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Effect of Plant Extracts Addition on the Physico-Chemical and Sensory Properties of Biscuits

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Abstract: Biscuits are one of the most consumed bakery products that contain a high content of fat, sugar, and different additives that may cause various health problems. This has led to an increased focus on enriching bakery products with plant extracts to improve their nutritional and sensory properties. The objective of the current work was to investigate the effect of replacing wheat flour with plant extracts such as blueberry and cranberry (at concentrations of 3%, 6%, and 9%) and compare with control biscuits regarding the physico-chemical and color parameters. In addition, sensory analysis was conducted to determine the consumer acceptability of the enriched biscuits. The enrichment of biscuits with blueberry powder significantly increased the moisture content and decreased pH values ($p < 0.05$). Similarly, cranberry-enriched biscuits had a significantly higher moisture content, water activity, and decreased pH values compared to control samples ($p < 0.05$). On the other hand, enrichment of biscuits with either blueberry or cranberry powder significantly decreased lightness (L^*), yellowness (b^*), chroma value (C^*), and h-value (h) but increased the redness values (a^* value) of samples ($p < 0.05$). Our results showed that with increasing concentrations of plant extract addition in biscuits, the sensory attributes such as odor and taste were significantly improved. The results of the study suggest that the addition of plant extracts to biscuits improved their physico-chemical and sensory properties.

Keywords: biscuits; blueberry; cranberry; color; sensory; physico-chemical parameters

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1. Introduction

Biscuits are important items of the confectionary industry which are rich in carbohydrates, fats, proteins, salts, and minerals. Traditional ingredients of biscuits such as oil, eggs, different additives, and flour, do not provide much nutritional value for the body. Their current great popularity has come as a result of the convenience they offer for consumption as a ready-made product, the long term of storage, and availability in different shapes, sizes, and compositions in the market. In recent years, improving the nutritional and sensory values of confectionary products is one of the main goals of this industry, which is developing rapidly [1]. Modification of traditional biscuit recipes by adding healthy ingredients has proven to have a positive effect on the production of a product which has functional properties and is acceptable for consumption. Enriching bakery products with natural antioxidants provides health benefits to consumers [2,3]. This affects the increase in the consumer intake of bioactive substances from bakery products that traditionally do not contain these compounds [4]. Such enrichment may also affect the rheological properties, physico-chemical characteristics, and consumer acceptability of bakery products. However, a less desirable aspect of adding plant ingredients to biscuits can be considered to be the possible negative impact on taste [5].

Plant ingredients provide a good solution to improve the nutritional content of biscuits because of their high concentrations of vitamins, minerals, prebiotics, probiotics, and fibers.

Therefore, it is in the interest of the bakery industry to incorporate such ingredients and their extracts in the development of biscuits with improved physico-chemical and sensory properties [6]. In this regard, there are many plant extracts that have been proven to be beneficial when added to biscuits such as lemon peel and its pomace [7] grapes seeds [8], apple powder [9], watermelon, orange pomace [10], horseradish [11], moringa flower powder, and leaf powder [12]. According to Kozlowska et al. [2] the addition of plant extracts to biscuit recipes can improve their sensory properties and extend shelf life by preventing oxidation.

Among various plant ingredients, berry fruits extracts are known for their excellent health properties, but also for their aroma, taste, and color. Blueberry powder addition is a simple way to improve the antioxidant content and the shelf life of biscuits [13]. Blueberries have multiple health properties due to their ingredients such as phenolic acids (caffeic, chlorogenic, ferulic, p-coumaric, and cinnamic acids) and flavonoids (anthocyanidins). In fact, studies show that berries, as fruits, ease problems with diabetes, heart disease, obesity, osteoporosis, and prevent bone loss [14]. The number of food products enriched with blueberries is expected to rise significantly as a result of all these functional advantages. Biscuits enriched with blueberries show a higher content of polyphenols, thus also a higher antioxidant activity that comes from the presence of blueberries [15]. According to Šarić et al. (2016) the addition of blueberry pomace in different concentrations up to 30% in the preparation of biscuits affects the reduction of fat content and the increase of beneficial ingredients such as fibers, vitamins, and phenolic compounds [16]. However, even the application of lower amounts of blueberry extract has shown positive effects on the characteristics of biscuits, where, according to Aksoylu et al. [17], biscuits enriched with only 5% blueberry extracts showed high antioxidant activity.

In the same way, cranberries are known for containing many bioactive components. Vitamins such as anthocyanins, procyanidins, and flavanols in cranberries have been documented to have potential effects in cancer prevention. Being a source of these bioactive ingredients, cranberries have proven to be effective in reducing the recurrence of urinary tract infections, thus reducing the need for taking antibiotics in such cases [18]. Also, cranberries positively affect atherosclerotic cholesterol profiles and reduce some cardiometabolic risk factors. Cranberry juice or cranberries themselves have been shown to protect against intestinal inflammation and inhibit bacterial colonization in the stomach [19]. They also have a high content of flavonoids and their antioxidant effect, due to the flavonoids they contain, protects the body from free radicals [20]. In general, consumers choose the processed forms of cranberry for consumption in their juice, sauces, supplements, and sweetened dried fruits, while few prefer their consumption to be in fresh form [21], therefore their incorporation in biscuits would bring innovation for consumers in the market. Similar to blueberries, the application of cranberries in the production of biscuits results in higher values of antioxidant activity and polyphenolic content compared to samples without cranberry extract [22]. Cranberry powder can also be used to give color to different foods instead of using synthetic additives.

Based on these health benefits, the formulation of biscuits fortified with different herbal ingredients can help improve the general nutritional status of the population. This technology can also be an encouragement for the food industry to develop new products through the principle of enriching them with different ingredients with functional properties [23]. The formulation of the biscuit's recipe with a certain percentage of blueberry and cranberry powder affects the increase in the nutritional value of the biscuits and their functional properties. Moreover, such components when incorporated into biscuits enable easier intake of these ingredients by consumers, thus offering new healthy options for obtaining plant ingredients in addition to their fresh form. The aim of this work was to produce biscuits enriched with blueberry and cranberry powder and to analyze the effect of these bioactive compounds in the physico-chemical and sensory attributes of biscuits.

2. Materials and Methods

2.1. Preparation of Biscuits

Raw materials used for biscuit preparation include: wheat flour, egg, butter, vanilla pudding, sugar powder, baking powder, and vanilla sugar (Table 1). All these ingredients were placed into a container and mixed by hand (3–5 min) until a compact mass was reached. The biscuit dough was kept at a temperature of 5 °C for two hours and then it was shaped. Baking was carried out for 10–15 min at 150 °C in the baking oven. The same recipe was used for all the biscuits, except for the biscuits enriched with blueberry and cranberry powder, where the corresponding extracts with 3%, 6%, and 9% have been added, replacing the wheat flour. Blueberry powder was purchased from Arctic Flavors, Espoo, Finland, and cranberry powder from LOOV, Tallinn, Estonia. Nutritional facts for blueberry powder per 100 g include: fat content of 6.5 g, carbohydrates 60.4 g, protein 4.7 g, fiber 19.5 g, salt 30.2 mg, vitamin C 42.6 mg, vitamin E 11.2 mg, and vitamin K 53.3 mg. Cranberries also have a very rich content with fat 0.2 g/100 g, carbohydrates 2 g, dietary fiber 6 g, potassium 28.23 mg, calcium 4.46 mg, vitamin E 0.23 mg, vitamin C 5.71 mg, manganese 1.56 mg, anthocyanin 34.8 mg, polyphenols 34.8 mg, and benzoic acid 5.04 mg. All biscuit samples were prepared in triplicate according to the recipe described in Table 1.

Table 1. Formulations for biscuit preparation.

Ingredients	Biscuits Composition (g)			
	C	B1	B2	B3
Wheat flour	100	97	94	91
Blueberry/cranberry powder	0	3	6	9
Egg	21.16	21.16	21.16	21.16
Butter	49.87	49.87	49.87	49.87
Sugar powder	59.89	59.89	59.89	59.89
Vanilla sugar	3.96	3.96	3.96	3.96
Vanilla pudding	15.30	15.30	15.30	15.30
Baking powder	1.31	1.31	1.31	1.31

C—biscuits without blueberry/cranberry powder, B1—biscuits with 3% blueberry/cranberry powder, B2—biscuits with 6% blueberry/cranberry powder, and B3—biscuits with 9% blueberry/cranberry powder.

2.2. Physico-chemical Evaluation of the Biscuits

The weight, height, and specific gravity of biscuits were determined for physical evaluation. Weight was determined using an analytical scale, height using a ruler, and specific gravity was determined using a pycnometer. Specific gravity results were obtained by dividing the weight of the dough mass of the sample with the equal volume of water [24].

From the chemical measurements, moisture content, acidity, pH value, and water activity were determined. Moisture content was determined by applying the temperature of 130 °C until reaching the constant weight of the samples [25]. A pH meter was used to measure the pH of the samples after calibration. Meanwhile, the acidity was determined by the titration method using sodium hydroxide 0.1 mol/dm^3 as a titrant [25]. A Novasina LabMaster-aw neo type instrument (Novasina, Zurich, Switzerland) was used to measure the water activity of the biscuit samples. All measurements were conducted in triplicates.

2.3. Color Attributes

Color attributes, such as lightness (L^*), redness (a^*), and yellowness (b^*) were measured using a CR-410-type colorimeter (Konica Minolta Sensing Inc., Tokyo, Japan) after white calibration of the instrument. Five parallel readings L^*, a^*, and b^* values were recorded for each sample and from the measured values chroma value (C^*) and hue angle (h^*) were calculated using the following equations:

$$\text{Chroma: } C^* = [(a^*)^2 + (b^*)^2]^{1/2} \quad (1)$$

$$\text{Hue angle: } h^* = \tan^{-1}(b^*/a^*) \quad (2)$$

Total color difference (ΔE) between biscuits samples was calculated using the method described by Knispel [26].

2.4. Sensory Analysis

Sensory parameters, including shape, color, odor, taste, texture, and mouthfeel, were evaluated through a 9-point hedonic evaluation scale, where 1 = dislike extremely and 9 = like extremely. For this study, 60 sensory non-trained panelists from the Food Technology with Biotechnology Department, Faculty of Agriculture and Veterinary, University of Pristina, were asked to evaluate the samples. Water and salt crackers were used during sensory evaluation to neutralize the mouths of the panelists.

2.5. Statistical Analysis

The experimental data were analyzed using IBM SPSS (Version 26.0, Armnouk, NY, USA, 2020). Data were analyzed using the analysis of variance (ANOVA) and General Linear Model (GLM). The Kolmogorov–Smirnov test was used to test the normality of residuals ($p > 0.05$). Levene's test was performed to check the homogeneity of variances ($p > 0.05$). The differences between groups were analyzed using Tukey's post hoc tests if homogeneity of variances was not violated. Meanwhile, if this assumption was violated then the Games–Howell test was performed.

3. Results

3.1. Physico-chemical Analysis of Biscuits

The physico-chemical parameters of the biscuits are presented in Table 2. The results showed that there was a significant difference ($p < 0.05$) in water activity between biscuits enriched with cranberry powder (6 and 9%) and control samples. Moreover, biscuits enriched with 9% cranberry powder had significantly higher water activity compared to biscuits with 3 and 6% cranberry powder. On the one hand, water activity of biscuits enriched with 3 to 9% of blueberry powder was not significantly different compared to control samples. On the other hand, significant differences were shown in moisture content ($p < 0.05$), where biscuits enriched with 9% blueberry and those with 9% cranberry differed from the control sample. Similarly, Mehta et al. [27] reported an increase in moisture content in samples enriched with tomato pomace, which can be explained by the fact that powdered cranberry and blueberry extracts may have greater water holding capacity than wheat flour. Similarly, Kolesárová et al. [28] reported a significant increase in moisture content with the addition of 5 and 15% of Saskatoon berry in biscuit composition.

Table 2. Physico-chemical parameters of biscuits enriched with plant extracts.

Sample	PE (%)	Weight (g)	Height (cm)	Specific Gravity (g/cm^3)	Moisture (%)	Water Activity	pH	Acidity
Control	0	8.76 ± 1.01 ^{a}	0.43 ± 0.06 ^{a}	0.73 ± 0.01 ^{a}	4.48 ± 0.24 ^{b}	0.32 ± 0.01 ^{c}	6.87 ± 0.08 ^{a}	7.36 ± 1.21 ^{b}
Blueberry-enriched biscuits	3	8.21 ± 0.47 ^{a}	0.55 ± 0.09 ^{a}	0.73 ± 0.02 ^{a}	5.26 ± 0.19 ^{ab}	0.32 ± 0.0 ^{c}	6.49 ± 0.04 ^{b}	8.99 ± 0.85 ^{ab}
	6	9.68 ± 0.23 ^{a}	0.43 ± 0.06 ^{a}	0.73 ± 0.01 ^{a}	5.63 ± 0.66 ^{ab}	0.34 ± 0.01 ^{bc}	6.25 ± 0.04 ^{c}	9.91 ± 1.68 ^{ab}
	9	9.52 ± 0.61 ^{a}	0.47 ± 0.06 ^{a}	0.74 ± 0.01 ^{a}	5.98 ± 0.35 ^{a}	0.35 ± 0.03 ^{bc}	6.10 ± 0.05 ^{cd}	11.22 ± 2.36 ^{ab}
Cranberry-enriched biscuits	3	8.81 ± 0.66 ^{a}	0.47 ± 0.06 ^{a}	0.74 ± 0.02 ^{a}	5.73 ± 0.48 ^{ab}	0.33 ± 0.01 ^{bc}	6.04 ± 0.04 ^{d}	11.68 ± 0.38 ^{ab}
	6	9.63 ± 0.72 ^{a}	0.40 ± 0.00 ^{a}	0.76 ± 0.03 ^{a}	5.75 ± 0.75 ^{ab}	0.39 ± 0.01 ^{b}	5.26 ± 0.04 ^{e}	13.74 ± 2.76 ^{a}
	9	9.42 ± 0.31 ^{a}	0.40 ± 0.00 ^{a}	0.78 ± 0.04 ^{a}	6.60 ± 0.64 ^{a}	0.49 ± 0.05 ^{a}	4.38 ± 0.08 ^{f}	14.16 ± 2.83 ^{a}

PE—Plant extract. Data are expressed as mean ± standard deviation. Means with different superscripts in same column are significantly different ($p < 0.05$).

The enrichment of biscuits with blueberry and cranberry powder also had an impact on the acidity and pH values of biscuits, where significant differences were recorded. Both

enriched biscuits samples with either cranberry or blueberry powder showed significant differences on pH values compared to the control biscuits samples (without plant extract) (Table 2). It can be emphasized that cranberry powder's addition of 3 to 9% had a significantly higher effect on decreasing pH values of biscuits compared with blueberry powder. Meanwhile, in terms of acidity, only the biscuit samples with 6% and 9% cranberry powder showed significant differences from the control biscuit samples. This can be explained by the fact that berries, including blueberry and cranberry, have a high content of organic acids, which has influenced the increase in the overall acidity of the biscuits [12]. On the other hand, there was no significant difference ($p > 0.05$) between analyzed samples in weight, height, and specific gravity parameters.

3.2. Color Attributes

Color is one of the key factors affecting the initial consumer acceptability of the food product. Nowadays, consumers are aiming for a healthy diet which includes natural dye compounds in foods instead of artificial ones. In this sense, the enrichment of biscuits with plant extracts that contain natural dyes such as anthocyanins could potentially have a positive influence on consumers' choice priorities. Color attributes of biscuits enriched with different concentrations of cranberry and blueberry extracts are presented in Table 3. Lightness values (L^*) were significantly decreased with increasing the blueberry powder from 0 to 6% in biscuits ($p < 0.05$). However, no significant differences were observed in lightness values between 6 and 9% blueberry-enriched biscuits ($p > 0.05$). A similar decreasing trend on lightness values was observed with increasing the cranberry powder from 0 to 9% in enriched biscuit samples. Lower lightness in enriched biscuits can be explained by the dark color derived from natural dye compounds of berries such as anthocyanins and by Maillard reactions during baking [17]. Similarly, Aksoylo et al. [17] reported that enriched biscuits with approximately 5% blueberry powder provided lower lightness compared to the control samples. Tarasevičienė et al. [29] also reported that the addition of 10% raspberry, red currant, and strawberry pomace significantly decreased the lightness of the enriched cookies.

On the other hand, redness values (a^*) were significantly increased with increasing the blueberry plant extract addition from 0 to 9% in biscuit composition. Similarly, redness values of the biscuits were increased with increasing cranberry powder addition from 0 to 3% and from 3 to 9% ($p < 0.05$). The increase in redness value in enriched biscuits can be attributed to high anthocyanin content known as red pigment present in berries [30]. Pasqualone et al. [31] reported a strong significant correlation between redness and anthocyanin content in anthocyanin-enriched biscuits. A previous study also reported that redness values were increased with increasing the blueberry content in biscuits [17].

Yellowness (b^*) values of biscuits were significantly reduced after 3% of cranberry powder addition ($p < 0.05$). Meanwhile, no significant change on yellowness was observed between 3, 6, and 9% cranberry-enriched biscuits ($p > 0.05$). On contrary, yellowness values of the biscuits were significantly reduced after 3% and after 6% blueberry powder addition ($p < 0.05$). The yellowness decrease in enriched biscuit samples can be explained by the lower amount of wheat flour in biscuit formulation (Table 1), and consequently lower carotenoid content, compared to control biscuit samples [31]. Tarasevičienė et al. [29] also reported that cookies enriched with addition of 10 to 20% raspberry, red currant, or strawberry pomace had significantly lower yellowness values compared to control samples. Chroma or saturation values (C^* value) of control samples (without plant extract) were significantly higher than both blueberry- and cranberry-enriched biscuits ($p < 0.05$). Similarly, Molnar et al. [32] reported that chroma values of biscuits were significantly reduced with addition of either black currant or jostaberry powders. The h-value of the biscuits was significantly decreased with increasing the concentration of blueberry powder from 0 to 9% ($p < 0.05$). Similarly, the h value of cranberry-enriched biscuits decreased with increasing the powder concentration from 0 to 3 % and from 6 to 9 % ($p < 0.05$). Previous

authors reported similar results of the *h*-value decreasing with the addition of plant extract powder in biscuits [17,32].

Table 3. Color attributes of biscuits enriched with plant extracts.

Attribute	Sample	Type of Plant Extract		*p*-Value
		Blueberry	Cranberry	
Lightness (*L**)	Control	76.89 ^{c}	76.89 ^{c}	
	3%	67.77 ^{bB}	63.28 ^{bA}	<0.001
	6%	65.06 ^{bB}	56.08 ^{aA}	<0.001
	9%	62.28 ^{aB}	54.86 ^{aA}	<0.001
Redness (*a**)	Control	0.08 ^{a}	0.08 ^{a}	
	3%	5.49 ^{bB}	3.43 ^{bA}	<0.001
	6%	6.35 ^{bB}	4.69 ^{cA}	<0.001
	9%	7.82 ^{cB}	6.76 ^{dA}	<0.05
Yellowness (*b**)	Control	34.52 ^{b}	34.52 ^{c}	
	3%	22.74 ^{aB}	15.55 ^{bA}	<0.001
	6%	22.62 ^{aB}	11.98 ^{aA}	<0.001
	9%	22.46 ^{aB}	9.56 ^{aA}	<0.001
Chroma (*C**)	Control	34.53 ^{b}	34.53 ^{c}	
	3%	23.40 ^{aB}	15.93 ^{bA}	<0.001
	6%	23.50 ^{aB}	12.88 ^{aA}	<0.001
	9%	23.80 ^{aB}	11.77 ^{aA}	<0.001
h-value (*h*)	Control	89.89 ^{c}	89.89 ^{d}	
	3%	76.42 ^{bA}	77.58 ^{cA}	0.193
	6%	74.33 ^{bB}	68.38 ^{bA}	<0.001
	9%	70.83 ^{aB}	53.80 ^{aA}	<0.001

a–d means with different letters in the same column are significantly different for percentage of plant extract ($p < 0.05$). A, B means with different letters in the same row are significantly different for plant extract type ($p > 0.05$; $p < 0.05$; $p < 0.001$).

Blueberry-enriched biscuits (3 to 9%) had significantly lower lightness, yellowness, and chroma values compared to cranberry-enriched biscuits ($p < 0.001$). Similarly, blueberry-enriched biscuits (3 to 9%) had significantly lower redness values compared to cranberry-enriched biscuits. *h*-values were significantly lower in blueberry-enriched biscuits compared to cranberry-enriched biscuits, with the exception of 3% enrichment. This shows that the addition of blueberry plant extract had a higher effect on changing the main color attributes of the biscuits compared to cranberry powder within the same concentrations.

However, for a better understanding of changes in color attributes of the enriched biscuits, authors believe that the total color difference can be evaluated between the studied treatments. The results of total color difference (ΔE) between biscuits enriched with different concentration of plant extracts are presented in Tables 4 and 5. According to Mokrzycki and Tatol [33], an observer notices two different colors when the ΔE is higher than 5. Our results showed that two distinct colors are perceived when the observer compares control biscuit samples (without plant extract) and enriched biscuits with either blueberry or cranberry powder (ΔE > 5) (Tables 4 and 5). Meanwhile, color differences can also be perceived by an inexperienced observer when 3 and 6% enriched blueberry biscuits samples are compared ($2 < \Delta E < 3.5$) (Table 4). A similar result was observed when comparing color properties (lightness, redness, and yellowness) of 6 and 9% blueberry and cranberry biscuits samples (Table 5).

Table 4. Total color difference between biscuits enriched with blueberry extracts.

Total Color Difference (ΔE)				
Treatment	**C**	**BB 3%**	**BB 6%**	**BB 9%**
C	-	V	V	V
BB 3%	15.86	-	III	V
BB 6%	17.92	2.84	-	III
BB 9%	20.47	5.97	3.15	-

BB—Blueberry plant extract. Latin numbers in the table indicate the total color difference (ΔE) categories: Category I: 0 < ΔE < 1, observer perceives no difference; category II: 1 < ΔE < 2, only the experienced observer perceives the difference; category III: 2 < ΔE < 3.5, the color difference is perceived also by an inexperienced observer; category IV: 3.5 < ΔE < 5, a clear color difference is perceived; and category V: ΔE > 5, observer notices two distinct colors.

Table 5. Total color difference between biscuits enriched with cranberry extracts.

Total Color Difference (ΔE)				
Treatment	**C**	**CB 3%**	**CB 6%**	**CB 9%**
C	-	V	V	V
CB 3%	23.59	-	V	V
CB 6%	31.02	8.13	-	III
CB 9%	33.96	10.85	3.41	-

CB—Cranberry plant extract. Latin numbers in the table indicate the total color difference (ΔE) categories: Category I: 0 < ΔE < 1, observer perceives no difference; category II: 1 < ΔE < 2, only the experienced observer perceives the difference; category III: 2 < ΔE < 3.5, the color difference is perceived also by an inexperienced observer; category IV: 3.5 < ΔE < 5, a clear color difference is perceived; and category V: ΔE > 5, observer notices two distinct colors.

3.3. Sensory Analysis

The main attributes on which consumers base the purchase and acceptability of a food or novel product are taste, nutritional values, and its impact on health. The addition of plant extracts to bakery products is seen as a future solution to improve their nutritional and functional properties due to the bioactivity derived from the phytochemicals of the plant ingredients [34]. However, the sensory attributes are those that are evaluated first by the consumer and influence the selection of a food product for consumption. Results of sensory attributes of biscuits enriched with different concentrations of blueberry and cranberry extracts are presented in Figures 1 and 2.

According to our results, there were significant differences in all the parameters included in the sensory evaluation of biscuits enriched with blueberry powder (Figure 1). The highest score for all parameters was obtained for biscuits enriched with 9% blueberry. Increasing the concentration of blueberry powder resulted in increasing the acceptability of consumers for all the attributes, especially taste and mouthfeel. Similarly, Kolesárová et al. [28] reported a significant increase on taste scores of biscuits enriched with 10 and 15% of Saskatoon berries. Contrary to this, another study has shown that there were no significant differences in aroma, taste, color, and overall acceptability of cookies with 10 and 20% red beetroot powder from the control samples [35]. This shows that consumers positively expect such formulations but differences in preferences vary depending on the amount of added extract and the extract used.

Compared to the control sample, slightly lower values were recorded by the samples of biscuits with 3% and 6% blueberry, which can be explained by the fact that the color of these biscuits was not as intense as that of biscuits with 9% blueberry which turned out to be the most liked. Ahmed and Ashraf [36] also reported an increase in liking for the appearance of the biscuits supplemented with different levels of whey protein concentrate, where the increase in the amount of whey protein concentrate was accompanied by an increase in the evaluation by consumers for the appearance and the aroma of the product. Consumers preferred biscuits with the darkest color and this result agrees with the results of a study for biscuits with buckwheat flour. Mouthfeel values were mostly affected by samples with 9% blueberry extract which is in accordance with Anselm et al.'s [37] results

for biscuits with African pear and orange flesh sweet potato flour blends. Generally, biscuits enriched with 9% blueberry powder were the most acceptable sample among panelists (48.3%), while biscuits without blueberry powder were the least liked (13.3%).

Similarly, results showed there were significant differences in the color, shape, texture, odor, and taste of biscuits with cranberry powder. The addition of cranberry powder significantly enhanced the scores for shape, texture, odor, and taste (Figure 2). Biscuits enriched with 6% and those with 9% cranberry were evaluated with the highest scores compared to samples with 3% cranberry and the control sample, which were evaluated with the lowest scores. The panelists considered that biscuits enriched with 6% cranberry had the best taste and had the most attractive sensory attributes (40%), while biscuits enriched with 3% cranberry received the lowest score of overall acceptance (10%). This may have happened since with 6% addition of cranberry powder the change in the biscuits' taste was clearly observed. These results agreed with the findings of Al-Marazeeq and Angor [38], who concluded that the taste of biscuits was enhanced by the addition of wheat germ at a level of 20%. In terms of texture and shape, the consumer acceptability was higher for biscuit samples with more cranberry extract which may be because of the greater softness of the product when a larger amount of plant extract was incorporated. Similar results were also achieved by Najjar et al. [39] in the study completed with cookies formulated with date seed powder.

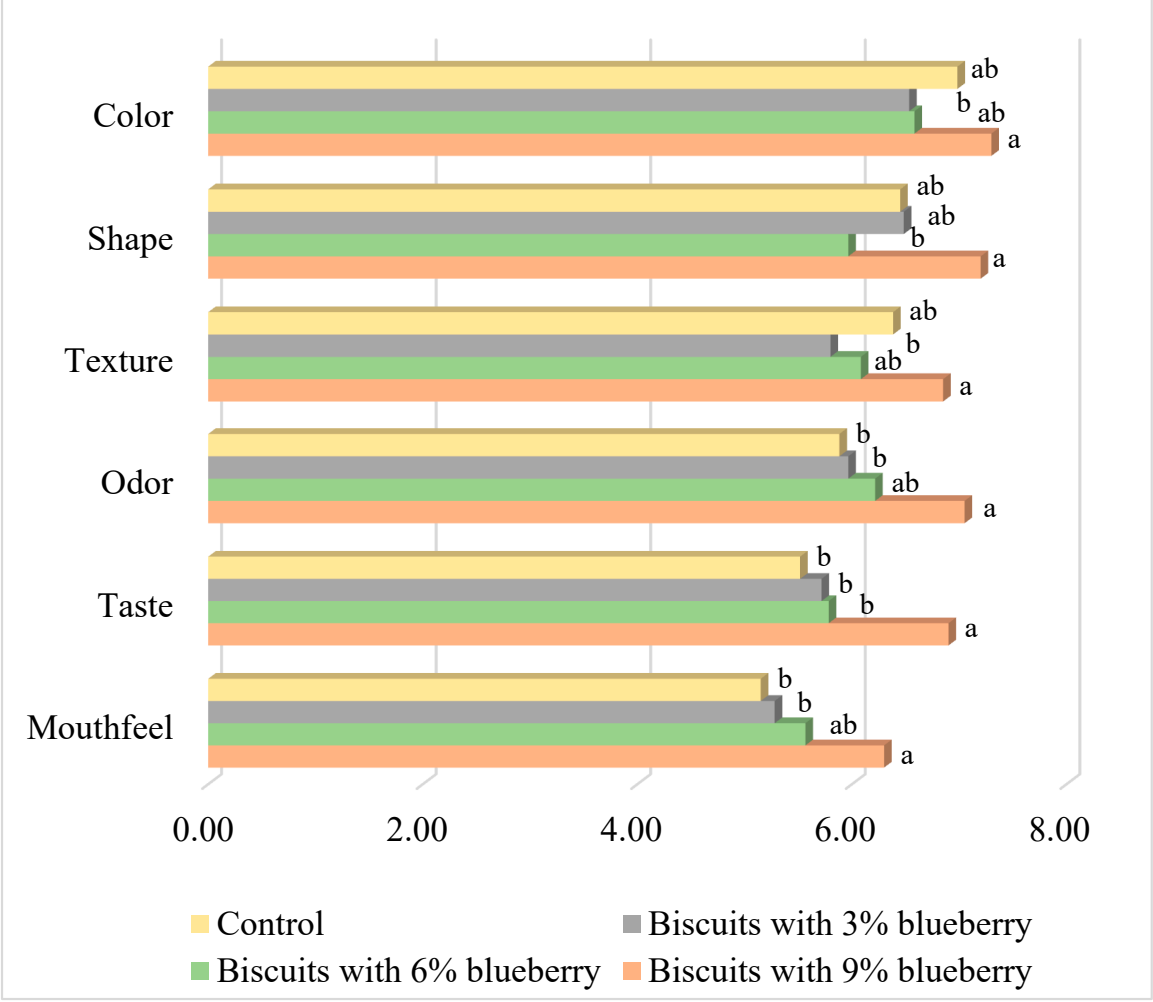

Figure 1. Sensory attributes of enriched biscuits with blueberry powder. a, b means with different letters next to the bars are significantly different for percentage of plant extract ($p < 0.05$).

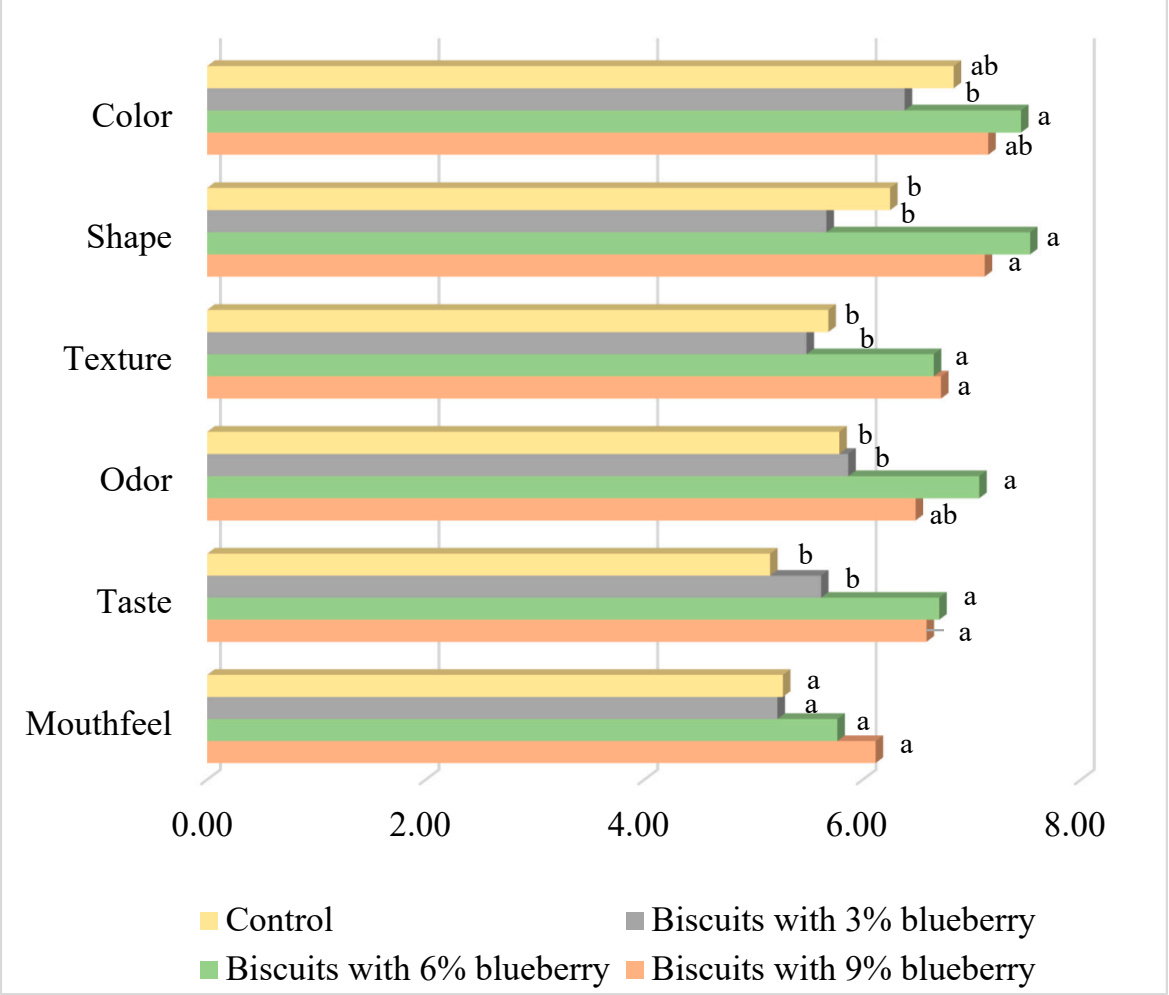

Figure 2. Sensory attributes of enriched biscuits with cranberry powder. a, b means with different letters next to the bars are significantly different for percentage of plant extract ($p < 0.05$).

Generally, biscuits enriched with blueberry and cranberry powder showed acceptable sensory attributes among panelists. These results agreed with Tarasevičienė et al. [29], who reported that the enrichment of cookies with berries' powder enhanced the acceptance of consumers for these products, since they had better color and taste characteristics. Based on our results, biscuits containing a higher amount of blueberry powder had better sensory properties including taste, mouthfeel, and texture. Similarly, Kolesárová et al. [28] reported that with higher addition of Saskatoon berry powder instead of flour the sensory properties of the biscuits were highly improved.

4. Conclusions

The present study demonstrated that the addition of plant extracts such as blueberry and cranberry had a positive effect on some of the physico-chemical and sensory properties of biscuits. The addition of blueberry extract increased the moisture content and decreased the pH values of biscuits. Meanwhile, cranberry-enriched biscuits had lower pH values, higher moisture content, water activity, and acidity compared to control biscuits. On the other hand, color attributes of biscuits such as lightness, yellowness, chroma, and hue values decreased with the addition of blueberry or cranberry extract. Meanwhile, redness values were higher in plant extract-enriched biscuits compared to control samples (without plant extract). Based on the overall acceptability results, biscuits enriched with 9% blueberry powder were the most favored regarding odor, taste, and mouthfeel. On the other hand, from cranberry-enriched biscuits 6 and 9% additions were the most favored among

consumers regarding shape, texture, and taste compared with 3% cranberry-enriched biscuits and control samples. This lead to the conclusion that berries' extracts can be applied in the food industry to develop bakery products with improved quality and sensory properties. However, future studies need to be conducted to examine the effect of berries' extracts on functional properties of biscuits such as antioxidant activity and polyphenolic content.

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