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Pumpkin Fruit Flour as a Source for Food Enrichment in Dietary Fiber

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Abstract

It is believed that fiber-rich diet reduces the risk of certain cancers, coronary heart and other diseases. Dietary fiber (DF) is not only used for its nutritional properties, but also for its functional and technological properties. Thus, to supplement daily diet, dietary fiber should be incorporated into frequently consumed foods. Pumpkins are a good source of carotenoids, mineral salts, vitamins, and other bioactive substances, such as phenol compounds. Also the pumpkin flour could be used for food enriching as fiber supplement. In the study standard methods were applied to determine and compare the neutral dietary fiber (NDF), acid dietary fiber (ADF), acid detergent lignin (ADL) and water-soluble carbohydrates (WSC) contents in pumpkins fruits flour obtained from different species and cultivars. The results imply that pumpkin fruit flour should be recommended as the component suitable for food production with high content of DF. The fiber content in the pumpkin fruit flour depends on the cultivar. The maximum insoluble fiber content (NDF, ADF, ADL) was accumulated in *C. maxima* 'Kroshka' pumpkin flour: 26.50%, 24.65% and 14.35%, respectively, and this cultivar is the most suitable one for enriching food with dietary fiber.

Keywords: acid dietary fiber, lignin, neutral dietary fiber, pumpkin fruit flour, water-soluble carbohydrates

Introduction

Dietary fiber is a group of food components that is resistant to hydrolysis by human digestive enzymes and is necessary for promoting good health (AACC Report, 2001). Although its health-promoting properties have been recognized for several decades, the dietary fiber itself has long been regarded as an indigestible ballast component of a edible plant (Jenkins *et al*., 1998; Jiménez-Escrig and Sánchez-Muniz, 2000).

Many studies on dietary fiber have revealed that the components show the ability to bind numerous substances, including cholesterol and gastric juice (Jenkins *et al*., 1998; Jiménez-Escrig and Sánchez-Muniz, 2000; Sangnark and Noomhorm, 2003; Mai *et al*. 2003; Correa Lima and Gomes da Silva, 2005; Rodrígez *et al*., 2006). Also, dietary fiber plays an important role in the prevention and treatment of diabetes, obesity, atherosclerosis, heart diseases, colon cancer and colorectal cancer (Wang *et al*., 2002; Ferguson and Harris, 2003; Ferguson, 2005; Figuerola *et al*., 2005; Nawirska and Kwasniewska, 2005). Furthermore, increased consumption of DF improves serum lipid concentrations, lowers blood pressure, improves blood glucose, promotes regularity, aids in weight loss and appears to improve immune function (Anderson *et al*., 2009). Papadina and Bloukas (1999) state that the diet characterized through an excess of energy-dense foods, rich in fats and sugar presents a deficiency of complex carbohydrates, which constitute the major portion of dietary fiber.

Dietary fiber, as a class of compounds, includes a mixture of plant carbohydrate polymers, both oligosaccharides and polysaccharides (e.g. cellulose, hemicelluloses, pectic substances, gums, resistant starch, inulin), that may be associated with lignin, and other non-carbohydrate components (e.g. polyphenols, waxes, saponins, cutin, phytates, resistant protein) (Elleuch *et al*., 2011). The structural polysaccharides are the major part of plant cell walls. The types of plant material that are included within the definitions of dietary fiber may be divided into two forms, based on their water solubility: insoluble dietary fiber, which includes celluloses, some hemicelluloses and lignin; soluble dietary fiber, which include β-glucans, pectins, gums, mucilages and some hemicelluloses (Elleuch *et al*., 2011).

In various countries, the pumpkin flesh is processed into jams, marmalades, sweetmeats, puree for children, ready-to-eat dried snacks (Gajc-Wolska *et al.,* 2005; Gliemmo *et a*l., 2009; Nawirska-Olszańska *et al.,* 2011; Konopacka *et al*., 2010). Pumpkin can also be processed into flour, which has a longer shelf-life. This flour could be used due to its flavour, sweetness, deep yellow-orange color and considerable amount of dietary fiber. It could be use to supplement cereal flours in bakery products, soups, sauces, instant noodle and also as a natural coloring supplement for food (Noor Aziah and Komathi, 2009; Noor Aziah *et al*., 2011). Bread made from wheat flour supplemented by pumpkin flour had good nutritional value and sensory characteristics (See *et al*., 2007). With increasing the level of substitution with pumpkin flour from 5% to 15% the ash and crude fiber

contents significantly increased. Pongjanta *et al*. (2006) obtained butter and chiffon cakes and cookies by adding pumpkin powder at the levels of 10, 20, 30, 40 and 50%. The supplementation significantly increased the β-carotene content in the samples by 2.5-9.0 times.

Foods prepared from pumpkin flour could have nutritional advantage in terms of vitamins, minerals, and dietary fiber content (Noor Aziah and Komathi, 2009). Pumpkin provides valuable source of carotenoids, provitamin A and ascorbic acid, which play major roles in human nutrition and have importance as antioxidants. Current scientific researches indicate that a diet rich in foods containing β-carotene may reduce the risk of developing certain types of cancer, offers protection against heart disease and helps prevent skin diseases and vision disorders (Fraserr and Bramley, 2004; Plaza *et al*., 2006; Liu *et al*., 2009).

Fiber-rich products present on the market are primarily those of natural origin (oat, peas, maize, grain bran) which may be added to food without modifications, as well as those that must be modified before they are added (Górecka *et al*., 2010). Some reports state that fruit and vegetables DF concentrates have better nutritional quality than cereals, due to the presence of significant amount of bioactive compounds, such as flavonoids and carotenoids (Figuerola *et al*., 2005). Pumpkins are a good source of carotenoids, pectin, mineral salts, vitamins and other bioactive substances, such as phenolic compounds, so we consider that it is possible to use the pumpkin flour for enriching food with fiber. There is shortage of information about the fiber fractions in the raw material for human nutrition. Usually, they are determined only in the raw materials for feed production.

Two pumpkin species, *Cucurbita maxima* and *Cucurbita pepo*, are commonly grown in Lithuania for fruit crops and are harvested at physiological maturity. The nutritional value of pumpkin fruits is high, but varies depending on the species and cultivars. The objective of our study was to determine and compare the amount of neutral dietary fiber (NDF), acid dietary fiber (ADF), lignin and water-soluble carbohydrates (WSC) contents in pumpkin fruits flour obtained from these two species and different cultivars.

Materials and methods

The following pumpkin cultivars were selected for the investigations: *Cucurbita pepo* L.: 'Miranda', 'Golosemiannaja', 'Herakles', 'Danaja', 'Olga'; *Cucurbita maxima* Duch: 'Chutorianka', 'Zalataja grusha', 'Arina', 'Chudo judo', 'Kroshka'.

The experiment was conducted during 2010-2012 at the Experimental Station of Institute of Agriculture and Food Sciences, Aleksandras Stulginskis University. Plants were grown in the soil with the following characteristics: limnoglacial loam on moraine loam, carbonate deeper gleyic luvisol (*Calearie Luvisol*), slightly neutral and neutral, medium humus content, phosphorus-rich and potassium-rich. The field was not additionally fertilized with mineral or organic fertilizers. The soil was drained by drainage, the relief was artificially levelled. Sprouts of pumpkins were planted in the third decade of May, in four repetitions. The crop was harvested in the third decade of September.

Flours making from pumpkin fruits

For the production of pumpkin flours ten fruits were taken from each cultivar. The pumpkin fruits were washed halved and the seeds were removed. The pulp was peeled, sliced and dried at 60 °C in the laboratory drying oven (Termaks, Norway). Dried slices of pumpkins were grinded using the grinder (Ultra Centrifugal Mill ZM 200, Retsch, Germany) to produce flours, which were kept, chilled in an air-tight container, until the analysis. The samples were evaluated in triplicate for each analysis.

Methods of samples preparation and chemical analyses

The study reported in this paper was carried out at the chemistry laboratory of Lithuanian Research Centre of Agriculture and Forestry (LAMMC) and laboratory of food technologies, department of Horticulture, Aleksandras Stulginskis University.

Dry matter (DM) content has been determined by drying samples to the constant weight at temperature of 105 °C (LST EN 12145:2001). The water-soluble carbohydrates (WSC) were determined using Anthrone method (Yemm and Willis, 1954). Samples were also subjected to the fiber components analyses: acid detergent fiber (ADF) (cellulose, lignin) and acid detergent lignin (ADL) and neutral detergent fiber (NDF) (cellulose, hemicellulose, lignin) using cell wall detergent fractionation method, according to Van Soest (Faithfull, 2002).

ADF extraction was done on an ANKOM220 Fiber Analyzer (ANKOM Technology Method 08-16-06) using F57 filter bags (25 - μm porosity). NDF was analyzed with sodium sulphite and the results were presented as ash-free. The content of cell wall structural carbohydrates hemicellulose and cellulose was calculated as it follows: cellulose = ADF - ADL and hemicellulose = NDF-ADF (Hindrichsen *et al*., 2006).

The experimental data were statistically processed by the dispersion analysis method (ANOVA), software STATISTIKA 7.0 (StatSoft, USA). Dispersion analysis was applied to evaluate chemical composition of pumpkin fruit. Arithmetical means and standard errors of the experimental data were calculated. Tukey test ($p<0.05$) was applied to estimate statistical significance of differences.

Results and discussion

Dry matter content in fruits influences yield quality. This content depends on the cultivar characteristics and climatic conditions (Tarek *et al*., 2001, Nawirska *et al*., 2008). The results showed that dry matter content in *C. maxima* fruits was higher than in *C. pepo* fruits, the quantity was twice as high (Fig. 1).

Within *C. pepo* fruits, significantly more dry matter was found in 'Golosemiannaja' and 'Danaja' flesh, while within *C. maxima* fruits the highest level was observed in 'Arina', 'Zalataja grusha' and 'Kroshka' cultivars. A considerable low amount of dry matter was determined in the fruits of *C. pepo* 'Olga' and *C. maxima* 'Chutorianka'.

There are many references to DF and DF-related problems in literature, but there is shortage of information on the DF content in the raw material, which can be used

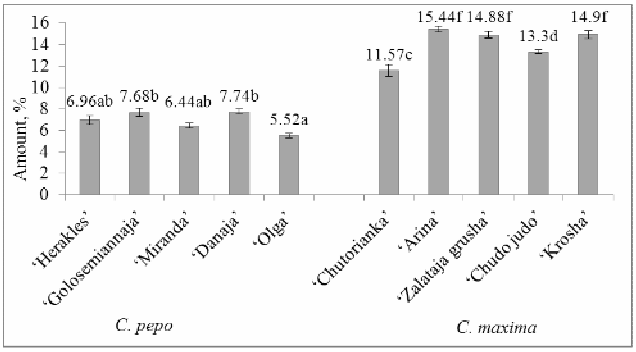

Fig. 1. Dry matter content in *C. maxima* and *C. pepo* pumpkin fruit flours; the same letters show no significant differences between means ($p<0.05$)

for the production of high-fiber content preparations (Borycka and Górecka, 2001; Nawirska *et al*., 2008).

According to Nawirska (2008), the NDF fiber content in *C. pepo* fruits flesh ranges from 0.23% to 4.37% FW, in *C. maxima* fruits from-1.20% to 4.37% FW, ADF fiber- from 0.22% to 0.47% FW and 0.43-1.46 % FW, respectively. *C. maxima* fruits accumulated higher amounts of starch, pectin, hemicellulose and NDF fiber than *C. pepo* fruits. The amounts of other fiber fractions (lignin, ADF fiber.) in fruits of both species of pumpkin were similar (Nawirska *et al*., 2008).

Our investigations of pumpkin fruits flours revealed that the content of ADF ranged between 10.12% and 24.65% DM. The largest amount of ADF was found in flour obtained from 'Kroshka', while the smallest amount in flour from 'Zalataja grusha' (Tab. 1).

According to the analysis of our data it can be concluded that the NDF fiber content is more dependent on the cultivar than on the specie. The NDF content ranged between 15.5% and 26.5% DM in the flour of ten pumpkin cultivars (Tab. 1). The NDF content is very high in the flour obtained from 'Kroshka' and 'Herakles' cultivars, slightly lower - in 'Chutorianka' and 'Miranda'.

The ADL content in the flour of all pumpkin cultivars was different. The ADL content varied between 0.86% and 14.3% DM depending on cultivar (Tab. 1). The highest ADL content was determined in 'Kroshka' flour and the lowest content in - 'Zalataja grusha' and 'Arina' flour.

It was observed that flour made of 'Kroshka' contained the highest amount of water-insoluble fiber. However, in 'Herakles', 'Olga' and 'Chudo judo' fruits had the highest number of NDF and ADF fiber was found, but less of lignin ADL, which decomposes more difficultly.

A big amount of lignin is an undesirable component in NDF fiber, since it reduces other fibers, hemicellulose and cellulose, degradation (Saha, 2003). In the tested pumpkin flour a moderate correlation between ADL and NDF fractions was established ($r = 0.490$, $p <0.05$). It might be thought that lower lignin content in pumpkin flour would make it easier for the human organism to absorb the cellulose and hemicellulose. The strong correlation between ADL and ADF fractions was established ($r = 0.972$, $p<0.05$). Lignin is more closely related to cellulose than to hemicellulose and has greater effect on its digestion (Van Soest *at al*., 1991).

Water soluble components (WSC) are quickly digested energy-rich compounds and are the primary products of photosynthesis, so their content is highly dependent on temperature, sunlight and other environmental factors (Halling *et al*., 2004).

The content of WSC varied, depending on cultivar. Pumpkin flours showed high content of total WSC (65.85% DM in 'Danaja'). The lowest content of WSC was characteristic to 'Kroshka' (26.45% DM).

Conclusions

The results imply that flour obtained from pumpkin fruits could be recommended as the component suitable for

Tab. 1. Fractional composition (mean ± s.d.) of dietary fiber in *C. maxima* and *C. pepo* pumpkin fruit flours samples

Cultivars	Amount* (% DM)			
	NDF	ADF	ADL	WSC
		C. maxima		
'Chutorianka'	15.50±0.14^{b**}	13.55±0.07^{c}	2.91±0.14^{ab}	61.20±0.00^{a}
'Zalataja grusha'	24.30±0.42^{c}	10.12±0.39^{a}	0.86±0.12^{a}	39.50±0.28^{bc}
'Arina'	19.10±0.00^{a}	11.50±0.28^{ab}	1.31±0.04^{a}	40.45±0.64^{c}
'Chudo judo'	25.00±0.28^{c}	21.95±0.07^{c}	11.80±0.42^{e}	38.30±0.14^{b}
'Kroshka'	26.50±0.00^{e}	24.65±1.06^{f}	14.35±0.21^{f}	26.45±0.49^{e}
		C. pepo		
'Herakles'	26.50±0.42^{e}	23.50±0.28^{ef}	12.25±0.64^{e}	51.05±0.49^{f}
'Golosemiannaja'	19.10±0.56^{a}	16.00±0.56^{g}	5.66±0.91^{c}	60.85±0.07^{ad}
'Miranda'	16.40±0.00^{b}	12.60±0.14^{bc}	4.29±0.95^{bc}	62.50±0.00^{a}
'Danaja'	18.90±0.14^{a}	18.20±0.14^{d}	8.45±0.42^{d}	65.85±0.49^{g}
'Olga'	21.80±0.42^{d}	19.35±0.07^{d}	7.84±0.39^{d}	59.20±0.70^{d}

*Amount: NDF - neutral dietary fiber; ADF - acid dietary fiber; ADL - acid detergent lignin; WSC -water-soluble carbohydrates
**Means in column with different letters are significantly different ($p < 0.05$) for the different cultivars

food production with high content of dietary fiber (DF). The fiber content in pumpkin fruits flour depends on the cultivar. The highest insoluble fiber content (NDF, ADF, ADL) was characteristic to flour obtained from *C. maxima* 'Kroshka' fruits (26.50%, 24.65% and 14.35% DM, respectively), so the flour of this pumpkin cultivar is the most suitable for supplementation of food with dietary fiber.

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