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Professional paper

INFLUENCE OF BEAN AND CHESTNUT FLOUR ON THE NUTRITIONAL AND SENSORY PROPERTIES OF BISCUITS

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Abstract

Biscuits are known as a food product with good taste and attractive to consumers, but with a high content of fats, sugar, and calories and low in dietary fiber, vitamins, and minerals. Therefore, this study is based on the research of the nutritional and sensory properties of biscuits enriched with bean and chestnut flour, as well as liquid whey.

Biscuits made from different flour mixtures generally had higher nutritional content than the M0 control biscuits, such as protein, fat, minerals, and cellulose, and lower carbohydrate content. The content of some mineral matter was also much higher in the biscuits made from the different flour mixtures than the control biscuits M0; respectively, the biscuits from the mixture M5 had a higher content of potassium, magnesium, and iron, while the biscuits from the mixtures M4, M5, and M6 had higher copper and zinc content, and the biscuits from the M4 mixture had a higher calcium content. Sensory properties showed that the control biscuits M0 had more accumulated points, but the biscuits from the M5 mixture had the same texture, mouthfeel, and taste as the control biscuits, while the biscuits from the M4 and M6 mixtures had poorer sensory properties. The biscuits from the M5 mixture had the best hardness, while the control biscuits M0 had the weakest. Based on the obtained results and the discussion, we recommend the use of biscuits from the M5 mixture, which in its composition had whey liquid instead of water and 70% wheat flour, 20% chestnut flour, and 10% bean flour.

Keywords*:* chestnut flour, sensory properties, mineral content, biscuits.

1. Introduction

Biscuits are one of the most popular wheat-based foods consumed by a wide range of people in the country and around the world. Although they differ in their shape, size, and composition, the three main permanent ingredients are flour, sugar, and fat (Caponio *et al*., 2006). Biscuits are known for their high content of fat, sugar, and calories but low content of fiber, vitamins, and minerals, which no longer corresponds to healthy nutrition (Kârklina *et al*., 2012). The effect of some major ingredients in the biscuit dough system on the final product has been studied by several researchers (Blanco et al., 2017; Macche-Rezzoug *et al*., 1998; Perego *et al*., 2007).

Good organoleptic properties, a relatively long shelf life, and ease of use (Adegoke *et al*., 2017) made biscuits attractive to the consumer, while for researchers, they offered a good opportunity for fortification and improvement of nutritional values (Sujirtha & Mahendran, 2015). As a result, flours derived from legumes, flours derived from other cereals, fruits, beta-glucans (Kerckhoffs *et al*., 2003; Wang & Thomas, 1989; Zucco *et al*., 2011), as well as dietary fiber improving the prebiotic characteristics of biscuits (Man *et al*., 2014), and so on, have been used to boost the nutritional value of biscuits.

Among the legumes, the local white bean (Phaseolus vulgaris) is known for its wide use in our country. The bean is characterized by a high content of complex carbohydrates, proteins, vitamins, minerals, and low fat (Anderson *et al*., 1999; Leahu & Rosu, 2014), as well as a high

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content of soluble and insoluble dietary fibers (Hughes, 1991). The presence of complex carbohydrates and dietary fiber in beans contributes to their low glycemic index, which has been proven to be associated with reducing the risk of heart disease, diabetes, and obesity (Anderson *et al.*, 2009). Despite the good nutritional and health benefits, the bean contains large amounts of anti-nutritive factors such as phytic acid, hemagglutinins, trypsin inhibitors, tannins, and saponin that reduce the absorption of proteins and some minerals (Shimelis *et al.*, 2007); therefore, it is necessary to soak or boil the bean before use to reduce or eliminate anti-nutritive factors (Nergiz & Gokgoz, 2007). Among the fruits, the chestnut is also a local fruit that, due to its high nutritional value, is known as the "bread tree". It is mainly rich in various starches and polysaccharides, high-quality dietary fiber, protein, low fat, various minerals such as potassium, phosphorus, magnesium, chlorine, iron, sodium, and vitamins B1, B2, and C (Mete & Dülger Altiner, 2017). Also, it has a significant content of polyphenols, with a predominance of gallic acid and ellagic acid (Barreira *et al.*, 2008). So chestnut flour has also found its own use in the technology of bakery products and confectionary (Hegazy *et al.*, 2014).
So, the aim of this study was to investigate the effect of the addition of bean flour and chestnut flour on the nutritional qualities and the content of some minerals in biscuits, as well as the hardness and the organoleptic properties of biscuits.

2. Materials and methods

2.1. Materials: For the production of each type of biscuit, 1000g of wheat flour or a mixture of wheat, bean, and chestnut flours was taken (Table 1). Instead of water, 200mL of pasteurized liquid whey was used for each type of biscuit in order to increase the nutritional values. The other ingredients used are margarine (200g), sugar (180g), sodium bicarbonate (4g), and baking powder (6g) (composition: disodium diphosphate, sodium bicarbonate, corn starch).

Table 1. Created flour mixtures for the production of biscuits

Mixtures	Wheat flour (g)	Bean flour (g)	Chestnut flour (g)
M 0	1000	-	-
M 1	800	200	-
M 2	800	-	200
M 3	800	100	100
M 4	700	200	100
M 5	700	100	200
M 6	700	150	150

2.1.1. Manufacturing of biscuits: Making biscuits begins with weighing all the ingredients for making biscuits. At first, the other flours were added to wheat flour according to the mixtures shown in Table 1 and mixed, then margarine was added and mixed. Then liquid whey and dissolved sugar were added to the prepared mixture, and they were mixed again. At the end, sodium bicarbonate and baking powder were added, which had been previously dissolved. The resulting dough is opened and shaped, placed on a baking tray covered with baking paper to prevent the biscuits from sticking, and baked in a Memmert oven (Germany) at a temperature of 200°C for 20 minutes. They were then allowed to cool at room temperature and stored in closed containers.

2.2. Methods: The moisture, protein, fat, and ash contents of wheat, bean, and chestnut flour, as well as the manufactured biscuits, were determined according to AOAC (2005) methods. The determination of cellulose content was determined by the standard method based on the treatment of the sample with sulfuric acid and potassium hydroxide, where the residue was separated by filtration, dried and baked, and finally weighed and calculated (Xhabiri & Sinani, 2011). The total content of carbohydrates was calculated by subtracting the total amounts of moisture, ash, protein, fat, and cellulose constituents of the sample from 100. The obtained value presents the carbohydrate content of the sample (g/100 g). Total calories (kcal/100 g) were calculated using the formula of James (1995) as follows: Total calories = fat x 9 + protein x 4 + total carbohydrates x 4.

The produced biscuits were also analyzed for the contents of the most important minerals; for this study, the analyses were performed with a Microwave Plasma-Atomic Emission Spectrometer (MP-AES, model 4200 Agilent Technologies, CA, US) according to Balaram (2020); Hoxha *et al*. (2023).

Hardness of biscuit was determined using a texture analyzer TA-XT2 Plus (Stable Micro System Ltd. Godalming, Surrey, UK). Three-point bending test (TPB) is a destructive test based on the application of a vertical force to obtain texturometric parameters. Each sample was placed on the two holders of the adapter and the cutting probe was lowered until it met the sample. The probe acts as a third point of contact, exerting increasing pressure until the product structure breaks. The results were expressed as maximum force in Newtons.

The produced biscuits were sensory evaluated using the scoring method (Pajin, 2009), by 15 trained assessors. All products were put on different coded dishes and served to the panelists. The procedure of scoring was based on assessment of quality attributes chosen (appearance, structure, mouthfeel, aroma, flavour, and overall total point). Each quality level expressed with the corresponding score (1 to 5 points) was precisely defined (Nakov *et al*., 2016). The individual parameters were corrected by correction factor (CF), whereby weighted points (WP) were obtained, the collection of which gives the total number of points for the sensory quality of the biscuits. Depending on the total number of points it was determined in which category the biscuits belong (Pajin, 2009).

2.2.1. Statistical analysis: The experimental results were expressed as the mean ± standard deviation (SD) of the three replications. The obtained data were statistically analyzed using One way analysis of variance (ANOVA), and Post-hoc (Duncan Multiple Range Test) with significance level at $p < 0.05$, using SPSS 16.0 software package for Windows (SPSS Inc., Chicago, Illinois, USA).

3. Results and Discussion

3.1. Chemical composition of raw materials: The chemical composition of the raw materials is presented in Table (2). Type 400 wheat flour was of suitable quality for the production of biscuits, with an average protein content and a fat content that did not differ significantly ($p<0.05$) from bean flour. Bean flour had high protein and cellulose content, while chestnut flour had the best mineral content, but the difference is significant with the minerals in bean flour.

Table 2. Physico-chemical composition of raw materials

Raw materials	Moisture (%)	Carbohydrate (g/100g)	Protein (g/100)	Fat (g/100g)	Cellulose (g/100g)	Minerals (g/100g)
Wheat flour	$13.36±0.26^a$	$73.61±0.41^c$	$9.50±0.24^b$	$1.17±0.08^a$	$0.84±0.04^a$	$0.44±0.06^a$
Bean flour	$14.82±0.38^b$	$48.90±0.92^a$	$22.35±0.94^c$	$1.27±0.07^a$	$10.81±0.54^c$	$2.81±0.05^b$
Chestnut flour	$25.44±0.46^c$	$52.91±0.39^b$	$4.89±0.28^a$	$3.16±0.20^b$	$6.59±0.11^b$	$2.82±0.06^b$

Values are means ± standard deviations (n = 3). Means with different superscript in the columns are significantly different ($p < 0.05$).

3.2. Nutritional values of biscuits: The nutritional values of the biscuits are shown in Table (3). The control biscuits M0 had the highest content of carbohydrates with 62.201.07 g/100g, while with the increase in the content of the flour mixtures, the carbohydrate content decreased, where it was the lowest in the biscuits from mixture M4. The results are similar to the study of Jayaweera *et al.* (2018), who used mixtures of sorghum, soybean, and millet flours, whereas the flour content increased, the carbohydrate content decreased. The protein content was lower in the control biscuits M0, but as the flour mixtures increased, the protein content increased and was higher in the biscuits from mixture M4; the results are similar to the study of Folake *et al.* (2018). The fat content was lower in the control biscuits M0; with the increase in flour mixtures, the content increased and was higher in the biscuits from mixture M5; the results are similar to those of the study by Kârklina *et al.* (2012). Cellulose content was lower in control biscuits M0, in all other biscuits it was higher, but higher in biscuits from mixture M4; these results are similar to the study of Xhabiri *et al.* (2014). Biscuits from mixtures M4, M5, and M6 among themselves are significant ($p<0.05$) and had higher mineral content; the results are similar to the studies conducted by Sampson & Assuah (2016); Xhabiri *et al.* (2014).
Biscuits from mixtures M1 and M4 had lower energy than control cookies M0, while cookies from mixture M2 have higher energy, which means that in biscuit mixtures where we had higher amounts of bean flour, the energy is lower. These results are similar to the study of El-Gohery (2021).

Table 3. Nutritional values of biscuits

Mixtures	Moisture (%)	Carbohydrate (g/100)	Protein (g/100g)	Fat (g/100g)	Cellulose (g/100g)	Minerals (g/100g)	Energy (kcal/100g)
M 0	6.54±0.27^{bcd}	62.20±1.07^{e}	7.94±0.47^{a}	17.66±0.32^{a}	2.72±0.25^{a}	2.73±0.20^{a}	439.4±8.13^{abc}
M 1	7.25±0.26^{e}	55.91±1.02^{bc}	9.98±0.17^{cd}	18.91±0.45^{b}	4.28±0.39^{cd}	3.49±0.45^{b}	433.7±0.96^{a}
M 2	5.81±0.30^{a}	58.88±0.96^{d}	8.38±0.34^{ab}	19.67±0.30^{bc}	3.54±0.30^{b}	3.52±0.41^{b}	446.2±4.43^{c}
M 3	6.89±0.23^{cde}	57.29±1.01^{c}	8.59±0.53^{ab}	19.43±0.55^{bc}	3.91±0.18^{bc}	3.41±0.24^{b}	438.4±3.89^{ab}
M 4	7.13±0.14^{de}	53.78±0.69^{a}	10.22±0.29^{d}	19.74±0.41^{c}	5.06±0.12^{e}	4.02±0.04^{c}	433.6±1.06^{a}
M 5	5.94±0.28^{ab}	56.09±0.62^{bc}	8.88±0.16^{b}	20.57±0.38^{d}	4.18±0.19^{cd}	4.13±0.13^{c}	445.1±2.15^{bc}
M 6	6.22±0.25^{abc}	54.86±0.50^{ab}	9.54±0.41^{c}	20.14±0.46^{cd}	4.49±0.16^{d}	4.09±0.12^{c}	438.8±1.22^{abc}

Values are means ± standard deviations (n = 3). Means with different superscript in the columns are significantly different ($p < 0.05$).

3.3. Mineral content of biscuits: Based on the composition of the raw materials that were used in this study, we can say that the results obtained for the mineral content are as expected. From Table (4), we can observe that, in general, the M0 control biscuits has a lower content of all analyzed minerals; therefore, they have a significant difference. The sodium content increases with the increase in the content of added flours and was highest in biscuits from mixture M6. The content of calcium also increases with the addition of flours and was higher in biscuits from mixture M4, the results are similar to the study of Inyang *et al.* (2018). The highest contents of potassium, magnesium, and iron were in biscuits from mixture M5, also Sakač *et al.* (2015)

had similar results. The content of copper and zinc was higher in biscuits from mixtures M4, M5, and M6, which are also significant $p<0.05$.

Table 4. Content of some minerals in biscuits

Mixtures	Na (mg/kg)	Ca (mg/kg)	K (mg/kg)	Mg (mg/kg)	Fe (mg/kg)	Cu (mg/kg)	Zn (mg/kg)
M0	1792.5 ± 11.18^{a}	1030.1 ± 37.85^{a}	1495.8 ± 7.38^{a}	147.7 ± 7.71^{a}	5.04 ± 0.19^{a}	0.59 ± 0.06^{a}	4.01 ± 0.16^{a}
M1	1892.5 ± 12.72^{b}	1086.5 ± 9.22^{b}	1802.0 ± 31.26^{b}	212.7 ± 4.77^{b}	7.54 ± 0.42^{b}	0.73 ± 0.05^{b}	6.02 ± 0.35^{b}
M2	1878.6 ± 20.41^{b}	1077.8 ± 25.95^{b}	1893.9 ± 27.94^{c}	224.4 ± 13.16^{bc}	7.86 ± 0.17^{b}	0.73 ± 0.09^{b}	5.85 ± 0.09^{b}
M3	1892.3 ± 14.18^{b}	1094.73 ± 14.82^{b}	1837.5 ± 36.52^{bc}	220.8 ± 11.53^{b}	7.81 ± 0.12^{b}	0.78 ± 0.05^{b}	6.01 ± 0.11^{b}
M4	1960.8 ± 31.68^{cd}	1207.2 ± 33.46^{d}	2062.8 ± 39.17^{d}	259.3 ± 10.06^{de}	10.05 ± 0.19^{c}	1.03 ± 0.07^{c}	9.21 ± 0.21^{c}
M5	1937.3 ± 34.35^{c}	1143.4 ± 25.74^{c}	2163.5 ± 26.05^{e}	278.6 ± 21.47^{e}	10.57 ± 0.37^{d}	1.04 ± 0.05^{c}	8.92 ± 0.25^{c}
M6	1991.2 ± 20.33^{d}	1171.5 ± 24.79^{cd}	2029.4 ± 35.64^{d}	247.5 ± 19.45^{cd}	10.36 ± 0.32^{cd}	1.01 ± 0.07^{c}	8.97 ± 0.23^{c}

Values are means ± standard deviations (n = 3). Means with different superscript in the columns are significantly different ($p < 0.05$).

3.4. Sensory properties of biscuits: The results of the sensory analyzes performed on the seven types of biscuits are presented in Table (5) and Figure (1), while the views are shown in Figure (2). The appearance of the biscuits produced with the increase in the percentage of flour mixtures weakens; the M6 mixture was the weakest, while the M1 biscuits had an appearance slightly better than the M0 control biscuits, these results are similar to those of Baljeet *et al.* (2010); Saewan & George (2020). Control biscuits M0 as well as biscuits from mixtures M1, M2, and M5 had better structure, while biscuits from other mixtures had weaker structure. The results are comparable to the work by Folake *et al.* (2018). In addition to the control biscuits M0, the biscuits from mixture M5 had the best mouthfeel, whereas the biscuits from mixture M6 had the worst mouthfeel.

Biscuits from mixtures M0 and M1 had the best aroma, which among itself was significant at $p<0.05$, the others had a slightly weaker aroma, except for the biscuits from mixtures M6 and M4, which had fewer accumulated points; similar data were also reported by Yadav *et al.* (2012) in their study, where they used defatted peanut flour. Flavour, which is one of the most valued sensory qualities by consumers, was better in the control biscuits M0 and the biscuits from mixture M5, while the biscuits from the other mixtures had a weaker taste; these data are similar to those from the study by Adegoke *et al.* (2017). The control biscuits M0 had a higher accumulated point, as did the biscuits from mixtures M1 and M5, while the aggregate of accumulated points for the other biscuits was lower, with the biscuits from mixture M6 having the lowest ratings.

Table 5. Sensory properties of biscuits

Mixtures	Appearance	Structure	Mouthfeel	Aroma	Flavour	Total points
M0	3.68±0.51^{cd}	3.57±0.51^{c}	3.52±0.59^{b}	2.80±0.37^{c}	3.73±0.88^{c}	**17.30**
M1	3.73±0.49^{d}	3.46±0.49^{c}	3.15±0.64^{ab}	2.68±0.45^{c}	3.60±0.83^{bc}	**16.62**
M2	3.25±0.47^{bc}	3.31±0.67^{c}	3.15±0.56^{ab}	2.32±0.50^{ab}	3.40±0.98^{abc}	**15.43**
M3	3.15±0.64^{b}	3.04±0.69^{bc}	3.09±0.67^{ab}	2.20±0.37^{ab}	3.46±1.18^{abc}	**14.94**
M4	2.98±0.56^{ab}	2.62±0.71^{ab}	3.03±0.54^{ab}	2.04±0.49^{a}	2.73±0.88^{a}	**13.40**
M5	3.20±0.61^{b}	3.31±0.73^{c}	3.36±0.62^{b}	2.48±0.45^{bc}	3.66±1.12^{c}	**16.01**
M6	2.66±0.84^{a}	2.51±0.79^{a}	2.67±0.89^{a}	1.90±0.57^{a}	2.87±0.99^{ab}	**12.61**

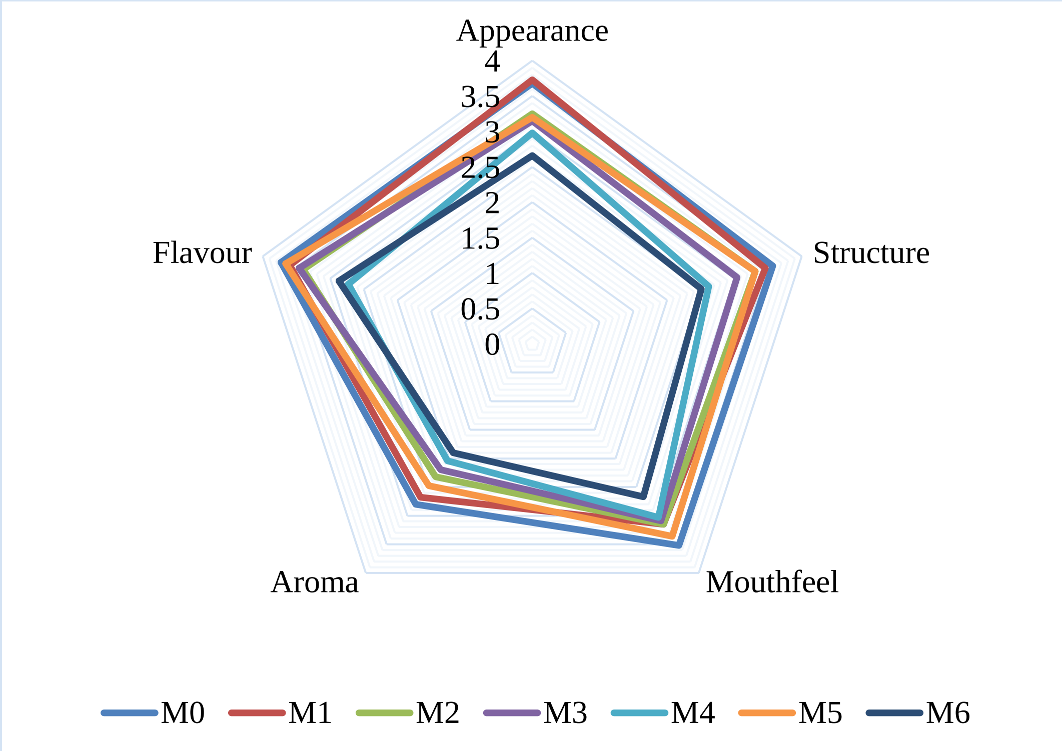

Figure 1. Sensory properties of biscuits

gelatinization and sugar content, rather than the protein/starch structure (Di Cairano *et al.*, 2018).

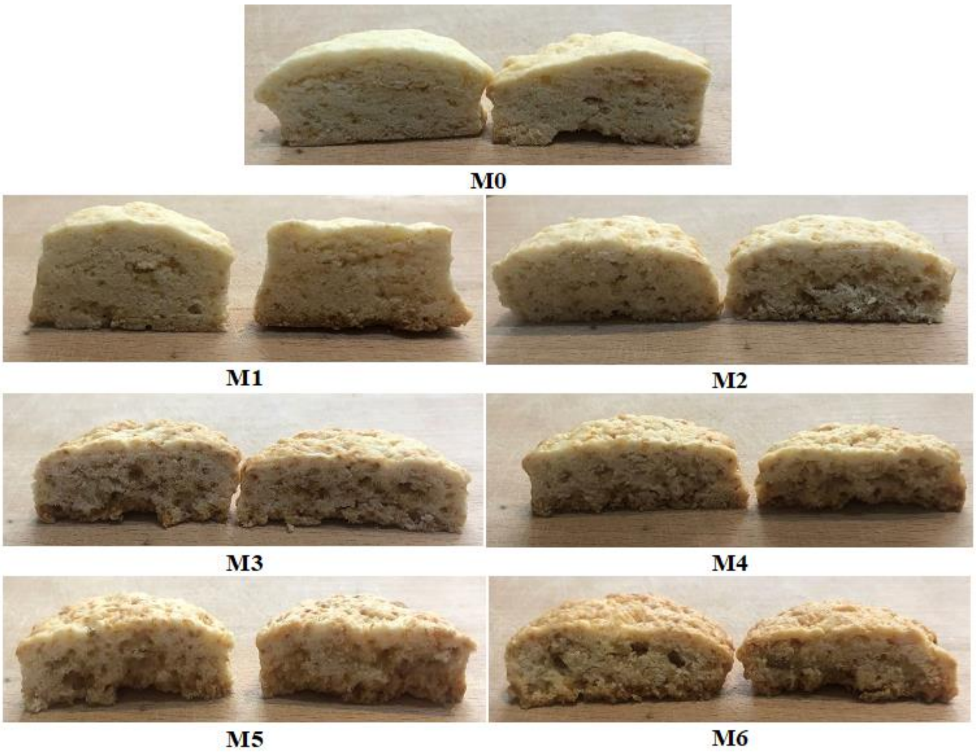

Figure 2. View of biscuits mixtures

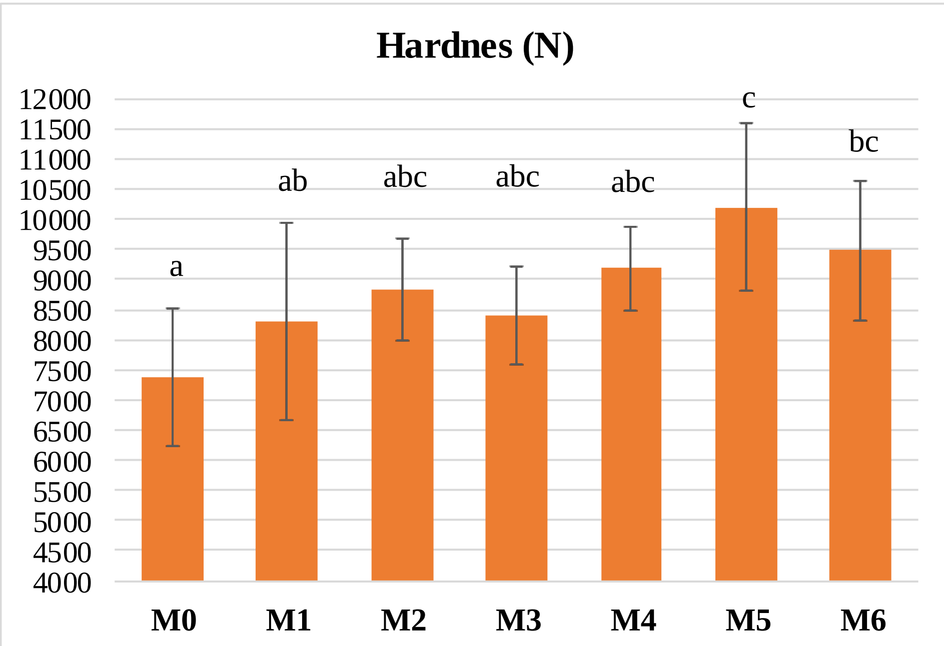

Figure 3. Hardness of biscuits mixtures

3.5. Hardness of biscuits: Hardness of biscuits is among the distinctive textural parameters for consumer acceptability and general textural properties of biscuits are highly related to the starch gelatinization and sugar content, rather than the protein/starch structure (Di Cairano *et al.*, 2018).

Hardness ranged between 7369.9±1138.7 and 10196.5±1383.6 N with the statistically significant ($p<0.05$) difference between the M5 and the other mixtures (Figure 3). Biscuits from mixture M5 had higher hardness, which was related to the higher content of chestnut flour; on the other hand, biscuits with a higher content of bean flour had lower hardness, which was related to the higher presence of protein and cellulose, which increase the amount of water absorption.

4. Conclusions

The results showed that the bean and chestnut flour had different physico-chemical contents, while the biscuits produced from the mixtures created from wheat flour with bean and chestnut flour in different ratios had a significant increase in their nutritional values, such as protein, fat, cellulose, and mineral matter. The content of minerals generally increased with the addition of flour mixtures, where biscuits from mixture M5 had a higher content of potassium, magnesium, and iron, biscuits from mixtures M4, M5, and M6, which were significant $p<0.05$ among themselves, had higher copper and zinc content, and higher calcium content in biscuits from the M4 mixture, while biscuits from the M6 mixture had a higher sodium content. The control biscuits M0 had better sensory properties with more accumulated points; the biscuits from the M5 mixture had the same texture, mouthfeel, and taste as the control biscuits. The biscuits from the M5 mixture had the best hardness, while the control biscuits from M0 had the weakest. Therefore, based on what was said, we recommend using biscuits from the M5 mixtures.

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