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Cereals and Legumes in Nutrition of People with Celiac Disease

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Abstract Cereals and legumes rank among the most important group of crop plant production. The aim of this paper was to point out the suitability of cereals and legumes in the diet of people living with an autoimmune disease of the small intestine, the celiac disease. Cereals match the best current ideas of healthy and balanced diet and provide decisive part of the energy intake from food in human nutrition and no small share from the total protein intake. Some cereals contain celiac active polypeptides and in susceptible individuals cause allergic reactions. Celiac active ingredients are found in the prolamin fraction. If the content of prolamine is in an amount of 4-8%, the products can be considered appropriate for the celiac diet. Wheat, barley, rye and oat should be excluded from the diet, if a person has confirmed celiac disease. On a worldwide basis, legumes contribute to about one-third of humankind's direct protein intake. Legumes also accumulate natural products (secondary metabolites) such as isoflavonoids that are considered beneficial to human health through anticancer and other health-promoting activities. The biggest advantage of legumes is that they are gluten-free and are suitable for gluten-free diet.

Keywords: *cereals, legumes, celiac disease*

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1. Introduction

Cereals rank among the most important group of crop plants, because they are an important source of high protein, carbohydrates, minerals, vitamins and fiber and they are also one of the cheapest food components.

They are grown primarily for grain, consumption, animal feed, industrial processing and seed. Cereals match the best current ideas of healthy and balanced diet and provide decisive part of the energy intake from food in human nutrition and represent no small share from the total protein intake. Cereals are rich in complex carbohydrates that provide ample energy, and help to prevent cancer, constipation, colon disorders, high blood sugar levels and also contribute to overall health with abundant proteins, fats, lipids, minerals, vitamins and enzymes. They are enriched with niacin, iron, riboflavin and thiamine, and most cereals have abundant fiber contents, especially barley, oat, and wheat. Cereals also have soluble bran that helps in lowering blood cholesterol levels [16].

Cereals or grains belong to the monocot families '*Poaceae* or *Gramineae*' and are cultivated widely to obtain the edible components of their fruit seeds. Botanically, these fruits are called '*caryopsis*' and are structurally divided into endosperm, germ, and bran. Cereal grains are cultivated in huge quantities and provide more food energy than any other type of crop; therefore, they are known as basic crops.

Whole cereal grains have an outer bran coat, a starchy endosperm and a germ.

Bran: The outer layers of the kernel are called bran, which is made of about 5% of the kernel. The kernel is rich in fiber and minerals while the bran contains high amounts of thiamine and riboflavin.

Aleuron: While refining, the bran layer is removed and the aleurone layer is exposed, which lies just below the bran. This layer is also rich in phosphorous, proteins, fat and thiamin.

Endosperm: Unfortunately, this layer is also lost during processing. When the endosperm is utilized, this large central part of the kernel has high percentage of starch and protein and is low in vitamin or mineral content.

Germ: The small structure at the rear part of the kernel is known as the germ. Rich in protein, fat, minerals and vitamins, this germ is the storehouse of nutrients for the seed while germinating [16].

The main nutrient component of cereal grains is carbohydrate which makes up 79-83% of the dry matter of grain. They are classified based on their chemical structure and digestibility. Hexoses (fructose, glucose and galactose) and pentoses (xylose and arabinose) are the most frequently represented monosaccharides in grain. Sucrose and maltose are the commonly occurring disaccharides in cereal grains. Polysaccharides are polymers consisting of more than 20 units of monosaccharid. Starch, cellulose and xylans are found mainly in grains. The total content of mono-, di - and oligosaccharides in cereals and pseudocereals are from 1 to 3% [19]. Starch is the most abundant saccharide in corn of cereals and is composed of amylose and amylopectin. Their ratio depends on the type of cereal and variety. Coating layer of grains is a rich source of fiber, especially insoluble fiber (cellulose, hemicellulose). Good sources of soluble fiber (pentosans, β-glucans and soluble hemicellulose) are particularly oats, barley and rye [38].

Grains of cereal have low content of lipids (approximately 1-7% of a kernel), but these lipids are rich in essential fatty acids, and almost no saturated fatty acids. Cereals contain trace amounts of phytosterols, in the absence of cholesterol [34]. The most lipids are in the germ. Wheat, barley, rice, rye and sorghum have lower lipid content than other cereals. For example, wheat, rice, corn, rye and barley contain 1-2% of lipid and oat contains 4-7%. The lipids are created by 72-85% unsaturated fatty acids, primarily, oleic acid and linoleic acid. Protein consists of 7-14% of the grain, depending on the grain. Cereals are low in the amino acids tryptophan and methionine and although potential breeding may produce cereals higher in the amino acid lysine, it remains the limiting amino acid in cereals [15]. Chrenková et al. (2003) monitored the protein quality of cereals (wheat, spelt, maize and oat) and found out that the limiting amino acid is lysine and the average content of albumin and globulin fractions were highest in oat, which determines the higher share of content of amino acids.

Some cereals contain celiac active polypeptides, which in susceptible individuals cause allergic reactions. Proteins with a molecular weight of 5-100 kDa feature low digestibility and low proportion of essential amino acids. Celiac active ingredients are found in the prolamin fraction. If the content of prolamine is in an amount of 4-8%, the products can be considered appropriate for the celiac diet [27].

Gálová et al. (2011) analyzed the content of prolamins in three cereals and five pseudocereals. The authors found out that amaranth, buckwheat, millet and chickpeas are suitable for the production of gluten-free food, because the content of prolamins was less than 5%. The other pseudocereals had the content of gluten <200 mg.kg-1. Wheat, rye and barley could not meet this criterion.

Protein digestibility ranges from 80 to 90%. Lower protein digestibility of cereal and pseudocereals in comparison to animal protein is caused by phytic acid, tannins and polyphenols, which bind proteins to insoluble complexes [34].

Storage proteins, which form the main part of the grain, are gliadins and glutenins. Gliadins are known to trigger celiac disease in persons sensitive to gluten and gluten affects the tensibility. The grain storage proteins, which are responsible for celiac disease, are classified into three groups [10,35]:

- High molecular weight (HMW)
- Middle molecular weight (MMW)
- Low molecular weight (LMW).

Proteins of these groups can be divided into different types on the basis of homologous amino acid sequence. HMW group contains HMW glutenin subunits (HMW - GS) (wheat), HMW secalins (rye) and D - hordein (barley). HMW - GS and HMW secalins can be divided into x - type and y - type. Molecular weight of subunit is in the range of 70 kDa to 90 kDa. The amino acid composition is characterized by high Gln, Gly and Pro, which together account for about 70% of the total residues. MMW group consists of homologous ωl, 2 - gliadins (wheat), ω - secalins (rye), C - hordeins (barley), and unique ω5 - gliadins (wheat), and have a very unbalanced amino acid composition, which is characterized by high Gln, Pro and Phe, which together represent 80% of the total residues. Most areas of the amino acid sequence are composed of repeating units, (Q) or QPQQPFP (Q) QQQFP. Glutenins are composed of subunits of HMW- GS (high molecular weight glutenin subunit) and LMW-GS (low molecular weight glutenin subunit), which determine the quality of flour. LMW (low molecular weight) group can be divided into monomeric proteins, including α/β- and γ-gliadins (wheat), γ-40k-secalins (rye), γ-hordeins (barley) and avenin (oat). LMW-GS (wheat), γ-75k-secalins (rye) and B-hordeins (barley) are assigned to aggregated proteins. All of these proteins have an N-terminal domain rich in Gln (glutamin), Pro (prolin), and aromatic amino acids (Phe, Tyr) and the C-terminal domain with more balanced amino acid composition and with the highest content of cysteine residues [10,43].

Glutenins also affect the elasticity and swelling of gluten and are the triggers of celiac disease. The most dangerous is fraction of α-gliadins, which consists of the tetrapeptide [8]. The fraction of gliadins contains celiac active polypeptides, which in sensitive individuals of human population trigger alergic reaction. Food allergy is a clinical manifestation of sensitization to food allergens [8]. Michalík et al. (2006) found that these are proteins with molecular weight of 5- 10 kDa. These proteins have low digestibility, low proportion of essential amino acids, and are poorer in nutritional quality.

Celiac disease is a multifactorial disease characterized by autoimmune destruction of the epithelium of an absorption in the small intestine, resulting in malabsorption of protein, and inability of intestinal walls to process gluten. Gliadin binds to the corresponding receptors of epithelial cells intestinal villous and effects them cytotoxic [28]. Treatment of the disease consists in a strict gluten-free diet, which is a lifetime. It means - preparing meals, which contain no gluten, so strict exclusion of flour and products made from wheat, barley, oats and rye. All patients express the antigen-presenting molecules human leukocyte antigen-DQ2 (HLA-DQ2) and/or HLA-DQ8, which bind gluten peptides and thus activate destructive intestinal T cells. Patients with untreated CD have circulating IgA autoantibodies to the enzyme tissue transglutaminase (tTG), a component of endomysium [36].

Celiac active proteins are present in the prolamin fraction with low molecular weight about 20 to 30,000 kDa [27] and are encoded in a locus in wheat Gli - 2, an estimate from 25-30 to 150 copies of the gene in the haploid genome [42]. The identified immunodominant epitope from alpha - gliadin is considered to be the most important stimulus activator of celiac disease [43]. It is a peptide sequence of 33 amino acids, the structure of which is the structure resistant to further digestion, and which contain three overlapping epitope sequences PFPQPQLPY, PQPQLPYPQ PYPQPQLPY, where P is proline, Q is glutamine, F is phenylalanine, L is leucine, Y is tyrosine, and G is glycine [8].

Gálová et al. (2011) found out that pseudocereals (buckwheat, amaranthus) had celiac agens below the limit value and recommended this crop group as a suitable raw material for expanding the range of gluten-free products.

Palenčárová et al. (2010) found out that the content of storage proteins - glutenin with high molecular weight (HMW-GS) does not exceed 4.44% in amaranth and 8.8% in buckwheat, and the proportion of HMW-GS in amaranth vary from 0.37% to 4.4% and in buckwheat from 1.57% to 8.8%. Low content of HMW-GS confirms that amaranth flour and buckwheat do not meet the criteria of bakery quality, so it can be used for bread only as an additive to wheat or rye flour and are suitable of gluten-free products. Representation of HMW-GS analyzed genotypes in chickpea and wheat was higher. Average proportion of HMW-GS in chickpeas reached 17.16% and 17.45% in wheat.

2. Legumes

Legumes constitute the third largest family of flowering plants, comprising more than 650 genera and 18,000 species [25]. Economically, legumes represent the second most important family of crop plants after *Poaceae* (grass family), accounting for approximately 27% of the world's crop production [11].

On a worldwide basis, legumes contribute by about one-third to human direct protein intake, while also serving as an important source of fodder and forage for animals and of edible and industrial oils. One of the most important attributes of legumes is their capacity for symbiotic nitrogen fixation, underscoring their importance as a source of nitrogen in both natural and agricultural ecosystems [14]. Legumes also accumulate natural products (secondary metabolites) such as isoflavonoids that are considered beneficial to human health through anticancer and other health-promoting activities [22].

Bean and peas are the mature forms of legumes. They include kidney beans, pinto beans, black beans, garbanzo beans, lima beans, black-eyes peas, split peas, and lentils. Beans and peas are excellent sources of protein. They also provide other nutrients, such as iron and zinc, similar to seafood, meat, and poultry. They are excellent sources of dietary fiber and nutrients such as potassium and folate, which also are found in other vegetables. Because of their high nutrient content, beans and peas may be considered both as a vegetable and as a protein food [17]. The most common legumes for human consumption are bean, lentil, pea, chickpea and faba bean [12].

Table 1. The composition of selected cereals and pseudocereals (g/100 g grain) [5,6,37,40]

Cereal	Proteins	Lipids	Fiber	Ash	Carbohydrates
Wheat	14.3	2.3	2.8	2.2	78.4
Rye	13.4	1.8	2.6	2.1	80.1
Barley	10.8	1.9	4.4	2.2	80.7
Millet	14.5	5.1	8.5	2.0	71.6
Oat	11.6	5.2	10.4	2.9	69.8
Amaranth	16.6	7.2	4.1	3.3	59.2
Buckwheat	12.3	2.3	10.1	2.3	66.0
Quinoa	16.5	6.3	3.8	3.8	69.0

However, grain legume seeds can be fractionated to obtain protein and starch concentrates and isolates, and as a by-product of the process, dietary fibre. Starch, protein and dietary fibre are indeed the main fractions of most European grain legumes, the main exceptions being lupin and soya, which are both rich in fat (Table 2). Dietary fibre content varies according to the species, the variety and processing of legume seeds. In most grain legumes consumed as pulses by humans, the content ranges from 8 to 27.5%, with soluble fibre in the range 3.3–13.8%. Dietary fibre, or cell wall material, content in the cotyledon of legume seed is generally low compared to that of the testa. Indeed, the cell walls accounted for about 90% of the testa dry weight [12]. Brillouet and Carre´ (1983) reported values of dietary fibre contents for pea, broad pea and soyabean cotyledons in the range 6.9–9.3% (on a dry weight basis). Lupin species have a special position within the *Leguminosae* family by containing a high amount of cell wall material in the cotyledons (in the range 7.5–3.1%) in the form of rather thick cell walls [4]. This could be ascribed to the high amount of galactans stored in the cell walls. Starch content varies between genera, from negligible amounts in *Glycine max* to half the dry seed weight in a wild-type, round-seeded, pea (*Pisum sativum*) (Table 2).

Table 2 Chemical composition (g/100 g dry matter) of some legume seeds [1]

Legume seed	Protein (Nx6.25)	Crude fat	Dietary fibre	Starch	Sucrose
Vicia faba	26 – 34	2 – 4	15 – 24	40 – 50	2.1 – 2.3
Pisum sativum	23 – 31	2 – 3	15 – 21	20 – 50	0.7 -5.7
Lupinus luteus, L. angustifolius, L. Albus	33 – 42	4 – 12	25 – 40	1 - 2	1.5 – 3.5
Glycine max	38 - 42	18 - 22	7 - 15	1 - 2	4.7 – 7.6

Although legumes have higher content of fiber, such as cereals, this does not diminish their digestibility and nutritional value, because hulls of legumes have high digestibility (low share of lignin and high share of hemicellulose and cellulose) [23].

Legumes are widely recognized as important source of food proteins. Legume seeds accumule large amount of proteins during their development [26]. Boye et al. (2010) reported that content of protein in pulses is 170 –350g.kg-1 dry matter. In terms of solubility in specific solvents, pulse proteins fall primarily into the albumin (water-soluble) and globulin (salt-soluble) classes. The storage proteins legumin and vicillin are globulins, and the albumins comprise the heterogeneous group of enzymes, amylase inhibitors, and lectins.

Table 3 Content of nutrients in pea (g.kg-1 dry matter) [19,21]

Parameter	Content
Crude protein	220-260
Protein	217-223
Fibre	61-71
Fat	12-16
Ash	28-31
Starch	442-536
Soluble N (% from total N)	54.4
NDV-Neutral detergent fibre	208.1
NFE –Nitrogen free extract	642.0
Lysine	1.79-2.09
Methionine + cystine	0.53-0.64
Threonine	0.75-0.95

For example, proteins of pea are characterized by high content of arginine and lysine (Table 3), and lower content of methionine, cystine and tryptophan [7]. For this fact, proteins of legumes were long time considered for biologically less valuable (lower content of methionine, cystine and tryptophan). The content of threonine is sufficient, which has a positive effect on the quality of the meat (animals) [21].

The nutritive value of legumes is particularly limited digestibility of protein, amino acid composition, amino acid utility, as well as the presence of anti-nutritional factors [3]. Pea protein utilization limits the presence of biologically active substances, which have anti-nutritional effect and can be eliminated by the heat treatment [29].

Content of starch is for 22–45% of pulse grain weight depending on the source, whereas starch content is low in the oilseeds [13]. As is typical of other grains, pulse starches are composed of amylose, a linear α- 1,4-linked glucan with few branches in the molecular weight range of 105–106, and amylopectin, a highly branched and much larger molecule (molecular weight 107–109) composed of α- 1,4-linked glycosyl units of varying lengths connected by α-1,6 branch points. Pulse starches generally have a higher content of amylose compared with cereal and tuber starches; this factor plus their associated high capacity for retrogradation may reduce the starch digestion rate, rendering them either slowly digestible and/or resistant to digestion [26].

Tosh and Yada (2010) found out that pulses are high in fiber, with 15–32% total dietary fiber; of this approximately one-third to three-quarters is insoluble fiber and the remaining is soluble fiber. Otto et al. (1997) prepared flours from chickpeas and smooth and wrinkled peas and found that flours originating from the outer layer of the cotyledon were higher in protein and fibre but lower in starch than flours from the central part of the cotyledon.

Legumes contain a number of bioactive substances including enzyme inhibitors, lectins, phytates, oligosaccharides, and phenolic compounds that play metabolic roles in humans or animals that frequently consume these foods. Some of these substances have been considered as antinutritional factors and have effect on diet quality, significantly reduce the digestibility of legumes. Phytic acid can diminish mineral bioavailability [33]. According to Chung et al. (1998) some phenolic compounds can also reduce protein digestibility.

Another valuable source of protein in human nutrition is lupine. Variability in the chemical composition of lupine seeds depends on genetic and environmental, including agronomic practices. In lupine seeds is a negligible quantity of starch, dominated soluble and insoluble non-starch polysaccharides and oligosaccharides. Compared to other legumes lupine contains a greater amount of hemicellulose in crude fiber. Lignin content is low, like in pea [41]. The protein content is between 29-45%, with the most amounts of globulins (85%). Lupine is rich in glutamic acid, aspartic acid, arginine and leucine. It has a smaller amount of methionine and cysteine. It is also low in lysine and tryptophan [32].

The average protein content was found in chickpeas (11.16%), which confirmed that the pulses are characterized by higher protein content compared with cereals and pseudocereals. Gálová et al. (2011) analyzed three types of cereals and five types of pseudocereals and one legume - chickpeas and found that the highest average protein content was in chickpeas (11.16%), which confirmed that the pulses are characterized by a higher content of protein compared with cereals and pseudocereals.

Gálová et al (2011) reported that the smallest content of cytoplasmic protein in the tested samples was in chickpeas – an average of 15.05%. Content of albumins and globulins in legumes – in sample of chickpeas was the highest 74.7%, while in cereals it was on average 28.6%, in pseudocereals 37.81%. Michalik et al. (2006) reported that the dominant fraction in chickpeas are nutritionally high value cytoplasmic proteins, as well as pseudocereals - amaranth, buckwheat, millet have content of prolamins 4.98% and they are suitable for the production of gluten-free food.

Pulses have a positive impact on human health. They are high in dietary fibre, which is important for healthy bowel function; further contain soluble fibre, which lowers blood cholesterol. Legumes have a low glycaemic index or GI (<55). These low GI foods are recommended to avoid hyperglycemia and/or increases in blood insulin levels, which are risk factors for cardiovascular disease, mortality, and 2 type of diabetes. Pulses contain antioxidants - vitamin E, selenium, phenolic acids, phytic acids, copper, zinc and manganese and phytoestrogens, which help in the prevention of hormone-related cancers, such as breast and prostate cancer. Legumes are good sources of folate – useful in the prevention of diseases, such as heartdisease and cancer. The B vitamin folic acid significantly also reduces the risk of neural tubedefects (NTDs) like spina bifida in newborn babies. Chickpeas, faba beans, lentils contain saponins and these lower blood cholesterol. The biggest advantage of legumes is that they are gluten-free and are suitable for gluten-free diet [44].

3. Conclusion

Considering to an autoimmune disease of the small intestine - celiac disease; legumes and pseudocereals are suitable for gluten free diet, because they have a content of prolamin less than 4% (legumes) and pseudocereals from 4 to 8%. Cereals with high content of prolamins - wheat, barley, rye and oats must be excluded from the diet, not to do health problems.

References

[1] Bagger CL, Bjergegaard C, Sorensen H, Sorensen J C, Sorensen S. Biorefining lupin seeds to obtain high value protein concentrates and isolates. In: Proceedings of the 3rd European Conference on Grain Legumes, Valladolid, Spain, 14-19 November 1998, pp. 48-49, Paris: AEP Editions.

[2] Boye J, Zare F, Pletch A. Pulse proteins: processing, characterization, functional properties and applications in food and feed. Food Res Int 2010; 43 (2): 414-431.

[3] Brand TS, Brandt DA, Van der Merwe JP, Cruywagen CW. Field peas (*Pisum sativum*) as protein source in diets of growing-finishing pigs. Journal of Applied Research 2000; 18: 159-164.

[4] Brillouet JM, Carre´ B. Composition of cell walls from cotyledons of *Pisum sativum*, *Vicia faba* and *Glycine max*. Phytochemistry 1983; 22: 841-847.

[5] Cai YZ, Corke H, WU HX. Amaranth. In: Encyclopedia of Grain Science. Elsevier Academic Press, Oxford, vol. 1, 2004 a, p. 1-10.

[6] Cai YZ, Corke H, Li W D. Buckwheat. In: Encyclopedia of Grain Science. Elsevier Academic Press, Oxford, vol. 1, 2004 b, p. 120-128.

[7] Čerešňáková Z., Szalayová M, Nitrayová S, Slaměna Z. Nutritive value of choice varieties of Pea (*Pisum Sativum ssp.).* Poľnohospodárstvo 1992; 38 (1-2): 101-108.

[8] Gálová Z. Genetické markery technologickej kvality zrna pšenice a jačmeňa. In: Mapovanie genómu zrna pšenice pre účely determinácie genetickej diverzity obilnín, VEGA projekt č. 1/7648/20: záverečná správa, 2002, p. 1-3.

[9] Gálová Z, Kečkešová M, Kopálová Z, Chňapek M, Poláčková A. Quality of cereals, pseudocereals and legume from the point of view gluten free diet. Potravinarstvo 2011; 5 (special issue February): 268-273.

[10] Gálová Z, Palenčárová E, Chňapek M, Balážová Ž. Využitie obilnín, pseudoobilnín a strukovín v bezlepkovej diéte, 1.vydanie, Nitra: Slovenská poľnohospodárska univerzita, 2012, 172 p.

[11] Graham PH, Vance CP. Legumes: Importance and constraints to greater use. Plant Physiol 2003: 131: 872-877.

[12] Guillon F, Champ M J. Carbohydrate fractions of legumes: uses in human nutrition and potential for health. British Journal of Nutrition 2002; 88(Suppl. 3): 293-S306.

[13] Hoover R, Hughes T, Chung HJ, Liu Q. Composition, molecular structure, properties, and modification of pulse starches. Food Res Int 2010; 43 (2): 399-413.

[14] http://onlinelibrary.wiley.com/enhanced/doi/10.1111/j.1440-1681.2008.04899.x/

[15] http://food--nutrition.blogspot.sk/2009/08/nutrient-composition-of-cereal-grains.html

[16] http://www.organicfacts.net/health-benefits/cereal/health-benefits-of-cereals.html

[17] http://www.pulsecanada.com/food-health/nutritional-benefits

[18] Chibbar R N, Ganeshan S, Båga M, Khandelwal RL. Carbohydrate Metabolism. In: Encyclopedia of Grain Science. Elsevier Academic Press, Oxford, 2004, vol. 1, p. 168-179.

[19] Chrenková M, Čerešňáková Z, Sommer A, Sojková Z, Slaměna Z. Influence of cultivar and year on biological value of pea. J. Anim. Sci, 1995; 28: 29-33.

[20] Chrenková M, Čerešňáková Z, Štefanka J, Slaměna Z, Sommer A. Hrach ako zdroj bielkovín vo výžive zvierat. In: Aktuálne problémy vo výrobe a využití priemyselných krmív a premixov kŕmnych aditív vo výžive zvierat: Zbor. prác zo 16. ved. konf. VÚK: Ivánka pri Dunaji, november 1997, p. 68-71.

[21] Chrenková M, Čerešňáková Z, Sommer A, Slaměna Z. Strukoviny, ich kvalita a možnosti využitia vo výžive zvierat. In: Slovenský chov, 4, 2000, p. 42-43.

[22] Chrenková M, Čerešňáková Z, Sommer A, Nitrayová S, Gálová Z. Quality of cereal proteins in animal nutrition. Agriculture 2003; 49: 489-495.

[23] Chrenková M, Čerešňáková Z. Growing and utilization of legumes as native source of proteins in east Slovakialowland. In: Uplatnenie vedy v poľnohospodárstve v kontexte rozvoja vidieka a prihraničnej spolupráce s Ukrajinou, Zborník referátov z odborného seminára s medzinárodnou účasťou, Zemplínska Šírava 29-30. 5. 2008, p. 71-77.

[24] Chung, KT, Wong TY, Wei CI, Huang YW, Lin Y. Tannins and human health: A review. Critical Reviews in Food Science and Nutrition 1998; 38:421-464.

[25] Lewis G, Schrirer B, Mackinder B, Lock M. Legumes of the World; Royal Botanical Gardens: Kew, UK, 2005, 592 p.

[26] McCrory MA, Hamaker B R, Lovejoy J C. -Eichelsdoerfer, P. E. Pulse Consumption, Satiety, and Weight Management. In: American Society for Nutrition. 2010, Adv. Nutr. 1, p. 17-30.

[27] Michalík I, Gálová Z, Urminská D, Knoblochová H. Bielkovinový komplex zrna obilnín a pseudoobilnín. In: Výživná a technologická kvalita rastlinných produktov a ich potravinárske využitie. Monografia. Nitra: SPU, 2006. p. 68-101.

[28] Moudrý, J, Kalinová J, Petr J, Michalová A. Pohánka a proso. Praha: ÚZAPI, 2005. 206 pp.

[29] O´Doherty J V, Keady U. The nutritive value of extruded and raw peas for growing and finishing pigs. J. Anim. Sci 2000; 70: 265-274.

[30] Otto T, Baik BK, Czuchajowska Z. Wet fractionation of garbanzo bean and pea flours. Cereal Chemistry 1997; 74 (2): 141-146.

[31] Palenčárová E, Gálová Z. Detection of celiac active proteins by electrophoretic and imunochemical methods. Potravinarstvo 2010;. 4 (special issue February): 485-490.

[32] Petterson DS, Sipsas S, Mackintosh J B. The chemical composition and nutritive value of Australian Pulses (2nd Edition). In: Grains research and development corporation, Canberra, 1997, 65 pp.

[33] Sandberg AS. Bioavailability of minerals in legumes. British Journal of Nutrition 2002; 88 (3): 281-285.

[34] Serna Saldivar SO, Caballero B. Cereals/Dietary Importance. In Encyclopedia of Food Science and Nutrition. Academic Press, 2003, vol. 3, p. 1027-1033.

[35] Shewry PR,Tatham AS. The prolamin storage proteins of cereal seeds: structure and evolution. Biochemical Journal 1990;. 267: 1-12.

[36] Schuppan D, Dennis M, Kelly C. Celiac. Disease: Epidemiology, Pathogenesis, Diagnosis, and Nutritional Management Nutrition. Clinical Care 2005; 8 (2): 54-69.

[37] Taylor JRN. Fermentation/Foods and Nonalcoholic Beverages. In: Encyclopedia of Grain Science. Academic Oxford Press, vol. 1, 2004, p. 380-390.

[38] Topping D. Cereal Complex Carbohydrates And Their Contribution To Human Health. Journal Of Cereal Science 2007; 46 (3): 220-229.

[39] Tosh SM, Yada S. Dietary fibres in pulse seeds and fractions: characterization, functional attributes, and applications. Food Res Int 2010; 43 (2): 450-460.

[40] Valencia-Chamorro SA. Quinoa. In: Encyclopedia of Grain Science. Academic Oxford Press, vol. 3, 2004, p. 1-8.

[41] Van Barneveld RJ. Understanding of nutritional chemistry of lupin (lupinus spp.) seed to improve livestock production eficiency. Nutrition Research Rew 1999; 12: 203-230.

[42] Van Herpen T, Riley, M.-Sparks, C.-Jones, H. D.-Gritsch, C.-Dekking, E. H.-Hamer, R. J.-Bosch, D.-Salentinj EMJ, Smulders MJ M, Shewry PR, Gilissen LJ. 2008. Detailed Analysis of the Expression of an Alpha-gliadin Promoter and the Deposition of Alpha-gliadin Protein During Wheat Grain Development. Annals of botany 2008; 102 (3): 331-342.

[43] Wieser H, Koehler P. The biochemical basis of celiac disease. Cereal Chemistry 2008; 85 (1): 1-13.

[44] www.pulseaus.com.au