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Researches regarding the quality of some sprouted grain flours

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Abstract The nutritional value of sprouted grain flour (sprouted grains) is given by many active principles: oligosaccharides, vitamins, antioxidants, enzymes, microelements etc., making it a very valuable raw material for food, pharmaceuticals and diets. The aim of our study was the biochemical characterization of flour obtained from germinated cereals (wheat, barley and oats) carried out for the proteins content, the lipids content and the B_1 B_2 and B_3 vitamins content. There were performed graphical representations for these biochemical characteristics from germinated and non-germinated cereals flours. The flour obtained from germinated Capo wheat genotype had the highest content of proteins (20,98 g/100 g flour) and lipids (11,12 g/100 g flour). Flours derived from non-germinated grains had significantly lower values of proteins and lipids content than those obtained from germinated cereals. Flour from IPZ 807 germinated barley variety had the highest content of B_1 and B_2 vitamins (0,040 mg/100 g and 0,254 mg/100 g) and flour made from germinated Capo wheat genotype had the highest B_3 vitamin content (1,875 mg/100 g) to all other studied genotypes. These flours may be used in food and in pharmaceutical preparations.

Key words

germinated cereals, sprouted grain, flours, proteins, lipids, vitamins, content

The chemical composition of cereal germs varies greatly, depending on the species and genotype. Cereals containing gluten, such as oats, rye, barley and especially wheat, are harder to digest, while buckwheat, rice and millet, which do not contain gluten, are much easier to digest. During germination it was synthesized phytase, an enzyme which makes available large quantities of Ca, Mg, Zn and even Fe in active forms. Functions of vitamins, hormones, enzymes are dependent on the presence of minerals that enter into the structure of enzymes as specific and nonspecific elements and have an active role or inhibitor (Fallon, 2001).

Proteins in grains, especially gluten, are difficult to digest. A diet rich in fermented whole grains with a high content of gluten, such as wheat, putting pressure on the whole extremely digestive system, causing, with age or overuse, allergies, celiac disease, chronic indigestion and overcrowding fungal (candida). During the maceration/fermentation, gluten and other difficult to digest proteins are partially broken down into simpler components and more accessible for absorption. Maceration, fermentation or sprouting before preparing the germination of the grain, neutralized phytic acid and enhances the absorption of minerals, especially calcium, magnesium, copper, iron and zinc. These methods allow enzymes, lactobacilli and other beneficial organisms not only to neutralize the phytic acid, but also to break down the complex starches, irritating tannins properties and indigestible proteins, including the gluten. For some people, these methods can decrease sensitivity or allergic reactions to certain cereals (Fallon, 2001).

Studies on wheat germ oil determined the percentage of fatty acids: linoleic acid - 55.2-56.9% oleic acid - 14.5-14.7% palmitic acid - 16.4-16.6% of the total fatty acids (Dunford and Zhang, 2003).

B complex vitamins and minerals such as magnesium and phosphorus are found in similar proportions in the aleurone of wheat seeds. (Apprich et al., 2013). Most visible changes induced germination were found in the vitamins group B. Merx et al. (1994) showed that riboflavin present the most part and thiamine present the lower part of "de novo" synthesis induced by germination. Some studies on vitamin content of wheat sprout during the germination concluded that the content of thiamine increased 120-240% (3 days germination at 21 °C) compared with starting material (Merx et al., 1994). May-Gi and Fields (1981) have shown that the nutritional value of

maize substantially increase germination. Germinated corn has a higher content of ascorbic acid, riboflavin and niacin compared to corn which do not germinate. The content of B vitamins synthesized during germination of wheat was significantly higher than that synthesized "de novo" in maize (Skarkos et al., 1978). In the sprouted grain, the most significant amount of thiamine is located in the scutellum, aleurone layer, respectively in the dephosphorylated form, linked to the protein in the tissue so that in the early germination stage has a high metabolic activity. At the beginning of the germination process, connected thiamine has been almost completely hydrolyzed and a part of thiamine is phosphorylated in TPP coenzyme required for the production of cellular ATP (Mitsunaga et al., 1986, Mitsunaga et al., 1987, Nishimo et al., 1980, Nishimura et al., 1984). Riboflavin (vitamin B_2) in the form of riboflavin-5-phosphate derivatives (flavin mononucleotide, FMN or FAD flavin adenine dinucleotide) is present in all living cells. So-called flavonoid enzymes coenzymes, FAD and FMN, participates in redox reactions and therefore have a central position in the oxidative metabolism of the germinating cereals. Vitamin B_2 synthesized in the germination of grain is partially converted into phosphate esters which are metabolically active (Brawn and Williamson, 1982). The recommended daily dose for vitamin B_1 is 1.2 mg for men and 1.1 mg for women, vitamin B_2, 1.7 mg, and vitamin B_3, 16 mg for men and 14 mg for women (Dasgupta and Klain, 2014).

Materials and Methods

Were used four varieties of wheat (Flamura 85, Ariesan, Alex and Capo) from experimental culture of USAMVB Timisoara, two varieties of oats (Lovrin 1 and Jeremy), two varieties of barley (Hyproly and IPZ-807) and two dubluhaploide barley lines (DH 77-18 and DH 295-3) with the same origin. To obtain cereal germ flours were taken several steps: sorting, weighing and washing, seed germination and germ washing, selecting and weighing them in the oven drying, grinding and sieving the flour obtained.

Determination of total protein in germinating cereal flours

For this determination was used the Bradford method which is based on the ability of proteins to bind the Serva Blue G colorant.

Principle. The absorbance value is read at 595 nm after 5 minutes of protein incubation with the colorant (Bearden, 1978). With the calibration curve is estimated the protein concentration of solution (or the total concentration of protein in the extract) (Bradford, 1976).

Determination of total fat sprouted grain flours

For this determination was used the Soxhlet method.

Principle. Lipid dosage is based on their solubility in organic solvents (acetone, diethyl ether, petroleum ether), using Soxhlet extractor. The method comprises the extraction of periodic further, using a well-defined volume of solvent. The total product obtained after removal of the solvents represents the crude fat (Dean, 1998).

Calculation and interpretation of results. Determine the weight of fat and the result is related to dry matter (https://ro.scribd.com/doc/232760138/Determination of Fat-Extractibile-% C5% 9Ei-Total-By-method-Soxhlet).

Determination of the Vitamins B_1, B_2 and B_3

Principle. VitaFast® test is a microbiological method for the quantitative determination of total content of vitamin B_1, B_2 and B_3 (added and natural) in food, feed and pharmaceutical products. The test used conforms to international rules (Zhang, 2014).

Statistical data analysis

To determine the significance of differences between flours, data processing was performed by analysis of variance and *t*-test (Ciulca, 2006). The significance of differences was expressed by the symbols (*, **, ***, $^{0,\ 00,\ 000}$) and letters, being considered as significant the differences between variants marked with different letters. Relationships and connections between different characters and the studied parameters were analyzed using covariance and correlation from the Bravais's formula.

- correlation coefficient

$$r = \frac{\sum xy - \frac{\sum x \times \sum y}{n}}{\sqrt{(\sum x^2 - \frac{(\sum x)^2}{n})(\sum y^2 - \frac{(\sum y)^2}{n}}}$$

- covariance

$$s^2_{xz} = \frac{\sum xy - \frac{\sum x \times \sum y}{n}}{n-1}$$

To allow in a single graphic representation the performance of each genotype for all studied characters, was used the basic principles of biplot method developed by Gabriel (1971) and GGE method developed by YAN & KANG (2003). The methods are based on the formula:

$$T_{ij} - \overline{T_J} = (\lambda_1 \xi\tau_{j1} + \lambda_2 \xi\tau_{j2} + \varepsilon_{ij}) / s_j$$

, in which:

T_{ij} – the average value of *i* genotype for *j* character, T_j – the average value of *j* character for all genotypes, s_j – the standard deviation of *j* character for all genotypes, ξ_{i1}, ξ_{i2} – the PC1 and PC2 values for *i* genotype, τ_{j1}, τ_{j2} – the PC1 and PC2 values for *j* character, ε_{ij} – the residual value of model for *i* genotype at the *j* character.

Results and Discussions

Results on the total protein content of sprouted grain flours

Analyses were performed in USAMVB Timisoara. The total protein content of the sprouted grain flours and do not germinate is varied depending on the genotype and species (Table 1).

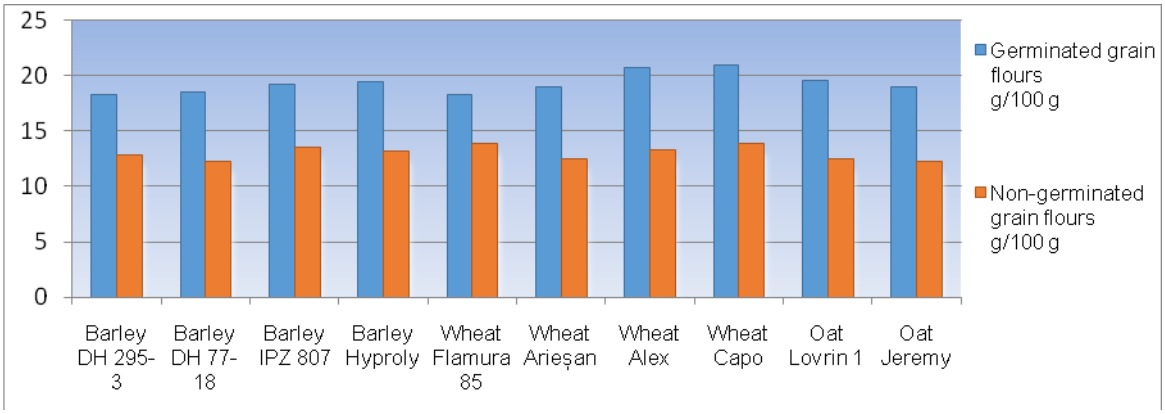

Fig. 1. Graphical representation of the total protein content of the flour obtained from germinated and non-germinated cereals

To achieve these determinations were used 20 flour samples: 10 samples of flour produced from germinated grains and 10 samples obtained from seeds which do not germinate.

Table 1

The total protein content of the flour obtained from germinated and non-germinated cereals

No.	Flour samples	Germinated grain flours g/100 g	Non-germinated grain flours g/100 g
1	Barley DH 295-3	18,33c	12,91abc
2	Barley DH 77-18	18,48c	12,32c
3	Barley IPZ 807	19,24bc	13,55ab
4	Barley Hyproly	19,41abc	13,18abc
5	Wheat Flamura 85	18,34c	13,88a
6	Wheat Arieşan	18,98c	12,56bc
7	Wheat Alex	20,69ab	13,34abc
8	Wheat Capo	**20,98a**	**13,89a**
9	Oat Lovrin 1	19,57abc	12,50bc
10	Oat Jeremy	18,96c	12,28c
	Average	**19,30±0,29**	**13,04±0,20**
	DL5%	1,65	1,11
	DL1%	2,33	1,57
	DL0,1%	3,33	2,24

By comparing the results obtained in cereal germ flours with those obtained from flours of signs which do not germinate is found that the values are in each case higher in samples obtained from seeds germinated flours. The highest value recorded in the determinations made on sprouted grain flours was found in the Capo wheat genotype (20.98 g/100 g), followed by the Alex wheat genotype (20.69 g/100 g). All other values obtained from germinated grain flours do not vary within wide limits. The highest value recorded in the determinations made on sprouted grain flours was found in the Capo wheat genotype (20.98 g/100 g), followed by the Alex wheat genotype (20.69 g/100 g). All other values obtained from germinated grain flours do not vary within wide limits. Among genotypes of barley, the highest value was observed at Hyproly variety (19.41 g/100 g) and from the oats, Lovrin variety had the highest value (19.57 g/100 g) (Figure 1).

Results on the total fat content of sprouted grain flours

Analyses were performed in USAMVB Timisoara using, also, 20 samples of flour (10 flours from germinated cereal flours and another 10 flours from seeds do not germinate).

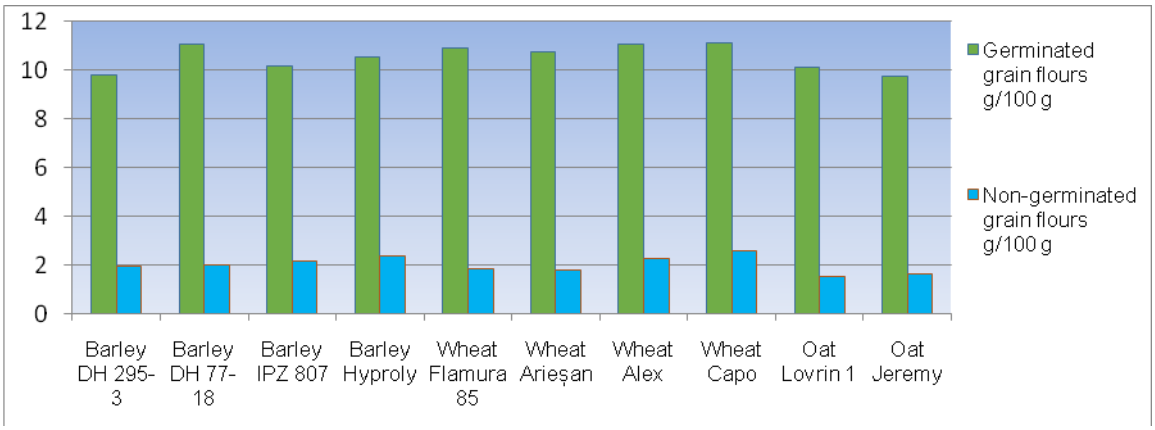

Fig. 2. Graphical representation of the total fat content of the flour obtained from germinated and non-germinated cereals

Analyzing the results shown in the table below (Table 2) shows that the highest value of the total fat content presents, also, the Capo wheat variety (11.12 g/100 g), which is very close to the value obtained for barley dubluhaploid line DH 77-18 (11.05 g/100 g), and the value obtained for the wheat variety Alex (11.04 g/100 g).

The results for all 20 studied samples (10 samples of flour from germinated seeds and 10 samples of flour from seeds do not germinate) were synthesized in graphical form (Figure 2), standing out significantly higher values for all samples of flour from cereals sprouted grain as compared with those which do not germinate.

Table 2

Total fat content of the flour obtained from germinated and non-germinated cereals

No.	Flour samples	Germinated grain flours g/100 g	Non-germinated grain flours g/100 g
1	Barley DH 295-3	9,80d	1,98bcd
2	Barley DH 77-18	11,05ab	2,03abcd
3	Barley IPZ 807	10,16bcd	2,14abc
4	Barley Hyproly	10,56abcd	2,35ab
5	Wheat Flamura 85	10,88abc	1,86bcd
6	Wheat Arieșan	10,74abc	1,79bcd
7	Wheat Alex	11,04abc	2,28ab
8	Wheat Capo	**11,12a**	**2,57a**
9	Oat Lovrin 1	10,11cd	1,55d
10	Oat Jeremy	9,76d	1,64cd
	Average	**10,52±0,17**	**2,02±0,10**
	DL5%	0,94	0,58
	DL1%	1,33	0,82
	DL0,1%	1,90	1,17

Between the values obtained from germinated cereal flours there are not great differences, but still stands the Capo and the Alex wheat genotypes (11.12 g/100 g, respectively 11.04 g/100 g) and the IPZ 807 barley variety (11.05 g/100 g).

Results on the content of vitamins B_1, B_2 and B_3 of sprouted grain flours

Analyzes to determine vitamins in germinated cereal flour were made at the National Institute of Research - Development for Food Bioresources - IBA Bucharest.

Following these analyzes performed on three samples of flour (the Capo wheat genotype, the IPZ 807 barley variety and the Lovrin 1 oat variety) found that the highest amount of vitamin B_1 is in the IPZ 807 barley variety (0.040 mg/100 g), the large amount of vitamin B_2 is found equally in the Capo wheat genotype and in the IPZ 807 barley variety (0.254 mg/100 g), and the Capo wheat variety flour has the highest amount of vitamin B_3.

Comparing the concentration levels of the B vitamins analyzed (Table 3) in all three samples of flour, it is found that vitamin B_1 is the least represented in these flours and the vitamin B_3 recorded the highest values.

The statistical analysis performed on the results obtained from vitamin B_1 indicate significant differences between values obtained from the Capo wheat genotype and from the Lovrin 1 oat variety. On the B_2 analyzed vitamin, there are significant differences between the values obtained from the Capo wheat genotype and from the Lovrin 1 oat variety and between values obtained from the IPZ 807 barley variety and from the Lovrin 1 oat variety. When analyzing the results for vitamin B_3, there are significant differences between the varieties of the Capo wheat genotype and from the IPZ 807 barley variety.

Table 3

The total content of vitamins B_1 B_2 and B_3 of sprouted grain flours

No.	Flour samples	Total B_1 vitamin (mg/100 g)	Total B_2 vitamin (mg/100 g)	Total B_3 vitamin (mg/100 g)
1	Wheat Capo	0,026b	**0,254a**	**1,875a**
2	Barley IPZ 807	**0,040a**	**0,254a**	0,710b
3	Oat Lovrin 1	0,029ab	0,204b	1,120ab
	Average	0,032±0,004	0,237±0,017	1,235±0,341
	DL5%	0,012	0,045	0,930
	DL1%	0,018	0,071	1,459
	DL0,1%	0,031	0,121	2,486

There are considered significant the differences between the genotypes noted by different letters.

The flour obtained from the Capo wheat genotype analyzed recorded significantly higher values for the B_2 vitamin content (0.254 mg/100 g) and for the B_3 vitamin content (1.875 mg/100 g). For the B_1 vitamin content, the value obtained was significantly inferior to the average (0.026 mg/100 g). The flour from the IPZ 807 barley variety presented a significantly superior value to the average for the B_1 vitamin content (0.040 mg/100 g) and for the B_2 vitamin content (0.254 mg/100 g). For the B_3 vitamin content the recorded value was significantly lower than the average (0.710 mg/100 g). The flour obtained from the third genotype analyzed, the Lovrin 1 oat, presented values close to the average for all determinations.

In the graph from below (Figure 3), there are observed the lowest values on the B_1 vitamin, higher values of the B_2 vitamin and the highest values recorded on the B_3 vitamin for all three flours studied, and the differences between the vitamin content of the each genotype separately.

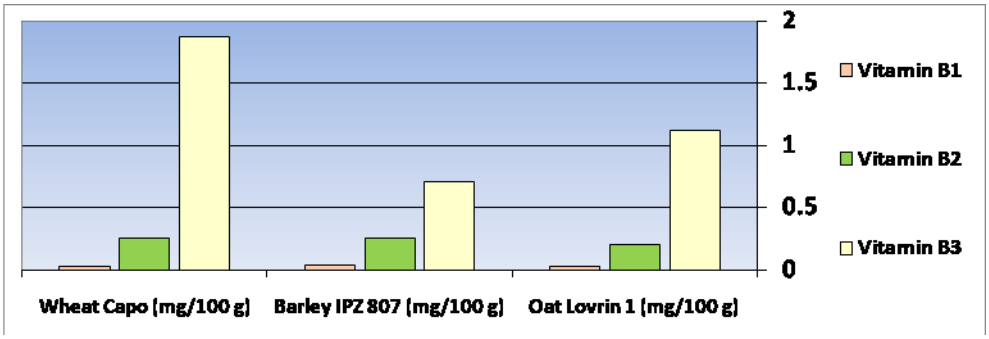

Fig. 3. Graphical representation of the total content of vitamin B analyzed from germinated cereals flours

Research by Chavan and Kadam (1989) on the B_1, B_2 and B_3 vitamins content in different non-germinated oat varieties indicate the following concentrations: thiamine: 0.002 mg/100 g, riboflavin: 0.001 mg/100 g and niacin: 0.032 mg/100 g. It is found lower values than those obtained by us from germs grain flour, because during the germination triggers certain processes that increase the amount of vitamins.

Conclusions

Compared with the flour derived from non-germinated grains, there were noted significantly higher levels of protein and fat content in all samples sprouted grain flour, which highlights their increased nutritional value.

Regarding the B_1, B_2 and B_3 vitamins content from the cereal germ flour, it is found that the largest amount of vitamin B_1 had the flour from IPZ 807 germinated barley variety. The highest content of vitamin B_2 is found equally in the flour made from germinated Capo wheat genotype and in the flour from IPZ 807 germinated barley variety and the highest B_3 vitamin content is found in the flour made from germinated Capo wheat genotype, demonstrating the superior nutritional value of studied cereal varieties.

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