Sensory Attributes and Anti-nutrient Composition of Maize Chips (Kokoro) Formulated Using Watermelon Rind Flour (WMRF), Soybean Flour, and Maize Flour

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ABSTRACT
The sensory qualities and anti-nutrient content of Kokoro (corn chips) manufactured from a blend of watermelon rind flour, soybean flour, and maize flour were assessed in this study. Sample A was the control sample, sample B was sample 85:10:5, sample C was sample 75:15:10, and sample D was sample 65:20:15. Colour, taste, flavour, appearance, crispiness, and overall acceptability received scores of 6.84-8.52%, 6.68-8.04%, 6.72-7.80%, 6.96-8.48%, 7.28-8.44%, and 7.12-8.48%, respectively, based on the sensory criteria. Significant variations in the products' sensory perception were revealed by the results ($p<0.05$). Sample B (85% maize, 10% soybean, and 5% watermelon rind flour) had the greatest scores for flavour, crispiness, and general acceptance (8.48%), while sample A (100% maize flour) received the highest ratings for colour, taste, and appearance. The enticing aroma and crispy texture of the prepared kokoro product may be the reason why sample B was preferred in this particular investigation. All samples had anti-nutrient contents, such as phytate (0.004 to 0.512 mg/100g), oxalate (0.002 to 0.368 mg/100g), and saponin (0.002 to 0.124 mg/100g), although at different levels that were acceptable. According to the study, the anti-nutrient contents fell below the FAO/WHO-recommended acceptable range. The study highlights the potential of using fruit peels, like watermelon rind, in innovative culinary applications, adding value to food products while maintaining safety and quality. Overall, the study provides valuable insights into creating nutritious and acceptable food products using unconventional ingredients.

KEYWORDS: Fruit peel, innovative culinary applications, value addition, anti-nutrient contents

INTRODUCTION

Nigerians eat a wide range of fruits and vegetables every day, and they constitute an essential component of our diet. Nevertheless, the seeds and peel of these fruits are typically discarded as food waste since only the meaty pulp is eaten. A tropical fruit that belongs to the Cucurbitaceae family, watermelon (Citrullus lanatus) is abundant in phytochemicals such as vitamins, minerals, pigments, amino acids, phenolics, and flavonoids. According to Choudhary et al. (2015), these substances have been shown to have positive health effects and the ability to prevent disease. The pulp, rind, and seeds are the three main components of the fruit (Smith et al., 2017). The pulp, rind, and seeds are the three main components of the fruit (Smith et al., 2017). The main by-product of watermelon processing is the rind, which contains significant levels of the majority of phytochemicals, including carotenoids, phenolic acids, flavonoids, citrulline, lycopene, and many other vital antioxidants.
Vitamins A, B1, and B6, as well as minerals including potassium, phosphorus, iron, and magnesium, are known to be abundant in watermelon. Its antioxidant components, including lycopene and carotenoids, are responsible for its therapeutic and medical advantages (Burton-Freeman, 2021).

Citrulline, a non-essential amino acid that is necessary to the urea cycle, is abundant in the inner rind of watermelons. Citrulline is transformed into arginine, which the body uses in the urea cycle to eliminate excess ammonia (Collins et al., 2017). There is interest in creating watermelon rind extracts or dietary supplements as a possible therapy option for arginine deficiency, since people with low arginine levels may suffer from deficiencies (Rezagholizade-Shirvan et al., 2023). Approximately 30 calories, 7-8 grams of carbs (mostly in the form of dietary fiber), a high water content, minimal protein, and very little fat comprise the nutritional makeup of 100 grams of watermelon rind. Additionally, it offers some minerals and vitamins, such as vitamin B6, vitamin C, potassium, and magnesium (Hussain et al., 2019).
A vital component of promoting long-term health and fitness may be including watermelon in your diet. Its antioxidants, like as lycopene and carotenoids, have been shown to lower ankle blood pressure in middle-

aged adults who are obese and have early-stage hypertension. Better health outcomes can result from eating a well-balanced, nutrient-rich diet and adopting healthy lifestyle choices.

MAIZE: Zea mays ranks third internationally after rice and wheat and fourth in Nigeria after millet, sorghum, and rice (Idowu, 2014). It is a nutritious source of vitamins, minerals, and carbs and may be processed into a wide range of dishes and snacks. Nigerian sweets produced from maize include donkwa (maize-peanut balls), kokoro (maize chips), and aadun (maize pudding). In many ways, maize is more nutritious than other cereals, with the exception of protein levels. Two essential amino acids that maize lacks are tryptophan and lysine. To increase the nutritional content of the composite flour, soybeans, which are rich in tryptophan and lysine, were added.

Soy-based diets have been linked to lower rates of cardiovascular disease, osteoporosis, breast, colon, and prostate cancers, as well as menopausal symptoms (Friedman and Brandon, 2001). As a result, the food industry has been using soybeans to create new foods. Therefore, the creation of a very palatable snack with excellent nutritional value is **required in order to combat malnutrition and nutrient shortages in nutrition programs. Idowu (2014).**

Anti-nutrients are compounds found in foods that can interfere with the body's ability to absorb essential nutrients. These compounds can be naturally occurring or formed during food processing. Examples of anti-nutrients include: Phytates: Found in whole grains, legumes, and nuts, phytates can bind to minerals like zinc, iron, and calcium, reducing their absorption. Oxalates: In foods like spinach, beets, and rhubarb, oxalates can bind to calcium and other minerals, potentially causing kidney stones or other health issues.Tannins: Found in tea, coffee, and some fruits, tannins can inhibit the absorption of certain nutrients, like iron. Saponins: In legumes, grains, and some vegetables, saponins can interfere with nutrient absorption and potentially cause gastrointestinal issues.

Analyzing these compounds of the formulated blends helps ensure the food product is safe, nutritious, and meets consumer expectations.

MATERIALS AND METHODS

Materials:

After being purchased at Sayedero Market in Ilaro, Ogun State, watermelon, soybeans, and maize were brought to the Department of Nutrition and Dietetics at the Federal Polytechnic of Ilaro for further processing.

Preparation of materials

The sample materials are manually cleaned of husks, broken grains, stones, dust, light materials, stalks, undersized and immature grains, and other extraneous components.

Processing watermelon rind into flour

The approach outlined by Çelik and ISIK (2023) was applied. To remove any debris, watermelon rinds were meticulously cleansed with distilled water. After being chopped into tiny bits, the rinds were dried for six hours at 50°C in a hot air dryer. To create a consistent flour, the dried rind pieces were ground into a fine powder in a hammer mill and then sieved through a 0.5 mm screen. After being sieved, the resultant powder was stored for later use in an airtight container.

Watermelon Rind

↓

Washing

↓

Cutting (Into small pieces)

↓

Drying (60^{0}C for 13hrs using Air oven dryer)

↓

Milling

↓

Sieving

↓

Watermelon rind fine flour

↓

Packaging

Fig.1: Flowchart Showing the Processing of Watermelon Rinds to Flour

Preparation of Soybean Flour

We used the approach outlined by Adegbusi et al., (2023). Sorting, cleaning, washing, draining, and roasting at low heat until light brown to remove the skin (peel) were all done before the soybean seeds were ground in a Thomas miller, sieved in an airtight container, and kept for later processing.

Soybean

↓

Sorting/Cleaning

↓

Soaking

↓

Draining

↓

Roasting

↓

Peeling

↓

Milling

↓

Sieving

↓

Soybean Flour

↓

Packaging

Fig.2: Flowchart for the Processing of Soybeans to Flour

Processing of Maize for Kokoro Production

The method outlined by Akinsola et al., (2020) was applied. The maize samples were sorted and cleaned to remove any dirt before being boiled for an hour, dewatered right away, and then steeped in clean tap water for the night to ferment. The fermenting grains were taken out of the steeped water using a plastic strainer and allowed to drain properly for about five minutes. The grains were wet-processed using a locally built attrition mill. To guarantee the fermentation of a thick dough-like consistency, a tiny quantity of water was added throughout the procedure. The thick, dough-like consistency was blended with wet-milled onions and iodized salt to enhance the flavour.

Maize

↓

Rinsing

↓

Boiling

↓

Draining

↓

Fermentation (24hr)

↓

Wet-milling

↓

Addition of salt and onions

↓

Maize dough

Fig.3: Flowchart showing the processing of maize for kokoro production

BLEND FORMULATION AND PREPARATION OF KOKORO

Table 1: The mixing ratio of the samples for blended flours

SAMPLE	MAIZE FLOUR	SOYBEAN FLOUR	WATERMELON RIND FLOUR
A	**100**	**0**	**0**
B	**85**	**10**	**5**

C	**75**	**15**	**10**
D	**65**	**20**	**15**

The kokoro's mix ratios were developed. Using a digital scale, watermelon rind flour and soybean flour were weighed in a bowl in the following ratios to create the thick dough: 100:0:0 (sample A, the control sample), 85:10:5 (sample B), 75:15:10 (sample C), and 65:20:15 (sample D). To get a dough-like consistency, a tiny bit of water was added to each component after it had been weighed separately in separate dishes. On a flat wooden tray, the dough was then separated into small sections, kneaded, and formed by hand into thin kokoro rings. These kokoro rings were deep-fried for three minutes at a high temperature in vegetable oil, producing a semi-finished, yellowish product. The fried food lacked the appropriate crispiness at this point, making it unfit for ingestion. After straining to remove extra oil, the semi-finished product was left in a covered basket for the night. A second round of frying was done the next day at 170°C for 1-2 minutes to develop the final product's colour, which ranged from light to deep yellow, and to get the appropriate crispiness. The product was placed in plastic containers for analysis once it had cooled.

The product was placed in plastic containers for analysis once it had cooled.

Maize Dough

↓

Addition of Composite Flour

↓

Mixing

↓

Dough Kneading

↓

Dough Rolling

↓

Cutting into Sizes

↓

1st Frying

↓

Draining

↓

2nd Frying

↓

Draining

↓

Cooling

↓

Packaging

Fig.4: Flowchart showing preparation of kokoro

SENSORY EVALUATION

Coded samples of kokoro (Maize snacks) were determined utilizing a twenty semi-trained panelist. Samples prepared from each mix were presented and coded white plastic plate, using a 9 point hedonic scale with a scale range of 1 to 9 with 1 signifying the least score (dislike highly) and 9 the highest score (like very). The panelists were given instructions to assess the coded samples for crispiness, colour, taste, texture, flavour, and overall acceptability. The samples were presented in a randomized order.

CHEMICALS AND REAGENTS

All chemicals used, including those used in the preparation of reagents, were of analytical grade and products of reputable companies.

DETERMINATION OF ANTI-NUTRIENT

The colorimetric approach was used to measure the amount of oxalate, phytates, and saponins in each sample (AOAC, 1984). Using a spectrophotometer, the absorbance of each sample was determined at 420 nm for phytate and 620 nm for saponin and oxalate.

STATISTICAL ANALYSIS

All analyses were conducted in duplicate, and the statistical package for social scientists (SPSS version 21) computer program was used to perform an analysis of variance (ANOVA) on the data. The New Duncans' Multiple Range Test was used to separate the means; significance was determined at $p<0.05$, and error was expressed as a standard deviation from the mean.

RESULT AND DISCUSSION

The sensory characteristics of maize chips (kokoro) prepared from blends of maize (MF), soybean (SBF), and watermelon rind (WMRF) are displayed in Table 1 below.

The items' sensory perception differed substantially ($p<0.05$), and their means for colour, taste, flavour, appearance, crispiness, and overall acceptability ranged from 6.84 to 8.52%, 6.68 to 8.04%, 6.72 to 7.80%, 6.96 to 8.48%), 7.28 to 8.44%), and 7.12 to 8.48%), respectively. The highest values for colour, taste, and appearance are found in sample A, which is made entirely of maize flour; the lowest values are found in sample D, which is made of 65% MF, 20% SBF, and 15% WMRF. **The study's results for colour, flavour, taste, and overall acceptability are comparable and fall between 7.76 and 8.42%, 6.66 and 8.33%, 7.76 and 8.33%, and 7.92 and 8.30% of the range that Ashoka et al. (2021) reported on the impact of adding watermelon rind flour on the nutritional and organoleptic qualities of cakes.** Because consumers are accustomed to the flavour of maize chips (kokoro), which are made entirely of maize flour, the sample in this study received higher sensory scores for colour, taste, and appearance. **Sample B, composed of 85% maize, 10% soybean, and 5% water melon rind flour, received the highest grade of 8.48% for flavour, crispiness, and overall acceptability; this is in contrast to the data obtained by Arivuchudar (2023) on nutritional and sensory characterization of watermelon rind powder incorporated crackers,** where the control sample had the highest score in all the sensory parameters probed. The enticing aroma and crispy texture of the prepared kokoro product may be the reason why sample B was preferred in this particular investigation. There is a significant difference (p<0.05) among the sensory characteristics.

Table 1: Sensory Properties of Maize Chips (Kokoro)

Sample	Color	Taste	Flavor	Appearance	Crispiness	Overall acceptability
A	8.52 ± 0.71^{a}	8.04 ± 0.93^{a}	7.60 ± 1.32^{ab}	8.48 ± 0.65^{a}	8.20 ± 0.76^{ab}	8.12 ± 0.88^{ab}
B	7.88 ± 1.01^{b}	7.64 ± 1.07^{ab}	7.80 ± 1.08^{a}	8.04 ± 1.02^{ab}	8.44 ± 0.58^{a}	8.48 ± 0.65^{a}
C	7.16 ± 1.21^{c}	7.32 ± 1.11^{b}	7.04 ± 1.09^{bc}	7.28 ± 1.10^{c}	7.72 ± 1.17^{bc}	7.68 ± 0.98^{b}
D	6.84 ± 1.54^{d}	6.68 ± 1.37^{c}	6.72 ± 1.17^{c}	6.96 ± 1.45^{c}	7.28 ± 1.45^{c}	7.12 ± 0.92^{c}

Value of duplicate mean ± standard deviation determination with the significant different in (p<0.05). Samples with different superscripts within the same column were significantly different (p<0.05).

According to the anti-nutrient analysis shown in table 2 below, the mean values of phytate, oxalate, and saponin range from 0.004 to 0.512 mg/100g, 0.002 to 0.368 mg/100g, and 0.002 to 0.124 mg/100g, respectively. Of all the anti-nutrients examined, only sample A (100:0:0 MF) exhibits significant differences (p<0.05). **In contrast, the phytate values of 0.208 mg/100g, 0.512 mg/100g, and 0.360 mg/100g for samples B (85:10:5), C (75:15:10), and D (65:20:15) obtained in this study fall within the range of 0.430 mg/100g reported by Johnson et al. (2012)** in **their study on the assessment of the anti-nutrient contents of watermelon rinds**. Compared to the values found in sample A (Control) of this investigation, these values are significantly higher (P > 0.05). **According to Munro & Bassir (2010), a phytic acid consumption of 4–9 mg/100g is thought to reduce human iron absorption by 4-5 times, and 3-5g of oxalate is the deadly dose in humans**. According to a study by Akwaowo et al., (2000), consuming 450 mg of oxalic acid per day has been shown to disrupt some metabolic functions.

While the lethal dosage recorded in other research is higher than the values obtained for phytate and oxalate, **the consumption of these fruits may not result in the toxic effect of these anti-nutrients since their levels are insufficient to cause toxicity.**

The samples' saponin content was significantly lower than the 3.0 mg/100 g value that Anthony (2015) stated for evaluating the anti-nutrient qualities of watermelon rind and seed. The bitter flavour of saponins may be linked to pharmacological potentials, such as haemolytic activities (Emmanuel & Deborah, 2018) and positive effects on blood cholesterol, bone health, cancer, and immune system stimulation (Lawal, 2014). **This study's findings are comparable to those of Johnson et al. (2012).** But **because anti nutrients are volatile and heat-labile (Egbuonu et al., 2014), this undesirable quality can be lessened or eliminated by straightforward processing methods like roasting, cooking, and some drying.** It has also been demonstrated that **heat treatment methods like boiling, frying, and drying can lower the anti-nutrient content of plant foods. (Akwaowo et al., 2000),** which calls for more research.

Table 2: Anti-nutrient Composition

Sample	Phytate	Oxalate	Saponin
A	0.004±0.00d	0.002±0,00d	0.002±0,00d
B	0.208±0.00c	0.166±0.00c	0.019±0.00c
C	0.512±0.00a	0.368±0.00a	0.124±0.00a
D	0.360±0.00b	0.219±0.00b	0.104±0.00b

Value of duplicate mean ± standard deviation determination with the significant different in ($p<0.05$). Samples with different superscripts within the same column were significantly different ($p<0.05$).

KEY:

Sample A = 100% maize flour

Sample B = 85% maize flour, 10% soybean flour, 5% watermelon rind flour

Sample C = 75% maize flour, 15% soybean flour, 10% watermelon rind flour

Sample D = 65% maize flour, 20% soybean flour, 15% watermelon rind flour

CONCLUSION

The results obtained from this study have shown that the rind of watermelon fruit and soybean flour contains a significantly high amount of phytate, oxalate, and saponin in the formulated blends, while the control sample made from 100% maize flour has a significant ($p<0.05$) low levels of the anti-nutrients probed. The anti-nutrient compounds in the rind, which is one of the parts always discarded, and soy bean flour, were below the FAO/WHO-recommended safe levels. Thus, the blend ratio can contribute immensely to the recommended daily allowance and maintenance of good nutritional status and, hence, good health for both old and young.

RECOMMENDATION

This study suggests that more research be done to better utilize watermelon seeds and rinds in meals and lessen the waste load they cause for the environment.

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