



Nutritional Enriched Muffins Based on Spelta Wheat and Sea Buckthorn (*Hippophae Rhamnoides L.*)

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Abstract

Sea buckthorn (*Hippophae rhamnoides L.*) which belongs to the Elaeagnaceae family, is a unique plant and valuable mainly for its medicinal and nutritional potential. The high percentage of active principles in sea buckthorn offers the possibility to use the whole plant in the waste-free technology and to reuse by-products for the production of high added value nutrients. The paper aims to study the nutritional, functional and sensorial properties of muffins obtained from Spelta wheat and fortified with sea buckthorn in different percentage (5-25%). The proximate composition (lipids, proteins, mineral substances, carbohydrates), macro and microelements and the content of total polyphenols, flavonoids but also the antioxidant activity of fortified products was determined. Also, the sensory analysis of the obtained products was evaluated. The results showed that the highest protein content was registered in the case of muffins with 25% (6.3%), respectively lipids (27.9%) and carbohydrates (37.4%). The content of total polyphenols varied between 946.05-1746.07 ppm, flavonoids (116.43-1212.88 ppm) and antioxidant activity (3.712-9.660 $\mu\text{M Fe}^{2+}/\text{g}$) the values increasing with de percentage of sea buckthorn addition. Sensorial analysis shown that the muffin obtained by addition of 25% sea buckthorn was considered the most appreciated in terms of all the sensory parameters analyzed.

Index Terms— functional food, muffins, sea buckthorn, spelta wheat

1. Introduction

Spelt (*Triticum aestivum ssp. spelta*), a primitive subspecies of common wheat, has a higher nutritional value, that includes sugars, proteins, lipids, vitamins and minerals [1]. Compared to wheat, spelt is higher in protein (and especially essential amino acids), lipids (with a low saturated fatty acid content) and minerals such as magnesium, iron, phosphorus, zinc and copper. [2, 3]. In addition, spelt grains are naturally higher in carbohydrates, fibre and B-complex vitamins, although variations in the composition of these compounds are reported in the literature [1].

The use of spelt wheat flour for the production of bakery products is of great interest, especially for the rheological characteristics of the dough. Spelt wheat flour doughs are less stable, less elastic and have a higher elasticity than wheat flour doughs. This is due to spelt gluten being predominantly gliadins, whereas common wheat gluten is predominantly

glutenins [4]. This negatively influences the manipulation of spelt dough, which is more complicated due to its stickiness and softness after kneading [1, 4]. Despite these drawbacks, spelt products are healthier in comparison to modern types of wheat. They can be used in a number of bakery products such as bread, biscuits, cookies and muffins [5], but also pasta, breakfast cereals and various bakery specialities [1, 2].

Because consumers are more and more concerned about healthy eating these days, specialists in the field are constantly looking for solutions to provide foods with increased functional value. One proposal would be to fortify bakery products with sea buckthorn (*Hippophae rhamnoides L.*), known to be a high source of bioactive constituents.

Sea buckthorn berries represent a valuable source of minerals, with Ca, P, Fe and K predominating. It is also high in vitamin C (360 and 2500 mg/100 g) [6], content which is several times higher compared to other fruits [7]. The plant constitutes a valuable source of B vitamins, mainly B1 (thiamine) and B2 (riboflavin) [7], but also other vitamins, e.g. vitamin E [8], vitamin A and K [9, 10]. Sea buckthorn pulp is also a rich source of carotenoids, mainly α -, β - and γ -carotenes, glycopenone [10], zeaxanthin, lycopene and lutein [8].

In the present work, the nutritional, physicochemical and sensory characterization of spelt wheat flour muffins fortified with cathine in different percentage was followed (5-25%).

2. Materials and Methods

A. Preparation of muffins from spelt wheat flour and sea buckthorn

Sea buckthorn was purchased from local producers belonging to the west area of Romania, spelt wheat flour (SF) was purchased from Pronat Timisoara, Romania. Sea buckthorn fruits were conditioned by drying in a dehydrator (Froilabo AC60, France) during 16 hours up to 60°C to prevent the degradation of bioactive compounds.

Dehydrated sea buckthorn fruits were ground using a laboratory mill (Grindomix GM 2000, Retsch GmbH, Germany) to a fine powder which was passed into a 60 mesh sieve. This powder was used to obtain the muffins according to the recipes presented in the Table 1. After dosing the raw materials according to the manufacturing recipe, the egg whites were separated from the yolks in individual dishes. White eggs and half of sugar quantity are mixed with a kitchen mixer at high speed until the eggs foam and a fairly consistent cream is formed (about 5 minutes). The egg yolks are mixed with the rest of the sugar and with different level of sea buckthorn flour. The oil is added in a thin stream under mixing until it is completely incorporated. The spelta flour and baking powder are added to the composition and mixed slowly. The composition is divided in equally parts in the holes of a muffin tray and baked in the oven preheated to 180 degrees Celsius for about 25 minutes. The muffins must be raised and the middle must be well baked.



Figure 1. Muffins samples

Table 1. Recipe for obtaining functional muffins from spelt wheat and buckwheat flour

Sample	Abbreviation	Spelt wheat flour (%)	Sea buckthorn powder (%)	Sugar (%)	Fat (%)	Eggs (%)	Baking powder (%)	Flavours (%)
Muffins with spelta wheat	SW	24.68	0.00	24.68	24.68	24.68	0.35	0.94
Muffins with spelta wheat and 5% sea buckthorn	SWS5	23.44	1.23	24.68	24.68	24.68	0.35	0.94
Muffins with spelta wheat and 10% sea buckthorn	SWS10	22.21	2.47	24.68	24.68	24.68	0.35	0.94
Muffins with spelta wheat and 15% sea buckthorn	SWS15	20.98	3.70	24.68	24.68	24.68	0.35	0.94
Muffins with spelta wheat and 20% sea buckthorn	SWS20	19.74	4.94	24.68	24.68	24.68	0.35	0.94
Muffins with spelta wheat and 25% sea buckthorn	SWS25	18.51	6.17	24.68	24.68	24.68	0.35	0.94

This resulted in 6 samples of muffins SW (100% spelt wheat flour), SWS5 (95% spelt wheat flour + 5% sea buckthorn); SWS10 (90% spelt wheat flour + 10% sea buckthorn); SWS15 (85% spelt wheat flour + 15% sea buckthorn); SWS20 (80% spelt wheat flour + 20% sea buckthorn); SWS25 (75% spelt wheat flour + 25% sea buckthorn) which were analysed in terms of proximate composition, functional properties and sensory analysis (figure 1).

B. Proximate composition

The proximate composition of the muffin samples obtained was determined according to following ISO Methods: Ash - SR ISO 2171/2010; Protein - SR EN ISO 8968-1:2014; Moisture - SR 91/2007 pct.10; Lipid - SR 91:2007 pct.14.4. The carbohydrate content (%) and nutritional value was determined according to the equation 1 and 2

$$\text{Carbohydrates (\%)} = 100 - (\text{lipids} + \text{proteins} + \text{water} + \text{ash}) \quad (1)$$

$$\text{Energy value (kcal/100g)} = (\text{lipids} \times 9) + (\text{carbohydrates} \times 4) + (\text{proteins} \times 4) \quad (2)$$

C. Phytochemical profile

The total polyphenol content (TPC) was determined by the modified Folin-Ciocalteu method [11] and was expressed as mg GAE/kg. Total flavonoid content (TFC) was determined as described in a modified method by Plustea, et al. 2022 [11] and was expressed as mg QUE/kg. Antioxidant activity by FRAP method was made according to the methodology described by Cocan et al. 2022 [12].

D. Macro and microelements

The macro and microelement content has been determined by atomic absorption spectroscopy (AAS) with Varian 220 FAA equipment as described by Plustea, et al. 2022 [11]. Results were expressed in ppm.

E. Sensory analysis

The muffin samples have been evaluated by a group of 50 evaluators (25 men and 25 women), aged between 18 and 50, non-smokers, with no known cases of food allergies. For the evaluation of sensory characteristics a five-point hedonic scale has been used with the following scores: 1=extremely unpleasant; 2=slightly unpleasant; 3=neither pleasant nor unpleasant; 4=slightly pleasant; 5=extremely pleasant.

The sensory characteristics that were assessed were: appearance, colour, texture, aroma, taste and overall acceptability. The range of scores and degree of acceptability was as follows: 1.00–1.49=not acceptable (NA); 1.5–2.49=slightly acceptable (SA); 2.50–3.49=moderately acceptable (MA); 3.5–4.49=acceptable (A); 4.5–5.00=highly acceptable (HA) [11].

F. Statistical analysis

All determinations were made in triplicate and the results are reported as mean values \pm standard deviation (SD). Differences between values were investigated by t-test (two-sample assuming equal variances) using Microsoft Excell 365. Differences were considered significant when p-values < 0.05 .

3. Results and Discussions

A. Proximate composition

The results reported in Table 1 illustrate the proximate composition of sea buckthorn-enriched muffins.

Table 1 Proximate composition of the muffins fortified with sea buckthorn

Sample	Moisture (g/100 g)	Ash (g/100 g)	Protein (g/100 g)	Lipids (g/100 g)	NaCl (g/100 g)	Carbohydrates (g/100 g)	Sugar (g/100 g)	Energy value [kcal/ 100 g]
SW	25.73 \pm 0.51 ^a	0.85 \pm 0.02 ^a	6.01 \pm 0.15 ^a	27.08 \pm 0.70 ^a	0.24 \pm 0.01 ^a	40.09	25.06 \pm 0.60 ^a	428.12
SWS5	25.96 \pm 0.52 ^{a,b}	0.87 \pm 0.02 ^a	6.07 \pm 0.15 ^a	27.28 \pm 0.71 ^a	0.24 \pm 0.01 ^a	39.58	25.39 \pm 0.61 ^{a,b}	428.10
SWS10	26.28 \pm 0.52 ^{b,c}	0.90 \pm 0.03 ^a	6.14 \pm 0.15 ^{a,b}	27.49 \pm 0.72 ^b	0.24 \pm 0.01 ^a	38.95	25.72 \pm 0.62 ^{a,b,c}	427.77
SWS15	26.61 \pm 0.53 ^{c,d}	0.92 \pm 0.03 ^a	6.20 \pm 0.16 ^b	27.69 \pm 0.72 ^{b,c}	0.24 \pm 0.01 ^a	38.34	26.04 \pm 0.63 ^{b,c}	427.37
SWS20	26.89 \pm 0.53 ^{d,e}	0.95 \pm 0.03 ^a	6.27 \pm 0.14 ^{b,c}	27.79 \pm 0.72 ^{c,d}	0.24 \pm 0.01 ^a	37.86	26.37 \pm 0.64 ^c	426.63
SWS25	27.19 \pm 0.54 ^e	0.97 \pm 0.03 ^a	6.30 \pm 0.15 ^c	27.90 \pm 0.73 ^d	0.24 \pm 0.01 ^a	37.40	26.70 \pm 0.65 ^d	425.90

^{a-e} Data from the same row with different superscripts is statistically significantly different (p < 0.05) by t-test.

The moisture content of the muffin samples ranged from 25.73 - 27.19 g/100g, increasing with increasing proportion of added sea buckthorn. The mineral substances in the muffin samples showed a slight increase, proportional to the amount of added fortified flour, with values ranging from 0.85 - 0.97 g/100g, with no statistical differences between values. Protein and lipid contents increased in proportion to the amount of added sea buckthorn, falling within the ranges 6.01 - 3.6 g/100g for protein and 27.08 - 27.90 g/100g for lipids. The NaCl content was 0.24 g/100 g for all muffin samples studied and the sugar content ranged from 25.06 - 26.70 g/100 g. The carbohydrate content was higher in the SW control sample (40.09%) compared to the muffin samples with the addition of sea buckthorn (37.40 - 39.58g/100g), which means that the addition of sea buckthorn contributes to the lower carbohydrate content.

Statistically significant differences in moisture, protein, lipid and sugar content of the muffin samples analysed are observed.

A similar trend in proximate composition was recorded by Lončar *și* colab. [13] who supplemented spelt flour muffins with apple powder. In the case of this study, values ranging from 10.57 - 12.75% for protein, 9.59 - 12.16% for moisture, 11.79 - 14.40% for fat and 31.3 - 36.84% for sugar were recorded. Also [14] showed similar results in samples of biscuits fortified with different proportions of baobab flour.

B. Macro and microelements

The results presented in Table 2 illustrate the macro and microelements of the muffin samples fortified with sea buckthorn.

Table 2. Macro and microelements of the samples

	Mg (mg/100g)	Ca (mg/100g)	K (mg/100g)	Na (mg/100g)	Zn (mg/kg)	Fe (mg/kg)	Cu (mg/kg)
SW	76.54 ± 1.58 ^a	42.87 ± 0.68 ^a	185.49 ± 3.28 ^a	55.48 ± 0.88 ^a	1.58 ± 0.01 ^a	2.57±0.02 ^a	0.77±0.02 ^a
SWS5	78.28 ± 1.52 ^b	44.68 ± 0.69 ^b	188.54 ± 3.33 ^a	56.97 ± 0.92 ^a	1.68 ± 0.01 ^{a,b}	2.71±0.03 ^b	0.76±0.03 ^a
SWS10	79.64 ± 1.53 ^c	47.250 ± 0.75 ^c	197.26 ± 3.42 ^b	58.82 ± 1.05 ^b	1.82 ± 0.01 ^{b,c}	2.92±0.02 ^c	0.72±0.05 ^{a,b}
SWS15	80.19 ± 1.55 ^c	49.73 ± 0.82 ^d	206.79 ± 3.64 ^c	59.92 ± 1.19 ^{b,c}	1.99 ± 0.01 ^c	2.99±0.01 ^c	0.69±0.1 ^{b,c}
SWS20	82.46 ± 1.57 ^d	50.46 ± 0.91 ^d	218.69 ± 3.89 ^d	60.83 ± 1.22 ^c	2.01 ± 0.01 ^{c,d}	3.05±0.03 ^d	0.65±0.04 ^c
SWS25	85.55 ± 1.61 ^e	51.28 ± 1.08 ^e	220.77 ± 3.96 ^d	62.95 ± 1.48 ^d	2.15 ± 0.02 ^d	3.19±0.02 ^e	0.63±0.06 ^c

^{a-c} Data from the same row with different superscripts is statistically significantly different ($p < 0.05$) by t-test.

The role of magnesium and calcium in the body is to maintain the health of muscles, bones and the nervous system and to strengthen the immune system. For a balanced life, it is important to maintain an optimal level of macronutrients in the body by adopting an appropriate diet [13]. From the experimental results obtained, it can be seen that the addition of buckwheat flour leads to an increase in the intake of macroelements in muffin samples

depending on the percentage added. Mg ranged from 76.54 mg/100 g in the control sample to 85.55 mg/100 g in the sample with 25% sea buckthorn added. The Ca content varied within narrower limits, between 43.87-51.28 mg/100 g, and the K content between 185.49-220.77 mg/100 g.

Similar results were recorded by Lončar et al. [13] in samples of spelt wheat flour muffins supplemented with apple powder, where 65.12 - 85.37 mg/100g Mg; 49.73 - 56.07 mg/100 g Ca; 191.47 - 256.85 mg/100 g K and 34.70 - 43 mg/100 g Na)

Micronutrients (Cu, Zn, Fe) are very important for the normal functioning of the living organism. In the human body, copper, like iron, plays an important role in the cells that form red blood cells and in maintaining healthy blood vessels and nerves, bones and the immune system. Zinc and iron are microelements whose assimilation is achieved exclusively through ingestion [11]. The copper content determined in the analysed samples ranges from 0.77-0.63 ppm and decreases with the addition of sea buckthorn in the muffin samples. Zinc and Fe content increases with the supplementation of the functional premix with buckthorn flour, the maximum value for Fe being recorded in the case of the sample with 25% sea buckthorn flour (3.29 ppm), respectively for Zn (2.15 ppm).

C. Phytochemical profile

Table 3 shows the phytochemical profile of spelt wheat flour muffin samples supplemented with sea buckthorn.

Table 3. Phytochemical profile of the muffins samples

	Total polyphenols content (mg/kg)	Total flavonoids content (mg/kg)	FRAP value average ($\mu\text{M Fe}^{2+}/\text{g}$)
SW	942.65±25.45 ^a	56.23±1.78 ^a	3.17±0.06 ^a
SWS5	946.05 26.08 ^a	116.43±3.49 ^b	3.71±0.10 ^a
SWS10	1114.01±30.25 ^b	185.30±5.55 ^c	4.64±0.12 ^b
SWS15	1356.09±36.48 ^c	194.75±5.75 ^c	5.40±0.14 ^b
SWS20	1575.39±40.25 ^d	586.34±17.21 ^d	7.25±0.19 ^c
SWS25	1746.07±45.67 ^e	1212.88±32.28 ^e	9.66±0.26 ^d

^{a-e} Data from the same row with different superscripts is statistically significantly different ($p < 0.05$) by t-test.

The TPC content of the muffin samples ranged from 942.65 - 1746.07 $\mu\text{M GAE/g}$. It is observed that TPC increases proportionally with increasing the proportion of added rennet, with the lowest TPC content in the control sample (SW 942.65 mg/kg) and the highest in the sample with 25% added sea buckthorn (SWS25 1746.07 mg/kg). The results showed that the total polyphenol content (TPC) increased with increasing the sea buckthorn content in muffins samples. This can be explained by the fact that the strawberry has high polyphenol content, i.e. 18.66 mg GAE/g [15]. A similar trend was recorded by Lončar et al. [13] who supplemented spelt flour muffins with apple powder. Similar results were also recorded by [16] who supplemented spelt wheat flour biscuits with different proportions of red beet powder.

The total flavonoid content (TFC) showed the same linearity as in TPC. Thus, the TFC content ranged from 30.297 ± 0.364 mg/kg. Similar to the TPC profile, TFC increased proportionally with increasing added sea buckthorn content in the composition, with statistically significant differences in the TFC content of the muffin samples with different sea buckthorn percentage.

Similar trend in TFC content for was reported by [16] which supplemented spelt wheat crackers with varying proportions of red beet powder.

The same trend was observed for TPC and TFC, and was maintained for the antioxidant activity (AA) profile, with values ranging from 3.17 to 9.66 $\mu\text{M Fe}^{2+}/\text{g}$. The highest value was recorded for SWS25 (9.66 ± 0.26 $\mu\text{M Fe}^{2+}/\text{g}$) and the lowest value for SW (3.17 ± 0.06 $\mu\text{M Fe}^{2+}/\text{g}$). Also in this case AA increased proportionally to the increase in the amount of sea buckthorn, showing statistically significant differences.

Mitrevski et al., [16] reported a similar trend for AA in chestnut flour ($61.57 \pm 0.05\%$) and in spelt wheat flour biscuits with different proportions of red beet powder.

D. Sensory analysis

Figure 1 shows the sensory analysis of spelt wheat flour muffin samples supplemented with sea buckthorn.



Figure 2. Sensory analysis of muffin samples analysed

The sensory analysis of the muffin samples showed that SWS25, with 25% added sea-buckthorn, was the most appreciated, with average scores of 4.75 for taste, 4.99 for colour, 4.89 for texture, 4.97 for aroma and 4.92 for overall acceptability (Figure 2), falling within the range of scores 4.5-5.00, indicating high acceptability (HA). The ranking of the samples following sensory analysis was for all characteristics as follows SWS25>SWS20>SWS15>SWS10>SWS5>SW.

4. Conclusion

The global evaluation of the muffins fortified with sea buckthorn, from nutritional, phytochemical and sensory point of view, shown that this matrix represents an important source in nutrients and active principles. Functional and nutritional attributes of muffins improved using 5-25% sea buckthorn flour were higher compared to the control sample.. The consumer's acceptability indicates that the most highly appreciated were the muffins with 25% sea buckthorn addition.

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