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Nutritional evaluation of fortified bread from soy-cheese, pineapple and wheat blends

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Abstract: Fortified foods have shown significant benefits, particularly in reducing the prevalence of nutrient-related diseases like iron deficiency anemia, vitamin A deficiency, and calcium insufficiency. Bread, a staple food in many diets worldwide, has emerged as a particularly effective vehicle for fortification due to its wide consumption and adaptability to nutrient enhancement. The aim of this study is to investigate the nutritional evaluation of fortified bread from soy-cheese, pineapple rind and wheat blends. Pineapple rind was prepared and soy-cheese was made by sorting and cleaning soybeans, followed by drying, milling, and sifting to produce flour. Bread samples were then prepared using a blend of wheat flour, soy- cheese flour, and pineapple rind in the following ratios: 91:5:4, 82:10:8, 73:15:12, and 64:20:16. A control bread sample was made from 100% wheat flour. All bread samples were analyzed for mineral, vitamin, and proximate composition. The incremental addition of soy cheese and pineapple rind led to notable improvements in the levels of calcium (74mg/100g) and iron (13 mg/100g), while also increasing the vitamin content, especially thiamine (2.25 mg/100g) and riboflavin (2.09 mg/100g) compared to 100% wheat sample. The proximate composition also showed an increase in protein (22.46 g/100g) and fiber (3.19 g/100g) content in the fortified samples. The fortification of wheat bread with soy cheese and pineapple rind offers a viable strategy for improving the nutritional value of bread while providing functional benefits.

1. Introduction

Bread has been a staple food in many civilizations for thousands of years because of its convenience, nutritional content, and diversity. It is still an important element of the diet in many countries, supplying necessary minerals and energy. Bread is a high-carbohydrate food that the body uses as its primary energy source. Whole grain breads include complex carbs,

which are slowly digested, providing prolonged energy and aiding in the maintenance of normal blood glucose levels [1]. Aside from carbohydrates, bread contains dietary fiber, which is vital for digestive health and can lower the risk of cardiovascular disease. Bread also contains essential vitamins and minerals such as B vitamins (thiamine, riboflavin, niacin, and folate) and minerals including iron, magnesium, and selenium, all of which promote general health [2]. Bread is a reasonably inexpensive and commonly available dietary item for many individuals, particularly those with modest incomes. Its cost assures that it can provide a significant share of daily caloric and nutrient requirements. Bread's adaptability enables it to be used into a variety of meals, increasing nutritional diversity and guaranteeing consistent nutrient consumption [3]. Bread has long played an important role in human diets. For example, in Ancient Egypt, bread was a daily staple consumed by all socioeconomic strata and frequently used as a kind of money for laborers. The Egyptians' diet was mainly based on bread prepared from barley or emmer wheat, which provided them with the nutrients and energy they need for their physically demanding jobs [4].

Despite its nutritional benefits, traditional bread may not contain all of the critical components needed for good health. Many people around the world suffer from nutritional inadequacies as a result of a lack of access to a variety diet. Common shortages include iron, iodine, vitamin A, and zinc, which can cause anemia, developmental disorders, and decreased immune function [5]. Bread fortification is an effective strategy for addressing these inadequacies. By incorporating nutrients such as iron, folic acid, and vitamin D into bread, it is feasible to boost the population's nutritional intake without needing large dietary modifications. Fortified bread can help avoid diseases caused by vitamin shortages while also improving general health.

Soy-cheese, commonly known as soy-based cheese or tofu cheese, is a dairy-free cheese substitute manufactured from soybeans. It is made by curdling soy milk generated from soybeans and pressing the resulting curds into a cheese-like consistency. Soy cheese is a flexible product that comes in a variety of textures and flavors, from soft and spreadable to firm and sliceable, making it suited for a wide range of culinary applications [6]. Soy cheese is high in quality protein, containing all of the essential amino acids required for human health. Soy protein composition is equivalent to that of animal proteins, making it a good choice for vegetarians, vegans, and lactose intolerant individuals. Furthermore, soy cheese is low in saturated fat and cholesterol, which promotes cardiovascular health [7]. It also contains vital elements like calcium, iron, magnesium, and numerous B vitamins, which improve its nutritional profile. Incorporating soy cheese into bread increases its protein value and supplies critical amino acids, which are frequently lacking in traditional bread. This makes the bread a more complete protein supply, which is good for muscle maintenance and repair. The addition of soy cheese also provides important phytochemicals such

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isoflavones, which have been linked to lower risk of heart disease and certain malignancies [7]. Furthermore, soy-cheese fortification can boost the bread's overall nutritional value by providing minerals and vitamins that promote improved health [6].

Pineapple rind is the pineapple fruit's outer skin, which is normally discarded during pineapple processing. The rind, on the other hand, includes vital nutrients and bioactive components like as dietary fiber, vitamins (particularly vitamin C), and phenolic compounds. Pineapple rind contains bromelain, an enzyme renowned for its anti-inflammatory and digestive health benefits. The use of pineapple rind in food products can considerably increase their nutritional value. Pineapple rind contains dietary fiber, which assists digestion, promotes bowel health, and may decrease cholesterol levels [8]. Pineapple rind contains a high concentration of vitamin C, which functions as a powerful antioxidant, protecting the body from oxidative stress and strengthening the immune system. Pineapple rind contains phenolic chemicals with health advantages, such as anti-inflammatory and anticancer characteristics. Adding pineapple rind to bread greatly improves its dietary fiber content, which promotes digestive health and may lower the risk of cardiovascular disease [8]. The high vitamin C concentration in the rind increases the bread's antioxidant potential, giving additional health benefits such as improved immune function and free radical protection. Pineapple rind contains phenolic chemicals that enhance the health benefits of fortified bread compared to conventional bread

Bread enhanced with soy cheese and pineapple rind has various advantages over ordinary bread. It has a better balanced nutrient profile since it contains high-quality protein and necessary amino acids from soy cheese, as well as added dietary fiber, vitamins, and antioxidants from pineapple rind. This combination is more successful at addressing common nutritional inadequacies than regular bread [6, 8]. Furthermore, increased vitamin content can benefit general health by improving muscle function, digestive health, and immune support. Including bioactive chemicals like isoflavones and phenolics enhances health benefits, including anti-inflammatory and anticancer capabilities [7]. Furthermore, using pineapple peel in bread fortification enhances sustainability by minimizing food waste and making better use of available resources, which is consistent with global initiatives to establish more sustainable food systems. As such the research is aimed at investigating the nutritional evaluation of fortified bread from soy-cheese, pineapple rind and wheat blends. However, despite the growing interest in functional bread formulations, there is still a notable gap in the literature regarding the combined utilization of soy-cheese and pineapple rind in composite flours for bread making. Most previous studies have focused on single fortification strategies or individual by-products, with limited research exploring their synergistic effects on the nutritional, functional, and sensory properties of bread. This study specifically addresses this gap by evaluating the nutritional potential of composite bread prepared from soy-cheese, pineapple rind, and wheat blends.

2. Methodology

2.1 Preparation of Pineapple rind

The Pineapple purchased was peeled and cut into smaller pieces. They were oven-dried at 600C. They were allowed to cool before milling into a powder form. The grounded fine powder was sieved through 250µm mesh size to obtain uniform particle. They were stored in a cool and dry place until needed for further analysis.

2.2 Production of Soy-cheese flour

Soybeans were soaked in boiled water for 1 hour, dehulled and mechanically milled into a paste. The paste was sieved through a 500µm mesh size, 2% lime was added and cooked to coagulate protein. The coagulated protein was pulverized and dried in hot air oven (MIDO/2/SSIF) at 600C for 24 hours. The dried cheese was milled with attrition mill and sieved through a 500µm mesh size sieve. The flour was packed in a close container and kept in a cool and dry place at room temperature until needed for further analytical work.

Table 1. Composition of samples

Samples	Wheat (%)	Soy-cheese (%)	Pineapple rind (%)
91%W+5%S+4%P	91	5	4
82%W+10%S+8%P	82	10	8
73%W+15%S+12%P	73	15	12
64%W+20%S+16%P	64	20	16
100W	100	-	-

W-wheat; S-soy-cheese; P-pineapple rind.

2.3 Bread Production

Dough was formed by mechanically mixing flour and all other ingredients in the appropriate amounts. A duration of two and a half hours (2 ½ hours) was given to the dough for fermentation. Once this duration had passed, the fermented dough was divided into pieces using a knife, mechanically mixed for an additional five minutes, and left to ferment for an additional one and a half hours. Each baking pan was filled with the dough after it had been divided into equal portions, rolled into a ball, and then shaped into sausage-shaped pieces. 45 minutes of 380C proofing and 45 minutes of 2200C baking were completed in an oven. Following cooling, the baked goods were packaged and kept in a dry, cool environment.

2.4 Determination of Moisture content

Dry matter was determined by oven drying at 105C to a constant weight. 5g of sample was weighed into a pre-weighed dry dish and kept in oven adjusted at 105C. After 6 hours, the sample was withdrawn, cooled in a desiccator and reweighed.

Moisture content of each sample were determined using standard methods [9].

2.5 Determination of Crude protein content

The sample (5 g) was combined with 15 g of potassium sulphate (K_2SO_4), 0.7 g of mercuric oxide (HgO), and copper sulphate (CU_2SO_4) as a catalyst and digested in a long necked Kjeldhal bottle with 40 ml of concentrated sulfuric acid for approximately 2 hours. Distilled water (200 mL) and 25 mL of sodium thiosulphate solution (80 g/L) were added. The contents of the digestive flask were combined and boiled until at least 150ml distilled into the receiver. Before titrating with 0.1 M sodium hydroxide, add five (5) drops of methyl red indicator solution (0.5 g/100 mL ethanol). To calculate the protein content, the percentage nitrogen obtained was multiplied by a conversion factor (6.25).

2.6 Determination of Crude Fat

This was completed using the Soxhlet method. Five grams (5 g) of sample were weighed into a small porcelain bowl and heated in an oven at 1050 degrees Celsius for one hour. After cooling, the dry samples were placed in a Soxhlet thimble. The samples in the thimble were then covered with glass wool and placed in a pre-weighted dry and clean fat extraction flask. The flask was then placed in the extraction unit with approximately 300 ml of petroleum ether (boiling point 40 - 600C) and allowed to reflux for six hours. Finally, the petroleum ether was evaporated from the flask, which was then dried in an oven at 1050C for about an hour before being transferred to a desiccator to cool. The weight increase of the flask was calculated as corresponding to the fat content.

2.7 Determination of Ash content

Ash content was determined by heating 5 g of the sample in a clean, dry crucible. This was charred over a Bunsen flame in a fume cupboard to eliminate the majority of the organic matter. The heated sample was then heated in a muffle furnace at 5000C for about 3 hours, until white ash remained. The heated sample was then allowed to cool in a desiccator and weighed again. The ash were determined using standard methods [9].

2.8 Determination of Crude Fibre content

The crude fiber content was determined by boiling a 5g defatted sample in sulphuric acid and sodium hydroxide. The defatted 5g sample was treated with light petroleum hydroxide (approximately 0.1313 N in 200mL NaOH). Sulphuric acid was used to disperse the samples. The mixture was brought to a boil in one minute (using a Liebig reflux condenser). The whole insoluble material was transferred to the filter paper using dilute hydrochloric acid. The final

residue was filtered through a Buckner funnel that was lined with pre-weighed filter paper and connected to a vacuum pump. The insoluble matter transferred to the weighed filter paper was dried at 1000 degrees Celsius to achieve a constant weight. The filter paper content was incinerated to produce ash. Weight of the ash was subtracted from the increase weight of the paper and insoluble material. The difference in weight was reported as crude fibre

2.9 Determination of Carbohydrate

Total carbohydrates were determined as by difference (subtracting crude protein (%), moisture (%), fat (%), crude fibre (%), and ash (%) content of the samples from 100)

2.10 Determination of mineral content

Minerals in the samples were determined using an Atomic Absorption Spectrophotometer (Buck Scientific, Model 200A/200, Inc., East Norwalk, Connecticut, USA) at the appropriate wavelengths. Each sample's ash (1.0 g) was digested with HNO3 and HClO4 (3:1 v:v) and

2.0 ml of hydrogen peroxide. The flasks were heated to 250 °C. The filtrate was made up to 10 ml using ultrapure water (Milli-Q system, Millipore, USA). A flame photometer (Jenway PFP 7, Staffordshire, UK) was used to determine the amount of Na and K present. Metal standard solutions of 1000 μg/ml in 1% v:v HNO3 were used to calibrate atomic absorption spectroscopy.

2.11 Determination of vitamin B2 (Riboflavin)

A 250 ml volumetric flask was filled with 1 g of each sample, 5 ml of 5 NHCL, and 5 ml of dichloroethene after that. After shaking, water was added to deionize the mixture. To extract all the riboflavin, the entire sample was shaken well and heated for 30 minutes in a steam bath. After the mixture was cooled, deionized water was added to bring it up to volume. After filtering, the first 20 milliliters of the aliquot were discarded. A second 250 ml volumetric flask was pipetted with 2 ml of the obtained filtrate, and the remaining volume was filled with deionized water. By dissolving 0.05 mg of riboflavin in 100 milliliters of distilled water, a standard solution was created. To determine the equivalency, different standard solutions with concentrations ranging from 0 to 5 ppm were made from the information above. The Fluorescent Spectrophotometer was used to measure the absorbance at 460 nm for the standards and samples.

2.12 Determination of vitamin B3 (Niacin) and B6 (pyridoxine)

5g of sample was blended with 100ml of distilled water to dissolve any Nicotinic acid or Niacin present.5mL of this solution was drawn into a 100mL volumetric flask and diluted to the mark with distilled water. A Niacin stock solution ranging from 10 to 50 ppm was also prepared. The absorbance of the diluted stock solutions and sample extract was measured using a spectrophotometer at a wavelength of 385nm. To determine the Gradient Factor, different concentrations of standard stock solutions were measured for absorbance at the specified wavelength using a Spectrophotometer.

2.13 Statistical analysis

The differences between various levels of supplementation in bread were obtained by using statistically analysis. The comparisons were carried out by SPSS programmed.

3.0 Results and Discussion

The result of the mineral content of Soy-cheese, pineapple rind and wheat blend fortified bread is presented in table 2. The results for calcium content ranged from 17.55 mg/100g to 74.77 mg/100g with control sample having the lowest value while sample 64% wheat + 20% soycheese + 16% pineapples rind had the highest value. The increase in calcium can be attributed to Soy-cheese and pineapple rind, both of which are known for their calcium content. According to Messina et al. [10], soy-based products are rich in calcium, especially in fortified versions of Soy-cheese. Pineapple rind has also been reported to contribute significantly to calcium levels [11]. Additionally, the results for magnesium content ranged from 7.84 mg/100g to 24.07 mg/100g with control sample having the highest value while sample 73% wheat + 15% soycheese + 12% pineapples rind had the lowest value. This decrease can be explained by the fact that wheat is naturally high in magnesium. In contrast, Soy-cheese and pineapple rind may contain lower magnesium levels. In like manner, the results for potassium content ranged from 37.44 mg/100g to 103.85 mg/100g with control sample having the highest value while sample 73% wheat + 15% soycheese + 12% pineapples rind had the lowest value. This reduction in potassium is notable because wheat is naturally rich in potassium. The lower levels in Soy-cheese and pineapple rind fortification are likely because these ingredients, while offering other benefits, may not contribute substantial amounts of potassium. Furthermore, the results for phosphorus content ranged from 3.57 mg/100g to 110.31 mg/100g with control sample having the highest value while sample 73% wheat + 15% soycheese + 12% pineapples rind had the lowest value. The initial reduction could be due to the low phosphorus content in Soy-cheese and pineapple rind compared to wheat. However, the subsequent increase might result from bioavailability improvements in phosphorus due to Soy-cheese. More so, the results for iron content ranged from 1.48 mg/100g to 13.02 mg/100g with control sample having the lowest value while sample 91% wheat + 5% soycheese + 4% pineapples rind had the highest value. This significant enhancement in iron content through fortification aligns with findings from De and Goswami [12], who showed that soy-based products are rich in iron. Pineapple rind also contains moderate levels of iron and might contribute to this increase. The results for the Zinc content ranged from 0.34 mg/100g to 0.81 mg/100g with control sample having the highest value while sample 82% wheat + 10% soycheese + 8% pineapples rind had the lowest value. This trend can be explained by the dilution effect, as Soy-based product and pineapple rind are not significant sources of zinc [10].

Table 2. Mineral content of Soy-cheese, Pineapple rind and Wheat blend fortified bread

Samples	Ca (mg/100g)	Mg (mg/100g)	K (mg/100g)	P (mg/100g)	Fe (mg/100g)	Zn (mg/100g)
91%W+5%S+4%P	68.09 ± 0.29a	19.45 ± 0.09a	46.30 ± 0.21a	2.49 ± 0.07a	13.02 ± 0.12a	0.41 ± 0.00a
82%W+10%S+8%P	68.71 ± 0.31b	17.32 ± 0.09b	43.13 ± 0.10b	0.88 ± 0.30b	12.02 ± 3.09a	0.34 ± 0.00b
73%W+15%S+12%P	71.08 ± 0.26c	7.84 ± 0.01c	34.29 ± 0.09c	3.57 ± 0.01c	6.09 ± 0.05b	0.43 ± 0.00a
64%W+20%S+16%P	74.77 ± 0.14d	9.65 ± 0.14d	37.44 ± 0.15d	4.34 ± 0.00d	7.20 ± 0.15b	0.47 ± 0.00c
100W	17.55 ± 0.07e	24.07 ± 0.04e	103.85 ± 0.05e	110.31 ± 0.05e	1.48 ± 0.01c	0.81 ± 0.01d

Ca-calcium; Mg-magnesium;K-potassium;P-phosphorus;Fe-Iron, Zn-Zinc;W-wheat;S-soy-cheese;P-pineapple.Values are mean ± SD of duplicate samples. Same superscript letters on the same row are not significantly ($p>0.05$) different.

The vitamin content of Soy-cheese, pineapple rind and wheat blend fortified bread is as shown in table 3. The results for the thiamine content ranged from 0.13 mg/100g to 2.25 mg/100g with control sample having the lowest value while sample 64% wheat + 20% soycheese + 16% pineapples rind had the highest value. The high thiamine content in the fortified samples could be attributed to the significant amount of thiamine present in Soy- cheese. Soy-cheese is known to be a good source of B vitamins, especially thiamine [10]. Fortifying wheat flour with soy products is beneficial in enhancing thiamine content, which is essential for energy metabolism and nervous system function [13]. Previous study have shown that soy-based fortification of bread improves its vitamin content, enhancing its nutritional value [13]. Similarly, Riboflavin results content ranged from 0.04 mg/100g to 1.30 mg/100g with control sample having the lowest value while sample 82% wheat + 10% soycheese + 8% pineapples rind had the highest value. The increase in riboflavin content could be due to the presence of this vitamin in Soy-cheese, as soy products are known to be rich in riboflavin. Riboflavin is crucial for energy production and cellular function, and its presence in fortified bread improves the bread's overall nutritional value. Studies have shown that fortification with soy improves B2 content in bread, making it more suitable for populations with riboflavin deficiency [13]. Furthermore, the results for the pyridoxine content ranged from 0.05 mg/100g to 2.21 mg/100g with control sample having the lowest value while sample 91% wheat + 5% soycheese + 4% pineapples rind had the highest value. The high pyridoxine content in the samples could be due to the differential effect of pineapple rind, which is rich in pyridoxine, although studies on the pyridoxine content of fortified wheat bread is scarce. Following the same trend, the results for the niacin content ranged from 1.17 mg/100g to 1.53 mg/100g with sample 64% wheat + 20% soycheese + 16% pineapples rind having the lowest value while sample 82% wheat + 10% soycheese + 8% pineapples rind had the highest value. The high pyridoxine content in the samples could be due to the effect of pineapple rind, which is also rich in niacin. Studies on the niacin content of fortified wheat bread is however scanty.

Table 3. Vitamin content of Soy-cheese, Pineapple rind and Wheat blend fortified bread

Samples	B1 (thiamine) (mg/100g)	B2 (riboflavin) (mg/100g)	B6 (pyridoxine) (mg/100g)	Niacin (mg/100g)
91%W+5%S+4%P	1.99 ± 0.00a	1.23 ± 0.00a	2.21 ± 0.02a	1.24 ± 0.00a
82%W+10%S+8%P	2.08 ± 0.01b	1.30 ± 0.00b	1.99 ± 0.37ab	1.53 ± 0.38a
73%W+15%S+12%P	2.15 ± 0.00c	1.04 ± 0.00c	1.67 ± 0.00b	1.13 ± 0.00a
64%W+20%S+16%P	2.25 ± 0.00d	1.12 ± 0.01d	2.09 ± 0.00ab	1.17 ± 0.01a
100W	0.13 ± 0.00e	0.04 ± 0.00e	0.05 ± 0.01c	1.31 ± 0.01a

W-wheat;S-soy-cheese;P-pineapple. Values are mean ± SD of duplicate samples. Same superscript letters on the same row are not significantly (p>0.05) different.

Table 4 presents the proximate analysis result of Soy-cheese, pineapple rind and wheat blend fortified bread. The results for the protein content ranged from 11.07 g/100g to 22.46 g/100g with control sample having the lowest value while sample 64% wheat + 20% soycheese + 16% pineapples rind had the highest value. Soy-cheese is known for its high protein content, which explains the significant increase in protein as the proportion of Soy- cheese increases in the blends. Previous studies corroborate that soy-fortified bread significantly enhances protein content [14]. This increase in protein makes fortified bread an excellent alternative for individuals with higher protein needs, such as athletes or people with protein malnutrition. The findings align with those of Syed et al. [13], who reported similar increases in protein content with the incorporation of soybean in baked products. Similarly, the results for the ash content ranged from 0.90 g/100g to 3.19 g/100g with control sample having the lowest value while sample 64% wheat + 20% soycheese + 16% pineapples rind had the highest value. The addition of Soy-cheese and pineapple rind increases the mineral content of the bread, as soy and fruit-based ingredients are rich in minerals like calcium, magnesium, and potassium [10, 13]. Increased ash content suggests improved nutritional value, as minerals play essential roles in various metabolic processes. The results are in line with those from Prajapati et al. [14], who demonstrated that bread fortified with plant-based ingredients had higher ash content than traditional wheat bread. Following the same trend, the results for the fiber content ranged from 1.12 g/100g to 3.19 g/100g with control sample having the lowest value while sample 64% wheat + 20% soycheese + 16% pineapples rind had the highest value. The inclusion of fiber-rich ingredients like pineapple rind improves the functional properties of the bread, making it beneficial for consumers seeking higher fiber intake. Furthermore, the results for the fat content ranged from 1.39 g/100g to 4.35 g/100g with control sample having the lowest value while sample

73% wheat + 15% soycheese + 12% pineapples rind had the highest value. The higher fat content in soy-fortified bread highlights its role in improving the texture and flavor of bread. While the fat content increases, the inclusion of soy and pineapple also improves the bread's nutritional profile due to the presence of healthy fats. Also, the results for the moisture content ranged from 8.52 g/100g to 9.26 g/100g with sample 64% wheat + 20% soycheese + 16% pineapples rind having the lowest value while the control sample had the highest value. The similarity in moisture content indicates that fortification with Soy-cheese and pineapple rind does not significantly affect the water-binding capacity of the bread, which is important for its shelf life and texture. Studies suggest that the moisture content in fortified bread can be influenced by the water-absorbing properties of the ingredients used, though the difference observed in this case is minimal [15]. Additionally, the results for the carbohydrate content ranged from 58.37 g/100g to 76.03 g/100g with sample 64% wheat + 20% soycheese + 16% pineapples rind having the lowest value while the control sample had the highest value. The reduction in carbohydrate content is expected due to the lower carbohydrate content of Soy-cheese and pineapple rind compared to wheat flour. This finding is consistent with the results of other studies that have observed reduced carbohydrate levels in bread fortified with plant-based ingredients [10, 13].

Table 4. The proximate analysis of Soy-cheese, Pineapple rind and Wheat blend fortified bread

SAMPLES	Protein (g/100g)	Ash (g/100g)	Fiber (g/100g)	Fat (g/100g)	Moisture (g/100g)	CHO (g/100g)
91%W+5%S+4%P	11.88 ± 0.02a	1.33 ± 0.01a	1.77 ± 0.60ab	2.60 ± 0.00a	8.73 ± 0.41a	73.23 ± 0.47a
82%W+10%S+8%P	13.71 ± 0.40b	2.03 ± 0.02b	2.22 ± 0.29bc	2.17 ± 0.02b	8.88 ± 0.19a	70.76 ± 0.16b
73%W+15%S+12%P	17.84 ± 0.28c	2.50 ± 0.02c	2.78 ± 0.36c	4.35 ± 0.00c	8.64 ± 0.33a	63.63 ± 0.64c
64%W+20%S+16%P	22.46 ± 0.04d	3.19 ± 0.02d	3.19 ± 0.02c	4.28 ± 0.02d	8.52 ± 0.69a	58.37 ±0.79d
100W	11.07 ± 0.03e	0.90 ± 0.02e	1.12 ± 0.28a	1.39 ± 0.01e	9.26 ± 0.05a	76.03 ± 0.13e

W = Wheat, S = Soy-cheese, P = Pineapple rind, CHO-carbohydrate. Values are mean ± SD of duplicate samples. Same superscript letters on the same row are not significantly (p>0.05) different.

4. Conclusion

Fortifying wheat bread with soy cheese and pineapple rind significantly enhances its nutritional profile, particularly in terms of protein content, dietary fiber, and essential micronutrients. The incremental addition of soy cheese and pineapple rind in sample 64% Wheat + 20% Soycheese + 16% Pineapple rind led to notable improvements in the levels of calcium, iron, and zinc, while also increasing the vitamin content, especially thiamine (B1) and riboflavin (B2). The proximate composition also showed an increase in protein and fiber content in the fortified sample (64% Wheat + 20% Soycheese + 16% Pineapple rind), which can have significant health implications, including improved satiety, better digestion, and enhanced muscle health. Moreover, the enhanced mineral content in the fortified bread, especially iron and zinc, highlights its potential to combat micronutrient deficiencies, particularly in regions where bread is a staple food. Further research is however recommended to assess the long-term health impacts and consumer acceptability of such fortified products.

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