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Nutritional Composition and Acceptability of Pearl Millet (*Pennisetum glaucum)* Snacks Enriched with Moringa (*Moringa oleifera*) Seeds

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Abstract

This study evaluated nutritional composition and acceptability of snacks made from pearl millet (*Pennisetum glaucum)* and moringa seeds (*Moringa oleifera)* flour blend. It was experimental research. The flour samples were formulated at the ratios of 9:1, 4: 2 and 7:3 moringa and pearl millet flour blends; and 100 percent wheat flour. Proximate and mineral compositions were determined using AOAC standard methods. Sensory evaluation involved standard procedures. Data were analyzed using means and standard deviation. Results show that meat pie 100 percent wheat flour had highest moisture content (34.30%), protein (9.63%), ash (2.05%) and lowest carbohydrate (29.39%). Fat varied significantly with sample with 7: 3 millet and moringa seed meat pie (MPC) having highest content (29.31%). Sample with 9: 1 millet and moringa seed meat pie (MPA) had highest fiber content (3.61%). There was no significant difference ($P \geq 0.05$) in the iron and zinc content of the composite snack samples. Potassium (70.40%), sodium (65.82%) and magnesium (18.63%) were significantly higher in meat pie with 90% millet and 10% moringa seed, while calcium was significantly higher (13.28%) in 100 percent wheat flour. Meat pie samples varied significantly in their color, texture, taste and overall acceptability. Wheat flour was most preferred having higher mean scores (8.00% and 8.35%) respectively for the sensory attributes.

Keywords: Nutritional, Acceptability, Snacks, Moringa, Pearl Millet, Enriched, Flour

Introduction

Snacks are small portable meals eaten in between meals to satisfy hunger and offer immediate energy (Hess *et al*., 2016). Snacks play a significant role in Nigerian cuisine, showcasing the nation's vast ethnic diversity and local delicacies. Snack foods are popular and frequently consumed, and they are regarded as vital means of providing consumers with nutrition. They can be produced by baking, frying, or extrusion. (Nawaz, Xiong, Li, Xiong, Irshad, Chen, Wang, Zhang, Hina, & Regenstein, 2019). Plantain chips, puff-puff (deep-fried dough balls), cake, meat pie, suya (spicy grilled meat), and boli (roasted plantains) are examples of snacks that are frequently eaten in Nigeria. Although snacks can provide people with an increase of energy swiftly and relieve hunger, there is cause for concern over the role that unhealthy snacking habits such as consuming high-calorie and low-nutrient snacks play in the development of chronic illnesses like obesity, diabetes, cancers and cardiovascular disease among others.

The creation of wholesome and sustainable food items has received more attention in recent years as a means of addressing issues related to global health. Adding nutrient-dense plant components to food formulations is one promising strategy for improving food's nutritional profile and fostering well-being (Ravindran, 2019). Plant-based diets have become increasingly common in recent years due to growing concerns about personal health. Consequently, there has been a substantial rise in the demand for plant-based snacks as consumers desire tasty, nourishing, and accessible substitutes for conventional animal-based products. . More focus has been placed on enhancing cereal-based diets with protein sources like oil seeds, plant vegetables, and legumes (Feyera, 2020). Exploring alternate snack components is becoming more popular as dietary demands and preferences change. One such ingredient is millet, a versatile and nutrient-rich grain.

Pearl millet (*Pennistum glaucum*), Millets are resilient, rainfed plants that grow in arid places and even in less fertile, low moisture soil. African countries produced around 55 percent of the world's millet, accounting for 59 percent of global millet production (Singh, Khan, Chauhan, Singh, Jaglan & Yadav 2019). People in the northern region of Nigeria produce pearl millet and use it to prepare beverages like *kunu* and *fura de nunu*, while the eastern region often uses it to prepare infant porridges like pap, and turn brown. According to Tarlor and Kruger (2016), pearl millet grains have a nutritional content of 8–9% dietary fiber, 9–20% protein, 2%–7% fat, and 63–78% carbohydrates. (Obinwa, Mbah, & Umeh-idika, 2023), noted that adding *moringa oleifera* seed flour to pearl millet flour enhances the nutritional content of the composite flour. The protein content of pearl millet ranges between 9.4 to 11.8g/ 100g with an amino acid profile predominantly comprising the essential leucine, isoleucine, valine and phenylanine, but lacking in lysine and methionine (Hassan, Sebola, Mabelebele, 2021). The grain also contains substantial phenolic compounds making it a potent source of antioxidants for populations that consume the cereal in porridge or beverage formats (Anitha, Govindaras & Kane- potaka, 2020). Millet-based snacks can be further enhanced by fortifying them with moringa seed (Moringa oleifera).

Moringa oleifera is gaining popularity on a global scale, particularly for its rich nutritional profile which includes high levels of antioxidants, protein, vitamins, and minerals and ability to help tackle the issue of malnutrition. It is found in many other tropical and dry nations and contains 13 species of shrubs and trees that are native to India and Africa (Kashyap, Kumar, Rilar, Jindal, Baniwal, Guine, Coneia, Mehra, & Kumar, 2022). The plant's antibacterial, antidiabetic, anti-inflammatory, antioxidant, and hepatoprotective characteristics make it possible to use practically every part of it, including the seeds, leaves, flowers, bark, roots, fruit, and immature pods (Islam, Islam, Hossen, Mahtab, Islam, Hasan, .& Karim, R 2021).

Cake are widely -enjoyed bakery items across all social levels because they are easy to eat, come in varieties and are affordable for most people , it can be made with flour, sugar, eggs and butter. In addition to other micronutrients, it is an excellent source of calories, protein, lipids, iron, calcium, and vitamins A and D (Lenka, Kumari, Pradhan , Biswal & Misra

2020). Similarly, meat pies are delicious pastries filled with cooked meat usually lamb, chicken, or pork and additional ingredients including seasonings, sauce, and vegetables. Meat pies may provide vital nutrients like protein, iron, and various vitamins and minerals (Smith & Jones, 2021). The incorporation of pearl millet-enriched moringa snacks into this setting creates opportunities to experiment with new flavor profiles to enhance the dietary value of these popular snacks, cake and meat pie. The assessment takes into account the nutritional composition, sensory characteristics, and general acceptability by consumers with the goal of establishing Pearl millet, and moringa fortified cakes and meat pie as a means of achieving sustainable economic development. From a broader viewpoint, the production of composite snacks can fulfill nutritional demands, provide food security, and contribute to economic growth.

Objectives of the study

The study was to evaluated nutritional composition and acceptability of snacks (queen cake and meat-pie) made from pearl millet (*Pennisetum glaucum)* and moringa seeds (*Moringa oleifera)* flour blend. Specifically, the study determined:

1. proximate composition of snacks made from millet fortified with moringa.
2. mineral composition of snacks made from millet fortified with moringa.
3. sensory properties of queen cake and meat pie

Materials and Methods

***Design of the Study*:** The study employed a laboratory-based experimental design.

***Procurement of Materials*:** Moringa seeds were collected from a mature moringa tree in a backyard garden in Umudike, Abia State. Pearl millet, wheat flour (used as a control), and other ingredients like sugar, shortening, eggs, salt, nutmeg, baking powder, milk, and flavorings were bought from a neighborhood market (Orie ugba) in the Abia state.

***Preparation of Materials*:** Moringa seeds were washed and dehusked, thoroughly cleaned, boiled for 15 minutes, allowed to cool down, then manually dehulled to remove the shell, rinsed thoroughly, and dried in an oven at 60°C for 5 hours and milled into flour. The milled flour was sieved and then stored in air tight plastic containers with the right labels on them for analysis and formulation.

Pearl millet grains were cleaned, washed in tap water, dried in an oven at 60°C for duration of 5 hours, and ground using a commercial grain mill machine. The flour was collected, sieved using a 0.4mm sieve, and stored at room temperature in an airtight bag for further research.

***Sample Formulation*:** Composite flour was formulated with moringa seed and pearl millet flours using the different ratios. QCA to QCD represent queen cake sample A to sample D while MPA to MPD represent meat pie sample A to D respectively.

100 percent (100%) Wheat flour was used as the control: QCD and MPD

90 percent (90%) Moringa seed and 10percent (10%) Pearl millet: 9:1 QCA and MPA

80 percent (80%) Moringa seed and 20percent (20%) Pearl millet: 4:1 QCB and MPB

70percent (70%) Moringa seed and 30percent (30%) Pearl millet: 7:3 QCC and MPC

Snacks (Millet – Moringa) Production: Queen Cake and meat pie were produced.

Queen Cake Samples

Ingredients	Quantity
Flour	200g
Sugar	50g
Margarine	150g
Baking powder	1 teaspoon
Nutmeg	1/4 teaspoon
Eggs	3
Vanilla essence	½ teaspoon
Salt	a pinch

Meat Pie Samples

Ingredients	Quantity
Flour	200g
Margarine	100g
Baking powder	1/4 teaspoon
Salt	a pinch
Water	75ml
Vegetable oil	2 tablespoon
Minced beef	200g
Onion	1 medium sized
Irish potatoes	2 medium sized

Preparation of queen cake samples: Eggs were washed, cracked and whisked for three minutes; they were gradually mixed in with the whipped mixture. Separately sieved flour, baking powder, and salt were added to the mixture and mixed until soft consistency dough was formed. After being moved to a baking pan that had been greased, the cake was baked and then allowed to cool for two hours before being examined.

Preparation of meat pie samples: Flour was sieved into a bowl and combined with baking powder. Margarine was added and mixed until crumb-like. Then, water was added and kneaded vigorously. In a vegetable oil, minced beef, chopped onion, and chopped Irish potatoes were fried with spices. The dough was flattened, cut, and filled with the ingredients. The edges were sealed with egg white. Baked for 30 minutes at 70°C until golden brown

Proximate Analysis procedure

Proximate composition of the snack products was analyzed using the Association of Official Analytical Chemists (AOAC) (2016) method to determine moisture, ash, protein, fat, and fiber contents. Moisture content was determined via thermogravimetric in muffle furnace (Sanyo Gallenkamp, Weiss Technik, West Midlands, UK) at 500C for 24hrs. Ash content was determined by heating two grams in a ceramic crucible at 550°C for three hours, The samples were then weighed and the formula, ash (%) = (w2 - w1) / (weight of sample) x 100, was applied. Protein was determined by Kjeldahl method. After distillation and titration, nitrogen was corrected using a factor of 5.25. Fat was determined by exhaustive extraction of 0.5g of sample with petroleum ether in a microsoxhlet extraction unit (Gerhardt, Bonn, Germany). Fiber content was determined by digesting two grams of each treatment in a conical flask with 200ml of 1.25% H_2so4 solution and boiled for 30 minutes. The solution and content were poured in a Buchner funnel, filtered and dried. The dry residue was heated in a muffle furnace until it turned to ash, then cooled in desiccators and weighed. These analyses were done in the food science laboratory from the department of home economics Michael Okpara University of agriculture Umudike.

***Determination of Mineral Composition*:** Mineral composition of the flour samples were analyzed according to the method of AOAC (2006) for the following minerals:

Iron: A 100 ml micro-Kjeldahl flask was digested with 10 ml of HNO2 in order to measure iron using Atomic Absorption Spectrometry (AAS). After that, the sample was diluted to volume using 0.1

ml of HCl solution in a 25 ml volumetric flask.

Potassium: By measuring the amount of light that potassium ions release in a flame using flame photometry, with KCl serving as the standard, the potassium concentration was ascertained.

Sodium: By atomizing the sample in a flame and measuring the light that is released at the distinctive wavelength of sodium using Nacl as a standard, sodium levels were determined using Flame Photometry.

Zinc: By measuring light absorption at a wavelength specific to zinc, the Atomic Absorption Spectroscopy (AAS) approach was used to determine the zinc level.

Calcium: The calcium content was ascertained using the Atomic Absorption Spectroscopy (AAS) approach, which involves dissolving the sample and detecting the absorption of light at a wavelength specific to calcium.

Magnesium: Atomic Absorption Spectroscopy (AAS) is a procedure that detects light absorption at a certain wavelength to determine magnesium. It was used to determine the amounts of magnesium.

Sensory Evaluation: A sensory evaluation was conducted using a 9 point hedonic scale as described by Iwe (2010). Twenty panelists consisting of students from Home Science department Michael Okpara University of agriculture Umudike who are familiar with the products were used. A 9- point hedonic scale was used for data collection. The scale ranged from (9) representing "liked extremely" (1) representing "disliked extremely". The samples were presented with coded plates that are identical. Each sample was evaluated for color, texture, taste, flavor, and over all acceptability. The panelists were instructed to rinse their mouths with water at intervals to avoid bias and samples were rated together with the control samples (100% queen cake and meat pie). They recorded their responses in the 9-point hedonic scale.

***Data Analysis*:** Mean and standard deviation were used for data analysis. Duncan's multiple range test and Analysis of Variance were also used.

Results

Table 1: Proximate Compositions of Queen Cake and Meat-pie Samples (%)

	Moisture (%)	Protein (%)	Ash (%)	Fat (%)	Fiber (%)	Carbohydrate (%)
Queens Cake						
QCA	$24.27^{b} \pm 0.09$	$6.50^{b} \pm 0.30$	$1.42^{a} \pm 0.02$	$17.11^{b} \pm 1.03$	$1.05^{b} \pm 0.12$	$49.65^{a} \pm 0.68$
QCB	$24.01^{b} \pm 0.14$	$6.80^{b} \pm 0.16$	$1.33^{b} \pm 0.02$	$21.34^{a} \pm 0.14$	$1.50^{b} \pm 0.69$	$45.02^{b} \pm 0.55$
QCC	$24.74^{a} \pm 0.04$	$6.93^{b} \pm 0.68$	$1.21^{c} \pm 0.01$	$22.79^{a} \pm 0.05$	$2.77^{a} \pm 0.33$	$41.56^{c} \pm 0.90$
QCD	$23.63^{c} \pm 0.16$	$7.58^{a} \pm 0.35$	$1.36^{b} \pm 0.02$	$17.49^{b} \pm 0.28$	ND	$49.94^{a} \pm 0.11$
Meat Pie						
MPA	$24.23^{b} \pm 0.40$	$5.59^{c} \pm 0.06$	$1.96^{a} \pm 0.04$	$24.67^{b} \pm 0.41$	$3.61^{a} \pm 0.04$	$39.94^{a} \pm 0.07$
MPB	$20.95^{c} \pm 0.29$	$6.09^{c} \pm 0.03$	$1.63^{b} \pm 0.12$	$28.40^{a} \pm 0.83$	$2.18^{b} \pm 0.13$	$40.75^{a} \pm 0.33$
MPC	$25.48^{b} \pm 0.70$	$6.80^{b} \pm 0.39$	$1.89^{a} \pm 0.04$	$29.31^{a} \pm 0.45$	$1.60^{b} \pm 0.11$	$34.92^{b} \pm 0.71$
MPD	$34.30^{a} \pm 0.52$	$9.63^{a} \pm 0.73$	$2.05^{a} \pm 0.04$	$22.81^{b} \pm 1.24$	$1.82^{b} \pm 0.53$	$29.39^{c} \pm 3.05$

QCA = Queen Cake A (9:1 pearl millet flour and Moringa seed flour), QCB= Queen Cake B (4:2 pearl millet flour and Moringa seed flour), QCC = Queen Cake C (7:3 pearl millet flour and Moringa seed flour), QCD= Queen Cake D Wheat flour 100 percent. MPA = Meat Pie A (9:1 pearl millet flour and

Moringa seed flour), MPB = Meat Pie B (4:2 pearl millet flour and Moringa seed flour), MPC = Meat Pie C (7:3 pearl millet flour and Moringa seed flour), MPD= Meat Pie D Wheat flour 100 percent.

Table 1 shows the proximate composition of the snack products. Moisture content ranged from 23.63 percent to 24.74 percent in queen cake samples and from 20.95 percent to 34.30 percent in meat pie samples. Protein content varied from 6.50 percent to 7.58 percent in queen cake samples and from 5.59 percent to 9.63 percent in meat pie samples. Ash content ranged from 1.21 percent to 1.42 percent in queen cake samples and from 1.63 percent to 2.05 percent in meat pie samples. Fat content ranged from 17.11 percent to 22.79 percent in queen cake samples and from 22.81% to 29.31% in meat pie samples. Fiber content varied from 1.05 percent to 2.71 percent in queen cake samples and from 1.60 percent to 3.61 percent in meat pie samples. Carbohydrate content ranged from 41.56 percent to 49.94 percent in queen cake samples and from 29.39 percent to 40.75 percent in meat pie samples.

Table 2: Mineral Compositions of Queen Cake and Meat-pie Samples (mg/100g)

	Iron	Potassium	Sodium	Zinc	Calcium	Magnesium
Queens Cake						
QCA	1.17^{b}±0.01	54.75^{a} ± 0.04	38.51^{b}± 0.13	0.84^{a}±0.01	9.84^{d} ± 0.02	18.61^{b}± 0.01
QCB	1.20± 0.01	32.49^{d} ± 0.01	39.27^{a} ± 0.04	0.72^{c}±0.00	15.47^{a}± 0.01	20.61^{a}± 0.01
QCC	1.34^{a}±0.02	35.63^{c} ± 0.04	35.69^{d}± 0.01	0.84^{a}±0.02	10.73^{c}± 0.01	20.54^{a}± 0.08
QCD	1.37^{a}±0.01	45.28^{b} ± 0.03	36.41^{c} ± 0.01	0.80^{b}±0.00	12.87^{b}± 0.04	11.87^{c}± 0.04
Meat Pie						
MPA	1.43^{a} ± 0.01	70.40^{a} ± 0.11	65.82^{a} ± 0.03	1.05^{a} ± 0.01	10.71^{b} ± 0.13	18.63^{a}± 0.01
MPB	1.30^{b} ± 0.00	33.82^{c} ± 0.03	40.32^{d} ± 0.05	0.54^{d} ± 0.00	9.67^{c} ± 0.04	15.65^{b}± 0.06
MPC	1.03^{d} ± 0.00	54.79^{b} ± 0.08	48.56 ± 0.06	0.68^{c} ± 0.00	9.71^{c} ± 0.13	15.38^{c}± 0.03
MPD	1.05^{c} ± 0.00	30.57^{d} ± 0.04	46.57^{a} ± 0.38	0.73^{b} ± 0.01	13.28^{a} ± 0.02	15.71^{b}± 0.02

QCA = Queen Cake A (9:1% pearl millet flour and Moringa seed flour), QCB= Queen Cake B (4:2 pearl millet flour and Moringa seed flour), QCC = Queen Cake C (7:3pearl millet flour and Moringa seed flour), QCD= Queen Cake D Wheat flour 100 percent. MPA = Meat Pie A (9:1pearl millet flour and Moringa seed flour), MPB = Meat Pie B (4:2 pearl millet flour and Moringa seed flour), MPC = Meat Pie C (7:1pearl millet flour and Moringa seed flour), MPD = Meat Pie D Wheat flour 100 percent.

Table 2 shows the mineral composition of the snacks. Iron content in queen cake samples ranged from 1.17mg to 1.37mg. Potassium varied significantly (P > 0.05), with values ranging from 32.49mg to 54.75mg. Sodium content ranged from 35.69mg to 39.27mg. Zinc content ranged from 0.72mg to 0.84mg. Calcium content varied from 9.84mg to 15.47mg, while magnesium ranged from 11.87mg to 20.61mg.

In meat pie samples, iron content ranged from 1.03mg to 1.43mg. Potassium content ranged from 30.57mg to 70.40mg. Sodium content varied from 40.32mg to 65.82mg. Zinc content ranged from 0.54mg to 1.05mg. Calcium content varied from 9.67mg to 13.28mg, while magnesium ranged from 15.38mg to 18.63mg.

Table 3: Sensory Evaluation of Queen Cake and Meat pie Samples

Samples	Color	Texture	Taste	Overall acceptability
Queens Cake				
QCA	$6.90^{b} \pm 1.74$	$6.00^{b} \pm 1.30$	$6.30^{b} \pm 1.53$	$6.40^{b} \pm 1.19$
QCB	$6.35^{b} \pm 1.84$	$6.80^{b} \pm 1.74$	$6.45^{b} \pm 1.57$	$6.53^{b} \pm 1.36$
QCC	$6.60^{b} \pm 2.06$	$6.55^{b} \pm 1.82$	$5.90^{b} \pm 2.51$	$6.35^{b} \pm 1.79$
QCD	$7.90^{a} \pm 1.17$	$8.10^{a} \pm 0.85$	$8.00^{a} \pm 1.30$	$8.00^{a} \pm 0.84$
Meat Pie				
MPA	$5.45^{b} \pm 2.19$	$5.05^{b} \pm 2.31$	$4.10^{b} \pm 1.94$	$4.87^{b} \pm 1.80$
MPB	$4.10^{c} \pm 2.02$	$4.00^{b} \pm 2.22$	$3.05^{b} \pm 1.50$	$3.72^{c} \pm 1.69$
MPC	$4.45^{bc} \pm 2.44$	$4.35^{b} \pm 2.58$	$3.10^{b} \pm 2.07$	$3.97^{bc} \pm 1.80$
MPD	$8.70^{a} \pm 0.57$	$8.20^{a} \pm 1.15$	$8.15^{a} \pm 1.66$	$8.35^{a} \pm 0.98$

Means with the same superscript in the same column are not significantly different (P ≥ 0.05) Key: QCA= Queen Cake A (9:1 pearl millet flour and Moringa seed flour), QCB= Queen Cake B (4:2pearl millet flour and Moringa seed flour), QCC= Queen Cake C (7:3pearl millet flour and Moringa seed flour), QCD= Queen Cake D Wheat flour 100 percent. MPA= Meat Pie A (9:1pearl millet flour and Moringa seed flour), MPB= Meat Pie B (4:2pearl millet flour and Moringa seed flour), MPC= Meat Pie C (7:3pearl millet flour and Moringa seed flour), MPD = Meat Pie D Wheat flour 100 percent.

Table 3 shows the sensory properties of the snack products. In queen cake samples, color values ranged from 6.35 percent to 7.90 percent, texture from 6.00 percent to 8.10 percent, and taste from 5.90 percent to 8.00 percent. Overall acceptability was highest in the control sample and lowest in the 70:30 percent pearl millet and moringa seed sample.

For meat pie samples, color values ranged from 4.10 percent to 8.70 percent, texture from 4.00 percent to 8.20 percent, and taste from 3.05 percent to 8.15 percent. Overall acceptability was lowest in the 80:20 percent pearl millet and moringa seed sample and highest in the control sample.

Discussion of Findings

Queen cakes had the lowest moisture content in the sample, ranging from (23.63% to 24.74%), while meat pies showed a wider range, from (20.95% to 34.30%). The observed increased variability in meat pies as opposed to queen cakes may result from variations in the composition and components used. Contrarily, Adekunle & Abiodun, (2018) reported a moisture content (8.79 - 8.60%) of Acha-Moringa seed flour blend biscuits. Opeifa, et al (2015) stated that 10percent of moisture content is generally specified for flour and related products. The higher moisture content for the composite snack may reduce the shelf life and lower their keeping quality. The protein content of the developed products in this study (6.50% - 7.58%) were significantly different ($P < 0.05$) for queen cake samples while the meat pie samples had protein content (5.59- 9.60%). Chinma, *et al* (2014) reported higher protein content (13.14 – 23.10%) in cakes made with defatted moringa and wheat cake. The ash content of queen cake (1.21% – 1.42%) was significantly different ($P < 0.05$) among the cakes. Samples prepared with 90 percent pearl millet, 10 percent moringa seed had the highest value. Meat pie ash content ranged from 1.63 – 2.05 percent. The control sample had the highest ash content The ash content reported in this study was higher than the ash content (0.53% – 0.91%) from white

maize ogi flour and moringa seed (Oladeji *et al*., 2017). Ash content indicates a rough estimation of the mineral content of product the may be beneficial for nutritional quality. The fat content value of queen cake ranged from (17.11% - 22.29%) while meat pie value ranged from (22.81%- 29.31%). Fat content of the samples increased with an increase in moringa seed. The fat content obtained from this study was higher than the fat content (4.00 – 5.95%) for cake made from wheat and moringa leaf (Kolawole, *et al*, 2013). The higher fat content of the samples could impact their energy density and sensory attributes. The fiber content in this study is higher than the fiber content (0.08% – 0.62%) of bread fortified with Moringa seed powder (Bolarinwa, *et al* , 2017). The carbohydrate content (41.56% - 49.94%) reported in this study was lower than the carbohydrate content (54.71 – 63.92%) of dakuwa snacks from finger millet, groundnut and moringa seed flour reported by (Yelmi, et al, 2022). Meat pie carbohydrate content (29.39% - 40.75%) varied significantly. This suggests that formulation changes can significantly impact carbohydrate levels in these products.

Abundance of the necessary elements found in the queen cake and meat pie including magnesium, potassium, calcium, sodium, and zinc, implies that a moringa seed and pearl millet snack could aid in reducing micronutrient deficiencies. Sodium content (39.27 mg/100g to 35.69 mg/100g) and (40.32 to 65.82 mg/100g) for queen cake and meat pie recorded in this study was higher than the sodium content (7.69 mg/100g to 10.64 mg/100g) of cookies prepared with Rice, Unripe banana and sprouted soybean (Inyang, *et al*, 2018). Calcium and magnesium content of queen cake and meat pie differed significantly. The calcium content is lower than the calcium content (76.95 mg/100g to 98.20 mg/100g) of biscuits made with Bambara groundnut, ground bean seed and moringa seed (Talabi, et al 2019). Yelmi *et al*., (2022) reported that the iron content of dakuwa snack produce from finger millet, groundnut, and moringa seed (100.5 to 128.0 mg/100g) was much higher compared to the iron content observed in this study (1.17 to 1.37 mg/100g) and (1.03 to 1.43 mg/100g) respectively. Furthermore, the zinc content (0.72 to 0.84 mg/100g) and (0/54 to 1.05mg/100g) in this study were notably lower (2.45 to 4.77 mg/100g) compared to those reported by Gwer, et al (2020) for weaning food made from millet, soya beans, and moringa leaf flour.

The findings on sensory properties showed that the control samples consistently scored higher in the attributes measured (color, texture, taste and overall acceptability). This preference for the control samples may be attributed to the panelist's familiarity with the control sample. However, queen cake prepared from composite flour were equally preferred and accepted. The low score for color, texture, and taste in meat pies made with composite flours suggest that adjustments in formulation could improve sensory appeal.

Conclusion

Based on the results of this study, it can be concluded that enrichment of pearl millet with moringa seed significantly enhanced its nutritional properties as shown in the proximate and mineral content results obtained. Enrichment of pearl millet with moringa seed also had significant effect on the sensory properties of the snack samples which affected its acceptability, especially the meat pie samples that scored below 5 on the 9-point hedonic

scale this could be attributed to the stringent taste of moringa seed which affected its acceptability.

Recommendation

Base on the results, the following recommendations are made**:**

1. Nutrient-dense plant products like pearl millet, and moringa seeds, should be used to produce snacks like meat pies and queen cakes.
2. More studies could be carried out on various combinations of nutrients and processing methods for developing nutrient-dense snacks.

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