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SCIENTIFIC PAPER

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SPELT PASTA WITH INCREASED CONTENT OF FUNCTIONAL COMPONENTS

Article Highlights

- Addition of flax seed flour in spelt pasta increases the share of ω-3 fatty acids and improves ω-6/ω-3 ratio
- Pasta with 20 g sesame flour/100 g spelt flour has the best content of essential minerals elements
- New functional product with enriched mineral content, a source of monounsaturated fatty acids

Abstract

This paper investigates the effects of addition of flax seed, sesame seed, or eggs (10 g/100 g of sample and 20 g/100 g of sample) in spelt flour to obtain new pasta products with improved ω-3/ω-6 ratio and minerals profile. Gas chromatography with mass spectrometry was used for carrying out a quantitative analysis of the liposoluble pasta extract. Post-hoc Tukey's HSD test at 95% confidence limit showed significant differences between observed samples. Daily average consumption of 75 g of spelt pasta containing 20 g flax seed/100 g of sample contributes to essential fatty acids intake of 3.8 g and improved ω-6/ω-3 ratio (1:2.4). The obtaind results indicate that the investigated spelt pasta samples are new products with improved nutritional properties due to higher level of ω-3 fatty acids and minerals content (Ca, Zn, Cu and Fe). Pasta (PS 7) with 20 g/100 g of eggs has the best sensory quality (maximum scores for odor, texture, flavor and overall acceptability were 8.8, 8.9, 8.9 and 8.9, respectively).

Keywords: ω-6/ω-3 ratio, fatty acid, mineral content, GC-MS analysis, functional properties.

Nutritional and functional properties of pasta can be improved by using spelt as basic raw material for the production of pasta and some additional raw material such as fatty acids, flax seed or eggs for improving functional properties [1,2]. Spelt is a suitable raw material for pasta production, breakfast cereals, bread and other products of altered nutritional characteristics compared to conventional wheat products. Some spelt cultivars have very high protein content and even 30 to 60% higher concentration of mineral elements (Fe, Zn, Cu, Mg and P) compared to *Triticum aestivum* [1,3,4]. Pasta is also suitable for correcting nutrition plans because it is quick and easy to prepare, easily digestible food and it is one of the widespread foods in many countries around the world [1,2].

Eggs added to pasta contribute to better mechanical properties and quality of the product and also increase the nutritive and biological value of the product, which is reflected in the increase of lysine, ω-3 fatty acids and lecithin. By consumption of products enriched with eggs human meets recommended needs ω-3 fatty acids [5-7]. Flax seed (*Linum usitatissimum*) contains important substances in its composition such as vitamins A, B and E, magnesium, calcium, zinc, selenium, phosphorus, and it is also an excellent source of fibres and one of the best sources of ω-3 fatty acid and lignan (phytoestrogens with antioxidant effects) [8]. The intake of long-chain ω-3 PUFA in many developed countries (average 0.15 g per day) is below the recommended level [9]. The ratio of ω-6 to ω-3 in the diet should be 4 to 1 [10]. For

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this reason, food products enriched with ω-3 fatty acids can improve the ratio of ω-3/ω-6 in the diet in order to decrease the level of risk of the diseases caused by "lifestyle", especially cardiovascular disease [11,12]. Sesame (*Sesamum indicum L.*) plays an important role in human nutrition. The chemical composition of sesame shows that the seed is an important source of oil (44-58%), protein (18-25%), carbohydrate (13.5%) and ash (5%) [13]. Sesame seed provides additional medical and nutritional enrichment by contributing high levels of polyphenol antioxidant rich dietary lignins that also have antimutagenic properties [14]. New studies are identifying potential benefits for a wide range of conditions including cancer, inflammatory bowel disease and other autoimmune diseases such as lupus and rheumatoid arthritis. The main challenges of food producers are to produce food enriched with ω-3 fatty acids in the way that it does not reduce their current quality despite the added active ingredient [15].

The aim of this study was to produce spelt pasta with addition of flax seed, sesame seed or eggs with improved nutritional properties: improved ratio ω-6/ω-3 fatty acids and minerals content.

MATERIAL AND METHODS

Materials

The following materials were used for pasta production: whole meal organic spelt flour, (Serbia, 2015) characterized by starch, protein, lipids and cellulose content of 56.6, 17.6, 2.5 and 2.4% d.m., respectively, and nutritive components:

- flax seed from organic production, purchased in an organic food store in Novi Sad,
- sesame seed from organic production, purchased in an organic food store in Novi Sad,
- eggs, purchased from a local food market.

The nutritive components and mineral profile of different flours are presented in Table 1.

Methods

Preparation of pasta

Pasta was made using the device "La Parmigiana D45" MAC 60 (Fidenza, Italy). The raw material was placed in a paddle mixer – a constituent part of the device (capacity 4 kg/h), equipped with 6 paddles (rotating speed of 60 rpm). The moisture content of raw material was adjusted to 31.5% by adding tap water preheated at 40 °C. During mixing (15 min), 6 paddles help to distribute added water evenly over the surface of flour particles [16]. Immediately after mixing, the hydrated mass entered the extrusion screw (length 300 mm, diameter 55 mm) which moved the loose dough forward (speed of feeding 250 g/min, screw speed 60 rpm, extruded temperature 40 °C) and simultaneously compressed it into a homogeneous plastic mass prior to extrusion through a die with 1.4 mm diameter used for spaghetti. The extrusion temperature was around 40 °C. Constant temperature during pasta forming was ensured by tap water circulating through the barrel.

Raw pasta was dried in a chamber drier EC25GE (Italgy S.r.l., Pasiano di Pordenone, Italy) about 12 h at controlled temperature that did not exceed 45 °C. Humidity was adjusted to 70% and controlled until pasta reached the moisture around 12.5%, followed by cooling to 25 °C, for 4 h and then stored at room temperature in sealed containers. Drying conditions and air flow were stringently controlled to avoid the creation of a discontinuity in the moisture

Table 1. Fatty acids and mineral profile of different samples; the results are presented as mean±SD; C16:0 palmitic acid, C18:0 stearic acid, C1:18 oleic acid, C18:2N linoleic acid ω-6, C18:3 N-linolenic acid ω-3

Property	Component	Sample			
		Spelt flour	Flaxseed flour	Sesame seed flour	Eggs
Fatty acids ($X\pm SD$, g/100 g of sample)	C 16:0	0.40±0.05	2.8±2.06	5.61±1.09	1.84±1.4
	C 18:0	0.11±0.09	2.72±1.94	0.54±0.77	0.70±0.05
	C 1:18	0.79±0.12	9.40±2.37	22.45±3.5	0.27±0.04
	C 18:2N, ω-6	0.89±0.25	6.84±1.15	3.58±1.6	3.93±0.07
	C 18:3N, ω-3	0.04±0.01	25.75±5.08	0.08±0.7	0.05±0.09
	ω-6/ω-3	22:1	1:3.8	44:1	78.6:1
Mineral content ($X\pm SD$, mg/100 g of sample)	Ca	247.55±9.15	1824.5±21.10	19065±17.45	0.05
	Zn	18.93±2.03	39.5±1.54	48.5±5.21	Trace
	Cu	3.37±0.74	11.89±2.04	13.82±1.6	Trace
	Mn	39.59±1.89	2143.5±33.12	16.36±3.54	Trace
	Fe	27.38±3.51	108.51±41.56	85.22±6.58	0.0027

gradient between the interior and exterior of spaghetti.

Seven formulations of pastas were tested. Table 2 describes pasta formulations enriched with different quantities of nutritive components: PS 1 (control sample), PS 2 (10% flax seed and 90% spelt flour), PS 3 (20% flax seed and 80% spelt flour), PS 4 (10% sesame seed and 90% spelt flour), PS 5 (20% sesame seed and 80% spelt flour), PS 6 (10% of liquid eggs and 90% spelt flour), PS 7 (20% of liquid eggs and 80% spelt flour). For each formulation, pastas were prepared in batches of 2 kg, with two replicates.

Table 2. Pasta formulation with different quantities of nutritive components

Sample	Raw material (g/100 g of sample)			
	Spelt flour	Flax seed	Sesame seed	Liquid eggs
PS 1	100	0	0	0
PS 2	90	10	0	0
PS 3	80	20	0	0
PS 4	90	0	10	0
PS 5	80	0	20	0
PS 6	90	0	0	10
PS 7	80	0	0	20

Fatty acid analysis - GC-MS analysis

The fat phase for fatty acid (FA) analysis was extracted from the samples by the Folch method as recommended for isolation of total lipids [17]. FA methyl esters were prepared from the extracted lipids by transmetilation using 14 wt.% boron trifluoride/ /methanol solution [18]. Obtained samples were analyzed by an Agilent 7890A gas chromatographer (Agilent Technologies, CA, USA) with a flame ionization detector (GC-FID), autoinjection module for liquid, equipped with a fused silica capillary column (Supelco SP-2560 Capillary GC Column 100 m×0.25 mm, d = 0.20 μm) and helium as a carrier gas (purity = 99.9997 vol.%, flow rate = 1.5 ml/min and pressure of 1.092 bar). The samples were injected in volumes of 1 μl in split regime with a ratio of 30:1. Following temperature regime was applied: initial temperature 140 °C, initial temperature hold time 5 min, heating rate 3 °C/min, final temperature 240 °C and final temperature hold time 10 min. Nitrogen was used as a makeup gas. The FAs peaks were identified by comparison of retention times with retention times of standards from "Supelco 37 component FA methyl ester mix" (Sigma-Aldrich) and with data from internal data library, based on previous experiments and FA methyl ester determination on GC-MS. The results were expressed as mass of individual fatty acid or fatty acid group (g) in 100 g of fatty acids, or as relative mass contents.

Mineral profile of pasta with nutritive components

Mineral contents of calcium, zinc, copper, magnesium and iron were determined using an Atomic Absorption Spectrophotometer, AOAC [19].

Sensory analysis

The test to assess the quality and acceptability was performed by 60 inexperienced tasters. The tasters were asked to evaluate the following sensory properties of seven formulations of pastas with different quantities of nutritive components: odor, texture, flavor, and overall acceptability using a 9 point hedonic scale (1 = dislike extremely, 2 = dislike very much, 3 = dislike moderately, 4 = dislike slightly, 5 = neither like nor dislike 6 = like slightly, 7 = like moderately, 8 = like very much, 9 = like extremely) [20].

Statistical analyses

Descriptive statistical analyses for all the obtained technological parameters were expressed as the mean ± standard deviation (*SD*). The evaluation of one-way ANOVA analyses of the obtained results were performed using StatSoft Statistica 10.0 software. Collected data were subjected to one-way analysis of variance (ANOVA) for the comparison of means, and significant differences are calculated according to post-hoc Tukey's HSD (honestly significant differences) test at $p < 0.05$ significance level, 95% confidence. The pattern recognition technique was applied within assay descriptors to characterize and differentiate various pasta samples, and the classification and discrimination of analyzed samples was done by principal component analysis (PCA) using presented fatty acid and mineral data.

The score analysis uses min-max normalisation of pasta samples fatty acids and mineral profile parameter responses and transfers them from their unit system in new dimensionless system which allows further mathematical calculation of different types of responses [21]. The maximum value of normalised score presents the optimum value of all analysed responses and indicates on optimal pasta formulation:

$$S_{ki} = 1 - \frac{x_{ki} - x_{k\min}}{x_{k\max} - x_{k\min}},\ k = 1\text{-}3 \quad (1)$$

where x_k represents: palmitic acid, stearic acid and ω-6/ω-3 ratio.

$$S_{ni} = \frac{y_{ni} - y_{n\min}}{y_{n\max} - y_{n\min}},\ n = 1\text{-}3 \quad (2)$$

where y_n represents: oleic acid, linoleic acid and linolenic acid.

$$S_{mi} = \frac{z_{mi} - z_{m\min}}{z_{m\max} - z_{m\min}},\ m = 1\text{-}5 \quad (3)$$

where z_m represents: Ca, Zn, Cu, Mn and Fe.

$$S_{ME_i} = \frac{\sum_{i=1}^{m} S_{mi}}{5} \quad (4)$$

$$S_{T_i} = \frac{\sum_{i=1}^{k} S_{ki} + \sum_{i=1}^{n} S_{ni} + S_{ME_i}}{k + n + 1} \quad (5)$$

$$\max\left[S_{T_i}\right] = \text{optimum}$$

RESULTS AND DISCUSSION

Fatty acids composition of the pasta with different shares of nutritive components

The distribution of saturated, monounsaturated and polyunsaturated fatty acids in spelt pasta, pasta with flax seed, sesame seed or eggs are given in Table 3. The spelt pasta (PS 1) contains 2.31 g/100 g of total fatty acids with the shares of linoleic acid (0.91 g/100 g) and linolenic acid (0.05 g/100 g, Table 3). In pasta PS 1, ω-6 fatty acids make a share of 39.2% while the ω-3 fatty acids make a share of only 2.1%, which is similar to findings of Abdel et al. [22], and the essential fatty acids ratio of ω-6/ω-3 was 18.2:1. The addition of flax seed (Table 2) in spelt pasta significantly ($p < 0.05$ level) increases the share of linolenic acid (Table 3). This resulted in improvement of ω-6/ω-3 ratio, which was 1:1.7 and 1:2.4, for the samples PS 2 and PS 3, respectively (Table 3). Pastas PS 4 and PS 5 have significant ($p < 0.05$ level) higher content of palmitic acid than other samples (PS 1, PS 2, PS 3, PS 6, and PS 7). The addition of eggs (20 g/100 g) (Table 2) in spelt pasta significantly increases the share of linoleic acids (Table 3) compared to PS1 and also significantly improved technological quality of the pasta as stated by Filipović *et al.* [1,6]. Despite conflicting evidence about the role of cholesterol intake in cardiovascular disease risk, according to Exler [7] the level of cholesterol in pastas PS 6 and PS 7 was low, around 11.5 and 23 mg/100 g, respectively. While obtaining pasta with eggs, it is also worth considering using eggs with low amount of cholesterol [7]. By consuming 75 g of pasta with 20 g/100 g of sample flax seed intake ω-3 fatty acids is about the 3.8 g, which contributes to the improvement of ω-6/ω-3 ratio (1:2.1) in the daily diet (Table 3). Consumption of 75 g pasta with 20 g/100 g of sample flax seed is also satisfying daily needs of ω-3 fatty acid intake recommended by the Food and Drug Administration (FDA) [23,24].

Mineral composition of the pasta with different shares of nutritive components

The mineral composition properties of pasta with different shares of nutritive components are presented in Table 4. Due to sesame seed mineral composition (Table 1), these tests show statistically significant differences in calcium and copper content between the values of pastas without sesame seed: PS 1, PS 2, PS 3, PS 6, PS 7 and pastas with sesame seed content in formulation: PS 4 and PS 5 (Table 3). The manganese content of different pastas ranged between 32.26 mg/100 g in PS 3 and 39.72 mg/100 g in PS 7. Tukey's HSD test indicates the significantly ($p < 0.05$ level) higher iron contents of pasta PS 5 (Table 3), which confirms that sesame seed (Table 1) is rich sources of essential minerals and its addition to pasta significantly improves mineral content intake. Highest values of Ca, Zn, Cu and

Table 3. Fatty acids composition of the pasta with different shares of nutritive components; the results are presented as mean±SD (g/100g of sample); different letter within the same column indicates significant differences (p < 0.05), according to Tukey's test, number of repetitions: n = 3; SFA-saturated fatty acids, MUFA-monounsaturated fatty acids, PUFA-polyunsaturated fatty acids, C16:0 palmitic acid,C18:0 stearic acid, C1:18 oleic acid, C18:2N linoleic acid ω-6,C18:3 N-linolenic acid ω-3

Sample/pasta	Fatty acid					ω-6/ω-3 Ratio
	SFA		MUFA	PUFA		
	C16:0	C18:0	C1:18	C18:2N,ω-6	C18:3N, ω-3	
PS 1	0.43±0.03^{a}	0.10±0.01^{a}	0.82±0.07^{a}	0.91±0.07^{a}	0.05±0.03^{a}	18.2:1
PS 2	0.50±0.06^{a}	0.26±0.03^{c}	1.64±0.10^{b}	1.51±0.08^{ab}	2.51±0.04^{b}	1:1.7
PS 3	0.99±0.04^{c}	0.52±0.04^{d}	2.57±0.24^{c}	2.09±0.11^{b}	5.10±0.27^{c}	1:2.4
PS 4	0.95±0.11^{c}	0.14±0.01^{ab}	0.82±0.19^{a}	2.94±0.23^{c}	0.06±0.01^{a}	49:1
PS 5	1.49±0.09^{d}	0.19±0.08^{abc}	0.8±0.44^{a}	5.19±0.59^{d}	0.07±0.02^{a}	74:1
PS 6	0.57±0.07^{ab}	0.16±0.03^{abc}	0.77±0.10^{a}	0.86±0.10^{a}	0.05±0.03^{a}	17.2:1
PS 7	0.71±0.02^{b}	0.22±0.04^{bc}	0.71±0.07^{a}	1.51±0.13^{ab}	0.05±0.01^{a}	30.2:1

Table 4. Mineral composition of the pasta with different shares of nutritive components; the results are presented as mean±SD (mg/100 g of sample); different letter within the same column indicates significant differences (p < 0.05), according to Tukey's test, number of repetitions: n = 3

Sample/pasta	Element				
	Ca	Zn	Cu	Mn	Fe
PS 1	251.92±6.98^{a}	18.77±1.01^{ab}	3.37±0.18^{a}	39.37±2.00^{a}	27.22±1.08^{ab}
PS 2	250.33±7.48^{a}	17.33±0.99^{a}	3.18±0.20^{a}	35.81±1.73^{ab}	29.4±1.94^{abc}
PS 3	257.74±11.97^{a}	15.88±1.10^{a}	3.0±0.31^{a}	32.26±1.70^{b}	31.58±1.75^{bc}
PS 4	417.38±25.78^{b}	21.76±1.24^{bc}	4.41±0.27^{b}	37.07±0.99^{ab}	33.02±2.03^{c}
PS 5	591.84±8.89^{c}	24.76±1.41^{c}	5.46±0.39^{c}	34.77±1.84^{ab}	38.82±1.69^{d}
PS 6	251.20±4.78^{a}	18.36±1.09^{a}	3.28±0.17^{a}	39.55±2.09^{a}	26.58±2.03^{ab}
PS 7	250.29±5.17^{a}	17.91±0.98^{a}	3.18±0.20^{a}	39.72±2.41^{a}	25.98±2.01^{a}

Fe (591.84; 24.76; 5.46 and 38.82 mg/100 g, respectively) were founded in pasta with 20 g/100 g sesame seed (PS 5). These minerals are positively contributing to recommended daily intakes. As these minerals have a vital role in bone mineralization, red blood cell production, enzyme synthesis, hormone production, as well as regulation of cardiac and skeletal muscle activities [25,26], pasta with sesame seed can be beneficial.

The optimal mineral status is essential for maintaining health and ensuring optimal body function. The nutritional status can be understood as the body condition that results from the process of using the nutrients contained in food, leading to an equilibrium between supply and assimilation of the nutrients and the nutrients consumption of the organism which is influenced by sex and age of the individual [27]. The recommended daily intakes according to FAO/WHO [24] for Ca, Zn, Cu, Mn and Fe are 100,15, 0.9, 5 and 15 mg/day, respectively.

The sensory parameters of pasta with different shares of nutritive components are presented in Table 5. Sensory values for odor, texture, flavor and overall acceptability statistically insignificantly decreased with addition of flax seed (10 g/100 g of sample and 20 g/100 g of sample). On the hedonic scale they were rated as "like moderately" (7), which indicates that flax seed had minor negative influence on pastas sensor quality. These products are designed for consumers interested in functional food and those who are willing to improve the ω-6/ω-3 ratio in their diet. The results of the present study show that the addition of sesame seed to pastas (PS 4 and PS 5) caused statistically significant changes in taste, odor, texture and overall acceptability of the product compared to the control (PS 1). The present study points that pastas with sesame seed (PS 4 and PS 5) were scored above 6.0 ("like slightly"). Adding eggs to pastas is highly scored from the sensory standpoint (scores above 8.0 – "like very much"). Addition of eggs in pasta is beneficial both the sensory quality (taste, odor, texture and overall acceptability). As the aim of this study was not to consider what is happening with the functional components during pasta cooking, these pasta products are recommended for soups or dishes where the pasta is not separately cooked. According Verado *et al.* [28], spaghetti enriched with long chain n-3 polyunsaturated fatty acids had a shelf life comparable to the control pasta.

The PCA allows a considerable reduction in a number of variables and the detection of structure in the relationship between measuring parameters and

Table 5. Sensory analysis of pasta with different shares of nutritive components; the results are presented as mean±SD; different letter within the same column indicates the significant difference in mean values (p < 0.05), according to Tukey's test. Number of repetitions: n = 60

Sample/pasta	Sensory parameter			
	Odor	Texture	Flavor	Overall acceptability
PS 1	8.1±0.91^{ab}	8.2±0.80^{abc}	8.1±0.82^{ac}	8.1±0.83^{abc}
PS 2	7.7±1.09^{ab}	7.1±1.07^{abcd}	7.8±0.28^{abc}	7.5±0.62^{abc}
PS 3	7.4±0.10^{ab}	6.6±0.70^{abd}	7.3±1.17^{abc}	7.1 ±1.45^{abc}
PS 4	6.8±1.24^{ab}	6.1±0.99^{ad}	6.6±0.78^{bc}	6.7 ±0.56^{ab}
PS 5	5. 9±1.31^{b}	5.9±0.86^{d}	6.0±0.49^{b}	6.2 ±0.45^{a}
PS 6	8.5±0.50^{a}	8.7±0.27^{bc}	8.8±0.18^{a}	8.7±0.31^{bc}
PS 7	8.8±0.15^{a}	8.9±0.05^{c}	8.9±0.07^{a}	8.9±0.09^{c}

pasta with different shares of nutritive components that give complementary information [29,30]. The full auto scaled data matrix consisting of pasta samples with flax seed flour, eggs and sesame seed flour addition was submitted to PCA. For visualizing the data trends and for the discriminating efficiency of the used descriptors a scatter plot of samples using the first two principal components (PCs) from PCA of the data matrix was obtained (Figure 1).

As can be seen, there was a neat separation of the seven samples of pasta formulation, according to fatty acids and mineral composition. Samples were grouped according to source of nutritive components (samples connected with a thin line).

Pasta samples located on the right part of the graph (PS 4 and especially PS 5, with added sesame seed) are characterized by higher contents of stearic, oleic, palmitic and linoleic acid and also by higher contents of Fe, Ca, Cu and Zn. Samples located on upper part of the graphic (PS 2 and PS 3) are chraracterized by increased content of linolenic acid, where PS 3 was prominent due to its higher quantity of added flax seed flour.

Quality results showed that the first two principal components, account for 95.58% of the total variance and could be considered sufficient for data representation. Concerning fatty acids and mineral composition, oleic acid (with 13.18% contribution based on correlation), Ca (13.03%), linoleic acid (12.74%) and palmitic acid (12.04%) mostly contributed to the first factor calculation, while linolenic acid (44.56%) and Mn (32.46%) contributed more to the second factor coordinate calculation.

The score analysis quantifies different pasta fatty acids and mineral profile parameter responses in dimensionless values that represent score values, which were comparable between samples of pasta with different formulations. In this way, score values allow the possibility of comparing total quality of the analyzed samples, and choosing the best source and quantity of oils.

Table 6 shows score values of pastas with different shares and types of nutritive components as fatty acids, where it can be seen that the addition of the flax seed flour has increased total score values in comparison to the addition of other components. The maximal total score value is obtained for pasta with addition of 20 g of flax seed flour per 100 g of sample, while the maximal partial score for mineral composition has shown that addition of 20 g of sesame seed flour per 100 g of sample has given the optimal result regarding mineral composition.

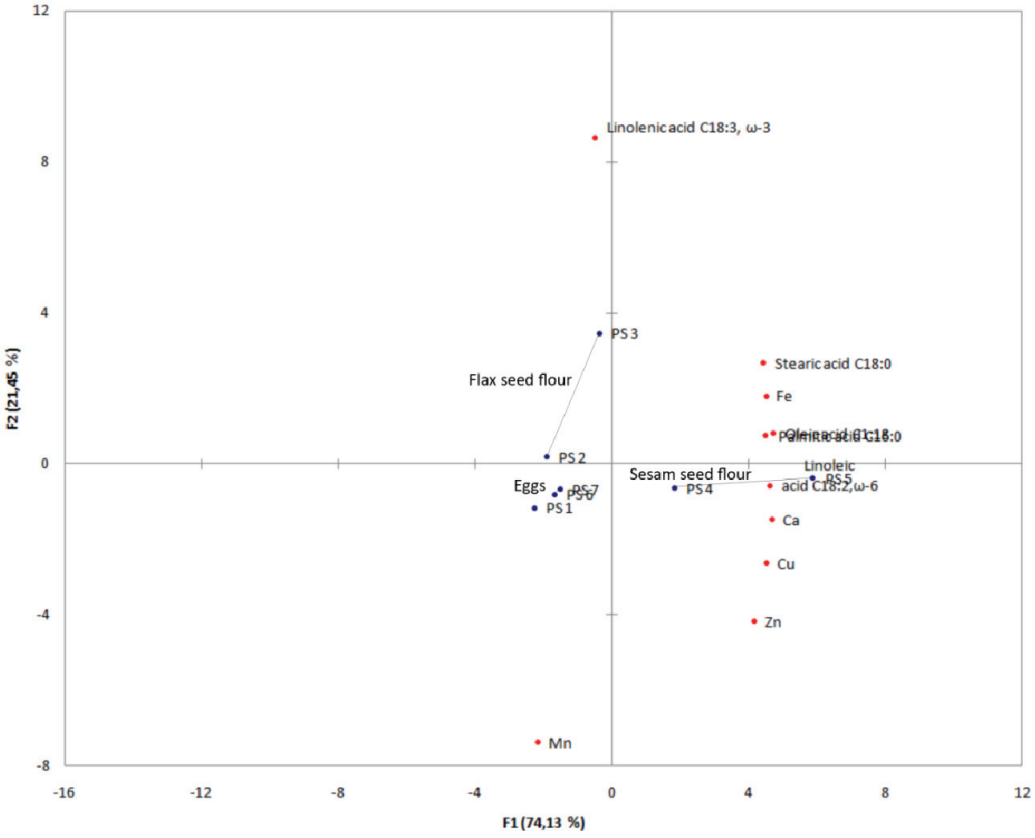

Figure 1. Biplot diagram of pastas with different shares of nutritive components.

Table 6. Score values of pasta samples with different shares of nutritive components

Sample/pasta	PS 1	PS 2	PS 3	PS 4	PS 5	PS 6	PS 7
Partial score values for mineral composition	0.31	0.20	0.09	0.58	0.87	0.281	0.26
Total score values	0.40	0.46	0.50	0.34	0.41	0.43	0.42

CONCLUSIONS

Based on the results of the investigation of the effects of the addition of flax seed, sesame seed or eggs, it can be concluded:

- The addition of flax seed flour in spelt pasta in the quantities of 10 or 20 g/100 g significantly increases the share of ω-3 fatty acids, which results in improved ratio of ω-6/ω-3, 1:1.7 and 1:2.4.
- Daily intake of 75 g pasta with 20 g flax seed /100 g of sample (PS 3) completely satisfies minimum daily needs of ω-3 essential fatty acids (3.8 g/100 g) recommended by FDA.
- The best content of essential minerals elements (maximum of Ca, Zn, Cu and Fe 591.84, 24.76, 5.46 and 38.82 mg/100 g; respectively) was experienced with pasta PS 5 (20 g sesame seed /100 g sample and 80 g/100 g of spelt flour).
- The best sensory quality (maximum scores for odor, texture, flavor and overall acceptability 8.8, 8.9, 8.9 and 8.9, respectively) was with pasta containing 20 g/100 g sample eggs (PS 7). Pasta with 20 g/100 g flax seed has good quality and it is recommended to consumers who are willing to improve ω-6/ω-3 ratio in their diet.

PCA is a useful tool for pointing at neat separation of samples according to different shares of nutritive components, while Score analysis was used to calculate the best quality of tested samples regarding fatty acid and mineral composition with sample PS 3 as the optimal.

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NAUČNI RAD

TESTENINA OD SPELTE SA DODATKOM FUNKCIONALNIH KOMPONENTI

Ovaj rad istražuje uticaj dodavanja lanenog semena, semena susama ili jaja (10 g / 100 g uzorka i 20 g / 100 g uzorka) u brašno za dobijanje nove vrste testenine sa poboljšanim odnosom ω-3/ω-6 masnih kiselina i minerali sastava. Gasna hromatografija sa masenom spektormetrijom je korišćena za kvantitativno određivanje liposolubilnog ekstrakta testenine. Post-hoc Tukey HSD test sa 95% pouzdanosti pokazuje da postoje statistički značajne razlike između posmatranih uzoraka. Dnevnim unosom 75 g testenine sa 20 g lanenog semena/100 g uzorka doprinosi unosu esencijalnih masnih kiselina (3,8 g) i poboljšanim odnosu ω-6/ω-3 (1: 2,4). Dobijeni rezultati ukazuju da je kreiran nov proizvod sa poboljšanim nutritivnim sastavom zbog višeg sadržaja ω-3 masnih kiselina i sadržaja mineralnih materija (Ca, Zn, Cu i Fe). Testenina (PS 7) sa 20 g / 100 g jaja ima najbolji senzorni kvalitet (najbolji rezultati za miris, teksturu, ukus i ukupnu prihvatljivost 8,8, 8,9, 8,9 i 8,9,).

Ključne reči: odnos ω-6/ω-3, masne kiseline, mineralni sastav, GC-MS analysis, funkcionalna svojstva.