The protein profile of cereals, pseudocereals and legumes

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Abstract

Cereal grains are a major source of dietary energy and nutrients worldwide. Gluten proteins from wheat (prolamins and glutelins) play a crucial role in the bakery industry. However, gluten also causes a negative response in a small subset of the population which suffers from coeliac disease. This is one reason for the incorporation of alternative crops into the human diet. Pseudocereals and legumes, which have a high nutritional value and a low content of prolamins, may be suitable substitutes. The aim of this study was to analyse a group of cereals, pseudocereals and legumes according to the composition of their proteins and their possible application in a gluten-free diet. We determined the total nitrogen content (and crude protein content), as well as the coefficient of nutritional quality and the fractional composition of proteins. The results showed that the crude protein content varies from 9.89% to 21.5%, while the highest protein content was found in legumes. Nutritional quality was based on the coefficient of nutritional quality. The highest value of the coefficient of nutritional quality was calculated in peas. The representation of storage proteins indicates the technological quality of the seeds. In this regard, the best technological quality was found in wheat.

Cereals, legumes, proteins, pseudocereals

Introduction

Cereals are a basic foodstuff for people all over the world and are an extremely important source of high-quality proteins, saccharides, vitamins, fibre and mineral substances. Cereal grains contain around 75% saccharides, 10 to 15% proteins and 2% fats and are used primarily in the food industry, though they are also used in other industries and as animal feed (Gajdošová and Šturdík 2004). Storage proteins are the most important indicators of the technological quality of cereal grains. From the medical viewpoint, prolamins are interesting for their content of coeliac-active polypeptides which may, in certain individuals, cause various food allergies or autoimmune diseases (Gálová et al. 2011b).

Coeliac disease or coeliac sprue is an autoimmune disease caused by an intolerance to gluten-forming proteins and related prolamins in rye, barley and oats in individuals with a genetic predisposition. Proteins forming gluten cause an inflammatory process and damage to the mucous membranes of the small intestine, which is then unable to fulfil its function. Individuals suffering from coeliac disease are dependent on a lifelong gluten-free diet which means that the content of prolamins in their diet should not, according to the valid legislation, exceed 5% (Alvarez-Jubete et al. 2009). Pseudocereals are dicotyledonous plants that produce grains rich in starch similarly to cereals (Hager et al. 2012). Amaranth (*Amaranthus* sp.) and buckwheat (*Fagopyrum* sp.) are classed as pseudocereals which are one of the gluten-free alternatives to cereals in the diet of people suffering from coeliac disease. The seeds of these plants are functionally and compositionally similar to cereal grains, and also represent a rich source of mineral elements and bioactive substances (Moreno et al. 2014). The seeds of leguminous plants represent a rich source of proteins, saccharides and certain water-soluble vitamins and minerals (Friedman 1996). The proteins in leguminous plants are characterised by a high content of lysine, leucine, arginine, aspartic acid and glutamic acid. The most important protein fraction in legumes are globulins, which may make up 50 to 60% of the total protein content (Juliano 1999).

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Materials and Methods

We analysed seeds from six commercially available samples of cereals, pseudocereals and leguminous plants, specifically wheat (*Triticum* sp.), buckwheat (*Fagopyrum* sp.), amaranth (*Amaranthus* sp.), peas (*Pisum* sp.), lentils (*Lens* sp.) and chickpeas (*Cicer* sp.). We determined the content of total nitrogen by the Kjeldahl method (Michalík 2002) and the fractional composition of proteins according to Golenkov (Michalík 2002) in whole-grain samples, on the basis of which we subsequently determined the content of crude protein and the coefficient of nutritional quality.

Results and Discussion

The use of cereals in human nutrition has a long tradition. One of the most frequently cultivated crops in the world is wheat, which is, thanks to its specific proportion of gluten-forming proteins (prolamins and glutelins), used mainly in the production of bread, pasta and various bakery products. The content and quality of storage proteins is the principal factor affecting the technological quality of cereal grains. However, the fraction of prolamin proteins is unsuitable for patients suffering from coeliac disease, for which reason interest in the use of alternative crops, such as pseudocereals and leguminous plants, in the production of gluten-free foodstuffs has been on the increase in recent years (Hager et al. 2012).

Coeliac disease is an autoimmune disease in which prolamins become bound to the epithelial cells of the intestinal villi which causes the destruction of the resorptive epithelium of the small intestine and a protein absorption disorder (Gálová et al. 2011b).

In relation to the above, we analysed one cereal, two pseudocereals and three kinds of legume for the content of crude proteins and the fractional composition of proteins in the grains of the individual crop plants.

It can be seen from the results (Table 1) that there is a considerable difference in the content of proteins between the individual crop plants (Fig. 1). The average content of crude proteins in the analysed crop plants was 16.73%, ranging from 9.89% (wheat) to 21.5% (chickpeas and lentils). This confirmed that legumes are characterised by a higher content of proteins as compared to cereals and pseudocereals (Gálová et al. 2011b).

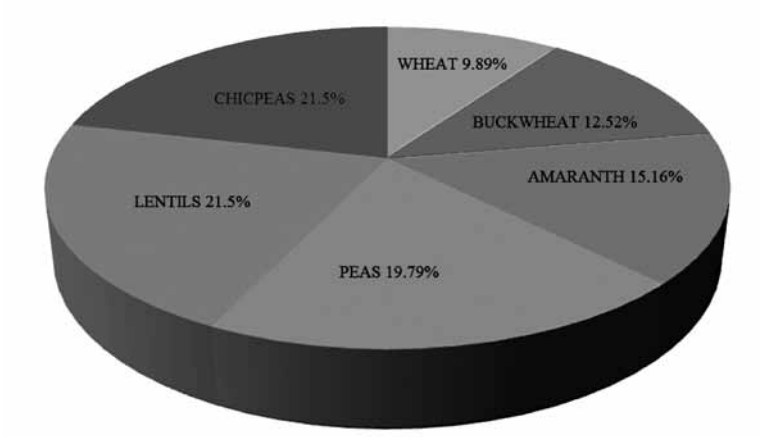

Fig. 1. Content of crude proteins in individual crop plants

The coefficient of nutritional quality shows the nutritional quality of individual crop plants. It can be seen from the results (Table 1) that the highest coefficient of nutritional quality was recorded in peas (8 571.43%), followed by lentils (2 027.17%), chickpeas

(1950.59%), buckwheat (955.80%) and amaranth (743.43%), with the lowest nutritional quality being recorded in wheat (99.68%).

Table 1. Total content of nitrogen and crude proteins and coefficient of nutritional quality (CNQ) in individual crop plants

Sample	Total N [%]	Crude proteins [%]	CNQ [%]
Wheat	1.74	9.89	99.68
Buckwheat	2.09	12.52	955.80
Amaranth	2.66	15.16	743.43
Peas	3.47	19.79	8571.43
Lentils	3.58	21.50	2027.17
Chickpeas	3.58	21.50	1950.59
X (%)	2.85	16.73	2391.35
σ (%)	0.74	4.51	2844.54
V (%)	25.96	26.96	118.95

Total N – total nitrogen, CNQ – coefficient of nutritional quality, X – average, σ – standard deviation, V – variation coefficient

Bojňanská and Urminská (2010) found the highest content of crude proteins in legumes (chickpeas 20.7%; lentils 27.4%) and buckwheat (14.3%) in a group of cereals, pseudocereals and legumes. The results we obtained are also in agreement with the research conducted by Gálová et al. (2011b) who determined an average crude protein content in cereals of 9.13% with a coefficient of nutritional quality of 117.54%. Magala et al. (2012) compared the protein content in flours made from legumes and wheat. The protein content in whole-grain chickpea (20.64%) and pea (20.94%) flour exceeded twice the amount of protein in wheat flour (10.07%), which is also in agreement with our results.

Table 2. Fractional composition of the proteins of individual crop plants

Sample [%]	Alb+glob	Prolamins	Glutelins	Remainder
Wheat	21.92	33.17	33.99	10.92
Buckwheat	53.51	8.76	9.22	28.53
Amaranth	52.06	8.68	26.79	12.47
Peas	88.47	1.05	8.95	1.53
Lentils	85.9	4.49	4.49	5.12
Chickpeas	73.33	4.25	12.85	9.57
X [%]	62.53	10.07	16.05	11.36
σ [%]	23.01	10.67	10.63	8.51
V [%]	36.80	105.96	66.23	74.91

Alb+glob – albumins and globulins, *X* – average, *σ* – standard deviation, V – variation coefficient

Determining the fractional composition of proteins makes it possible to evaluate the analysed materials from the viewpoint of their nutritional and technological quality. The albumin and globulin fractions of proteins contain a large amount of essential amino acids, which has a positive influence on the nutritional quality of products, while the presence of prolamins and glutelins – gluten-forming proteins – is necessary to achieve the

optimal technological quality of bakery products. The presence of coeliac-active proteins can be detected in the prolamin fraction of a number of crops (wheat, barley, rye, oats) (Palenčárová and Gálová 2010). Hischenhuber et al. (2006) state that the Codex Alimentarius limits the gluten content to 20 $mg \cdot kg^{-1}$ for naturally gluten-free foods. For food products that are not naturally gluten-free, a maximum limit for the content of gluten of 200 $mg \cdot kg^{-1}$ is stipulated, which corresponds to 0.02% gluten (Wieser and Koehler 2008).

The results (Table 2) show that the proportion of albumins and globulins in grain ranged from 21.92% (wheat) to 88.47% (peas). The content of albumins and globulins amounted to 53.51% in buckwheat and 52.06% in amaranth. On the other hand, the highest value for the percentage of prolamins was found in wheat (33.17%) and the lowest in legumes (1.05% to 4.49%). The highest glutelin content was found in wheat (33.17%) and the lowest in peas (8.95%) and lentils (4.49%). Gálová et al. (2011a) state fractional percentages of 24.49% for albumins and globulins, 37.42% for prolamins and 29.46% for glutelins. In their research, Socha et al. (2010) determined a content of albumins and globulins of 22.62% in wheat and 56.98% in amaranth. The prolamin content was 3.15% in amaranth and 33.78% in wheat, while the percentage proportion of the glutelin fraction was 34.95% in wheat and 23.02% in amaranth. The given results agree with the percentage proportions of the individual protein fractions in the samples we analysed. It can be said, on the basis of the above, that peas, lentils and chickpeas can be classed as gluten-free crop plants and, therefore, used for the purposes of a gluten-free diet.

Conclusions

The aim of this work was to determine the protein profile of the analysed cereals, pseudocereals and legumes and to recommend which of these crop plants are suitable for use in a gluten-free diet. We can, on the basis of the results obtained, state that the highest content of crude proteins was found in lentils and chickpeas (21.5%). The best nutritional value from the viewpoint of the percentage proportion of albumins and globulins was shown by peas (88.47%) with a CNQ value of 8 571.43%. On the basis of the proportion of storage proteins, the best technological quality was shown by wheat, with a prolamin content of 33.17% and a glutelin content of 33.99%. Pseudocereals and legumes are characterised by the fact that their dominant fraction are cytoplasmic proteins, while they also have an extremely small content of gluten-forming proteins, which allows their use in a gluten-free diet for sufferers of coeliac disease.

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