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Professional paper

INVESTIGATION THE IMPACT OF LOCAL BEAN FLOUR ON THE NUTRITIONAL AND SENSORY PROPERTIES OF BISCUITS

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Abstract

Biscuits enjoy widespread popularity among diverse populations worldwide, including our country. These food items are crafted from soft wheat flour, boasting an enticing flavor and aroma for consumers. While they boast high sugar, fat, and energy content, they tend to lack in other nutritional values. Against this backdrop, the present study endeavors to augment the nutritional profile of biscuits. This is achieved by substituting wheat flour with locally sourced bean flour at varying proportions: 10%, 15%, 20%, 30%, and 40%. The study further aims to uphold or enhance sensory and textural attributes.
The analysis of nutritional components was conducted using established methods. Sensory evaluations were undertaken by a panel of 12 assessors, employing a scoring system ranging from 1 to 5 points, which were subsequently corrected using a correction factor. Additionally, textural properties were assessed using the TA. XT plus from Stable Micro Systems P-36.
Findings reveal that, on the whole, nutritional values of biscuits exhibit an increase with escalated proportions of bean flour, excluding carbohydrates, which experience a decline. For instance, biscuits with 40% bean flour (M5) exhibit heightened mineral and protein content. Conversely, those with 30% bean flour (M4) demonstrate elevated fat and invert sugar content. In terms of sensory attributes, biscuits with 10% bean flour (M1) display superior structural and mouthfeel qualities, accumulating a commendable total point score of 17.10. Of the textural properties scrutinized, biscuits with 20% bean flour (M3) showcase improved attributes like hardness, gumminess, chewiness, and resilience.
In conclusion, the incorporation of bean flour has a discernible impact on sensory and textural characteristics. Consequently, its addition is viable only up to a certain threshold—no more than 20%—to preserve the desired sensory and textural qualities in biscuit production

Keywords: bean flour, nutritional values, sensory properties, biscuits.

1. Introduction

Biscuits are one of the most popular cereal foods consumed all over the world and in our country, after bread. They are cheap food products with better shelf life, good taste, and ease of portability (Mbassi et al., 2022) they often contain substantial amounts of carbohydrates, fats, and energy but are poor in protein and other nutrients that contribute to poor nutritional quality (Akpapaunm&Darbe, 1994; Aloba, 2001). Since it is a food product suitable for eating, it becomes imperative to enrich these products with nutritionally valuable substances.

Good nutritional quality makes biscuits attractive for protein fortification and nutritional improvements, especially in child nutrition programs, for the elderly and low-income groups (Banureka & Mahendrn, 2009). Improvement of the nutritional quality of wheat-based biscuits through fortification with other materials from different plants has been investigated in several studies (Preedy et al., 2011), while legumes have received considerable attention (Ayo&Olawale, 2003).

The white bean a widely utilized legume in our country, it has high nutritional value, often consumed as a cooked food. The white bean (Phaseolus vulgaris) is characterized as an almost perfect food in terms of nutritional values because in its content there are high amounts of proteins, dietary fibers, prebiotics, group B vitamins, and different compositions of mineral matter (Lyimo et al., 1992; Geil et al., 1994). However, carbohydrates are the main components of the bean, accounting for an average of 55-65% of the dry matter, with polysaccharides as the main component (Campos-Vegar et al., 2013) and significant dietary fiber content. Among the essential amino acids, lysine is predominant; however, beans lack sulfur-containing amino acids. Combining wheat flour with bean flour can establish a favorable balance of essential amino acids, effectively addressing the challenge of malnutrition (Livingstone et al., 1993). Regarding mineral content, iron, phosphorus, magnesium, and manganese take the lead (Hughes, 1991).

While there are limited studies on biscuit production using bean flour (Bedier et al., 2021), numerous investigations have focused on the utilization of other legumes in biscuit production (Feyera, 2020; Okoye et al., 2008). Hence, this study endeavors to create biscuits with heightened nutritional value, alongside appealing sensory and textural attributes, by incorporating white beans at varying ratios.

2. Materials and methods

2.1. Materials: In the production of biscuits, wheat flour with a moisture content of 12.3%, protein content of 10.6%, wet gluten content of 26.3%, and ash content of 0.47% was employed. In order to improve the nutritional qualities of the biscuits, we used local bean flour in different percentages. Before usage, the beans were soaked in water for a durationon of hours, and then it was ground into flour, where we then replaced wheat flour with bean flour in different ratios ant that 10%, 15%, 20%, 30% and 40% (Table 1). Also, for the production of biscuits, we used light margarine, and that in each mixture was 125 g; sugar was 90g; sodium bicarbonate (sodium hydrogen carbonate) was 10g; and table salt was 2.0g.

Table 1. Mixtures created for the production of biscuits

Mixtures	Wheat flour (g)	Bean flour (g)	Water (ml)	Light margarine (g)	Sugar (g)	Sodium bicarbonate (g)	Salt (g)
M 0	500	-	210	125	90	10	2.0
M1	450	50	190	125	90	10	2.0
M2	425	75	160	125	90	10	2.0
M3	400	100	190	125	90	10	2.0
M4	350	150	150	125	90	10	2.0
M5	300	200	160	125	90	10	2.0

2.1.1. Production of biscuits: Biscuits according to the mixtures shown in Table 1 were produced in the laboratory of the Faculty of Food Technology and Nutrition at the University of Tetova. The production process initiated with the meticulous measurement of all constituent elements required for biscuit preparation. At first, bean flour was added to wheat flour and mixed, then margarine was added and mixed. Then water and sugar (dissolved) were added to the prepared mixture and mixed again, and finally sodium bicarbonate dissolved in water was added. After forming the dough, it is opened and shaped, placed on a baking tray that is covered with baking paper so that the biscuits do not stick, and baked in the baking oven in Memmert, Germany, at a temperature of 210°C for 20 minutes.

2.2. Methods: Physical and chemical analyses, alongside moisture determination, were conducted following established protocols. Moisture content was determined using the standard drying method at 130°C for a duration of 90 minutes. Mineral content was determined through incineration at 900°C for 2 hours using the Norbertherm apparatus. Protein content was assessed using the Kjeldal method as outlined in AOAC 920.87. Fat determination was achieved using the Soxhlet apparatus in accordance with AOAC 922.06 (AOAC, 2005). Carbohydrate content was calculated through the difference method (Eyeson & Ankrah, 1975).

Reducing sugars were evaluated using the Lane Eynon method in accordance with ISO 5377. Total energy (kcal/100g) was calculated using conversion factors of 9 for each gram of fat and 4 for each gram of carbohydrates and proteins. Sensory properties of biscuits such as appearance, texture, mouthfeel, aroma, taste, and overall total points were evaluated by 12 raters using the scoring method (1–5 points) and being corrected with the correction factor (Nakov et al., 2016). The texture of the biscuits was determined with the TA. XT plus device, Stable Micro Systems P-36, Godalming, UK. Texture refers to those qualities of a food that can be felt with the fingers, tongue, palate, or teeth. A texture analyzer implements this principle by performing the procedure automatically, measuring it, and reporting the result.
Statistical analysis was performed using SPSS statistical software (Version 16.0 SPSS, Chicago, USA). The results are presented as mean ± standard deviation with three replications. Data underwent analysis of variance (ANOVA) and differences between means were assessed for significance using Duncan's test at a significance level of $p \leq 0.05$.

3. Results and discussion

3.1. Nutritional values of biscuits: Biscuits are the most consumed baked goods due to their nature, nutritional quality, affordability, and diverse availability. Various nutrient-dense ingredients can be incorporated into baked goods to increase nutritional value. The bean is one of the most commonly used legumes, and in this study, bean flour was used in order to increase the nutritional values of the cookies shown in Table 2.
The results show that the moisture content is within the limits provided by regulations. The content of all nutrients generally increases with the increasing addition of bean flour, in addition to the reduced carbohydrate content. As for the content of ash, respectively mineral substances, they increase gradually as the share of bean flour increases, so the biscuits from the M5 mixture, respectively the mixture with 40% bean flour, had the highest content. Similar results were also found by Bedier et al. (2021), who in their study used red kidney bean flour at 5, 10, 15, and 20%.
The protein content increases with the increase in the participation of bean flour, so biscuits from the mixture M5 had a higher protein content with 10.46±0.12 g/100g. The fat content increases very little compared to the control biscuits M0, and the highest was in the biscuits from the M4 mixture with 13.92±0.08 g/100g. Similar results were also obtained by Obasi et al. (2012), who in their study used African Yam Bean flour. The content of carbohydrates in biscuits decreases gradually as the content of bean flour increases, whereas the content of invert sugars is variable and does not depend on the content of bean flour.

Table 2. Nutritional value of biscuits

Mixtures	Moisture (%)	Ash (g/100g)	Protein (g/100g)	Fat (g/100g)	Carbohydrate (g/100g)	Invert sugars (g/100g)
M0	5.80±0.11^{a}	1.58±0.02^{a}	7.21±0.09^{a}	12.99±0.09^{a}	69.95±0.51^{e}	9.74±0.11^{a}
M1	5.90±0.08^{a}	1.72±0.04^{b}	7.90±0.11^{b}	13.31±0.12^{bc}	68.03±0.77^{d}	10.71±0.09^{b}
M2	6.10±0.09^{b}	1.83±0.04^{c}	8.21±0.08^{c}	13.11±0.13^{ab}	66.14±0.74^{c}	17.02±0.10^{d}
M3	6.40±0.07^{d}	1.94±0.03^{d}	7.98±0.12^{b}	13.20±0.15^{ab}	65.62±0.69^{c}	9.87±0.08^{a}
M4	6.20±0.07^{bc}	2.03±0.02^{e}	7.26±0.11^{a}	13.92±0.08^{d}	63.53±0.66^{b}	18.62±0.15^{e}
M5	6.30±0.06^{cd}	2.44±0.02^{f}	10.46±0.12^{d}	13.47±0.09^{c}	60.32±0.81^{a}	13.07±0.06^{c}

The energy of the biscuits was higher in the control biscuits M0 (426.9±3.87 kcal/100g) and biscuits from the M1 mixture (423.5±2.32 kcal/100g), which are significant among themselves for $p \leq 0.05$, while in other biscuits, as the bean flour content increased, the energy decreased (Figure 1).

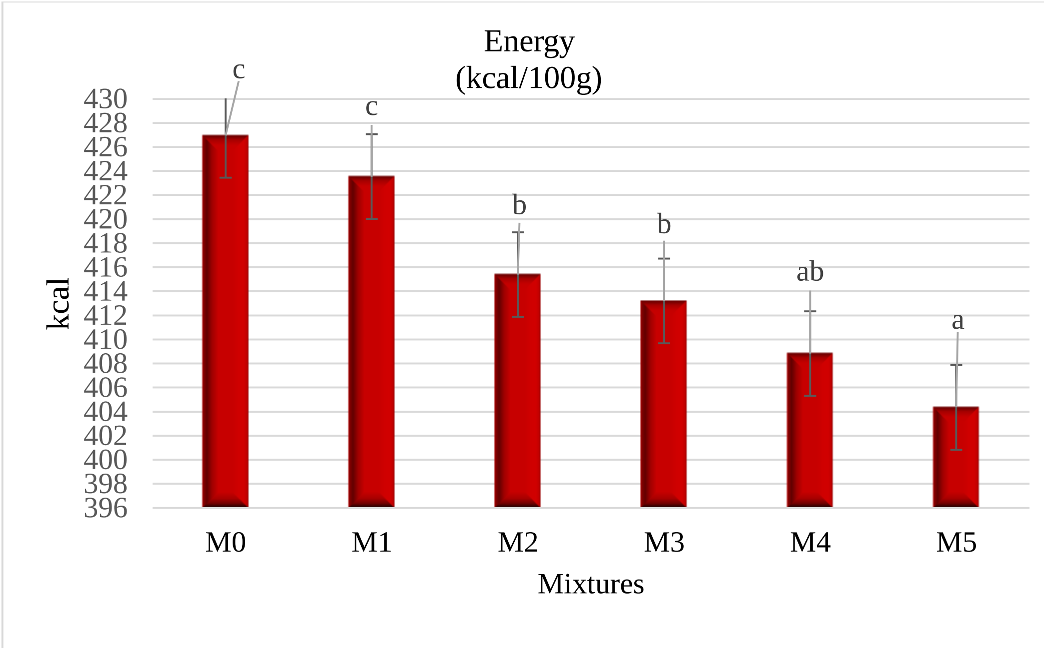

Figure 1. Energy of biscuits

3.2. Sensory properties of biscuits: Figure 2 shows the images of the biscuits produced according to the created mixture, while Table 3 shows the results obtained by a group of 12 evaluators.

Figure 2. Appearance of the manufactured biscuits

All the biscuits produced in terms of their external appearance did not have significant differences among themselves for $p \leq 0.05$, though the biscuits from the M3 mixture had more points gained. The M1 mixture had a much better structure than all the other biscuits, with 3.73±0.41 points, even the biscuits from the mixes other than those from M4 had good structure. Thongram et al. (2016) had similar results. The control biscuits M0 had better mouthfeel, but also the biscuits from the mixture M1 and M5 had good mouthfeel; therefore, even among themselves, they are significant for $p \leq 0.05$. The control biscuits M0, and biscuits from the M1 mixture had the best aroma. Ezegbe et al. (2023) had similar results. Flavour is the most important characteristic that describes the sensation perceived in the mouth and throat of the food product (Olurin et al., 2021), and according to Small&Prescott (2005), the flavour of each food product depends only on the quality of the ingredients used, where the biscuits from the M3 and M1 mixtures, as well as the control M0, had the best flavour.

Of the total points accumulated, the biscuits from the M1 mixture had the most points accumulated with 17.10, and together with the control biscuits M0, which had 16.44 points accumulated, they fall into the qualitative group very well. Biscuits from other mixes fall into the good quality group.

Table 3. Sensory properties of biscuits

Mixtures	Appearance	Structure	Mouthfeel	Aroma	Flavour	Total points
M0	3.33±0.61[a]	3.06±0.93[b]	3.52±0.59[b]	2.80±0.37[c]	3.73±0.88[b]	16.44
M1	3.33±0.61[a]	3.73±0.41[c]	3.46±0.58[b]	2.72±0.45[c]	3.86±0.83[b]	17.10
M2	3.33±0.61[a]	3.06±0.93[b]	3.15±0.56[ab]	2.32±0.50[ab]	3.40±0.98[ab]	15.26
M3	3.46±0.65[a]	3.04±0.69[b]	3.09±0.67[ab]	2.20±0.37[ab]	3.93±0.96[b]	15.72
M4	3.06±0.61[a]	2.62±0.71[a]	3.03±0.54[ab]	2.04±0.49[a]	2.73±0.88[a]	13.72
M5	2.93±0.65[a]	3.25±0.83[bc]	3.36±0.62[b]	2.48±0.45[bc]	3.46±1.12[ab]	15.48

3.3. Texture of biscuits: The results for the texture of the biscuits, which were carried out with the TA. XT plus device, Stable Micro Systems P-36, Godalming, UK, are shown in Table 4.
The obtained results prove that biscuits from the M3 mixture have shown higher hardness, and these biscuits have also shown better gumminess, chewiness, and resilience. All biscuit mixes do not differ significantly in terms of springiness and cohesiveness.

Table 4. Texture of biscuits

Mixtures	Hardness (g)	Springiness (g s)	Cohesiveness (g s)	Gumminess (g s)	Chewiness (g s)	Resilience (g s)
M0	3468.9±88.1	0.87±0.03	0.73±0.08	2486.9±46.3	2156.9±39.6	0.38±0.04
M1	2263.3±84.6	0.89±0.03	0.78±0.04	1771.1±67.6	1591.2±61.1	0.42±0.04
M2	1835.6±32.2	0.88±0.02	0.74±0.05	1354.4±27.1	1203.9±25.8	0.36±0.03
M3	6449.2±31.3	0.87±0.05	0.73±0.08	4715.1±76.2	4139.8±90.8	0.49±0.07
M4	4209.4±107.1	0.89±0.02	0.81±0.03	3420.3±94.7	3054.1±88.4	0.49±0.02
M5	3947.1±102.0	0.87±0.04	0.77±0.06	3058.1±87.7	2688.4±84.3	0.45±0.05

4. Conclusion

Biscuits rank prominently among baked goods, earning immense popularity and offering a versatile canvas for nutrient fortification. Our study underscores the feasibility of leveraging bean flour as a partial substitute for wheat flour in crafting biscuits endowed with commendable nutritional merit and satisfying sensory and textural attributes. Biscuits created from the M5 mixture, integrating 40% bean flour, exhibited heightened mineral and protein content. In contrast, M4 biscuits, comprising 30% bean flour, showcased elevated fat and invert sugar content. Concomitantly, the carbohydrate content of the biscuits experienced a gradual reduction with increasing bean flour content, with M0 and M1 biscuits topping the energy scale.
Biscuits originating from the M1 mixture, featuring a 10% bean flour composition, excelled in sensory attributes, boasting superior structure, mouthfeel, and an impressive cumulative point score of 17.10. Among the various textural aspects evaluated, biscuits crafted from the M3 mixture, encompassing 20% bean flour, exhibited superior traits including hardness, gumminess, chewiness, and resilience. While differences prevail, the study conclusively establishes the potential to enhance wheat flour with bean flour in biscuit production, though within the confines of a specific threshold, not surpassing 20%.

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