289.01 mg/100 g. Potassium is an essential nutrient and has an important role in the synthesis of amino acids and proteins [33].

Magnesium content of all the samples ranged from 76.18 to 176.23 mg/100 g with significant ($p > 0.05$) variations among the samples. Sample GAV (5% Indian spinach) had the highest value of 176.23 mg/100 g for magnesium while sample ACF (100% wheat) had the lowest value of 76.18 mg/100 g. This result showed that there is an increase in magnesium content of samples from 26.61 to 131.33% as the amount of vegetable incorporated into *chinchin* increased. An increase of 26.61 to 72.16% was observed in the magnesium content of samples with the addition of *ugu* vegetable while an increase of 53.92 to 131.33% was observed in magnesium content of samples with addition of Indian spinach. Addition of vegetables contributed to higher magnesium content but Indian spinach contributed more than *ugu*. This might be due to the magnesium content of Indian spinach (191.81 mg/100 g) which was higher than that of *ugu* (120.97 mg/100 g). The high value of magnesium in *chinchin* might be due to the contribution of magnesium from other ingredients used for preparation such as egg, milk and margarine. Magnesium helps in keeping the muscle relaxed and the formation of strong bones and teeth [34]. The recommended daily allowance (RDA) for magnesium is 350 mg.

The iron content of the samples ranged from 34.54 to 49.69 mg/100 g with significant ($p < 0.05$) variations among the samples. Sample DUV (5% *ugu*) had the highest value of 49.69 mg/100 g for iron content while sample ACF (100% wheat) had the lowest value of 34.54 mg/100 g. It was observed that there was an increase of iron content from 16.94 to 43.86% with increase in incorporation of vegetable into *chinchin*. The increase in iron content of enriched samples might be due to high iron content of *ugu* and Indian spinach vegetables added [32]. The trend of result is in agreement with the observation of [16] that the iron content of *mathri* increased from 2.39 mg/100 g in the control sample to 6.03 mg/100 g when 12% greens were incorporated into the product. An increase of 22.99 to 43.86% was observed in the iron content of samples with the addition of *ugu* vegetable (69.91 mg/100 g of iron) while an increase of 16.94 to 30.49% was observed in the iron content of samples with addition of Indian spinach (37.14 mg/100 g of iron).Iron helps in formation of red blood cells and is an important element in the diet of pregnant women, nursing mothers, infants, convulsing patients and elderly to prevent anaemia and other related diseases [35].

Table 2. Proximate composition of vegetable enriched *chinchin*

Samples	Moisture (%)	Ash (%)	Fibre (%)	Protein (%)	Fat (%)	Carbohydrate (%)
ACV	5.30±0.03^{c}	0.92±0.10^{g}	1.80±0.02^{f}	10.51±0.44^{f}	11.67±0.05^{e}	69.67±0.35^{a}
BUV	5.06±0.04^{e}	1.32±0.05^{f}	2.03±0.01^{d}	11.06±0.11^{e}	13.83±0.03^{c}	66.70±0.10^{c}
CUV	4.92±0.02^{f}	1.43±0.06^{ef}	2.13±0.02^{c}	11.49±0.11^{e}	15.94±0.01^{b}	64.08±0.10^{d}
DUV	4.17±0.04^{g}	1.72±0.06^{d}	2.17±0.01^{c}	12.37±0.11^{d}	17.34±0.08^{a}	62.23±0.03^{e}
EAV	5.17±0.02^{d}	1.52±0.07^{e}	1.97±0.01^{d}	11.28±0.11^{e}	12.79±0.08^{d}	67.27±0.06^{b}
FAV	4.85±0.03^{g}	1.76±0.04^{d}	2.09±0.01^{c}	12.04±0.44^{d}	13.02±0.01^{c}	66.22±0.43^{c}
GAV	4.78±0.02^{h}	1.92±0.06^{c}	2.12±0.02^{c}	14.58±0.55^{c}	13.91±0.06^{c}	62.79±0.45^{e}
CCC	5.18±0.02^{d}	0.98±0.12^{g}	1.94±0.02^{d}	11.28±0.11^{e}	11.49±0.08^{e}	69.27±0.91^{a}
Ugu	6.62±0.14^{b}	6.21±0.11^{b}	5.91±0.10^{a}	20.71±0.12^{b}	1.71±0.02^{g}	58.84 ±0.44^{f}
Indian spinach	6.80±0.16^{a}	7.10±0.13^{a}	5.14±0.08^{b}	27.94±0.33^{a}	2.91±0.04^{f}	50.11±0.19^{g}

Mean ± standard deviation of triplicate determinations. Mean with the same superscripts in the same column are not significantly different at p<0.05

Keys: ACV-100% Wheat chinchin; BUV-98.5/1.5% wheat/ugu; CUV-97/3% wheat/ugu; DUV-95/5% wheat/ugu; EAV-98.5/1.5% wheat/Indian spinach; FAV-97/3% wheat/Indian spinach; GAV-95/5% wheat/Indian spinach; CCC-commercial chinchin

Table 3. Mineral composition of enriched *chinchin* (mg/100 g)

Sample	Potassium	Magnesium	Calcium	Iron	Zinc
ACV	261.30±1.70^{i}	76.18±2.89^{h}	643.91±1.10^{h}	34.54±0.62^{f}	11.07±0.13^{g}
BUV	346.40±2.43^{g}	96.45±1.15^{f}	748.64±1.63^{g}	42.48±2.07^{cd}	12.94±0.27^{f}
CUV	360.12±2.72^{f}	99.47±1.68^{f}	775.11±1.10^{fg}	48.21±2.95^{b}	14.21±0.22^{e}
DUV	409.14±2.01^{d}	131.15±1.44^{d}	1484.55±3.26^{b}	49.69±0.55^{b}	17.93±1.35^{c}
EAV	356.73±2.58^{f}	117.26±2.32^{e}	797.86±1.35^{f}	40.39±2.03^{d}	11.62±0.17^{g}
FAV	380.09±2.55^{e}	138.61±1.95^{c}	1085.61±2.58^{e}	43.67±2.04^{c}	14.13±0.55^{e}
GAV	425.89±3.71^{b}	176.23±2.57^{b}	1684.27±1.95^{a}	45.07±1.01^{c}	16.01±1.00^{d}
CCC	339.27±1.38^{h}	92.32±1.96^{g}	591.62±1.64^{i}	37.92±0.24^{e}	11.57±0.46^{g}
Ugwu	1581.21±1.63^{b}	120.97±1.70^{e}	1120.21±1.43^{d}	69.91±0.82^{a}	51.50±1.09^{a}
I. spinach	2289.01±1.95^{a}	191.81±1.36^{a}	1272.8±2.00^{c}	36.14±1.01^{e}	38.21±0.75^{b}

Mean ± standard deviation of triplicate determinations. Mean with the same superscripts in the same row are not significantly different at p<0.05

Keys: ACV-100% Wheat chinchin; BUV-98.5/1.5% wheat/uguchinchin; CUV-97/3% wheat/uguchinchin; DUV-95/5% wheat/uguchinchin; EAV-98.5/1.5% wheat/Indian spinach chinchin; FAV-97/3% wheat/Indian spinach chinchin; GAV-95/5% wheat/Indian spinach chinchin; CCC-commercial chinchin

The zinc content of the samples studied ranged from 11.07 to 17.93 mg/100 g. There was significant difference ($p < 0.05$) in the zinc content of all the samples but no significant difference ($p > 0.05$) in samples ACV (100% wheat), EAV (1.5% Indian spinach) and CCC (commercial *chinchin*). Sample GAV (5% Indian spinach) had the highest value of 17.93 mg/100 g for zinc content while sample ACV (100% wheat) had the lowest value of 11.07 mg/100 g. It was observed that there was an increase in the percentage of zinc content from 4.97 to 61.97 with increase in incorporation of vegetable into *chinchin*. [32] reported that the leaves of *Telfairia occidentalis* (*ugu*) are moderate sources this zinc element (55.2 mg/100 g). The increase in zinc content of the enriched *chinchin* might be due to the contribution of zinc from vegetable added. An increase of 16.89 to 61.97% was observed in the zinc content of samples with the addition of *ugu* vegetable while an increase of 4.97 to 44.63% was observed in zinc content of samples with addition of Indian spinach. Zinc is a trace element which is needed in minute amount and it aids digestion and enhances body functions by protecting the liver from chemical damage.

The calcium content of all samples ranged from 591.62 to 1684.27 mg/100 g. Samples GAV (5% Indian spinach) had the highest value of 1684.27 mg/100 g for calcium content while sample CCC (commercial *chinchin*) had the lowest value of 591.62 mg/100 g. It was observed that there is an increase of calcium content from 16.26 to 161.57% with increase in incorporation of vegetable into *chinchin*. This result is in agreement with the report of [16] that the calcium content of *mathri* snack almost doubled by the addition of 4% dried greens to the *mathri*. An increase of 16.26 to 130.55% was observed in the calcium content of samples with the addition of *ugu* vegetable while an increase of 23.91 to 161.57% was observed calcium content of samples with addition of Indian spinach. The high difference in comparism of *chinchin* incorporated with *ugu* and Indian spinach is in agreement with the report of Idris [32] that *ugu* is a poor source of calcium, sodium and phosphorus. Hossain et al. [13] reported that Indian spinach is a good source of potassium, calcium and manganese. Calcium plays an important role in building strong and keeping healthy bones and teeth in both early and later in life.

Generally, the addition of vegetable increased the mineral levels of *chinchin* samples. Vegetables are valuable sources of nutrients especially in rural areas where they contribute substantially to protein, minerals, vitamins, fibres and other nutrients which are usually in short supply in daily diets [36].

3.3 Shelf Life Studies

Shelf life is to shed light on the changes that occur in product quality over time and explain the effects of storage time, storage condition, and composition of *chinchin*. The effect of storage time on peroxide and moisture content of the *chinchin* were determined.

3.4 Effect of Storage Time on Peroxide Value of *Chinchin*

The peroxide value is a commonly used indicator of the shelf life of a product because an elevated peroxide value will accompany disagreeable odours. Table 4 showed the peroxide value of *chinchin* samples stored on the shelf at ambient temperature (35°C) for four weeks in a plastic container. Sample CCC (commercial *chinchin*) had the highest peroxide value of 0.1149 $meqO_2/kg$ at the end of the first week followed by sample ACV (100% wheat) with the value of 0.1131 $meqO_2/kg$. Sample DUV (5% *ugu*) had the least value of 0.1122 $meqO_2/kg$. From the results, it was observed that peroxide value increased by 28.26 to 35.59% with storage time from week 0 to week 4, respectively. Also, the peroxide value of samples decreased with increase in incorporation of vegetable into *chinchin*. The process of peroxide formation in foods can be controlled by adding antioxidants that react with free radicals and slow down auto-oxidation or the natural formation of peroxides. [36] reported potato peels were potent sources of natural antioxidant that may be explored to prevent oxidation of vegetable oil.

Chinchin enriched with Indian spinach vegetable had higher peroxide value than *chinchin* enriched with *ugu*. The low peroxide value of the samples at the first week indicated slow oxidation of these oils. The increase in peroxide value of *chinchin* with storage time is in agreement with [9] who reported an increase in peroxide value of vegetable incorporated pasta with storage time. Among reaction that occur during frying and storage are oxidation and hydrolysis which is also known as rancidity [37]. Table 4 also showed the percentage change of peroxide value of *chinchin* samples with increase in storage time from week 1 to week 4. Sample ACV, *chinchin* sample without vegetable had a percentage change of 9.74% in PV at the second week which increased to 32.19% by the fourth week. Sample CCC (commercial *chinchin*) had the highest percentage change of 35.39%, followed by ACV with value of 32.19% while sample DUV (5% *ugu*) had the least percentage change of 28.26%. This trend in peroxide value of the product is in agreement with the report of [38] that peroxide value of deep fried snack increased gradually with increase in storage time. The effect of storage time may be due to peroxidation of lipid present in *chinchin* during storage [39].

3.5 Effect of Storage Time on Moisture Content of *Chinchin*

The effectiveness of storage conditions has been assessed in some instances by measuring moisture content [40]. Table 5 showed the results of change in moisture content of *chinchin* samples stored on the shelf at ambient temperature for four weeks. At the end of the week 4, the moisture lost was found to be between 3.54 to 4.39% for all the *chinchin* samples. Sample DUV (5% *ugu*) had the highest percentage change of 4.39% followed by sample CUV (3% *ugu*) with the value of 4.34%. Sample CCC (commercial *chinchin*) had the least percentage change of 3.54%. The change in moisture content was observed to reduce marginally as storage time increased. This might be attributed to the protein content which has greater affinity for moisture than carbohydrate [41].

Table 4. Peroxide values (PV) of *chinchin* samples stored for four weeks

Sample	First week	Second week	Third week	Fourth week
ACV	0.1131±0.13[b]	0.1253±0.20[b] (9.74%)	0.1476±0.15[b] (23.37%)	0.1668±0.25[b] (32.19%)
BUV	0.1129±0.15[c]	0.1251±0.20b (9.75%)	0.1467±0.15[bc] (23.04%)	0.1647±0.15[c] (31.45%)
CUV	0.1127±0.15[cd]	0.1248±0.22[cd] (9.69%)	0.1457±0.2[bcd] (22.65%)	0.1597±0.15[d] (29.43%)
DUV	0.1122±0.20[e]	0.1242±0.25[e] (9.66%)	0.1439±0.15[d] (22.03%)	0.1564±0.25[d] (28.26%)
EAV	0.1130±0.18[b]	0.1252±0.10[b] (9.74%)	0.1475±0.13[b] (23.25%)	0.1641±0.10[c] (31.14%)
FAV	0.1128±0.18[c]	0.1250±0.15[c] (9.76%)	0.1466±0.15[bc] (23.06%)	0.1607±0.25[c] (29.81%)
GAV	0.1125±0.22[d]	0.1246±0.21[d] (9.71%)	0.1452±0.10[cd] (22.52%)	0.1577±0.15[d] (28.66%)
CCC	0.1149±0.30[a]	0.1269±0.28[a] (9.46%)	0.1577±0.22[a] (27.05%)	0.1784±0.10[a] (35.59%)

Keys: ACV-100% Wheat chinchin; BUV-98.5/1.5% wheat/ugu chinchin; CUV-97/3% wheat/ugu chinchin; DUV-95/5% wheat/ugu chinchin; EAV-98.5/1.5% wheat/Indian spinach chinchin; FAV-97/3% wheat/Indian spinach chinchin; GAV-95/5% wheat/Indian spinach chinchin; CCC-commercial chinchin

Table 5. Moisture content of *chinchin* samples with storage time

Sample	Week 1	Week 2	Week 3	Week 4	% Change
ACV	5.23±0.42	5.15±0.31	5.08±0.35	5.04±0.20	3.63%
BUV	4.98±0.25	4.91±0.21	4.83±0.25	4.79±0.21	3.82%
CUV	4.82±0.15	4.75±0.35	4.64±0.20	4.61±0.30	4.34%
DUV	4.10±0.40	4.02±0.45	3.95±0.25	3.92±0.31	4.39%
EAV	5.09±0.25	5.03±0.31	4.95±0.30	4.89±0.40	3.93%
FAV	4.75±0.30	4.68±0.20	4.61±0.15	4.55±0.15	4.21%
GAV	4.72±0.25	4.65±0.15	4.57±0.35	4.52±0.20	4.23%
CCC	5.08±0.40	5.01±0.36	4.92±0.31	4.90±0.20	3.54%

Keys: ACV-100% Wheat chinchin; BUV-98.5/1.5% wheat/ugu chinchin; CUV-97/3% wheat/ugu chinchin; DUV-95/5% wheat/ugu chinchin; EAV-98.5/1.5% wheat/Indian spinach chinchin; FAV-97/3% wheat/Indian spinach chinchin; GAV-95/5% wheat/Indian spinach chinchin; CCC-commercial chinchin

Higher level of moisture gives higher rate of microbial spoilage of food products. Therefore, moisture loss of samples could reduce the spoilage of *chinchin* by microorganisms and increase storage stability. This result is in agreement with the report of [41] who reported decrease in moisture content of biscuit improved with beniseed as storage days increased. Moisture content is an important shelf life parameter and moisture content of any food is an index of its water activity. The moisture content of food depends among other factors on the packaging, storage time and conditions.

3.6 Sensory Evaluation of Enriched Vegetable *Chinchin*

3.6.1 Colour

There was a significant difference ($p < 0.05$) in the colour of the samples. Sample ACV (100% wheat) had the highest (8.90) score and sample DUV (5% *ugu*) had the least (4.5) score for color. Sample ACV (100% wheat) was rated best in terms of appearance followed by sample CCC (commercial *chinchin*). Sample EAV (1.5% Indian spinach) with the score of 7.00 was ranked best among the enriched samples followed by FAV (3% Indian spinach) while sample DUV was rated lowest by the panelists. The scores for appearance suggested that the higher percentage of vegetables addition, the lower the acceptability of the colour of the products. Vegetable incorporation increased the darkness in colour and reduced the surface smoothness of the products. This might be attributed to chlorophyll content in vegetable which is green in colour. *Ugu* leaves are dark green in colour while Indian spinach is light green in colour. People may not be familiar or used to greenish *chinchin*. The scores suggested that products have some level of acceptable colour as the scores are above 6.40. Indian spinach *chinchin* samples had higher scores for colour than *ugu* samples.

3.6.2 Taste

The scores for the taste of the samples ranged from 5.80 to 7.80. Sample BUV (1.5% *ugu*) had the highest (7.8) score while sample DUV (5% *ugu*) had the least (5.8) score. There was no significant difference (p > 0.05) but there was slight variation in the taste of samples. Sample BUV (98.5% flour /1.5% *ugu*) was most preferred in terms of taste, followed by sample ACV (100% flour) and sample CCC (commercial *chinchin*). The score for taste of *chinchin* improved at the level of incorporation with *ugu* vegetable at 1.5% and exceeding this level the scores decreased. The preference score for taste reduced as the percentage of vegetable added increased more than 3%. *Ugu* enriched samples had higher scores in taste than Indian spinach enriched samples. This suggests that incorporation of *ugu* vegetable into *chinchin* up 3% may still be acceptable in taste.

3.6.3 Flavour

The scores for the flavour of the samples ranged from 5.70 to 8.20. Sample ACV (100% wheat) is the most preferred, followed by samples BUV (1.5% *ugu*) and EAV (1.5% Indian spinach). The preference score for flavour reduced as the percentage of vegetables added increased. This could be due to the proportion of the vegetable added; its presence might have reduced the flavour of the samples. There was no significant difference (p > 0.05) in the flavour of samples CUV, FAV and GAV but there was slight variation between BUV and EAV. This suggested that the incorporation of vegetables into *chinchin* up to 3% may still be acceptable in flavor.

3.6.4 Crispiness

The sensory scores for crispness of the samples ranged from 5.8 to 7.8.Sample ACV (100% wheat) had the highest score of 7.8 while sample GAV (5% Indian spinach) had the least score of 5.8. There was no significant difference (p > 0.05) between samples but there were slight variations in the crispness of the enriched samples. Sample ACV was most preferred in terms of crispness, followed by samples CUV and EAV (1.5% Indian spinach). Sample GAV (5% Indian spinach) is the least preferred. The crispness of the *chinchin* samples decreased with increase in percentage of vegetables added. Samples CUV, EAV and FAV are preferred in crispness among the enriched *chinchin*. This suggested that inclusion of vegetables into *chinchin* at 3% in crispness may be acceptable.

Table 6. Sensory evaluation of vegetable enriched *chinchin*

Samples	Colour	Crispiness	Taste	Flavor	Overall acceptability
ACV	8.90 ± 0.32^{a}	7.80 ± 0.92^{ab}	7.60 ± 0.70^{ab}	8.20 ± 0.79^{a}	8.40 ± 0.84^{a}
BUV	6.60 ± 1.17^{b}	6.70 ± 1.95^{bc}	7.80 ± 0.79^{a}	7.20 ± 0.63^{ab}	7.20 ± 1.25^{bc}
CUV	6.40 ± 0.97^{bc}	7.30 ± 0.68^{ab}	7.10 ± 0.57^{ab}	6.70 ± 0.82^{bc}	7.20 ± 0.63^{bc}
DUV	4.50 ± 1.51^{d}	6.60 ± 1.35^{bc}	5.80 ± 2.10^{c}	5.70 ± 1.95^{c}	5.10 ± 1.66^{d}
EAV	7.00 ± 0.67^{b}	7.10 ± 0.88^{ab}	7.40 ± 0.84^{ab}	7.20 ± 1.03^{ab}	7.00 ± 0.82^{bc}
FAV	6.90 ± 0.99^{b}	7.10 ± 1.45^{ab}	6.80 ± 1.14^{abc}	6.70 ± 1.49^{bc}	6.50 ± 1.08^{c}
GAV	5.50 ± 1.18^{c}	5.80 ± 1.23^{c}	6.50 ± 1.96^{bc}	6.70 ± 1.77^{bc}	6.10 ± 1.91^{cd}
CCC	8.40 ± 0.84^{a}	8.10 ± 0.74^{a}	7.60 ± 0.52^{ab}	7.30 ± 0.82^{ab}	7.90 ± 0.74^{ab}

Mean ± standard deviation of triplicate determinations. Mean with the same superscripts in the same column are not significantly different at p<0.05

Keys: ACV-100% Wheat chinchin; BUV-98.5/1.5% wheat/ugu; CUV-97/3% wheat/ugu; DUV-95/5% wheat/ugu; EAV-98.5/1.5% wheat/Indian spinach; FAV-97/3% wheat/Indian spinach; GAV-95/5% wheat/Indian spinach; CCC- commercial chinchin

3.6.5 Overall acceptability

The sensory scores of the overall acceptability of the samples ranged from 5.1 to 8.4. Sample ACV (100% wheat) had the highest (8.4) score followed by sample CUV (3% *ugu*) with a score of 7.20 and sample DUV (5% *ugu*) had the least (5.10) score. Sample ACV which serves as control and CUV were most preferred amongst all the enriched samples and were rated the best. These values indicated that addition of higher amount of vegetable decreased the sensory quality characteristics such as taste, flavour, and colour of the product in comparison to the control. On the basis of this observation, supplementation of vegetable at the level of 3% could be considered the best from sensory point of view. This result is in agreement with the findings of [4], who reported that increased levels of millet in *chinchin* resulted in significant decrease in the sensory attributes of the cookies.

4. CONCLUSION

It was observed that there was an increase in the nutrient density of all samples, protein (5.23 to 38.73%), fibre (9.44 to 20.56%), and ash (43.48 to 108.70%) of *chinchin* but a decrease in carbohydrate from 10.02% to 4.26%. For the enriched *chinchin*, there was percentage increase in the mineral content from (16.26 to 161.57), (32.57 to 62.99), (26.61 to 131.33), (14.48 to 30.49), (4.97 to 61.97) for calcium, potassium, magnesium, iron and zinc, respectively. The shelf life result for showed that PV increased by during storage and there was minimal decrease in moisture content during storage. It also showed that presence of vegetable decreased PV during storage. *Chinchin* from 100% wheat flour ranked better in color, crispness, overall acceptability while enriched *chinchin* ranked higher in taste. The most acceptable enriched *chinchin* was the one containing 3% vegetable.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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