Prospects of pea grain coats use for obtaining dietary fibers

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Abstract. The study of pea grain coats was carried out according to the following parameters: mass of 1000 seeds, coats content and thickness. Studying chemical composition of modern pea varieties seed coats it was revealed that they contain a small amount of protein, starch, lipids and cinder. The predominant component is dietary fibers and cellulose in particular. The study of the biological value of pea seed coats showed the presence of the basic macro- and microelements, as well as vitamin B_1. The technique of getting of insoluble dietary fibers from pea coats was developed. The obtained fiber had a peculiar taste, smell and color, moisture was 9,35 %, acidity was 2,0 degrees. Increased moisture adhesive and fat emulsifying capacity of dietary fibers was detected.

[Shelepina N.V., Polynkova N.E., Klimova D.O. **Prospects of pea grain coats use for obtaining dietary fibers.** *Life Sci J* 2014;11(12s):802-805] (ISSN:1097-8135). http://www.lifesciencesite.com. 173

Keywords: pea, grain, coat, dietary fiber

Introduction

Pea grain quality as a raw material for various industries is characterized not only by the chemical composition determining the nutritional and feeding value. The indicators affecting the product ield, and the ability to maximize the extraction of the most valuable grain nutrients are also of great value. Pea seeds are characterized by high protein (19-29 %), lysine, cellulose and low fat content [1].

During the pea processing quite a lot of waste that are not used in food industry, are accumulated. However, they are a source for nutrients. The seed coats can be referred to them. According to chemical composition analysis they contain dietary fibers [2].

Dietary fibersare a complex of substances forming the plant cell wall and consisting of cellulose, hemicellulose, lignin, and pectin and some other water-soluble polysaccharides [3]. Dietary fibres are one of the most important components which are a part of functional foodstuffs [4].

In 2009 Codex Alimentarius Commission accepted the definition of dietary fibres which divided them into 3 categories: “present in meal as they are consumed”; “obtained from food raw materials by physical, enzymatic or chemical way” and “synthesized carbohydrate polymers” [5].

According to the classification of dietary fibers they are divided into homogeneous ones formed from polymers of one kind (cellulose, lignin, pectin) and heterogeneous, i.e. formed from polymers of two or more kinds (cellulose, lignin, hemicelluloses and others). According to physicochemical properties of dietary fibers they are divided into water-soluble (pectin, gums, dextrins) and insoluble (cellulose, lignin, hemicelluloses) [6].

Pectin, gums, dextrins refer to soluble dietary fibers. Pectins are a part of the cell walls and intercellular structures and are formed of galacturonan, arabinans, galactan. Chemical composition and pectin substances content are different in different plant species. Thus, their content in the barley seed may reach 2,0%, in rice – 1,0%, in wheat – 0,5 %, in rye – 0,7 %, in soybean – 1,11 %, in pea – 0,25 %.

Cellulose as insoluble dietary fiber is the most common one in food products. It is the most wide-spread polysaccharide consisting of the remains of D-glucose. The seeds of filmy cereals (oats, rice, millet) contain 10-15 % of cellulose, the seeds of leguminous crops – 3-5 %, the roots and tubers of potatoes – about 1 %.Cellulose stimulates bowel activity in the digestive system, normalizes the activity of the bowel microflora, adsorbs sterols and promotes the release of cholesterol [7].

Hemicellulose is a group of plant polysaccharides, having galactose, mannose, xylose, arabinose and glucose in their structure. It is in all organs and tissues of plants and forms from 5 to 48 % of dry solid matter. In the biomass of herbaceous plants its quantity is 16-25 %; in wheat bran – 26 %; in the pulp of sugar beet – 37 %; in wheat – 8-14 %; in cobs – 40 %. The substance basically prevails in grain products and in small amounts it is contained in vegetables and fruits [2].

Lignin is a water-insoluble compound which is not digested in the bowel. Fruits and vegetables, cereals and legumes are rich in lignin. Lignin content of the grain processing by-products, stems, cereals leaves, and vegetables increases with the hemicellulose increase. In the dietary fibers lignin is used as drugs for various gastrointestinal diseases treatment. Lignin-based drugs have sorption properties, hold heavy metal sions, bacteria, toxins on their surface, and egest them from the human and animal organisms [2].

Dietary fibres are known to reduce the risk of development ischemic heart disease [8]. Consumption of grain fibres reduces the risk of development of diabetes of the 2^{nd} type [9].

Different methods are used to excrete the fiber from the plant cells. They are based on the removal of low molecular substances from the shredded plant cells: glycosides, alkaloids, sugars, minerals and starch extraction. Depending on the type of raw material dietary fibers are extracted with water under heating (vegetables and fruits pressing),with dilute solutions of mineral acids (sulfuric, phosphoric, chloride), with salts of sulfurous acid, with peroxides (grain coats, films, stems of cereals), with alkalis (vegetable processing waste, bran, shorts) and by processing of amylolytic enzymes (starch raw materials) [6].

Material and method

The object of research was the seed coats, excreted from seeds of modern pea varieties Temp (leaf with smooth seeds), Amir (leafless with wrinkled seeds) and selection line LU-153-06 (lupinoid with smooth seeds) produced by the All-Russia Research Institute of Legumes and Groat Crops, Orel, Russia.

Determining the mass of 1000 seeds was carried out in accordance with State Branch Standard (SBS) 10842-89, filminess was done in accordance with SBS 10843-76. Pea coats thickness was determined with the help of a micrometer.

The research of the chemical composition and content of toxic elements in pea coats was carried out in accordance with the current SBS. Hemicellulose content was determined by heating the sample with a solution of hydrochloric acid and by obtaining a filtrate to define the content of sucrose.

Lignin determination is based on hydrolysis of cellulose hydrochloric acid and the mass determination of the lignin remains.

Determination of aflatoxin B_1 content was carried out with the help of system Ridascreen Aflatoxin system B_1 with the use of equipment Elx 800 Universal Microplate Reader 30/15.

Pesticide content was determined by high performance liquid chromatography (HPLC) using an autosampler Agillent Technologies 7693 .

To measure the activity of radionuclides scintillation gamma and betaspektrometer with the software «Progress» was used.

The mass fraction of moisture in dietary fiber was determined according to SBS 13586.5-93; acidity - according to SBS 10844-74; functional and technological properties – according to the method of V.V. Kolpakova and A.P. Nechayev [10]. Fractional composition of dietary fiber was determined on laboratory sieves with a hole diameter of 0.1-1.2 mm.

Statistical data manipulation with the use of Microsoft Excel 2010 gave an opportunity to define exact mean quality value of the research objects.

Results and discussion

It was found out that the pea coats content ranges from 7,72-12,51 %. And types of pea with wrinkled seeds have a higher filminess compared with the ones with smooth grains. Coat content is positively correlated with the thickness and negatively with the mass of 1000 seeds.

It was found out that the mass of 1000 seeds of the analyzed varieties of pea ranged from 219,9 to 287,3 g. The smooth pea variety Temp had the maximum value of this index (287,3 g). The selection line LU-153-06 had the minimum mass of 1000 seeds (219,9 g). The average coat content in the pea experimental samples was 8,28 %. Wrinkled Amior variety had the highest values of this index (10,35 %), the variety Temp with smooth grain had the lowest value (6,73 %). The coat thickness of the investigated varieties ranged from 0,148 to 0,166 microns.

Pea seed coats humidity ranged from 7,60 (Amior) to 8,12 % (LU-153-06). The research of the chemical composition of coats showed that the average protein content in these varieties was 4,07 %, lipids – 1,35 %, starch – 2,30 %, cinder – 3,04 % (Table 1).

Table 1. The chemical composition research of pea coats

Varieties / lines	Content, % to absolute dry material			
	protein	lipids	starch	cinder
Amior	3,45±0,00	1,68±0,02	2,35±0,01	2,40±0,13
Temp	4,33±0,00	1,34±0,01	2,08±0,01	3,27±0,20
LU-153-06	4,44±0,00	1,04±0,01	2,47±0,01	3,44±0,20

The highest protein percentage was detected in the seed coats of the line LU-153-06, the lowest – in the variety of Amior. Coats of the selection line LU-153-06 were marked out according to starch and cinder content. The greatest percentage of lipids was found in the seed coats in the variety Amior.

Dietary fibers of pea seed coats were presented by cellulose, hemicellulose, lignin and pectins. Cellulose was predominant polysaccharide of the pea coats, its content was 54,09 (LU-153-06) and 57,48 % (Amior). The amount of hemicellulose in the studied varieties ranged from 7,20 (LU-153-06) to

10,45 % (Amior). Lignin in the seed coats was presented in the amount of 5,30 (LU-153-06)-5,60 % (Amior). Average pectin content in varieties was 2,89 %, with a variation from 2,81 (Amior) to 3,01 % (LU-153-06).

Pectins of the pea seed coats were presented by two fractions: the water-soluble and water-insoluble. Water-insoluble protopectin formed the largest part in the composition of this group at average 85,54 %. Also it was found out that the proportion of the soluble form of pectins in the pea grain coats with smooth seeds was higher than in the wrinkled seed coats type. So, in the Temp pea coats and the line LU-153-06 it was respectively 15,73 and 16,61 % from the total amount of pectins, in coats of Amior it was 11,03 %.

The mineral composition study of pea seed coats showed that they contain small amounts of macronutrients such as potassium, calcium, sodium and phosphorus. The iron content ranged from 0,94 (Temp) to 1,09 mg/100 g (Amior). Microelements such as copper, magnesium and zinc were also found out in the composition of pea grain coats, an average the amount of which was 0,073; 0,050 and 0,010 mg/100 g, respectively.

In addition, we found that vitamin B_1 was in the pea grain coats, the contents of which ranged from 312,0 (Amior) to 450,0 mg/100 g (Temp).

It was found out that the content of toxic elements such as lead, arsenic and cadmium in pea grain coats was considerably lower than the acceptable level. There wasn't mercury in the analyzed varieties. There were not chloro- and organomercury pesticides and radionuclides in the seed coats in studied pea varieties (Table 2).

Table 2. Indicators of grain coats safety research

Safety indicators	Acceptable level, mg/kg, not more	Varieties / lines		
		Amior	Temp	LU-153-06
Toxic elements, mg/kg: lead	0,5	0,3270±0,03	0,2039±0,01	0,1463±0,01
arsenic	0,3	0,0468±0,02	0,0353±0,02	0,0501±0,04
cadmium	0,1	0,0460±0,03	0,0791±0,01	0,0613±0,01
mercury	0,02	not found	not found	not found
Mycotoxins, mg/kg: Aflatoxin B_1	0,005	0,0035±0,01	0,0035±0,01	0,0020±0,00

We have developed a method of getting insoluble dietary fibers from the pea grain coats of the Temp, Amior varieties and selection line LU-153-06.

Pea grain coats reduced to the size of not more than 1,0 mm were processed by 1 % sulfuric acid solution at the temperature of 95ºC for 60 minutes at 1:15 liquor ratio. The obtained dietary fibers were washed out with distilled water to reach a neutral reaction. Then, raw materials were processed with 3 % hydrogen peroxide solution for 24 hours for their lightening.

Then the dietary fibers were washed out with distilled water and dried under the temperature of at a temperature of 30-35ºC in thermostat. Dietary fibers were packed in paper bags with polyethylene liners and stored at a temperature of from 3 to 23ºC and a relative humidity of 75-80 %. Dietary fiber quality indicators are presented in table 3.

Table 3. Quality indicators of dietary fibers from grain pea coats

Indicators	Characteristics		
	Temp	LU-153-06	Amior
Taste	inherent to the product, without extraneous taste, not acid, not bitter	inherent to the product, without extraneous taste	inherent to the product, without extraneous taste
Flavour	inherent to the product, without extraneous flavour, not fusty, not musty	inherent to the product, without extraneous flavour, not fusty, not musty	inherent to the product, without extraneous flavour, not fusty, not musty
Colour	cream	light yellow	light green
Moisture mass level, %	9,35±0,13	10,28±0,10	9,15±0,25
Acidity, deg.	2,00±0,10	2,00±0,15	2,00±0,10
Fraction size, mm, not more	1,00	1,00	1,00
Protein content, %	2,41±0,00	2,30±0,00	2,20±0,00
Hemicellulose, %	7,47±0,33	6,39±0,55	8,16±0,48
Cellulose, %	83,54±1,16	84,55±1,54	83,26±1,33
Lignin, %	8,97±0,65	9,04±0,36	8,56±0,45
Total content of dietary fibers, %	99,98	99,98	99,98

We have found that the obtained dietary fibers have no extraneous taste and smell. Their color depends on the color of pea grain coats. Dietary fiber acidity is 2,0 deg. In our method of producing dietary fibers protein substances are extracted from the pea grain coats by more than 40 %, and their dietary fiber content ranges from 2,20 % (Amior) to 2,41 % (Temp).

The obtained dietary fibers are presented by insoluble fraction consisting of cellulose at average 83,78 %, hemicellulose – 7,34 % and lignin– 8,85 %. The largest amount of cellulose and lignin and the smallest amount of hemicellulose are in the LU-153-06 line. The largest amount of hemicellulose is in the dietary fibers of Amior variety – 8,16 %.

Also, we studied the functional and technological properties of dietary fibers – solubility, water retention, fat binding and fat emulsifying capacity (Table 4).

It was found out that dietary fiber solubility at average was 54,84, Temp dietary fibers having the largest solubility level – 60,62 %. Dietary fibers from the coats of the selection line LU-153-06 linked the greatest amount of moisture, the smallest amount of moisture was linked by the Temp variety coats. Fat binding capacity of analyzed varieties at average was 54,00 %. Dietary fibers of LU-153-06 had the largest fat emulsifying capacity.

Table 4. Functional and technological properties of dietary fibers

Indicators	Varieties / lines		
	Amior	Temp	LU-153-06
Solubility, %	50,62±0,00	60,62±2,50	53,30±2,50
Moisture adhesive capacity, %	241,83±0,85	224,20±0,10	278,34±1,33
Fat binding capacity, %	54,54±2,00	54,11±0,71	53,05±0,67
Fat emulsifying capacity, %	125,33±0,05	123,70±0,65	157,24±0,55

In determining the fractional composition of dietary fibers it was found out that the largest part was the fractions of 0,7 mkm size (31,5-43,0 %). The smallest part was the fractions of 0,5 and 1,0 mkm size (3,5-4,0 and 2,7-4,2) from the total fiber mass.

Conclusions

Thus, it was found out that the composition of the grain coats of modern pea varieties has a small amount of protein, starch, cinder and lipids, and besides macro-, microelements and vitamin B_1. The predominant component is dietary fibers and, in particular, cellulose. The method to separate insoluble dietary fibers from pea grain coats was developed. Obtained dietary fibers had higher moisture adhesive and fat emulsifying capacity. Pea grain coats are prospective materials for the production of dietary fiber, which have acceptable consumer properties and may represent a valuable raw material for the production of functional orientation goods.

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7/29/2014