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Original Research Article

Valorization of Pumpkin Flour in Cookie Formulations: Effects on Nutritional Composition and Mineral Content

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Abstract: Pumpkin is a highly nutritious food that offers protective benefits against various health conditions, such as diabetes, cardiovascular diseases, constipation, appendicitis, hemorrhoids, and colon cancer. This study aimed to examine the proximate composition of pumpkin-wheat cookies. An experimental research approach was employed to produce pumpkin powder, incorporate it into cookie production, and analyze its nutritional constituents. The results revealed that as the proportion of pumpkin flour in the composite flour increased, there was a corresponding increase in moisture, ash, fat, protein, and fiber content. Additionally, the study demonstrated an increase in mineral content with higher amounts of pumpkin. The iron and manganese levels ranged from 244.1mg/kg to 312.1mg/kg and 74.52mg/kg to 88.17mg/kg, respectively. Calcium and potassium contents also ranged from 0.24% to 0.40% and 0.39% to 0.57%, respectively. The beta-carotene content of the samples varied between 0.18mg/kg to 0.57mg/kg, while the folic acid content ranged from 13.7ug/g to 144.95ug/g.

Keyword: Pumpkin, Nutritious, Proximate composition, Cookies, Minerals, Beta-carotene.

INTRODUCTION

Cookies are baked goods prepared from dough that undergoes heat treatment in an oven to produce an appealing final product (Subhashree & Sushama, 2019). They are convenient, inexpensive, and ready-to-eat snacks containing essential dietary fiber. Cookies contribute significant amounts of iron, calcium, protein, calories, fiber, and B-vitamins to our diets (Bonyadian & Moshtaghian, 2018). Consumer preferences for food have drastically shifted in recent decades, as highlighted by Karaman *et al.*, (2018). Consumers now expect food not only to satisfy hunger and provide nourishment but also to prevent nutrition-related diseases and enhance overall physical and mental well-being; pumpkin meets these expectations.

Pumpkin, a tropical and subtropical vegetable crop, holds a prominent position due to its high productivity, nutritional value, and year-round availability (Sayed *et al.*, 2019). Its nutritional composition varies across species, but it is generally rich in β-carotene, a precursor to Vitamin A, which aids in preventing various ailments and diseases like eye disorders, cancer, and skin problems. Pumpkin also possesses hypnotic, refrigerant, diuretic, and thirst-quenching properties (Singh *et al.*, 2018). However, fresh pumpkin fruit, which can be consumed boiled, steamed, or processed into soups or curries, is perishable due to its high moisture content and susceptibility to microbial spoilage after peeling and color changes. Various drying and powdering techniques are widely employed for preservation, providing an alternative to fresh fruit and vegetable consumption and enabling their use during off-seasons (Rizo *et al.*, 2019). According to Kuchar *et al.*, (2021), pumpkin-wheat composite bread exhibits good nutritional value and sensory attributes, making it acceptable and well-appreciated by consumers.

Consequently, this study utilized cookies made with a composite pumpkin-wheat flour. As defined by Ismail *et al.*, (2021), composite flour is a blend of flours from various sources, such as roots, tubers, cereals, legumes, and others, with or without the addition of wheat flour. The primary objective of producing composite flour is to create a product superior to its individual components. In this study, cookies were prepared with a combination of pumpkin flour and wheat flour. The overall aim is to examine the proximate composition of these pumpkin-wheat cookies.

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The need for this study arises from the growing demand for healthier and more nutritious food products that can cater to the changing consumer preferences and address the rising prevalence of lifestyle diseases (Karaman *et al*., 2018). By incorporating pumpkin, a highly nutritious and functional ingredient, into a commonly consumed snack like cookies, this study aims to develop a product that not only satisfies taste preferences but also offers potential health benefits. Analyzing the proximate composition of these pumpkin-wheat cookies is crucial to understand their nutritional profile and evaluate their suitability as a healthier alternative to traditional cookies. This study contributes to the development of innovative and nutritionally enhanced food products that align with the evolving consumer demands for health-promoting and disease-preventing foods.

MATERIALS AND METHODS

Source of Raw Material

For this study, a 20kg pumpkin was used. Other key ingredients required for cookie production included wheat flour, sugar, salt, baking powder, eggs, and margarine. The solar drying process for the pumpkins was carried out in the Food Engineering Department laboratory at the University of Ghana, while the experimental analyses were conducted in the Food Technology Department laboratory at Kwame Nkrumah University of Science and Technology.

Pumpkin flour preparation

The fresh unripe pumpkins were thoroughly washed, cut, and peeled to remove any soil, rotten parts, and insect damage. The pumpkin was then sliced into 1.5cm thick pieces, arranged on trays, and sun-dried for 72 hours on solar panels. After the drying process, the dry samples were ground into flour using a laboratory grinder. The pumpkin flour was subsequently sealed in plastic bags and stored at room temperature until needed for further use.

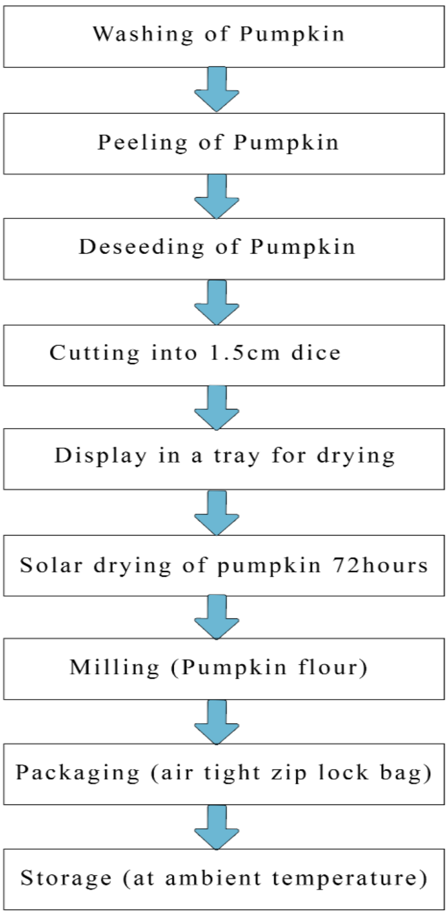

Fig 1: Flow chart for the preparation of pumpkin flour
Fieldwork, 2023

Product development

The wheat-pumpkin flour composites were prepared in different ratios (100:0, 60:40, 50:50, and 20:80), with the other ingredients carefully weighed according to the formulations, as shown in Table 1. The cookie preparation process involved sifting together the flour, salt, and sugar, followed by rubbing in the margarine with fingertips until the mixture resembled breadcrumbs. This ensured thorough incorporation of the fat, preventing the formation of margarine lumps in the dough. As the flour was already coated with fat, mixing the oil before adding liquid to the flour helped prevent gluten development. The baking powder was then mixed in. Next, the eggs were whisked, and milk was added to the flour mixture. The ingredients were carefully kneaded together to form a smooth dough. The dough was then removed from the bowl and flattened using a rolling pin. Circular disc-shaped cookies were cut out from the dough using a round cutter. The cookies were baked in an oven at 160°C for 20 minutes. After baking, the cookies were allowed to cool completely for 10 minutes before being wrapped for further analysis. As shown in Table 1, PWC 10 represents cookies made entirely from wheat flour. Similarly, PWC 11 denotes cookies made with 60% wheat and 40% pumpkin flour, PWC 12 denotes cookies made with 50% wheat and 50% pumpkin flour, and PWC 13 denotes cookies made with 20% wheat and 80% pumpkin flour.

Table 1: Proportionate ratio of Ingredients that was used in the preparation of cookies

Ingredients	**Amount added per(g)**			
	PWC10	**PWC11**	**PWC12**	**PWC13**
Wheat flour	100	60	50	20
Pumpkin flour	0	40	50	80
Powdered sugar	15	15	15	15
Margarine	50	50	50	50
Baking powder	1tsp	1tsp	1tsp	1tsp
Salt	0.5	0.5	0.5	0.5
Egg	40ml	40ml	40ml	40ml
Milk	30ml	30ml	30ml	30ml

*Legend: *PWC10=Control (100%WF) *PWC11=(40%PF: 60% WF) * PWC12= (50% PF : 50% WF) *PWC13= (80% PF : 20% WF)*

Fieldwork, 2020

Determination of Moisture Content

The moisture or water content in a sample is commonly determined by measuring the weight loss that occurs when it is dried to a constant weight in an oven. Official methods recommend drying a representative sample in an oven for 24 hours at 95°C–110°C, 2 hours at 135°C, or 48 hours at 60°C–70°C. However, these methods may not accurately identify the moisture level in certain feedstuffs that contain additional volatile compounds, such as short-chain fatty acids, fats, or fatty products. In such cases, the distillation of moisture in toluene is considered an appropriate procedure.

Calculations

Moisture content is calculated using the following formula:

Moisture (%) = (Weight of moisture / Weight of sample) × 100

Where:

A = Weight of the crucible
B = Weight of the sample
C = Weight of the dry sample
D = Weight of the moisture

The calculations can be expressed as:

A = B - (A + C)
D = (A + B) - (A + C) = B - C
Moisture (%) = D/B × 100

This formula allows for the determination of the moisture percentage in a sample by measuring the weight loss during the drying process.

Determination of Ash

Ashing is the process of heating a food ingredient until only non-combustible ash remains, which can then be analyzed for its elemental composition. The residue left after the complete combustion of an oven-dried food sample is referred to as ash.

Calculations

The percentage of ash in a sample is calculated using the following formula:

Ash (%) = (Weight of ash / Weight of sample) × 100

Where:

A = Weight of the empty crucible
B = Weight of the sample
C = Weight of the crucible + ash

The calculations can be expressed as:

C - A = Weight of ash
Ash (%) = (C - A) / B × 100

This formula allows for the determination of the ash percentage in a sample by measuring the weight of the non-combustible residue remaining after the complete combustion of the oven-dried sample.

Determination of Crude Fat

Ether extract (fat) refers to glycerol fatty acid esters. All ether-soluble compounds are collectively termed "lipids." Fats are solid glycerol esters at typical temperatures, whereas oils are liquid. Groundnut, soybean, and cottonseed all contain oil as a reserve food source. The determination of ether extract involves extracting the dry sample with ether. After distilling the ether, the weight of the remaining residue is measured to calculate the weight of the extracted fat.

Calculations

The percentage of ether extract (fat) in a sample is calculated using the following formula:

Ether extract (%) = (Weight of ether extract / Weight of sample) × 100

Where:

A = Weight of the empty flask
B = Weight of the ether extract
C = Weight of the sample

The calculations can be expressed as:

B = (A + Weight of flask with ether extract) - A
Ether extract (%) = B / C × 100

This formula allows for the determination of the ether extract (fat) percentage in a sample by measuring the weight of the residue obtained after extracting the sample with ether and evaporating the solvent.

Determination of Crude Fiber

Food carbohydrates are divided into two categories: (1) crude fiber and (2) nitrogen-free extractives. Crude fiber is defined as the organic residue of a feed that remains insoluble after boiling with prescribed methods using 0.255 N H_2SO_4 and 0.312 N NaOH solutions. The determination of crude fiber is an attempt to distinguish between carbohydrates that are more readily digestible and those that are less digestible. The crude fiber component consists of cellulose, lignin, and hemicelluloses. The process of boiling a sample with weak acid and alkali is an attempt to mimic the digestive process that occurs in the digestive tract. This method is based on the assumption that carbohydrates that are easily dissolved by this method will also be easily digested by animals, whereas those that are insoluble under these conditions will not be digested. While this is only an approximate estimation of the indigestible substance in feedstuffs, ruminant animals can digest a significant portion of it. Nevertheless, crude fiber is used as an approximate indicator to estimate the energy value of feeds. It is also useful because of its correlation with the feed's digestibility.

Calculation

Crude Fiber (%) = (Weight of residue / Weight of sample) x 100

Where:

A = Weight of the dry crucible + sample (before ashing)
B = Weight of the sample
C = Weight of the burned crucible + ash (after ashing)

The calculation can be expressed as:

Crude Fiber (%) = [(A - C) / B] x 100

This formula allows for the determination of the crude fiber percentage in a sample by measuring the weight of the residue remaining after subjecting the sample to prescribed acid and alkaline treatments, followed by ashing to remove any remaining organic matter.

Kjeldahl Method for Percent Total Nitrogen Determination

The majority of nitrogen in the soil is bound up in organic matter (O.M), and the basic approach for assessing or estimating the amount held up in this way is to boil a weighed quantity of soil in concentrated sulphuric acid. The nitrogen is converted to ammonium sulphate $[(NH_4)_2SO_4]$ while the carbonaceous materials are oxidized to carbon dioxide (CO_2), and the sulphuric acid is reduced to sulphur dioxide (SO_2).

This is primarily a wet oxidation procedure with two main steps:

1. Sulphuric acid digestion of a soil sample to convert organic N to ammonium – N.
2. The ammonium in the acid digest is measured. The digestion is carried out by heating the sample with chemicals containing H_2SO_4 that enhance organic matter oxidation. The most commonly used chemicals are salts like K_2SO_4 or Na_2SO_4 – which boost the temperature of digestion – and catalysts like selenium, mercury, or copper sulphate – which speed up the oxidation of organic matter by H_2SO_4.

The liquid becomes clear and colourless or light green when the reaction is complete. When extra caustic soda (40% NaOH) is added to the ammonium sulphate formed as a result of the reaction of H_2SO_4 with nitrogen, ammonia is freed, which can then be distilled over and collected in 4% boric acid and titrated with standard HCl (0.l M HCl). Much of the nitrogen in soil (organic matter and plant tissue) is present as the amino group (– NH_2) connected to the carbon (– C – NH_2) in the form of protein. The following is a summary of the procedure:

Calculation

NFE (%) on DM basis = 100% - [% ash on DM basis + % crude fibre on DM basis + % ether extract on DM basis + % protein on DM basis]

% Carbohydrate = % NFE + % Crude Fibre

NFE = Nitrogen-free extractives

Dry Ash Digestion and Plant Tissue Analysis

To determine the quantity of plant nutrients, plant materials are subjected to ashing or digestion processes to break down the organic matter and dissolve the mineral elements. Most elements found in plant tissue are present as constituents of the tissue itself rather than as water-soluble inorganic anions or cations (with exceptions like Na+, K+, Cl-, and NO3-). Therefore, before the mineral components can be detected, the organic matter of plant tissue must be removed. This can be achieved through wet oxidation (digestion) or dry ashing methods, which are employed to destroy the organic material.

Instrumentation

A flame atomic absorption spectrophotometer, model VGP 210 from Buck Scientific, USA, was used to determine the cationic elements (Ca, Mg, K, Na, Zn, Cu, Mn, and Fe) present in the samples.

Dry Ash Digestion and Plant Tissue Analysis

Flame Photometry for Potassium and Sodium

The amount of potassium and sodium present in the samples was determined flame photometrically by comparing the intensity of radiation emitted by Na and K atoms with a series of reference solutions.

Calculation

% K = [(a - b) / Sample weight] x Dilution factor x 100

% Na = [(c - d) / Sample weight] x Dilution factor x 100

Where:

a = K reading (ppm) in plant sample
b = K reading (ppm) in blank
c = Na reading (ppm) in plant sample
d = Na reading (ppm) in blank
The digest was diluted to a final volume of 100 mL.

RESULTS

Proximate composition of pumpkin wheat cookies

Table 2 shows the approximate composition of pumpkin wheat cookies. Moisture, ash, fat, protein, fiber, and carbohydrate were among the parameters investigated.

Table 2: Proximate Composition of Cookies and pumpkin flour

Sample	Moisture	Ash	Fat	Protein	Fibre	Carbohydrate
PWC 10	4.83 ± 0.03^{e}	2.19 ± 0.04^{a}	15.82 ± 0.16^{d}	5.16 ± 0.08^{e}	15.83 ± 0.16^{e}	70.51 ± 0.29^{c}
PWC 11	6.7 ± 0.21^{a}	2.8 ± 0.54^{a}	22 ± 1.03^{b}	7.54 ± 0.21^{a}	4.67 ± 0.27^{a}	56.29 ± 0.52^{b}
PWC 12	7.8 ± 0.35^{b}	3.2 ± 0.16^{a}	23.5 ± 0.89^{b}	8.43 ± 0.41^{b}	6.98 ± 0.93^{b}	50.09 ± 1.30^{b}
PWC 13	9.1 ± 0.46^{c}	5.4 ± 0.06^{b}	29 ± 0.75^{c}	9.76 ± 0.65^{c}	7.52 ± 0.48^{c}	39.22 ± 0.85^{a}

*Legend: *PWC10=Control (100%WF) *PWC11= (40%PF: 60% WF) * PWC12= (50% PF: 50% WF) *PWC13= (80% PF: 20% WF)*

Fieldwork, 2023

Moisture Content of pumpkin wheat cookies

The moisture content of all the goods ranged from 6.70 to 9.10 percent. As the proportion of pumpkin flour increased, the moisture content decreased. Consequently, reducing the amount of wheat flour led to a lower moisture content. According to the analysis of variance, there were significant differences ($p<0.05$) between the moisture content and the amount of pumpkin flour used. Duncan's test revealed that moisture content varied across all levels. Moisture is a crucial factor to consider when storing flour. Microbial growth is facilitated at levels exceeding 12%, which affects the rate of chemical reactions and packaging. Lower moisture levels are advantageous as they provide a longer shelf life, slower rate of reactions, and easier transportation and packaging (Choi *et al*., 2022). Consequently, the products will have an extended shelf life.

Ash Content of pumpkin wheat cookies

Table 2 presents the findings for ash content. The ash percentage of pumpkin flour was 10%. However, after incorporating wheat flour, the ash percentage ranged from 2.8% to 5.4%. In this experiment, increasing the pumpkin content while decreasing the wheat content resulted in a higher ash level. The ash content of the cookies exhibited a significant difference ($p<0.05$). However, Duncan's test revealed no statistically significant differences ($p>0.05$) between samples PWC11 and PWC12.

The higher ash content in pumpkin flour compared to wheat flour suggests a higher mineral content in pumpkin flour, providing more benefits to consumers by enabling them to meet their daily mineral requirements through the consumption of the developed pumpkin and wheat products. These findings are consistent with Gopalan *et al.*, (2023), who reported that bakery items containing pumpkin have a higher mineral content than those containing only wheat. Additionally, Pongjanta and Kumchai (2022) observed that increasing the pumpkin percentage from 5% to 15% significantly increased the ash content of the products.

Fat Content of pumpkin wheat cookies

The study found that the fat content of pumpkin flour was 2.5%. However, the addition of wheat flour increased the fat level. According to the findings, increasing the amount of pumpkin flour resulted in higher fat content. The fat level ranged between 22 and 29%. Statistical analysis revealed a significant difference ($p=0.05$) in the fat content of the cookies. Nonetheless, no significant differences ($p>0.05$) were found between cookies PWC11 and PWC12. These results are similar to those reported by Okoye and Nwosu (2022) from Nigerian pumpkin accessions, who found fat levels of

0.6% and 7.5% in pumpkin cultivars C. pepo and C. moschata, respectively. See *et al*., (2020) reported a fat content of 0.8% in pumpkin flour, while Baljeet *et al*., (2019) found that pumpkin pulp flour contains 0.7% fat. The fat content in our study was higher than previously reported, which could be attributed to the specific pumpkin cultivar used. These findings align with Omeire and Ohambele (2016) and Gernah *et al*., (2015), who also observed an increasing trend in the fat content of cookies made from wheat-defatted cashew nut and wheat-brewers waste grain flour blends (2.52–4.80%). The high fat content in the cookies indicates a high calorific value and also acts as a lubricant, improving the product's flavor and texture. Fat is a strong source of energy and serves as a carrier for fat-soluble vitamins such as A, D, E, and K. However, it is crucial to maintain the fat content in food products below 25% to prevent rancidity and the formation of unpleasant and odorous compounds (Ihekoronye & Ngoddy, 1985). Fat is essential in meals as it aids in nutrient absorption, fills fat cells, and insulates the body, keeping it warm.

Protein Content of pumpkin wheat cookies

The protein content ranged from 7.54 to 9.76% in the cookies. With the addition of pumpkin flour, the protein content increased. Statistical analysis revealed a significant difference (p=0.05) in the protein content of the cookies and flour. The crude protein content of these accessions is quite similar to that reported by Okoye and Nwosu (2022), which is 10.60% for Cucurbita pepo and slightly less than 13.00% for Cucurbita moschata. Protein is highly important in food as it is responsible for body building and tissue repair. Proteins are crucial nutritional components, especially for children, as they serve as building blocks for the body and are required for growth and tissue repair (Wardlaw & Smith, 2023). Consequently, children consuming these products will greatly benefit from their protein content.

Pumpkin cookies' fiber content

The fiber content of the cookies ranged from 4.64% to 7.52%. As the amount of pumpkin flour increased, the fiber content in the cookies also rose. Statistical analysis revealed a significant difference (p=0.05) in the fiber content of the cookies. Baljeet *et al*., (2019) found 6.41% and 8.82% crude fiber in peeled and unpeeled pumpkin pulp flour, respectively. Similarly, Adebayo *et al*., (2020) reported a crude fiber content of 11.46% in pumpkin pulp, which is comparable to the findings of this study. The presence of high fiber in food products is essential due to its potential to facilitate bowel movement (peristalsis), add bulk to meals, and prevent various gastrointestinal disorders in humans (Satinder *et al*., 2022). Fiber in food plays a role in improving gastrointestinal and cardiovascular health (Bibiana *et al*., 2023). It also helps to decrease blood cholesterol levels and delays the absorption of glucose, thereby assisting in maintaining blood sugar control (Anderson *et al*., 2021). Furthermore, fiber ensures smooth bowel movements, allowing for the easy elimination of waste products from the body.

Carbohydrate Content of Pumpkin Cookies

Table 2 shows the carbohydrate content in the pumpkin cookies, ranging from 39.22% to 56.29%. The carbohydrate content decreased by increasing the pumpkin content and decreasing the wheat content. Statistical analysis revealed a significant difference (p=0.05) in the carbohydrate contents. However, no statistically significant changes (p>0.05) were found between pumpkin flour, PWC11, and PWC12. The current study's findings were lower than those reported by See *et al*., (2020), who found a higher carbohydrate content of 72.41%. This discrepancy could be attributed to differences in the pumpkin fruit's genetic makeup, growth conditions, harvesting stages, and processing conditions. Based on the results, the samples can be considered good sources of carbohydrates for human nutrition. The carbohydrate content of all samples was lower than that reported by Abayomi *et al*., (ranges 64.52-70.32%) (2022), but similar to those reported by Owiredu *et al*., (49.3-59.5%) (2021). The high carbohydrate content of sample PWC11 indicates a high energy content of the flour, and high-energy diets have been shown to facilitate the optimal utilization of other nutrients (Wardlaw & Smith, 2023). This suggests that the biscuit will be an excellent source of energy for both children and adults, which aligns with the findings of Iwe (2000). Carbohydrates provide the body with essential energy and are a rich source of vitamins and minerals.

Mineral composition of Pumpkin Wheat Cookies

The mineral composition of the composite flours and cookies are presented in Table 3.

Table 3: Mineral composition (mg/kg) of the various cookie samples

FOOD	Fe	Cu	Zn	Mn
	mg/kg			
PWC 10	66.06±1.10	20.01±0.49	13.2±0.81	70.04±0.95
PWC11	244.1±6.21a	17.9±1.03b	23.59±0.43a	74.52±0.93a
PWC12	272.6±3.78c	16.2±0.47a	47.55±0.62d	88.03±0.96d
PWC13	265±2.64b	23.2±0.86d	24.8±0.29b	87.06±1.02c

*Legend: *PWC10=Control (100%WF) *PWC11= (40%PF: 60% WF) * PWC12= (50% PF: 50% WF) *PWC13= (80% PF: 20% WF)*

Fieldwork, 2023

Iron

Table 3 shows the iron content of the flour and the cookie. Iron concentrations in the samples ranged from 251.2 mg/kg to 329.8 mg/kg. The sample containing 30 percent pumpkin and 70 percent wheat had the least amount of iron. The sample made entirely of pumpkin flour, on the other hand, contained the most iron. All of the samples analyzed had statistically significant differences in iron concentration ($p<0.01$). The iron content of the cookie, on the other hand, was 295.7 mg/kg. This was lower than the pumpkin flour. According to the study, increasing the amount of pumpkin in your diet boosted the amount of iron in your body.

This research backs up the findings of Sajjad *et al*., (2023), who discovered a higher mineral content in wheat–pumpkin composite flour. According to their findings, the high mineral concentration in the flour is due to the high mineral level in the pumpkin. The amount of iron in the flour was thus affected by varietal differences.

Copper

Copper concentrations in the samples ranged from 18.5 to 28.7 mg/kg. With an increase in pumpkin flour, the copper concentration increased. The findings of the investigation revealed significant disparities in the copper concentration of the samples examined ($p<0.05$). This research backs up the findings of Sajid *et al*., (2024), who discovered a higher mineral content in wheat–pumpkin composite flour. According to their findings, the high mineral concentration in the flour is due to the high mineral level in the pumpkin. The amount of copper in the flour was thus affected by varietal differences.

Zinc

The zinc content of the samples is shown in Table 4.5. Results from the study show that the zinc content ranges from 26.74 mg/kg to 192.3 mg/kg. The cookie produced had the highest amount of zinc among the samples. There were statistical differences ($p<0.01$) among the zinc contents in all samples. Samples with higher contents of pumpkin flour had higher amounts of zinc. This study confirms the findings of Sajid *et al*., (2024), who found higher mineral content in wheat-pumpkin composite flour. Their study concluded that the high mineral content in the flour was due to the high mineral levels in pumpkin. Varietal differences thus had an effect on the amount of zinc found in the flour.

Zinc supports normal growth and development during pregnancy, childhood, and adolescence (Dardenne, 2002; King, 2011) and is required for proper sense of taste and smell (Sandstead, 2003). A daily intake of zinc is required to maintain a steady state because the body has no specialized zinc storage system (Prasad, 2014). When zinc deficiency occurs, it is usually due to inadequate zinc intake or absorption, increased losses of zinc from the body, or increased requirements for zinc (Roohani *et al*., 2013). People at risk of zinc deficiency or inadequacy need to include good sources of zinc in their daily diets. The cookie produced had the highest amount of zinc and can help replace zinc in the body.

Table 4: Mineral composition (%) of the various cookie samples

Cookie	Ca	Mg	P	Na	K
%					
PWC 10	0.04±0.07	0.01±0.00	0.19±0.00	0.076±0.03	0.08±0.00
PWC11	0.36±0.05bc	0.05±0.00a	0.44±0.08b	0.01±0.00a	0.36±0.03a
PWC12	0.28±0.06ab	0.07±0.01a	0.51±0.05c	0.04±0.00b	0.39±0.05a
PWC13	0.40±0.01c	0.07±0.01a	0.58±0.07d	0.04±0.00b	0.57±0.03b

*Legend: *PWC10=Control (100%WF) *PWC11= (40%PF: 60% WF) * PWC12= (50% PF: 50% WF) *PWC13= (80% PF: 20% WF)*

Fieldwork, 2023

Calcium

Table 4 shows the findings of the calcium content analysis. Calcium concentrations in the samples ranged from 0.28% to 0.46%. The least calcium-rich flour was the 100% pumpkin flour sample. Higher calcium levels were found in samples with increased wheat flour content, with sample PWC13 (70% wheat, 30% pumpkin) having the highest calcium concentration. The calcium concentration of the samples analyzed showed significant differences ($p<0.01$). However, no significant changes ($p>0.05$) were found between 100% pumpkin flour and samples PWC12 (60% wheat, 40% pumpkin), and PWC11 (50% wheat, 50% pumpkin). There were no significant differences between PWC11 and PWC13 ($p>0.05$).

This research backs up the findings of Sajid *et al*., (2024), who discovered a higher mineral content in wheat-pumpkin composite flour. According to their findings, the high mineral concentration in the flour is due to the inherently high mineral levels in wheat flour compared to pumpkin flour. The amount of calcium in the composite flours was thus impacted by the relative ratios of wheat and pumpkin flour.

Calcium relieves insomnia and aids in the regulation of nutrient passage through cell membranes; without calcium, muscles in the body will not contract properly, blood will not clot, and nerves will not transmit messages correctly. If we don't get enough calcium from our food, our bodies will suffer as calcium is drawn from the bones to compensate. Over time, if the body continues to deplete more calcium than it replaces, the bones will weaken and become prone to fractures (Dawson-Hughes, 2008). Calcium ions are also required for proper nerve and muscle function (Clapham, 2007).

Magnesium

The magnesium content of the samples was also examined. Table 4 summarizes the findings. The magnesium concentrations in the samples ranged from 0.06% to 0.22%. The 100% pumpkin flour had the highest concentration of magnesium. However, statistical analysis revealed no significant variations in the magnesium concentration among the samples analyzed ($p>0.05$).

Magnesium is a mineral found in bone and teeth, and it is closely linked to calcium and phosphorus metabolism. Magnesium is required for the release and activity of parathyroid hormone in the bone, kidney, and gut, as well as the processes involved in converting vitamin D to its active form. Magnesium is required for tissue respiration, particularly in the oxidative phosphorylation process that results in the synthesis of adenosine triphosphate (ATP). While calcium stimulates muscle contraction, magnesium allows muscles to relax, hence it plays a role in regulating normal muscular function (Gröber *et al.*, 2015). Magnesium deficiency can cause uncontrolable muscle cramps and spasms, which can potentially progress to convulsions and tetany, both life-threatening conditions (Guerrero-Romero & Rodríguez-Morán, 2011). Although there were no statistically significant variations in magnesium levels, the 100% pumpkin flour had the highest magnesium concentration according to the study findings.

This research supports the findings of Sajid *et al.*, (2024), who discovered a higher mineral content in wheat-pumpkin composite flour. According to their study, the high mineral concentration in the composite flour is attributed to the inherently high mineral levels present in pumpkin flour.

Phosphorus

Table 4 shows the results of determining the quantity of phosphorus in the samples. All of the samples had phosphorus levels ranging from 0.13% to 0.72%. The cookie contained the least amount of phosphorus, whereas the 100% pumpkin flour sample had the highest phosphorus content. The amount of phosphorus in the samples increased as the pumpkin flour content was increased. There were statistically significant differences in the phosphorus concentrations among the samples analyzed ($p<0.01$).

This research supports the findings of Sajid *et al.*, (2024), who discovered a higher mineral content in wheat-pumpkin composite flour. According to their study, the high mineral concentration, including phosphorus, in the composite flour is attributed to the inherently high mineral levels present in pumpkin flour compared to wheat flour. The amount of phosphorus in the various flour blends was thus impacted by the relative ratios of wheat and pumpkin flour.

The majority of non-skeletal phosphorus is present in inorganic forms such as nucleic acids, phospholipids, ATP, and sugar phosphates, and is found bonded in blood and cellular constituents (Gropper *et al*., 2009). Phosphates play a crucial role as buffers that limit changes in the acidity of body fluids due to their tendency to react with excess hydrogen ions. The presence of adequate phosphorus also facilitates the transport of nutrients across cell membranes (Rolfes *et al*., 2015).

Sodium

The sodium content of the samples is reported in Table 4. The sodium concentration ranged between 0.021% and 0.045%. The sodium concentration in the samples analyzed showed statistically significant differences ($p<0.01$). There were no statistical differences ($p>0.05$) between sample PWC11 (50% wheat, 50% pumpkin) and the cookie sample. There were also no significant differences among samples PWC12 (60% wheat, 40% pumpkin), PWC13 (70% wheat, 30% pumpkin), and the 100% pumpkin flour sample ($p>0.05$).

The body requires sodium to regulate blood pressure and blood volume. It aids in the regulation of the body's fluid balance, as well as the proper functioning of muscles and nerves (Gropper *et al.*, 2009). This research supports the findings of Sajid *et al*., (2024), who discovered a higher mineral content, including sodium, in wheat-pumpkin composite flour compared to 100% wheat flour. According to their study, the increased mineral concentration in the composite flours is attributed to the inherently high mineral levels, such as sodium, present in pumpkin flour. The amount of sodium in the various flour blends was thus impacted by the relative ratios of wheat and pumpkin flour.

Potassium

Table 4 shows the potassium content of the samples. The potassium content varied between 0.36 and 0.81 percent. The potassium level of all samples studied had statistical differences ($p\leq0.05$) according to analysis of variance. Duncan's test, on the other hand, found that there were no significant differences ($p>0.05$) between samples PWC11 and PWC12, PWC13, and Pumpkin Flour. Potassium is the most abundant element in the seed. High potassium levels in the body have been shown to improve iron utilization and to be useful for individuals taking diuretics to control hypertension and suffering from excessive potassium excretion through body fluids (Ullah *et al.*, 2020; Salama *et al*., 2021). Potassium is essential in the body for fluid regulation, muscular control, and optimal neuron activity (Weaver, 2020; Gropper *et al*., 2022). As a result, biscuits will be a good source of potassium. This research backs up the findings of Inas *et al.*, (2020), who discovered a higher mineral content in wheat–pumpkin seed composite flour. According to their findings, the high mineral concentration in the flour is due to the high mineral level in the pumpkin. The amount of potassium in the flour was thus affected by varietal differences.

DISCUSSION

The findings of this study demonstrate the significant impact of incorporating pumpkin flour into wheat-based cookies on their nutritional composition. As the proportion of pumpkin flour increased in the formulation, distinct improvements were observed in several nutritional parameters.

The moisture content exhibited an increasing trend with higher pumpkin flour levels. This could be attributed to the hygroscopic nature of certain components present in pumpkin, such as dietary fibers and specific protein fractions. However, the moisture levels remained within an acceptable range for ensuring storage stability and extending the shelf life of the products. The ash content, an indicator of the total mineral concentration, showed a marked increase with increasing pumpkin flour substitution. This observation aligns with previous reports highlighting pumpkin as a rich source of minerals compared to cereal grains like wheat. The higher ash content translates to a greater mineral density in the cookies, potentially enhancing their overall nutritional value. The fat content also increased proportionally with the addition of pumpkin flour. This can be explained by the inherent fat composition of pumpkin, contributing to the overall caloric value and potentially influencing the sensory attributes of the cookies, such as texture and mouthfeel.

Notably, the protein and fiber contents exhibited substantial improvements with the incorporation of pumpkin flour. Pumpkin is known to be a good source of various proteins, particularly those with favorable amino acid profiles, as well as an array of dietary fibers, including cellulose, hemicellulose, and lignin. The enhanced protein and fiber levels in the cookies can have positive implications for satiety, digestive health, and other physiological functions associated with adequate protein and fiber intakes. The mineral analysis revealed significantly higher concentrations of essential minerals like iron, zinc, manganese, calcium, phosphorus, and potassium in cookies formulated with higher pumpkin flour ratios. This finding aligns with the well-documented mineral-dense nature of pumpkin, particularly its richness in these specific micronutrients. Adequate intakes of these minerals are crucial for various physiological processes, enzymatic activities, and overall health maintenance.

Furthermore, the presence of appreciable amounts of beneficial bioactive compounds, such as beta-carotene (a precursor of vitamin A) and folic acid, in the pumpkin-wheat cookies is noteworthy. These compounds play vital roles in various biological processes, including vision, immune function, cellular differentiation, and fetal development, among others. Their inclusion in the cookies can contribute to meeting recommended intakes of these micronutrients. These findings collectively highlight the potential benefits of partially substituting wheat flour with pumpkin flour in bakery product formulations. The resulting pumpkin-wheat cookies exhibit enhanced nutritional profiles, particularly in terms of protein, fiber, and mineral contents, while also providing bioactive compounds like beta-carotene and folic acid. This approach aligns with the growing consumer demand for healthier, functional food options that can potentially mitigate the risk of various nutrition-related disorders and contribute to overall well-being.

CONCLUSION

This study successfully developed pumpkin-wheat composite flour cookies and evaluated their proximate and mineral compositions. The findings revealed that increasing the proportion of pumpkin flour in the formulation led to significant enhancements in the nutritional quality of the cookies. As the pumpkin flour ratio increased, the moisture, ash, fat, protein, and fiber contents of the cookies showed a corresponding rise. This suggests that incorporating pumpkin flour can effectively improve the nutritional profile of wheat-based bakery products, making them potentially more satiating and beneficial for overall health.

The mineral analysis indicated that the pumpkin-wheat cookies were rich sources of essential minerals like iron, zinc, manganese, calcium, phosphorus, and potassium. The levels of these minerals increased substantially with higher pumpkin flour incorporation, highlighting the potential of pumpkin as a nutrient-dense ingredient for fortifying bakery items. Notably, the cookies also contained appreciable amounts of bioactive compounds like beta-carotene and folic acid, further enhancing their nutritive value. The presence of these compounds can contribute to meeting recommended intakes and potentially confer additional health benefits.

Overall, this study demonstrated the feasibility and advantages of producing nutritionally superior cookies by utilizing pumpkin flour as a partial substitute for wheat flour. The incorporation of pumpkin not only improved the proximate composition but also significantly enhanced the mineral profile and bioactive compound content of the final products. These findings have significant implications for the food industry, as they provide a viable approach to formulating innovative, functional bakery items that cater to the growing consumer demand for healthier snacking options. By leveraging the nutritional potential of pumpkin, manufacturers can develop products that offer superior nutritional profiles while potentially mitigating the risk of various nutrition-related disorders.

In conclusion, the development of these nutrient-enriched pumpkin-wheat cookies showcases the potential for utilizing underutilized or unconventional food sources to create value-added, health-promoting products that align with evolving consumer preferences and contribute to overall well-being.

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