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Proximate and Mineral Composition of Noodles Incorporated with Moringa and Sardine Powders

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ABSTRACT

This study aims to investigate the effect of incorporating *Moringa oleifera* leaf powder and sardine powder into wheat-based noodle formulations on their nutritional composition. Different formulations were prepared with varying ratios, expressed in percentage (%): WM1 (99.6 wheat: 0.4 moringa), WM2 (99.2 wheat: 0.8 moringa) andWM3 (99 wheat :1 moringa); WS1 (95 wheat: 5 sardine), WS2 (90 wheat: 10 sardine), WS3 (85 wheat: 15 sardine) and the control sample (WC) containing 100% wheat was also included for comparison. The nutritional parameters assessed included crude protein, crude fiber, crude fat, ash, carbohydrate and energy content. Mineral compositions were also determined, including calcium (Ca), magnesium (Mg), iron (Fe) and zinc (Zn). The results demonstrated significant variations in the nutritional composition of the different formulations compared to the control sample. Results of proximate composition based on dry matter showed that the crude protein values ranged from 11.76-21.40g/100g, crude fibre values ranged from 0.00-0.02g/100g, crude fat values ranged from 1.89-2.94g/100g, ash content values ranged from 1.38-2.26g/100g, carbohydrate content values ranged from 62.31-74.29g/100g and energy values ranged from 358.50-364.53 kcal/100g. Furthermore, the minerals results showed iron values ranged from 32.55-65.50mg/100g, calcium values ranged from 7.39-66.61g/100g, magnesium values ranged from 28.86-87.35mg/100g and zinc values ranged from 2.21-39.25mg/100g. These results indicate that the fortification of noodles with moringa and sardine powders can be a viable approach for enhancing the nutritional value of the final product.

Keywords: Proximate composition, Micronutrients, Moringa leaf, Sardine, Recommended Dietary Intake**.**

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INTRODUCTION

Malnutrition remains a pressing global issue, particularly affecting vulnerable populations such as adolescents who are going through critical growth and development stages (Heslin and McNulty, 2023). Adequate nutrition during this period is crucial for their overall health and well-being, as well as for the prevention of various nutrition-related diseases (LeLeiko et al., 2022). Ronan et al. (2021) postulate that malnutrition significantly impacts human health and well-being as it leads to a range of health problems, including stunted growth, weakened immune systems, anemia, and a heightened susceptibility to various diseases. Malnutrition can impair the physical and cognitive development of adolescents, having a long term effect on their health and productivity.

The world faces the largest cohort of adolescents, aged between 10 and 19 years, with approximately 90% of these adolescents residing in low- and middle-income countries (LMICS). In many of these countries, adolescents often enter this critical stage of development thin, stunted, anemic, and micronutrient deficient (Madjdian et al., 2018). These conditions can be attributed to a variety of factors, including limited access to nutrient-rich foods, economic constraints, and wrong dietary choices, which are more prevalent in low- and middle-income countries (Kavle and Landry, 2018). The study done by Mrimi et al. (2022) showed that in Tanzania, adolescents are affected by malnutrition. Though this is underreported, little has been done to improve the health and nutritional status of adolescents.

Furthermore, Nicholaus et al. (2020) postulate that in recent years, innovative approaches have been explored to address malnutrition, and one such approach involves the development of nutrient-rich food products using materials which are high in nutrients. Examples are sardine, seaweed, beans, chickpeas as well as vegetables, such as carrots and leafy greens.

Noodles are a popular staple food consumed by millions of people worldwide due to their convenience, affordability, and versatility (Akubor, 2023). However, the basic composition of traditional noodles often lacks essential nutrients required for optimal nutrition, which can be particularly problematic for vulnerable populations, such as children and adolescents (Ikbal et al., 2022). In many low- and middle-income countries, noodles are a widely consumed and accessible source of calories, but they lack key nutrients. This can exacerbate the malnutrition issue among adolescents in these regions, as these individuals rely on noodles as a significant part of their diet.

In Tanzania, noodles are a commonly consumed food due to their affordability and ease of preparation. They serve as a quick and convenient meal option, especially for individuals with busy lifestyles, such as university students (Noort et al., 2022). Also, Ang et al. (2020) argue that noodles are readily available in various forms, including instant and non-instant versions, making them a popular choice among people of all age groups. Despite their convenience, the basic composition of these noodles often falls short in terms of nutritional value (Adejuwon et al., 2020).

Vishwakarma et al. (2022) argue that, in recent years, there has been growing interest in fortifying food products with nutrient-dense ingredients to combat malnutrition effectively. *Moringa oleifera*, a plant commonly found in tropical and subtropical regions and often referred to as the "miracle tree," is recognized and has gained significant attention for having rich nutrient contents, including vitamins, minerals and antioxidants. This makes it a better ingredient for food fortification (Cao et al., 2023). Also, this superfood has been extensively studied for its potential health benefits, including its ability to combat malnutrition and support overall growth and development (Islam et al., 2021). Similarly, Santos et al. (2023) supported that, sardines which are fatty fish rich in omega-3 fatty acids, protein, and various micronutrients, have shown promising nutritional advantages in improving overall dietary quality.

Carpentieri et al. (2022) postulate that, the incorporation of natural nutritional components in wheat noodles could be a better option and in day to day requirements. Many studies are investigating the possibility of fortifying noodles as an effective public health intervention and improving its nutritional attributes (Binou et al., 2022; Shubham et al., 2020). Therefore, enhancing the nutrient content of noodles could be a practical and effective way to address malnutrition in our locality.

To address these challenges, this study aimed to develop noodles incorporated with sardines and moringa leaf powders and investigate the proximate composition and mineral content of these innovative noodles. The proximate composition analysis will evaluate the levels of macronutrients, including protein, fats, carbohydrates, and dietary fiber. The mineral analysis will focus on essential elements, such as iron, calcium, zinc, and magnesium. These findings will provide valuable insights into the potential of incorporating moringa and sardines into noodles as a means of enhancing their nutritional value. The approach offers a practical and affordable solution to address adolescent malnutrition as well as provides evidence-based recommendations for such interventions to improve the quality of diets for adolescents.

MATERIAL AND METHODS

Samples collection

Moringa leaves were collected from Frida Home Steady Farms located in Morogoro Region. Dried sardines, cooking oil, salt, wheat flour and baking powder (sodium carbonate) were collected from Chief Kingalu Market at Morogoro Region, Tanzania.

Sample preparation

Preparation of moringa leaf powder

Moringa leaf powder was made according to the methods of Orisa and Udofia. (2019) and Kumar. (2021), with slight modifications . Moringa leaves Figure 1a) collected from the farm were sorted, with healthy leaves chosen for further processing and damaged leaves discarded. The selected leaves were washed with distilled water to remove all dirt and dust. The leaves were placed on perforated trays and widely spread for 20 minutes to drain excess water from them. After 20 minutes, trays were arranged on laboratory tables and dried for 4 days under shade until the moisture content reached 7%. After drying, the leaves were ground into a fine powder, as shown in Figure 2 with a high speed multifunctional crusher machine (model 750A). Then, the leaves were sieved through a stainless steel sieve with 500 µm. Then, **the** powder was packed in an airtight zipped bag to avoid absorption of the surrounding moisture which may degrade its quality and nutrients for further processing.

Preparation of sardine powder

Dried sardines, as shown in Figure 1b were prepared by removing their heads first. Then, the remaining parts of their bodies were washed with portable water to remove sand and other foreign matters. The sardines

Figure 1: Main ingredients used to make noodles.

Figure 2: Moringa leaf powder.

Figure 3: Sardine powder.

were spread on oven trays after being washed. Then, they were placed in an oven set at 60^{0}C for them to dry. After 42 hours, the dried samples with moisture content of 10% were removed from the trays and ground into fine powder (Figure 3) using a high speed multifunctional crusher machine (model 750A). Then, they were sieved through a stainless steel sieve with 500 µm. Finally, the fine powder was sealed in airtight zipped bags and stored for further processing (Mamun et al., 2022).

Sample formulation and composition

The samples were combined in proportions that met the FAO/WHO energy and micronutrient requirement for adolescents aged 14-19 years using linear regression method. Six samples of noodles were formulated as indicated in Table 1. Thus, a total of seven samples were prepared including 1 control sample.

Dried noodle preparation

The dried noodles were prepared following the method described by Zula et al. (2021) as shown in Figure 4. The obtained moringa leaf powder and wheat flour (Figure 1C and Figure 2) were mixed in the following proportions: 100:0, 99.6:0.4, 99.2:0.8, and 99:1. Also, sardine powder and wheat flour were mixed in the

Table 1: Composition of noodles incorporated with moringa leaf powder and sardine powder (g/100g).

Ingredients	Formulation name	Ratios
Wheat flour	WC	100:0
Wheat flour + moringa leaf powder	WM1	99.6:0.4
	WM2	99.2:0.8
	WM3	99:1
Wheat flour + sardine powder	WS1	95:5
	WS2	90:10
	WS3	85:15

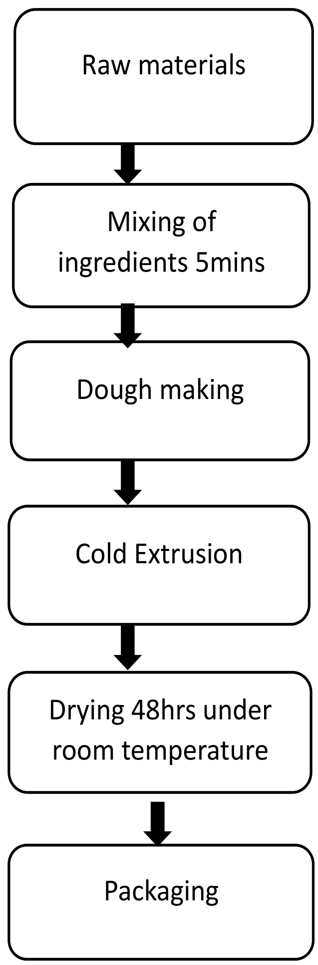

Figure 4: A flow diagram showing noodle preparation. Source: modified from Orisa and Udofia. (2019)

following proportions: 95:5, 90:10, and 85:15. They were measured using BOECO Germany analytical balance (Boeckel + Co BBL31 21505716 XX43-0035) before processing. After measuring those proportions, the composite flour was mixed for five minutes in Amasadora Spiral Mixer Heavy Duty 3 Speed Flour Dough Mixer Machine (model number SC-B30). Then, 300mls of water, 3g of salt, 2% cooking oil and 5g of sodium carbonate (baking powder) were added. They were continuously mixed to ensure that the dough had adequate consistency. The prepared dough was then placed in a laboratory extruder machine (China pasta making machine model number IT-IPM60) for the cold extrusion of desired shape noodles. Finally, the extruded noodles were cut into similar sizes and arranged on trays before drying at room temperature for

48 hours (2 days). Then, they were packed into zipped bags and stored at room temperature for about 25^0C for further analysis and sensory evaluation.

Proximate and mineral composition

Crude protein

Crude protein in the samples was determined by Kjeldahl method of 981.10 (AOAC, 1998). 0.5 g of the dried samples was weighed and then transferred into a digestion flask. Ten (10) mL of concentrated H_2SO_4 and 8 g of digested mixture were added into the flask. The flask was swirled in order to mix the contents thoroughly. Then, the samples were digested using Tecator digestion system 40 (Model 1016 digester, Sweden) for 2 hours until the mixture became clear (blue green in color). The digest was cooled and transferred to 100 mL volumetric flask, in which distilled water was added up to the mark.
The digest was distillated, in which 10 mL of 0.5 N NaOH was gradually added through the same way. Distillation was continued for 10 min and NH_3 produced was collected as NH_4OH in a conical Erlenmeyer flask containing 20 mL of 4% boric acid solution with 3 drops of modified methyl red indicator. The distillate was then titrated against 0.1 N HCl (hydrochloric acid) until pink color appeared. The blank was also run following all the above steps.
The formula used to calculate the crude protein content of the samples was,

$$\%\, crude\ protein = 6.25 \times \%N$$

Where

$$\%\, N = \frac{(S - B) \times N \times 0.014 \times D}{weight\ of\ the\ sample\ (g) \times volume\ (mL)} \times 100$$

Crude fat

The crude fat of the samples was determined by ether extract method of 920.39, using soxhlet apparatus (AOAC, 1998). 5 g of moisture free sample was placed in fat free extraction thimble with cotton wool in the bottom. The thimble was covered by cotton wool on top and then introduced in the extraction tube. Weighed, cleaned and dried receiving beaker was filled with 60 mL of petroleum ether and fitted into the soxhlet apparatus. Water and heater were turned on to start the extraction. Three phases were accomplished in 55 min: the boiling phase for 15 min, fat extraction phase for 30 min and petroleum ether recovery phase for 10 min. Then, the cups were placed in an oven at 105^0C for 10 min to evaporate the remaining petroleum ether. This was followed by cooling it in a desiccator for 20 min and weighed.

The percent of crude fat was determined by using the following formula:

$$\%\, crude\ fat = \frac{weight\ of\ ether\ extract(g)}{weight\ of\ dry\ samples\ (g)} \times 100$$

Crude fibre

A sample of 1.0 g was weighed and put in a porous crucible. The crucible was then placed in a dosi-fiber unit while the valve was left in the "OFF" position. After that, each column received 150 mL of warmed sulphuric acid (H_2SO_4) solution and a few drops of foam suppressor. The cooling circuit was then opened, and the heating elements were turned on (power at 90%). When it began to boil, the power was reduced to 30% and it was left for 30 minutes. To prevent the formation of acid salts, valves were opened for acid drainage and washed three times with distilled water to ensure full removal of acid from the sample. The same technique was utilized for alkali digestion, but instead of sulphuric acid (H_2SO_4), potassium hydroxide (KOH) was used as it is a suitable chemical for alkali digestion. The sample was dried in an oven at 150^0C for 1 h. The sample was then allowed to cool in a desiccator before being weighed. The sample crucibles were kept in a muffle furnace at 550^0C for 3 hours. After cooling in a desiccator, the sample was weighed again.
Calculations were done by using the formula:

$$\%\, crude\ fibre = \frac{weight\ of\ loss(g)}{weight\ of\ dry\ samples\ (g)} \times 100$$

Ash content

The ash content of the samples was determined according to AOAC (1998)'s method of 923.03. For the determination of ash, clean empty crucible was placed in a muffle furnace at 600^0C for an hour. It was cooled in desiccator and then the weight of the empty crucible was noted. Five (5 grams) of each of one sample was taken in the crucible. Then, the crucible was placed in a muffle furnace at 600^0 C for 5 hrs. Grey white ash appeared, which indicates complete oxidation of all organic matter in the sample. The ashing furnace was switched off and the crucible with the sample was cooled and weighed.
Percentage of ash was calculated by the following formula:

$$\%\, Ash\ content = \frac{final\ weight\ (g) - crucible\ weight\ (g)}{weight\ of\ dry\ samples\ (g)} \times 100$$

Carbohydrate

The percentage of carbohydrate was calculated as percentage difference using the formula,

Table 2: Proximate composition (g/100g DM) and energy (kcal/100g) of dried noodles incorporated with moringa leaf and sardine powders.

formulation	Crude protein	Crude fibre	Crude fat	Ash	Carbohydrate	Energy
WC	11.67±0.07[a]	0.00±0.00[g]	2.12±0.04[k]	1.40±0.04[n]	74.29±0.14[t]	362.91±0.67[x]
WM1	11.49±0.13[a]	0.01±0.00[h]	1.92±0.01[k]	1.38±0.06[n]	74.27±0.89[t]	360.32±3.09[x]
WM2	12.42±0.08[b]	0.02±0.00[i]	1.89±0.08[k]	1.64±0.01[p]	72.96±0.02[t]	358.50±0.42[x]
WM3	16.38±0.01[c]	0.02±0.00[j]	2.63±0.07[l]	3.18±0.01[r]	67.61±0.22[u]	359.65±0.20[x]
WS1	14.84±0.03[d]	0.00±0.00[g]	1.99±0.05[k]	1.43±0.00[n]	71.28±0.07[v]	362.41±0.58[x]
WS2	17.00±0.06[e]	0.00±0.00[g]	2.82±0.03[lm]	1.79±0.10[p]	67.74±0.60[u]	364.53±2.51[x]
WS3	21.40±0.06[f]	0,01±0.00[h]	2.94±0.10[m]	2.26±0.03[s]	62.31±0.23[w]	361.29±0.18[x]

$$\%carbohydrate = 100\% - (\%protein + \%crude\ fat + crude\ fibre + \%\ ash)$$

Energy

According to Igbabul et al. (2018), Atwater's conversion factor method was used to calculate energy content. The percent calories in the selected samples were calculated by multiplying the percentage of crude protein and carbohydrate by factor 4 and crude fat by factor 9. The values were converted and expressed in kcal/100g.

$$energy\ content = (4 \times crude\ protein) + (4 \times carbohydrate) + (9 \times crude\ fat)$$

Mineral analysis

Analysis of minerals was carried out according to the method of Jachimowicz et al. (2021), with slight modifications. Samples were grounded using mortar and pestle to reduce particle size for them to be suitable for analysis, Then, they were sieved using a sieve with 1.18 mm. 0.5 g was weighed and placed in vials. 2mL (1:1) of nitric acid (HNO_3) and water were added to each sample for digestion. Then, 5 mL of (1:4) hydrochloric acid (HCl) and distilled water were also added and each of the vials was covered by watch glass. The samples were placed on hot block 150 (model: SC-154-240 S/N: 2022CECW5737 MFG DATE: 04/06/2022) at 95^{0}C and boiled for 30 minutes until they reached 85^{0}C . After reaching 85^{0}C, the samples were removed and cooled to room temperature. Distilled water was added up to 50 mL. Then, the samples were poured into a test tube and transferred to inductive coupled plasma optical emission spectrometry (Model Agilent 5900 SVDV ICP-OES, Serial number MY2215CP04, Software version 7.6.0.12121 and firmware version 5590) for detection of minerals.

Data analysis

All data of proximate and mineral compositions were analyzed using statistical software known as Statistical Package for Social Sciences (SPSS) version 25. One way analysis of variance (ANOVA) test was performed followed by a post-hoc test, Turkey (HSD) with significant difference being determined at a 5% level of significance ($p<0.05$). All results of all determinations were expressed as mean ± SD of duplicate values.

RESULT AND DISCUSSION

Values are expressed as mean± standard deviation. Mean values with different superscript letters along the column are significantly different at $p\leq0.05$. The following formulations were made:
WC (100% Wheat), WM1 (99.6%wheat: 0.4% moringa leaf powder), WM2 (99.2% wheat: 0.8% moringa leaf powder), WM3 (99% wheat: 1% moringa leaf powder), WS1 (95% wheat: 5% sardine powder), WS2 (90% wheat: 10% sardine powder), WS3 (85% wheat: 15% sardine powder).

Crude protein

From the results presented in Table 2, it is seen that the protein content values of the dried noodles incorporated with moringa leaf and sardine powders ranged from 11.67g/100g to 21.40g/100g. The results portrayed that there was a significant difference ($p<0.05$) in the protein content of the dried noodles among all the samples, but it was not significantly different ($p>0.05$) in the control sample (WC) and samples with 0.4% of moringa leaf powder . The protein content increased in the control sample as the amount of moringa leaf powder increased, as shown in WM2 and WM3 samples. This increase in the protein content occurred because the noodles contained both the protein naturally present in the base ingredients and also that from the added moringa leaf powder. Although sample WM1 consisted of 0.4% of moringa leaf powder, it showed no significant difference in protein content with the control sample. This might be attributed to the small concentration of moringa leaf powder added to the wheat flour for the preparation of noodles.
As the sardine powder increased, the protein content of the noodles also increased from 14.84g/100g to 21.40g/100g. The increasing trend in the protein content can be attributed to the protein-rich nature of sardine powder, which adds additional protein to the noodles when incorporated into the manufacturing

process. Current studies show that there was a significant increase in the protein content of the noodles containing moringa leaf and fish powders. These results support the study conducted by Orisa and Udofia (2019), who reported the increase of protein content of noodles incorporated with moringa leaf powder, cowpea flour and acha flour. The research conducted by Manaois et al. (2013) proved that, the protein content of rice cracker increased after the addition of 1% of moringa leaf powder**.** Another comparable study of Wani et al. (2013) indicated that, the substitution of cauliflower leaf powder resulted in a substantial increase in the protein content of noodle samples. Monteiro et al. (2016) researched on Nutritional Profile and Chemical Stability of Pasta Fortified with Tilapia (*Oreochromis niloticus*) and revealed there was increase in the protein content as the concentration of tilapia fish powder increased.
The protein recommended limits set by CODEX (2006) for adolescents are 46 g/100g for females and 52g/100g for males. In this study, the amounts of protein increased, but based on the recommended values, they all were below the limits. So, in order to meet the recommended levels, the concentrations of moringa and sardine powders should be increased to 5%, 10%, 15% and 20%, 25% and 30%, respectively.

Crude fibre

The results from this study (Table 2) show that the amount of crude fibre increased as the amount of moringa leaf and sardine powders increased. Noodle samples with moringa leaf powder had higher fibre content compared to the control sample (WC) and noodles with sardine powder (WS1, WS2 and WS3). This could be attributed to the addition of moringa leaf powder to the wheat flour, which is rich in both soluble and insoluble dietary fibers. Also the increase in the fibre content depends on the concentration of moringa leaf powder added. As the concentration increased, the fibre content also increased. Table 2 shows that there was no significant difference between the control sample (WC) and samples with 5% (WS1) and 10% (WS2) of sardine powder ($p>0.05$) in terms of their fibre content . This is because sardines are not known to be a significant source of dietary fibre, but they are rich in protein and omega-3 fatty acids; their fiber content is relatively low compared to other food sources (Poggioli *et al*., 2023). In order to increase the fibre content in noodles, alternative sources of fiber, such as whole grains or fiber-rich vegetables could be considered instead of relying on sardine powder. Similar results were observed in a study conducted by Zula et al. (2021) on Proximate Composition, Antinutritional Content, Microbial Load, and Sensory Acceptability of Noodles Formulated from Moringa (*Moringa oleifera*) Leaf Powder and Wheat Flour Blend, It was discovered there was increase in fibre content upon the addition of moringa leaf powder in the noodles samples. Sengev et al. (2013), who studied the effect of moringa leaf supplementation on some quality characteristics of wheat bread, postulate that, the amount of fibre content increased as the amount of moringa leaf powder increased.
According to CODEX (2006), the recommended dietary fibres are 25.2g/100g for females and 30.8 g/100g for males. Based on the findings, sardine and moringa powder contributed a small amount of fibre as all samples were below the recommended amount.

Crude fat

The fat content of the dried noodles ranged from 2.12g/100g to 2.94g/100g; noodles with 15% of sardine powder were high in fat content compared to the other samples. There was no significant difference between the control sample and samples with 0.4% and 0.8% moringa leaf and 5% sardine powder ($p>0.05$) in terms of their fat content. Noodles with 10% and 15% of sardine powder had high values of fat contents. As the concentration of sardine increased, the amount of fat content also increased. This can be attributed to the fact that sardines themselves are a rich source of fat particularly in the form of omega-3 fatty acids. As the fat from the fish was transferred to the noodles, their overall fat content increased. Also, the increase in the concentration of moringa leaf powder resulted in increased amount of fat content from 2.12g/100g for the control sample to 2.63g/100g for WM3 sample containing 1% of moringa powder. Khan et al. (2023) reported similar results. The addition of moringa leaf powder in the whole wheat flour showed a significant increase in fat content, which ranged from 2.03 to 3.63% based on the supplementation ratios from 2.5 to 10% of moringa leaf powder. Omeire et al. (2014) postulate that, there was an increase in fat content (1.39-3.00%) in noodles produced with wheat, acha and soybeans composite flours. Furthermore, Chude et al. (2018) found an increase in fat contents in noodles with increased Bambara groundnut in wheat. Monteiro et al. (2016) reported there was increase in fat contents in noodles as the amount of fish increased.

Ash

Ash content in food refers to the inorganic residue left behind after complete combustion of organic matter. It is also an indicator of the mineral elements in the particular food sample. Results of the study show that there was no significant difference between the control sample (100% WC), WM1 (0.4%) and WS1 (5%) at $p>0.05$ degree of significance in terms of their ash content. Also, WM2 (10) and WS2 (10%) samples showed no significant difference in ash content at $p>0.05$. There was a significant difference in ash content between sample WM3 (1%) and WS3 (15%) at $p<0.05$. Substitution of 0.4% of moringa leaf powder into wheat flour showed no significant difference with the control sample at p>0.05. This might be attributed to the small concentration of moringa leaf powder used. As the concentration of moringa leaf powder increased the ash content increased since the noodle sample with 1% of moringa leaf powder (WM3) had higher mean value (3.18g/100g) of ash content compared to all the other samples. This can be due to the addition of moringa leaves which are known to be rich in minerals essential for plant growth and development, such as calcium, potassium, magnesium, and phosphorus. Also, noodles incorporated with sardine powder showed an increase in ash content as the concentration of sardine powder increased. This might be due to the presence of inorganic minerals in sardines, including calcium, magnesium and potassium, which increased the overall ash content when incorporated into wheat noodles. These results are comparable with Effiong et al. (2018), who reported the increase in ash content in noodles made with wheat and orange-fleshed sweet potatoes. Chude *et al*. (2018) reported that the substitution of fermented Bambara groundnuts in wheat noodles resulted in increased ash content of noodles from 1.80-3.08%. Ahmad et al. (2022) found an increase in the ash content of value-added noodles produced by fenugreek seed powder, which ranged from 0.9-3.12g/100g.

Carbohydrates

It is further shown that the amount of carbohydrates in the noodle samples decreased from 74.29g/100g to 62.31g/100g (Table 2). The control sample (WC) contained a high amount of carbohydrates compared to the other samples, although the difference was not statistically significant in samples with 0.4% and 0.8% of moringa leaf powder at p>0.05 level of significance. This might be due to the small concentration of moringa leaf powder incorporated into the wheat flour during the processing. The amount of carbohydrates decreased as the amount of moringa leaf and sardine powders increased. This could be attributed to the inclusion of the supplements, which are low in carbohydrates in wheat flour, resulting in the dilution of the carbohydrates present in wheat flour. Thus, the higher the concentration of these powders, the greater the dilution effect. This results in a decrease in carbohydrate contents. These results abide with those of Igbabul et al. (2018), who reported a decrease in carbohydrate contents in cookies produced with wheat, sweet detar (The underutilized species of tree legume that grows naturally in the drier regions of West and Central Africa has a wide range of uses due to its medicinal properties, edible fruit, and flour) and moringa leaf flour blends. A similar decrease in carbohydrate contents was observed in a study conducted by Hussin et al. (2020) on the effect of including Bambara groundnuts and moringa leaf powder in wheat flour for making noodles. Handayani et al. (2022) reported that the inclusion of moringa leaf powder resulted in decreased carbohydrate contents of pasta.

The carbohydrate content limit set by CODEX (2006) for adolescents is 130g/100g. The values of carbohydrates in all samples incorporated with sardines and moringa leaf powders were below the recommended limits.

Energy

The study results show that, the energy content of noodles ranged from 358.5-364.35kcal/100g (Table 2). The difference in energy contents among all the samples was observed, but the difference was not statistically significant at p>0.05. Noodles incorporated with moringa leaf powder showed a decrease in energy contents compared to the control sample. This is because moringa leaves are not rich in fat contents as well as carbohydrate contents compared to the wheat flour. Sample (WS2) which consists of 10% of sardines had the highest energy value of 364.35kcal/100g than all the other samples because of the high fat content derived from sardines; its carbohydrate content was not very low compared to sample (WS3) with 15% of sardine powder. Similar results are shown by Ndife et al. (2014), who reported increase in energy content in cookies with increase of full-fat soya in wheat flour. Furthermore, these results are comparable with those of Gomaa et al. (2023), who reported a decrease in the energy content of instant noodles with increase in moringa leaf and mushroom powders.

MINERAL COMPOSITION OF NOODLES

Values are expressed as mean± standard deviation. Mean values with different superscript letters along the column are significantly different at p≤0.05. The following formulations were made:

WC (100% wheat), WM1 (99.6% wheat: 0.4% moringa leaf powder), WM2 (99.2% wheat: 0.8% moringa leaf powder), WM3 (99% wheat: 1% moringa leaf powder), WS1 (95% wheat: 5% sardine powder), WS2 (90% wheat: 10% sardine powder), WS3 (85% wheat: 15% sardine powder).

Calcium

According to Ali (2023), calcium is an essential mineral for the human body. It plays a crucial role in maintaining bone health, nerve function and muscle function. Incorporating calcium-rich ingredients in food products can be an effective way to enhance the nutritional value of food and provide consumers with additional health benefits (Bourassa et al., 2022).

The findings in Table 3 show that the calcium content of noodles ranged from 7.39- 66.61 mg/100g. The amount of calcium differs significantly among all the samples at p<0.05. For the noodles incorporated with moringa leaf powder, the amount of calcium increased as the concentration of moringa leaf powder increased

Table 3: Mineral composition of noodles incorporated with moringa and sardine powders (mg/100g).

Sample	Ca	Fe	Mg	Zn
WC	7.39±0.05^{a}	32.55±0.07^{i}	28.86±1.21^{n}	2.21±0.01^{u}
WM1	9.21±0.02^{b}	34.45±0.21^{j}	33.85±0.92^{np}	2.22±0.01^{u}
WM2	11.21±0.04^{c}	39.35±0.21^{h}	42.5±0.00^{pq}	2.31±0.01^{u}
WM3	12.03±0.03^{d}	40.25±0.21^{h}	52.5±1.41^{q}	3.93±0.03^{t}
WS1	14.02±0.05^{e}	42.60±0.14^{k}	55.34±0.01^{q}	14.65±0.07^{v}
WS2	29.37±0.06^{f}	51.75±0.49^{l}	74.60±3.52^{r}	27.55±0.06^{w}
WS3	66.61±0.06^{g}	65.50±0.42^{m}	87.35±5.05^{s}	39.25±0.07^{y}

compared to the control sample (WC). The increase in calcium content could be attributed to the amount of calcium present in moringa leaf. Furthermore, the incorporation of sardine powder into wheat flour for noodle-making resulted in a significant increase in calcium content compared to 100% wheat noodles. Five percent (5%), 10% and 15% of sardines powder resulted in increased calcium content of 14.02mg/100g, 29.37mg/100g and 66.61mg/100g respectively. As the concentration of sardines increased, the amount of calcium increased. The increase of calcium content could be due to the addition of sardines, which are rich in calcium content and hence contributed to an increase. These findings are closely related to the earlier studies done by Prayitno et al. (2022), who found an increase in calcium content upon the addition of moringa leaf powder in the ratios of 5%, 10% and 15% in wheat flour for making wet noodles. Also, Govender and Siwela. (2020) reported that, calcium content was increased upon the inclusion of moringa leaf powder in white and brown breads. Similarly, Mamun et al. (2022) revealed that the inclusion of small marine pelagic fish powder in food results in increased mineral contents, including calcium, iron and zinc.

According to WHO (2006) and CODEX (2006), the recommended calcium limit is 1200mg/100g for adolescents. All formulations in this study show increase in their calcium contents except the control sample. However, they were below the recommended levels (WHO 2006; CODEX 2006). In order to meet the recommended levels, the combination of moringa leaf and sardine powders could be useful or the addition of supplementing materials which are rich in calcium, such as okra (77mg/100g), soy bean (277mg/100g) and parsley (138mg/100g calcium) (Gomes et al., 2022).

Iron

The findings of the study showed that the inclusion of moringa leaf and sardine powders resulted in increased amount of iron content (Table 3). There was a significant difference in iron content among all samples compared to the control sample at $p<0.05$. Although the use of 0.8% and 1% of moringa leaf powder showed no significant difference in iron content at $p>0.05$, but the control sample and 0.4% moringa leaf powder showed difference. Iron content ranged from 32.55-65.50mg/100g and such increase could be attributed to the addition of supplements (moringa leaf and sardine powders) which are known to be rich in minerals, including iron (Gomaa et al., 2023). These results abide with the study done by Desai et al. (2018), who found an increase in iron content in pasta through the incorporation of protein powder from fish. These results also are in accordance with another current study of Roni et al. (2021), who revealed an increase of iron content amounting to 42.59mg/100g in fortified cake; it is higher than the unfortified cake. So this proves that the fortification of wheat flour with moringa leaf powder results in increased iron content, which is highly important to anemic people. In our previous study, it was found that noodles fortified with moringa (at 0.4%) had good cooking quality, sensory attributes and acceptability (Mpalanzi et al., 2023). Thus, the products can contribute to combat the hidden hunger. Generally, iron deficiency is a common health concern worldwide; therefore, using these natural sources to enhance the iron content of a food product or supplement could have potential benefits, especially for individuals at risk of iron deficiency, including adolescent girls.

Iron content limit set by WHO (2006) and CODEX (2006) for adolescent females is 15mg/100g and for males it is 11mg/100g. From the results, all formulations incorporated with moringa leaf and sardine powders were above the recommended levels. So, these are good sources of iron and can be used for the fortification of different food products, which can help people with anemia, especially adolescent girls who are prone to iron deficiency.

Magnesium

From the results in Table 3, wheat-based samples showed a gradual increase in magnesium contents as the concentration of moringa leaf powder or sardine powder is added to the wheat. The WC sample, which represents 100% wheat, had the lowest magnesium contents of 28.86 mg/100g compared to the other samples. There was a significant difference in magnesium contents between the samples at p<0.05, although samples WS2, WM2 and WS1 showed no statistical differences in magnesium contents at p>0.05. Moving towards the samples with moringa leaf powder and sardine powder supplementation (WM1, WM2, WS1, WS2, WS3), there was a consistent and significant increase in magnesium levels. The highest magnesium content was found in WS3, with a remarkable quantity of 87.35mg/100g.The increase in magnesium can be attributed to the enrichment of the wheat-based samples with moringa leaf and sardine powders as both moringa leaf and sardine powders are known to be rich sources of magnesium. Moringa leaves are naturally abundant in this mineral, and the addition of moringa leaf powder to wheat-based products results in a proportional rise in magnesium levels. Similarly, sardine powder, derived from sardine fish, also contributes to the elevated magnesium content due to the inherent magnesium stores in the fish. These results abide with the study of Mamun et al. (2022), who revealed that the inclusion of small marine pelagic fish powder in food results in increased magnesium content. Govender and Siwela. (2020) postulate that moringa leaf powders are rich in magnesium and adding them in bread resulted in significant increase in magnesium.

The set limits of magnesium for adolescents recommended by CODEX (2006) are 360mg/100g for females and 410mg/100mg/100g for males. Therefore, all formulations in this study were below the recommended amount.

Zinc

Zinc is another essential mineral required for numerous enzymatic reactions and it plays a pivotal role in supporting the immune system and promoting overall health (Patil et al., 2023). From the results, zinc content increased with the increase of moringa leaf and sardine powders concentration.

From the findings shown in Table 3, the control sample WC (100% wheat) consisted of 2.21mg/100g of zinc, which is small amount compared to other samples incorporated with sardine and moringa leaf powders. Although there was no significant difference in zinc content between the control sample, WM1 and WM2 at P>0.05, sample with 1% moringa leaf powder (WM3) and all noodle samples incorporated with sardine powder (WS1, WS2 and WS3) showed a significant difference in zinc content compared to the control sample at p<0.05 level of significance. Among the moringa-supplemented samples, WM3 showed the highest zinc content of 3.93mg/100g and this can be due to the high amount of moringa leaf powder used compared to samples WM1 and WM2. Furthermore, when sardine powder was introduced into samples WS1 (5%), WS2 (10%) and WS3 (15%), the zinc content significantly increased; WS3 exhibited the highest zinc content at 39.25mg/100g. The increase in zinc content can be attributed to the inherent zinc concentration present in both moringa leaf and sardine powders as they are recognized for their substantial zinc content and other minerals. So, the enriched zinc content in the supplemented noodle samples highlights the potential of moringa leaf and sardine powders as effective fortifying agents for boosting the zinc content in wheat-based foods. This contributes to improved nutritional value. These results abide with the study done by Simonato et al. (2021), who found an increase in zinc content as moringa leaf concentrations (5%, 10% and 15%) increased in pasta fortified with moringa leaf powder . Furthermore, Kamble and Bhuvaneshwari. (2018) revealed there was an increase in zinc content through the incorporation of moringa leaf; with the addition of 5% of moringa leaf, the highest zinc content found was 9.66mg/100g.

According to CODEX (2006), the limit levels for zinc content are 9 mg/100g for females and 11mg/100g for males. Based on the results obtained, the amounts of zinc were below the recommended levels for samples incorporated with moringa leaf powder (WM1, WM2 and WM3). Samples incorporated with sardine powder were above the limits.

CONCLUSION

This study demonstrates significant improvements in both the proximate and mineral composition of noodle samples. It shows the positive impact of incorporating sardines and moringa leaf powders into the noodles. By analyzing the data, it becomes evident that the addition of these powders led to increased levels of essential minerals, such as calcium (Ca), magnesium (Mg), iron (Fe), and zinc (Zn). It also enhanced proximate parameters, including proteins, carbohydrates, fats, ash contents, and fibers.

The significance of these findings extends beyond the ordinary demonstration of improved noodle composition. This research addresses a critical problem: the deficiency of key nutrients in common food products. The study's innovative approach of fortifying noodles with moringa and sardine powders provides a practical solution to this problem, which is effectively enriching the nutritional content of these staples.

The impact of these findings on humans is profound. Health-conscious consumers and the broader public will benefit from these more nutritious and health-promoting food products. By consuming these fortified noodles, individuals can enhance their intake of essential minerals and proximate nutrients, thereby contributing to an overall improvement in public health.

In conclusion, this research highlights the potential of moringa and sardine powders as valuable fortificants for a wide range of food products deficient in nutrients. By significantly enhancing mineral and proximate content in noodles, it paves the way for similar innovations in the food industry, offering a practical means to address nutritional deficiencies and promoting the health and well-being of consumers.

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