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ORIGINAL PAPER

SEEDS OF OILSEED RAPE AS AN ALTERNATIVE SOURCE OF PROTEIN AND MINERALS*

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Abstract

Many components of human diet which have not received much attention before, nowadays play an important role in the prevention and treatment of the advancing civilisation diseases in the world. Particularly important in this respect is food of plant origin that contains numerous compounds with health-promoting properties. Current research indicates possible use of oilseed rape seeds in the food industry, e.g. for the production of sprouts, protein concentrates, and preparations classified as health food, rich in minerals, fibre, and compounds with anti-neoplastic properties. The present study was conducted to evaluate seeds of fifteen oilseed winter rape cultivars (experimental cultivations at the COBORU Cultivar Testing Research Station in Głębokie) in terms of their content of protein and minerals (Na, K, Ca, Mg, Zn, Fe, Mn and Cu). The analyses revealed that the seeds of the analysed winter rape cultivars contained protein in amounts of about 177 to 233 g kg^{-1} DM, and nutritionally significant levels of minerals (mg kg^{-1} DM): Na – 43.7, K – 7052, Ca – 765, Mg – 2761, Zn – 33.2, Fe – 69.0, Mn – 50.6, Cu – 3.9. Compared to raw materials traditionally used so far, such as seeds of legumes – soybean, pea, lupine, broad bean, as well as seeds of certain cereal species – wheat, triticale, rye, oat or barley, the values of the content of the analysed compounds in seeds of oilseed rape suggest that oilseed rape seeds can be a valuable source of protein and minerals for various branches of the food processing industry.

Keywords: seeds of oilseed rape, alternative source of protein and minerals, functional food.

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INTRODUCTION

After years of fascination with food products as well as pharmaceuticals, the composition of which was dominated by synthetic chemical substances which do not occur in nature, we now observe a reverse trend, oriented at the use of natural plant materials, among which special attention is paid to seeds of plants (Podleśny 2005, Jerzak 2012, Majchrzycki et al. 2012, Boczar 2018). The intensive development of chemistry has led to the application of countless chemical compounds in many branches of industry, but a side-effect of the chemisation of our environment is the spread of diseases occurring in the entire human population, and often leading to thedeterioration of the comfort of living or even death. Constant research in this area indicates significant values of natural raw materials, compared to products containing synthetic components (Chan et al. 2011, Pedersen et al. 2013). Due to the increasing pace of life, combined with stress, lack of exercise, excessive use of drugs (nicotine, caffeine etc.) and inadequate and ill-balanced diet, it is highly important to be aware of the need to supplement one's diet with essential nutrients, i.e. minerals, vitamins or biologically active substances. In this aspect, the consumer's interest is drawn to health food and dietary supplements, which generate a dynamic growth in this branch of production (Hashmi et al. 2010, Szwejkowska 2014). Studies conducted in search for new plant materials also take into account the possibility of using materials that are already known, such as seeds of oilseed rape, which so far have been treated solely as oil-bearing raw material or a feed admixture (Acikgoz 2014, Egorova, Lenkova, 2015, Kapusta 2015, Beyzi 2019, Tomaszewska et al. 2019). Current studies have demonstrated methods for the application of oilseed rape in food production, for example in the production of sprouts, protein concentrates, preparations classified as health food, rich in minerals, dietary fibre and compounds with anti-neoplastic properties, and also as an additive to bakery products, pastas, beverages, desserts, or protein bars (Kozłowska et al. 2002, Ostrowska et al. 2018). Characteristics of rapeseed include the presence of high-quality protein with a well-balanced amino acid composition, as well as a favourable content of minerals. These features enable us to use oilseed rape seeds as an alternative raw material to traditionally used legume seeds – soybean, pea, lupine, broad bean, or cereal species – wheat, triticale, rye, oat or barley (Banaszkiewicz 2008, Boros et al. 2015, Szczepaniak et al. 2017). The objective of this study was to evaluate seeds of fifteen oilseed rape cultivars in terms of their content of protein and minerals.

MATERIALS AND METHODS

Seeds of oilseed rape cultivars originated from experimental cultivations conducted at the COBORU Cultivar Testing Research Station in Głębokie. Analyses were conducted on 15 cultivars of oilseed rape – Contact, Lirajer, Kana, Bazyl, Batory, Bojan, Kronos F_1, Capio, Californium, Mazur F_{12}, Wotan, Rasmus, Buffalo F_1, Bosman and Kaszub F_{12}. Samples for the analyses originated from the years 2009-2011. Seeds of oilseed rape cultivars were dried in a shaded and airy place and then ground to powder.

The content of crude protein was determined as 6.25-times the nitrogen content of the sample. Nitrogen was determined by the Kjeldahl-method (PN-EN ISO 5983-1:2006) using Kjeltec 2300 apparatus (FOSS, Sweden) after prior mineralisation with H_2SO_4 in a Tecator Digestor Auto 20 system (FOSS, Sweden).

The concentration of minerals, i.e. Na, K, Ca, Mg, Zn, Fe, Mn and Cu, was determined by the AAS (atomic absorption spectroscopy) method using a spectrometer SpectrAA 280 FS with an autosampler SPS 3 (Varian, Australia), which was equipped with a deuterium lamp, hollow cathode lamp for each element, and an air-acetylene burner. In order to avoid sample ionisation during determinations of potassium, a Schinkel buffer solution (a mixture containing 10 g dm^{-3} cesium chloride and 100 g dm^{-3} lanthanum chloride) was used. The content of minerals in the analysed oilseed rape cultivars was determined after prior microwave mineralisation. Approximately 0.5 g of oilseed rape seed sample was placed in a Teflon vessel. 10 cm^3 of 65% HNO_3 (suprapur grade) supplied by Merck, Germany, was added to the vessel and the sealed vessel was put into a microwave mineraliser MARS Express (CEM, USA). Microwave mineralisation was performed stepwise at 400 W and 363 K, at 800 W and 393 K, at 1600 W and 483 K. The cooled digestion solution was then diluted to 50 cm^3 using high purity deionised water.

All certified, single-element standard solutions used to prepare a calibration curve (1000 mg dm^{-3}) were of highest purity grade (99.999%) and were supplied by Ultra Scientific. The calibration standards for AAS analysis were prepared by dilution in high purity deionised water. The validation parameters of analytical procedures are presented in Table 1.

Data were analyzed by an analysis of variance (Duncan's test) at a 5% significance level using the SAS statistical system (SAS Vers. 9.1, SAS Inst., Cary, N.C., USA.).

Table 1

Validation parameters of the analytical procedure for determination of protein and minerals

Validation parameters	Protein	Minerals							
		Na	K	Ca	Mg	Zn	Fe	Mn	Cu
LOD (mg kg^{-1})	400	20	20	28	18	0.4	4.3	1.1	1.3
LOQ (mg kg^{-1})	800	40	40	56	36	0.9	8.6	2.2	2.2
Linearity	-	1	1	1	1	1	1	1	1
Repeatability (%)	0.72	2.4	4.6	7.0	14.0	4.8	8.6	9.4	2.3
Reproducibility (%)	0.72	3.4	4.9	7.0	13.9	5.1	8.6	9.2	2.3
Recovery (%)	101	75	90	99	99	117	117	119	121
Expanded uncertainty (%)	8	50	28	15	28	30	39	43	41

RESULTS AND DISSCUSION

The content of protein in the analysed oilseed rape cultivars is presented in Table 2. On the basis of the analyses performed, it was demonstrated that the average content of protein in the analysed material was 206.1 g kg^{-1} DM – ranging from 176.7 g kg^{-1} to 232.7 g kg^{-1}, which is a value comparable to the content of this nutrient in raw materials conventionally used to date. In addition, variation in the protein content was observed among the studied varieties in particular years of cultivation, with the highest protein content determined in 2011 (Table 2). Research results presented in publications by Biel and Maciorowski (2012), Boros et al. (2015) and Kotue et al. (2018) indicate that the average content of protein in seeds of cereal plants was approximately 130 g kg^{-1} - 160 g kg^{-1} in wheat grain and 110 g kg^{-1} in rye kernels, while in seeds of legumes its content was as follows: beans – 230 g kg^{-1}, pea – 207 g kg^{-1}, narrow leaf lupine – 320 g kg^{-1}, broad bean – 298 g kg^{-1}, and soybean – 283 g kg^{-1}. High competitive advantage of seeds of oilseed rape over cereal grain in terms of the protein content is also supported by results of experiments conducted on oat and wheat. Selected literature data indicate that the average content of proteins in these plant materials from 114 to 165 g kg^{-1} for oat and from 119 to 128 g kg^{-1} for wheat (Gibiński et al. 2005, Jurga 2011, List 2015), thus being lower than the value obtained for seeds of oilseed rape. Similar results related to seeds of legumes are presented by Jerzak et al. (2012), who reported the average content of protein at 220 g kg^{-1} in peas, 340 g kg^{-1} in broad bean, 420 g kg^{-1} in lupine, and 430 g kg^{-1} in soybean meal. It is also worth noting studies on the content of protein in plants from the gourd family, e.g. in seeds of a melon, where the average protein content assayed was 306 g kg^{-1} (Jacob et al. 2015). The classification of oilseed rape seeds into the group of high-protein plant materials is additionally justified by the study of Mattila et al. (2018), who estimated the nutritive value of protein-rich plant products and demonstrated

Table 2

Protein content in seeds of the analysed oilseed rape cultivars

Variety	Content (g kg^{-1} DM)			
	2009	2010	2011	Mean
Contact	201.0	221.5	231.6	218.0*a*
Lirajer	176.7	205.2	230.7	204.2*a*
Kana	191.0	222.4	232.7	215.4*a*
Bazyl	199.2	221.8	229.4	216.8*a*
Batory	177.8	205.9	222.1	201.9*a*
Capio	180.7	224.6	227.7	211.0*a*
Bojan	194.8	211.0	220.9	208.9*a*
Californium	181.9	230.5	227.9	213.4*a*
Mazur F_{12}	184.6	212.6	227.8	208.3*a*
Wotan	188.0	203.1	223.9	205.0*a*
Rasmus	193.1	192.8	224.6	203.5*a*
Bufallo F_1	183.0	195.3	222.3	200.2*a*
Bosman	186.0	199.1	211.5	198.9*a*
Kronos F_1	180.7	188.2	218.0	195.6*a*
Kaszub F_{12}	185.4	208.9	215.6	203.3*a*
Range	176.7-201.0	188.2-230.5	211.5-232.7	176.7-232.7
Mean	184.9	208.9	224.4	207.0

Values designated with the same letters (*a*, *b*, *c* …) within a column do not significantly differ at 5% error (Duncan's test).

higher levels of protein content in broad bean (312 g kg^{-1}), lupine (305 g kg^{-1}) and oilseed rape (357 g kg^{-1}), than in buckwheat (148 g kg^{-1}) and quinoa (130 g kg^{-1}). The results obtained in the present study are also consistent with earlier studies on seeds of oilseed rape alone, where the average protein content was 208-220 g kg^{-1} (Krasucki et al. 2001, Dziamba, Dziamba 2011, Wielebski 2011). The data presented in this article indicate that seeds of oilseed rape are not inferior in terms of protein content to seeds of beans, peas and buckwheat, and also to the commonly used grain of cereals. Somewhat higher levels of this nutrient can be found in seeds of lupine or soybean, but is should be emphasised that numerous studies report decidedly more favourable and better balanced amino acid composition of oilseed rape protein compared to soybean and lupine protein (Bell 1984, Banaszkiewicz 2008, Boczar 2018).

Table 3

The mineral content of the analysed oilseed rape cultivars (means from 2009-2011)

Variety	Minerals (mg kg^{-1} DM)							
	Na	K	Ca	Mg	Zn	Fe	Mn	Cu
Contact	40.5*a*	6882*a*	789.6*a*	3075*ab*	36.0*a*	78.9*a*	47.1*bc*	3.5*de*
Lirajer	46.7*a*	6914*a*	785.0*a*	2843*abc*	32.6*ab*	69.0*abcd*	48.1*abc*	3.3*e*
Kana	39.9*a*	6912*a*	814.0*a*	2647*abc*	32.6*ab*	77.9*ab*	46.6*bc*	3.5*de*
Bazyl	45.1*a*	7236*a*	788.5*a*	2457*bc*	34.6*a*	66.4*abcd*	42.9*c*	2.3*f*
Batory	40.4*a*	6622*a*	772.3*a*	2585*bc*	28.2*b*	64.9*bcd*	46.1*bc*	3.3*e*
Capio	46.6*a*	7352*a*	786.5*a*	2759*abc*	33.8*ab*	70.0*abcd*	54.4*ab*	3.1*e*
Bojan	46.2*a*	7807*a*	563.3*b*	2850*abc*	32.2*ab*	74.2*abc*	48.0*abc*	3.2*e*
Californium	39.9*a*	7363*a*	756.9*a*	3141*a*	35.1*a*	68.0*abcd*	53.3*ab*	4.1*cd*
Mazur F12	44.6*a*	6878*a*	754.0*a*	2983*abc*	32.1*ab*	70.4*abcd*	54.5*ab*	4.2*c*
Wotan	44.7*a*	7239*a*	801.6*a*	2697*abc*	36.6*a*	72.3*abcd*	52.6*ab*	4.3*bc*
Rasmus	43.1*a*	7188*a*	754.3*a*	2558*bc*	31.0*ab*	63.8*cd*	55.0*ab*	3.5*de*
Bufallo F1	42.9*a*	6872*a*	795.0*a*	2632*abc*	31.1*ab*	59.5*d*	57.1*a*	4.5*bc*
Bosman	47.0*a*	6632*a*	740.5*a*	2836*abc*	31.5*ab*	68.2*abcd*	56.9*a*	5.8*a*
Kronos F1	44.7*a*	6665*a*	817.1*a*	2688*abc*	34.3*ab*	60.5*d*	48.8*abc*	4.6*bc*
Kaszub F12	43.6*a*	7222*a*	756.2*a*	2670*abc*	36.2*a*	71.0*abcd*	48.2*abc*	4.9*b*
Mean	43.7	7052	765.0	2761	33.2	69.0	50.6	3.9

Values designated with the same letters (*a*, *b*, *c* …) within a column do not significantly differ at 5% error (Duncan's test).

This study also included determinations of the content of minerals in seeds of oilseed rape, and the results are collated in Table 3. The amounts of particular elements were as follows: 43.7 mg kg^{-1} DM for Na, 7052 mg kg^{-1} DM for K, 765 mg kg^{-1} DM for Ca, 2761 mg kg^{-1} DM for Mg, 33.2 mg kg^{-1} DM for Zn, 69 mg kg^{-1} DM for Fe, 50.6 mg kg^{-1} DM for Mn, and 3.9 mg kg^{-1} DM for Cu. In a comparative study by Martial et al. (2018), on the content of macroelements in products from high-protein plants, it was demonstrated that oilseed rape (rapeseed press cake) belonged to the group with the highest levels of some of those elements (Ca – 8720, K – 1320, Mg – 5440 mg kg^{-1} DM), next to buckwheat, broad bean, lupine and flax seed (Ca: 220-3100, K: 860-9400, Mg: 1500-3820 mg kg^{-1} DM). The content of trace elements was also at comparable levels in all of the analysed products. The highest content of zinc was noted in products from oilseed rape, buckwheat and broad bean, at 58.7, 76.0 and 72.0 mg kg^{-1} DM, respectively. Hemp oil was found to contain the highest level of manganese – 105 mg kg^{-1} DM, while buckwheat bran had the highest levels of copper and iron, at 64.0 and 59.0 mg kg^{-1} DM, respectively. Selected literature data show that seeds of oilseed rape are also superior to oat grain in terms of the content of potassium and manganese, which in the former reached 5300-6300 mg kg^{-1} DM and 1200-1400 mg 100 g^{-1} DM, respectively, while in our experiment, the amounts of these elements were determined at 7052 mg kg^{-1} DM and 2761 mg kg^{-1} DM, respectively. Also, the content of sodium and calcium in oat grain was comparable to the values determined in oilseed rape seeds (Szumiło, Rachoń 2006, Barczak, Nowak 2013, Witkowicz 2016). Our data for the content of minerals in oilseed rape seeds are consistent with results reported by other authors who investigated the mineral composition of seeds of this plant. According to their results, the content of K and Mg in seeds of oilseed rape was between 7028-10 800 mg kg^{-1} DM and 2790-3126 mg kg^{-1} DM, respectively, which agrees with the results obtained in this study (Table 3). In some references, the content of Zn, Fe, Mn and Cu equalled 35.7-46.4 mg kg^{-1} DM, 63.5-118.6 mg kg^{-1} DM, 36.1-40.8 mg kg^{-1} DM and 3.4-4.4 mg kg^{-1} DM, respectively, which confirms our results (Banaszkiewicz 1998, 2008, Stępień et al. 2017, Szczepaniak et al. 2017). It should be noted that in our experiment oilseed rape seeds were characterised by greater variability in the content of such microelements as Fe, Mn and Cu than in the content of macroelements. Concerning their content of minerals, oilseed rape seeds are also comparable to seeds of plants from the gourd family, which are characterised by a high content of such minerals as iron – 88.2 mg kg^{-1} DM, zinc – 78.1 mg kg^{-1} DM and manganese – 45.4 mg kg^{-1} DM, which are important in the alleviation of harmful effects of free radicals and therefore can play a significant role in the prevention of numerous diseases (Dar et al. 2017).

The growing concern about the impact of consumed food on human health and quality of life, in addition to the increasingly severe threat of civilisation diseases to the population, have stimulated a dynamic growth of a new market of functional food, adapted to the diverse needs of the contemporary consumer, expecting products that will not only satisfy the basic nutritional requirements but will be also capable of ensuring such health benefits as the prevention or at least delay of the occurrence of symptoms of chronic diseases. Among the group of bioactive components of functional food, protein and minerals are worth mentioning. They are distinguished by antioxidant properties, and they also participate in many metabolic processes enhancing the immune system of the organism. Unquestionably, the richest source of these nutrients are seeds of legumes, Brassicaceae, and oil-bearing plants (Szwejkowska 2014). They are commonly used to enrich bread with valuable nutrients, and also to supplement potential losses of nutrients caused by processing (Gambuś 2005, Kowalska, Kowalski 2018). Seeds of certain plants are used in the dairy industry for the improvement of nutritive value of products, for example yoghurt enriched with seeds of chia *Salvia hispanica* (Kibui et al. 2018). They are also popular among food producers the production of sprouts, which supply human diet with phytocompounds, attributed health-promoting properties. Thus far, seeds of certain cereals, sunflower, radish, bean or soybean have been used in the production of sprouts. Recently, there has been ongoing research on the possibility of using oilseed rape seeds for sprout production, owing to their content of glucosinolates, which can contribute to reducing the incidence of cancers and cardiac disorders (Hashmi et al. 2010). With their high content of protein and minerals, oilseed rape seeds can be also an excellent alternative to plant materials popular so far (Kozłowska et al. 2002, Irzykowska, Kononowicz 2017).

CONCLUSIONS

1. The average content of protein in seeds of the analysed oilseed rape cultivars was 206.1 g kg^{-1} DM, ranging from 176.77 to 232.7 g kg^{-1} DM, which is comparable to the content of this nutrient in protein raw materials commonly used so far.

2. Seeds of the analysed oilseed rape cultivars had nutritionally significant levels of minerals: Na: 43.7, K: 7052, Ca: 765, Mg: 2761, Zn: 33.2, Fe: 69.0, Mn: 50.6, Cu: 3.9 mg kg^{-1} DM.

3. Seeds of oilseed rape should considered as a valuable alternative source of protein and minerals for various branches of the food processing industry.

4. It is recommended to consider the possibility of using oilseed rape seeds in the production of functional food.

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