

EVALUATION OF THE NUTRITIONAL QUALITY OF WHEAT BREAD PREPARED WITH QUINOA, BUCKWHEAT AND PUMPKIN SEED BLENDS

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Abstract: The purpose of this research was to blend quinoa (*Chenopodium quinoa* Willd.), buckwheat (*Fagopyrum esculentum* Möench) and pumpkin (*Cucurbita pepo* L.) seed kernels at 40% level with wheat flour and to examine the effect of this blend on nutritional and sensory quality and also energy values of the pan bread. Hydrothermal preparation of these supplements is included. Chemical composition of the investigated materials, wheat bread and supplemented bread, was determined using relevant AOAC methods. Chemical composition of supplemented bread with an increase in protein, oil and crude fiber was superior in comparison with control wheat bread. Sensory properties of supplemented bread such as specific volume, appearance, crust and crumb texture, aroma-odor and color were evaluated and found excellent.

Key words: quinoa, buckwheat, pumpkin, bread, functional food.

Introduction

Functional foods are defined as any substance or component of a food that offers health benefits, including the prevention and treatment of diseases (Milovanovic et al., 2009). The main functional components of foods are fibers, proteins, polyunsaturated fatty acids, phytochemicals, prebiotics and probiotics (Chauhan et al., 1992; Linnemann and Dijkstra, 2002). In recent years, the chemical composition, nutraceutical applications, and processing effects of quinoa have been studied and reported (Koziol, 1992; Enriquez et al., 2003; Vega-Galvez et al., 2010). According to the recommendations published by the FAO/WHO/UNU, quinoa (*Chenopodium quinoa* Willd., family Amaranthaceae) possesses well-balanced protein amino acid content that could improve dietary protein balance when consumed by itself or combined with cereal grains (FAO/WHO/UNU, 1985). Buckwheat

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(*Fagopyrum esculentum* Möench) is a valuable source of proteins, fibers, and minerals, such as iron, manganese and selenium. Some buckwheat components, such as proteins possess valuable cholesterol lowering properties and remarkable outstanding health-promoting properties (Christa and Soral-Smetana, 2008). Nutritional characteristics and application of buckwheat in functional foods: wheat bread enriched with buckwheat (Lin et al., 2009), or functional properties of enriched cakes (Im et al., 2003) have also been reported. Pumpkin seeds (*Cucurbita pepo* L.) are utilized directly for human consumption as snacks after roasting (Al-Khalifa, 1996). These seeds are an excellent source of protein, ranging between 25 and 37% and oil (37–45%) and are recognized as valuable high protein oil seeds for human consumption (Milovanovic and Vucelic-Radovic, 2008). Total carbohydrate content ranges from 10% to 20%, while the moisture of around 5% is registered. Additionally, seeds contain considerable amounts of minerals such as magnesium, manganese, and calcium, but only a low amount of copper. The presence of vitamins B, D, K, and especially high level of A and C is also observed (Longe et al., 1983). Fluted pumpkin seed flour has been reported to have good potential for use in bakery products on account of its high water absorption capacity (Giami and Isichei, 1999). Evaluation of the functionality and nutritional quality of the breads prepared from the wheat and fluted pumpkin seed flour blends was also reported (Giami et al., 2003).

Many researchers have investigated protein quality, starch properties and other nutrients of quinoa seeds, but other aspects related to technological applications have received less attention. Particularly, the breadmaking ability of quinoa seeds and wheat flour blends are not common in the literature. Because of its low baking quality, which is due to the absence of gluten, quinoa flour can only partially substitute wheat flour in breadmaking and other baked products. The sensory evaluation of the flavor, texture, and appearance shows the products to be moderately acceptable. A crunchy texture, a unique shape, and a nutty or wheaty flavor are also described (Linnemann and Dijkstra, 2002). However, supplementation of wheat flour dough with purified quinoa seeds (Stikic et al., 2012) and mixture of buckwheat and purified quinoa seeds (Demin et al., 2013) resulted in nutritionally enhanced breads with sensory acceptance. Obviously, according to the literature data, the breadmaking ability of quinoa, pumpkin and buckwheat seeds and wheat flour blends has not been reported yet.

The objective of this study was to determine the chemical compositions of the quinoa, buckwheat and pumpkin seeds as supplements in the production of wheat pan bread. Also, the effects of the mixture of these seeds on nutritional quality and energy value of the bread were assessed. In addition, sensory evaluation of the bread was performed.

Material and Methods

Quinoa (*Chenopodium quinoa* Willd.), variety KVL37 was produced in the vicinity of Belgrade, Serbia in the field of the agroindustrial complex “Stara Pazova”, harvest season of 2011. The quinoa variety was provided by the University of Copenhagen. The buckwheat (*Fagopyrum esculentum* Mönch) and pumpkin (*Cucurbita pepo* L.) seeds were purchased at a local healthy food store. Investigated seeds quality traits included: chemical compositions of the selected seeds, nutritional values of the breads as well as sensory characteristics of the breads.

Chemical compositions of the seeds

Whole quinoa seeds were dehulled and purified as we previously reported (Demin et al., 2013). Briefly, dehulled quinoa seeds were washed with cold water, dried at 45°C and conditioned in an airtight container. Pumpkin and buckwheat seed kernels were analyzed without any purification. Standard AOAC methods (A.O.A.C., 1997) of numbers 925.10, 923.03 and 920.87 were used to determine moisture, ashes and protein (Kjeltec 2300 system, Foss, Höganäs, Sweden) content, respectively. Nitrogen conversion factors used were: for quinoa seeds 6.25, and for buckwheat and pumpkin seeds 6.0 and 5.5, respectively. Automatic extraction method AOAC of number 920.39 (Foss-Tecator Soxtec Avanti, system 2050, Höganäs, Sweden) was used for oil content. Fibertek 2010 System (Foss, Höganäs, Sweden) was used to determine cellulose (as crude fiber) content, using AOAC 962.09 standard. The total starch content was calculated according to Grosso et al. (2000). All seeds were milled in Cemotek Sample Mill type 1090 (Foss, Höganäs, Sweden) and analyzed in triplicate.

Chemical characteristics of the breads

The same standard AOAC methods as previously described were used to determine the nutritional values of wheat control bread and wheat bread supplemented with blends of selected seeds. Prior to analysis, breads (after drying in the storage conditions) were milled using the Knifetec model of mill, type 1095 (Foss Tecator, Höganäs, Sweden). All the results were mean values of three replicates of the same sample. To determine the protein content in the examined breads, conversion factor of 6.25 was used.

Breadmaking process

Commercial wheat flour (type T-500) containing 12.6% moisture, 0.51% ash, 11.04% protein and 25.5% moist gluten was used for breadmaking. The bread was

prepared according to a three-phase procedure, using a mixture of soft wheat flour (60%) and quinoa, buckwheat and pumpkin seeds (15%, 15% and 10%, respectively) and with the addition of 3% of yeast and 2% of salt. In the first phase, the boiling water was poured over the seeds (1:1). After cooling at 30–40°C, flour and supplements were mixed for 4 minutes using a Taddy mixer, and finally with finishing touches by hand for around 1 minute. Water was added in an amount to produce dough with acceptable handling characteristics. Dough consistency and stickiness were subjectively estimated by an experienced baker. Short term fermentation, at room temperature, took 15 minutes before dough being divided and kneaded into loaves and put in a greased mould. The loaves were left to prove in fermentation chamber (Bongard, Holtzheim, France) at 34–35°C for 55–60 minutes at relative humidity of 80%. Finally, in the third phase, loaves were baked in a rotary kiln (Bongard, Holtzheim, France) at 200–220°C for 21 minutes.

Energy values of the breads

The total energy content was calculated from the proximate composition of breads expressed on a dry weight basis. The quantities determined per gram of the various fractions (protein, oil, crude fiber and starch) of different breads were multiplied by the known mean combustion equivalents (in the body) of these compounds (FAO, 2002).

Sensory analyses of the breads

Sensory analyses of breads were carried out 6–8 h after baking by 3 trained panelists, using the relevant ISO standards (ISO, 1992). Sensory evaluations included the selected, representative, or dominant attributes of bread qualities: appearance (shape, crust color, nuance, brightness and uniformity), crust texture, crumb texture, aroma-odor of crust and crumb and aroma-taste of crust and crumb. The scores for each attribute ranged from 1 to 5 (differing by 0.25). Before performing the evaluations, weight coefficient for each property was determined (4 for appearance, 4 for crust texture, 4 for crumb texture, 3 for aroma-odor of crust and crumb, 5 for aroma-taste of crust and crumb), and balanced in such a way that their sum equals 20. Adding individual scores gave a complex indicator representing the overall sensory quality, expressed as “% of maximum possible quality”. Dividing these values by the sum of weight coefficients gave the weighted mean score, which also represented the overall sensory quality of breads. Quality category was determined depending on score spans. Products, which were evaluated with less than 2.5 points were considered as unsatisfactory, i.e., as unacceptable. Scores within limits of 2.5–3.5 characterized good quality products, within 3.5–4.5 - very good, and those within 4.5–5 - excellent products.

Statistical analyses

The results were expressed as the mean value \pm standard deviation (SD) of three separate determinations. The data were statistically analysed using analysis of variance (ANOVA, STAT), and the means were compared by Student's t-test (Sigma Plot 6.0 for Windows – SPW 6.0, Jandel Scientific, Erckhart, Germany). Significant differences between means were determined at $p < 0.05$.

Results and Discussion

Chemical compositions of the selected seeds

Pseudocereal seeds, including quinoa and buckwheat, received a renewed interest owing to their gluten free, high protein content of valuable amino acid composition (Vega-Galvez et al., 2010; Christa and Soral-Smetana, 2008). Pumpkin seed kernels were chosen as a rich source of high quality protein and oil (Giami and Isichei, 1999; Milovanovic and Vucelic-Radovic, 2008).

Table 1. Chemical composition of quinoa, buckwheat and pumpkin seeds.

Composition (%)	Quinoa	Buckwheat	Pumpkin
Moisture	11.52 \pm 0.06 ^a	11.90 \pm 0.21 ^a	5.26 \pm 0.15 ^b
Ash	1.53 \pm 0.02 ^b	2.09 \pm 0.05 ^b	3.26 \pm 0.03 ^a
Protein	12.60 \pm 0.19 ^b	10.66 \pm 0.07 ^c	24.46 \pm 0.20 ^a
Oil	6.02 \pm 0.26 ^b	3.06 \pm 0.10 ^c	38.53 \pm 0.10 ^a
Crude fiber	3.03 \pm 0.16 ^c	9.01 \pm 0.18 ^b	14.77 \pm 0.21 ^a
Starch	65.30 ^a	63.28 ^a	13.72 ^c

Means \pm standard deviation with the different letter in the same row were significantly different at $p < 0.05$ (a>b). The values are expressed on a dry weight basis.

Chemical characteristics (given in g per 100 g on a dry weight basis) of the investigated seeds are presented in Table 1. Starch was the main component in quinoa and buckwheat seeds. Quinoa seeds of the investigated KVL 37 variety were slightly higher in protein (12.60%) than buckwheat and superior to other pseudocereals. The protein and oil content was especially high in pumpkin kernels. In spite of the high level of nutritionally desirable unsaturated fatty acids, which are susceptible to oxidation, pumpkin and buckwheat oils are quite stable due to the high levels of vitamin E (Longe et al., 1983; Al-Khalifa, 1996; Christa and Soral-Smetana, 2008). These findings were the reason for using seeds high in protein and oil in a new bread formulation. Besides high content of good quality oil, all seeds possessed a high amount of crude fiber.

Nutritional value of the breads

In the literature, there is no information on the nutritional quality of the bread made from the wheat flour supplemented with quinoa, buckwheat and pumpkin seed kernel blends. In our study, soft wheat flour supplemented with quinoa, buckwheat and pumpkin seeds at levels 15%, 15% and 10% was used for breadmaking.

Table 2. Chemical composition of the wheat bread supplemented with the mixture of quinoa, buckwheat and pumpkin seeds.

Composition (%)	Wheat bread	Supplemented bread
Moisture	13.29 ± 0.19 ^a	6.98 ± 0.18 ^b
Protein	11.21 ± 0.20 ^b	17.27 ± 0.18 ^a
Ash	2.56 ± 0.15 ^a	2.07 ± 0.18 ^a
Oil	0.85 ± 0.10 ^b	4.69 ± 0.12 ^a
Crude fiber	4.7 ± 0.16 ^b	9.29 ± 0.14 ^a
Starch	67.39 ± 0.16 ^b	59.70 ± 0.37 ^b

Means ± standard deviation with the different letter in the same row were significantly different at $p < 0.05$ (a>b). The values are expressed on a dry weight basis.

As expected, supplemented bread exhibited significantly higher protein, oil and fiber contents (Table 2). It was higher in protein by 6% and in crude fiber by 4.6% than the wheat bread, as control. The oil content was 4.5-fold higher. The addition of selected seed kernels did not affect the ash amount in comparison with the control bread. Finally, the supplemented bread was lower in starch by 7.7%. Very good nutritional quality and functional properties of pumpkin seed flour and pumpkin seed kernel flour are reported (El-Adawy and Taha, 2001). Also, buckwheat and quinoa seed flours are examined (Enriquez, 2003; Im et al., 2003; Lin et al., 2009; Demin et al., 2013). The effects of blending wheat flour with pumpkin kernel flour at level of 10% on enhancement of nutritional properties of composite bread have been reported (Giami et al., 2003). Also, the chemical and enhanced nutritional characteristics of wheat breads blended with quinoa seed flour were observed. In breadmaking, 10% substitution rates have been reported to be acceptable based on dough stability, loaf volume, weight, structure, texture, taste and color (Lorenz and Coulter, 1991). The same authors reported a bitter aftertaste at higher levels of enrichment (20–30%). However, other authors mentioned the possibility of using quinoa flour inclusion in quantities as high as 20–30%. The baking quality of the blends in bakery products as well as in pan bread were also reported (Enriquez, 2003). Finally, the baking conditions of buckwheat seed flour at levels 10–50% in food formulations were observed (Lin et al., 2009; Filipcev et al., 2011). Our results on the incorporation of the investigated seeds into moulded bread also showed the enhancement of the bread nutritional quality.

The energy available for metabolism from supplemented bread can be estimated by calculating the contributions from the starch, oil and protein contents, taking into account the digestibility of each and their heat of combustion. Samples of supplemented bread, obtained by the applied method of production, had higher energy value than the control wheat bread. In both breads, major portion of energy came from starch. However, energy values coming from protein, oil and fiber were remarkably higher for supplemented bread (Table 3).

Table 3. Energy values calculated for breads supplemented with the mixture of quinoa, buckwheat and pumpkin seeds.

Composition (%)	Wheat bread		Supplemented bread	
	Energy (kJ·100g ⁻¹)	Energy (%)	Energy (kJ·100g ⁻¹)	Energy (%)
Protein	190.57	13.56	293.59	18.86
Oil	31.45	2.24	173.53	11.15
Crude fiber	37.6	2.68	74.32	4.77
Starch	1145.63	81.52	1014.90	65.21
Total	1405.25	100.00	1556.34	100.00

Sensory analyses

On the basis of sensory evaluation, the bread with the addition of pseudocereals and pumpkin seeds belonged to the category of excellent bread as it was the case with the control bread.

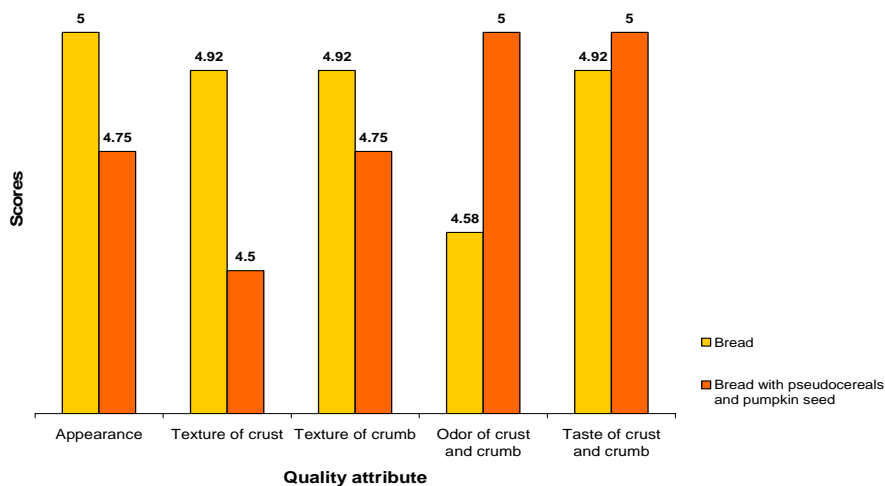


Figure 1. Sensory evaluation of wheat bread supplemented with quinoa, buckwheat and pumpkin seeds.

The addition of these ingredients affected the color of the crumb, aromatic properties and specific volume of the bread. Unusual greenish color of this type of the product is quite acceptable but it was the reason for lower score given to the appearance of the bread. Very well blended combination of supplements had a positive effect on the aromatic properties (odor and taste of crust and crumb) that received maximum scores. Specific volume of 5.2 ml/g was much higher than the specific volume of the control (4.6 ml/g). Sensory characteristics of the breads are presented in Figure 1.

Conclusion

This study has shown that the wheat flour supplemented at 40% level with quinoa, buckwheat and pumpkin seed kernels (15%, 15% and 10%, respectively) produced pan bread with increased protein, crude fiber and oil contents that was nutritionally superior to wheat bread, as control. Supplemented bread had higher energy value with increased energy portions coming from protein, oil and fiber. The applied technological procedure using well blended combination of supplements resulted in larger specific volume of the bread and its excellent sensory properties of aroma-odor and taste.

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ODREĐIVANJE NUTRITIVNE VREDNOSTI PŠENIČNOG HLEBA
SA DODATKOM MEŠAVINE SEMENA KVINOJE, HELJDE I TIKVE

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R e z i m e

Cilj rada je bio da se ispita mogućnost proizvodnje pšeničnog hleba sa dodatkom semena kvinoje, heljde i tikve do nivoa od 40%. Kvinoja (*Chenopodium quinoa* Willd., familija Amaranthaceae) je pseudocerealija. U ovom radu je korišćena danska sorta KVL 37, gajena u okolini Beograda. Domaća komercijalna semena heljde (*Fagopyrum esculentum* Mönch) i tikve (*Cucurbita pepo* L.) su nabavljena u lokalnoj radnji zdrave hrane. U ovom radu su prikazani hemijski sastavi prečišćenog semena kvinoje, kao i semena heljde i tikve. Heljda i kvinoja su odabrane zbog toga što ne sadrže gluten, a imaju visok sadržaj kvalitetnih proteina. Očišćeno seme tikve (golica) je odabrano zbog toga što sadrži veliki procenat nutritivno i zdravstveno vrednog ulja i proteina. Analizirane su hemijske i tehnološke osobine mešavine ovih semena i pšeničnog brašna, kao i mogućnost njihove primene u proizvodnji hleba u kalupu. Određen je hemijski sastav i nutritivna energetska vrednost pšeničnog hleba pripremljenog sa dodatkom 15% semena kvinoje, 15% semena heljde i 10% golice. U odnosu na kontrolni pšenični hleb, obogaćeni hleb je sadržao 6% više proteina, 3,8% više ulja i oko 5% više sirovih vlakana. Sadržaj skroba u obogaćenom hlebu je bio niži za oko 8%. Energetska vrednost obogaćenog hleba je porasla za oko 150 kJ/100 g. Obogaćeni hleb je imao dobru specifičnu zapreminu i odlične senzorne osobine. Pokazano je da je ispitivana mešavina pšeničnog brašna i odabranih semena pogodna za proizvodnju hleba u kalupu, povećane nutritivne vrednosti.

Ključne reči: kvinoja, heljda, golica, hleb, funkcionalna hrana.

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