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Chemical composition of rape seed from low glucosinolate varieties grown in Poland

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ABSTRACT

Basal nutrients, fatty acids, macro–and microelements, and antinutrients: glucosinolates, tannins and phytates, were determined in 26 samples of sowing seed of 5 varieties of low glucosinolate rape obtained from local branches of Seed Company covering an area of Poland. Amino acids, carotene, and xanthophyll were assayed in pooled samples of each variety. The differences among the samples representing each variety were rather small. Crude protein content was from 19.1 to 22.7% DM, in Libravo and Bolko varieties, respectively, lysine from 6.48 to 7.30 g/16 g N, substantial intervarietal differences in erucic acid content were found; mean value was 0.99%. Aliphatic glucosinolate content ranged from 8.1 in Bolko to 15.7 μmol/g defatted matter in Ceres and was closely correlated with sulphur content. Phytic phosphorus comprised 74.8% of total P content.

KEY WORDS: low glucosinolate rape seed, amino acids, fatty acids, minerals, antinutrients

INTRODUCTION

Rape seed production in Poland amounted to 1.043 million tons in 1991, and dropped by about 27% in 1992 because of unfavourable climatic and economical conditions. Low glucosinolate (LG) rape accounts for about 98% of total rape production in Poland (Krzymański, 1993). The main varieties grown are: Bolko, Ceres, Liporta, Libravo and Mar. According to Polish Standard (1990) glucosinolate content in LG rape seeds should not exceed 25 micromoles per gram of defatted seed.

Due to an almost total elimination of glucosinolates and erucic acid, the full fat rape seed may be considered as a dietary component for poultry and pigs. However, the level of inclusion of seeds is limited by the residual glucosinolates, tannins, phytate and fibre which decrease its nutritive value.

An assay of chemical composition of LG rape seed grown in North-Eastern Poland by Matyka et al. (1992) did not include the intervarietal comparison. It seemed therefore important to take into account possible changes in seed

composition associated with development of new varieties of LG rape seed and to repeat the study on the chemical composition of LG rape seed grown in Poland.

MATERIAL AND METHODS

Twenty-six samples of sowing seed of LG rape obtained from regional stores of Seed Company from all of Poland, were represented 5 varieties: Bolko (9 samples), Ceres (7), Liporta (4), Libravo (3), Mar (3). The number of samples per variety was related to the proportion of the variety in total crop of rape seed. Bolko, Ceres, Liporta and Libravo were obtained from 1991 harvest, Mar from 1992.

The seeds were finely ground for analysis, the fat-free samples were prepared for glucosinolate, phytate and tannin determinations.

Basal nutrients were assayed using Weende methods with modifications presented in Poland Standards.

For amino acid (AA) analyses, composite samples were prepared by pooling 5 g of each sample within the variety. AA concentration was measured using a Beckmann Model 119 CL Liquid Chromatograph with an ion-exchange system after 20 h hydrolysis in 6 N HCl at 110^{0}C. Methionine and cystine were defermined after oxidation according to Moore et al. (1958) and tryptophan after alkaline hydrolysis according to Miller (1967).

After estrification of FA with a boron trifluoride catalyst in methanol (Matyka, 1976), the fatty acid (FA) composition of lipid fraction was determined by gas chromatography using Hewlett-Packard 8750 Serie II chromatograph.

For macro– and microelement determination, samples were ashed at 550^{0}C for about 20 h. The following detection methods were used: a flame atomic absorption spectrometry using the Unicam Model PU 100X spectrometr for calcium (Ca), magnesium (Mg), iron (Fe), zinc (Zn), manganese (Mn), copper (Cu), cobalt (Co), chromium (Cr) and nickel(Ni); the flame emission spectrometry using the above mentioned apparatus for sodium (Na) and potassium (K); colorimetric molybdate method (Fiske and Subbarow, 1925) for phosphorus (P); colorimetric thiocyanate method (Czuba et al., 1970) for molybdenum (Mo) and the Cunningham method with modification of Korol and Boluk (1979) for sulphur (S).

Carotene and xanthophyll were estimated according to La Roche method (Keller, 1988) in composite samples prepared as for AA analysis.

The isothiocyanate level was estimated by gas chromatography (Polish Standard, 1986) and recalculated as glucosinolates. Tannin content in defatted samples was estimated by a spectrophotometric method (Tyczkowska, 1977).

Phytates were extracted and phytic acid was precipitated with ferric chloride and analysed for P after digestion (Oberleas, 1971).

The data was subjested to analysis of variance.

RESULTS AND DISCUSSION

With the exception of crude protein and nitrogen-free extractives, the basal nutrient contents did not differ among five varieties of LG rape (Table 1). The CP means ranged from 19.1 to 22.7% DM for Libravo and Bolko varieties,

TABLE 1

Chemical and amino acid composition, % of dry matter

Indices	Variety					Total	
	Bolko	Ceres	Liporta	Libravo	Mar	Mean	SD
Chemical composition							
Dry matter	93.7	94.3	94.1	93.3	93.6	93.8	0.63
crude protein (Nx6.25)	22.7a	20.2b	21.6ab	19.1b	21.8ab	21.6	1.68
ether extract	46.7	47.2	47.3	47.5	45.9	46.9	1.25
crude fibre	6.65	7.27	7.12	6.75	7.05	6.96	0.67
ash	4.16	4.06	4.05	4.42	4.50	4.14	0.21
nitrogen free extractives	19.8b	21.3a	19.9ab	22.3a	20.7ab	20.4	1.23
Amino acid							
aspartic acid	1.76	1.57	1.63	1.54	1.69	1.64	0.09
threonine	1.01	0.95	0.97	0.89	0.97	0.96	0.04
serine	0.99	0.95	0.99	0.85	0.94	0.94	0.06
glutamic acid	4.28	3.82	3.96	3.50	4.11	3.93	0.29
glycine	1.21	1.06	1.11	1.03	1.17	1.11	0.07
alanine	1.04	0.94	0.98	0.91	1.03	0.98	0.06
cystine	0.58	0.54	0.58	0.48	0.60	0.56	0.05
valine	1.19	0.96	0.97	1.07	1.17	1.07	0.11
methionine	0.44	0.43	0.45	0.42	0.48	0.44	0.01
isoleucine	0.91	0.72	0.76	0.79	0.89	0.82	0.08
leucine	1.62	1.40	1.47	1.34	1.56	1.48	0.11
tyrosine	0.60	0.55	0.56	0.53	0.57	0.56	0.03
phenylalanine	0.89	0.77	0.82	0.77	0.87	0.83	0.05
lysine	1.57	1.39	1.44	1.42	1.56	1.48	0.09
histidine	0.67	0.61	0.63	0.58	0.67	0.63	0.04
arginine	1.56	1.33	1.39	1.28	1.50	1.41	0.12
tryptophan	0.24	0.24	0.24	0.20	0.24	0.23	0.02

values in the same line followed by different letters are significantly different ($P < 0.05$)

respectively ($P \leqslant 0.05$). Similar high protein content (23.3% DM) in LG rape seed produced in North-Eastern Poland (mainly var. Bolko) was found by Matyka et al. (1992).

The Polish LG rape seed, except var. Bolko, had slightly lower CP than the Canadian rape of Canola type (Nwokolo and Sim, 1989; Sibbald, 1986). The contents of ether extract, crude fibre and ash in Polish rape seed were in agreement with Canadian data, except for lower fibre content than 13.5% in Canola seed found by Nwokolo and Sim (1989) but this result probably refers to defatted sample.

Differences in AA concentration in seeds (% DM) were associated with variation in crude protein values (Table 1). The highest levels of AA were found in Bolko and the lowest in Libravo but when expressed as g/16 g N the levels of most essential amino acids were the highest in Libravo. The lysine content was in the range from 1.39 to 1.57% DM and from 6.48 to 7.30 g/16 g N (Table 2). Lower values for lysine are given in INRA Tables (1.21% and 5.59%; Raw Material Compendium, 1992). Bell and Keith (1991) noted 5.96% of lysine in rape seed protein.

The fatty acid composition of seeds (Table 3) was rather uniform, but some differences, especially in palmitic, oleic, eicosenoic and erucic acid content were

TABLE 2

Amino acid content, g/16 g N

Amino acid	Variety					Total	
	Bolko	Ceres	Liporta	Libravo	Mar	Mean	SD
aspartic acid	7.56	7.56	7.30	7.88	7.56	7.57	0.42
threonine	4.32	4.57	4.38	4.57	4.35	4.44	0.19
serine	4.25	4.59	4.44	4.34	4.21	4.38	0.28
glutamic acid	18.34	18.41	17.79	17.96	18.35	18.17	1.38
glycine	5.17	5.12	4.97	5.25	5.23	5.15	0.33
alanine	4.45	4.51	4.39	4.68	4.59	4.52	0.28
cystine	2.50	2.62	2.60	2.43	2.70	2.56	0.24
valine	5.11	4.63	4.38	5.52	5.23	4.97	0.52
methionine	1.90	2.07	2.00	2.15	2.14	2.05	0.05
isoleucine	3.91	3.48	3.39	4.05	3.98	3.76	0.38
leucine	6.92	6.75	6.64	6.89	6.99	6.84	0.52
tyrosine	2.58	2.64	2.55	2.71	2.55	2.61	0.14
phenylalanine	3.81	3.72	3.66	3.94	3.89	3.80	0.24
lysine	6.76	6.71	6.48	7.30	7.00	6.85	0.43
histidine	2.89	2.94	2.82	2.98	2.98	2.92	0.19
arginine	6.70	6.40	6.28	6.57	6.68	6.52	0.57
tryptophan	1.02	1.17	1.09	1.01	1.08	1.07	0.10

TABLE 3

Fatty acids content, % of total fatty acids

Fatty acids	Variety					Total	
	Bolko	Ceres	Liporta	Libravo	Mar	Mean	SD
C 14:0 – myristic	0.12	0.10	0.09	0.10	0.10	0.10	0.02
C 16:0 – palmitic	6.79a	5.84b	5.13c	6.55ab	6.18ab	6.16	0.73
C 16:0 – palmitoleic	0.65	0.60	0.49	0.54	0.57	0.60	0.09
C 18:0 – stearic	1.32	1.12	1.10	1.35	1.51	1.23	0.21
C 18:1 – oleic	54.4b	55.3b	56.8a	56.0ab	50.9c	55.1	2.08
C 18:2 – linoleic	20.6	20.8	20.2	21.0	18.9	20.5	0.74
C 18:3 – linolenic	11.7	10.5	11.9	10.6	10.8	11.3	0.79
C 20:0 – eicosenoic	0.92	0.83	0.86	1.04	0.93	0.89	0.07
C 20:1 – eicosenoic	1.61	1.83	1.63	1.52	3.36	1.75	0.63
C 22:0 – behenic	0.46	0.41	0.35	0.33	0.39	0.42	0.13
C 22:1 – erucic	0.54	1.79	0.76	0.37	1.50	0.99	0.36
Others	0.78	0.84	0.64	0.55	0.75	0.76	0.14
PUFA [1]	32.3	31.4	32.1	31.6	29.8	31.8	0.86

[1] polyunsaturated fatty acids, linoleic and linolenic

values in the same line followed by different letters are significantly different ($P<0.05$)

noted. Sum of polyunsaturated fatty acids (PUFA), linoleic and linolenic, ranged from 29.8% (Mar) to 32.3% (Bolko). The 1:2 ratio of linolenic to linoleic acid was high as compared with the range from 1:6 to 1:3, recommended for oil used for nutritional purposes (Krzymański, 1993). The average erucic acid content amounted to 0.99% (similar values were reported by Drozdowski et al. (1990) and Matyka et al. (1992)), however substantial intervarietal differences were found in recent study.

Macro- and microelement contents are shown in Table 4. Ca and P contents ranged from 3.21 to 3.84 g/kg DM and from 7.25 to 7.70 g/kg DM with the means of 3.38 and 7.35 g/kg DM, respectively. S content ranged from 4.43 to 5.41 with the mean 5.00 g/kg DM. Other macroelements showed similar range of values. Levels of Ca (3.7 g/kg DM), Mg (3.2 g/kg DM), Na (0.1 g/kg DM) and Mn (36 g/kg DM) reported by Nwokolo and Sim (1989) in full fat Canola seed were similar to the here obtained but those of Fe (216 mg/kg DM) and Cu (6.5 mg/kg DM) were about twice the value found in Polish samples.

The mean content of carotene was 1.6 and of xanthophyll 21.0 mg/kg DM (Table 5). The highest levels of these compounds were found in seeds of var. Mar. Similar data concerning the xanthophyll content in Canola seed (19.2 mg/kg) were reported by Blair and March (1989).

TABLE 4

Mineral content, g or mg per kg dry matter

Elements	Variety					Total	
	Bolko	Ceres	Liporta	Libravo	Mar	Mean	SD
g							
Ca	3.52	3.14b	3.35ab	3.21ab	3.84a	3.38	0.30
P	7.50	7.07	7.34	7.70	7.25	7.35	0.52
Mg	2.82a	2.40b	2.65ab	2.89a	2.78ab	2.67	0.26
Na	0.06	0.08	0.07	0.06	0.05	0.07	0.02
K	8.02	8.43	7.31	8.10	8.44	8.05	0.75
S	4.43b	5.41a	5.07ab	5.07ab	5.00ab	5.00	0.45
mg							
Fe	96.9	94.3	88.1	78.4	99.9	93.8	12.9
Zn	43.7	52.3	57.6	41.3	46.2	48.2	17.9
Mn	43.6	40.5	40.7	42.7	44.4	42.1	7.8
Cu	3.08a	2.46b	3.66ab	2.68ab	3.04ab	3.00	0.89
Co	0.48	0.48	0.48	0.56	0.59	0.51	0.09
Mo	0.43	0.38	0.43	0.42	0.44	0.42	0.13
Ni	1.04	1.04	1.03	0.84	1.27	1.04	0.31
Cr	4.07	4.14	5.40	4.82	3.58	4.31	1.03

values in the same line followed by different letters are significantly different ($P < 0.05$)

TABLE 5

Carotene and xanthophyll content, mg per kg dry matter

Indices	Variety					Total	
	Bolko	Ceres	Liporta	Libravo	Mar	Mean	SD
Carotene	1.6	1.4	1.3	1.2	2.3	1.6	0.4
Xanthophyll	22.3	19.5	19.5	16.6	27.2	21.0	4.0

TABLE 6

The content of antinutritional factors

Antinutrients	Variety					Total	
	Bolko	Ceres	Liporta	Libravo	Mar	Mean	SD
Tannin, %	1.16a	1.00b	1.05ab	0.94b	1.02b	1.08	0.12
Glucosinolate							
μmol/g DM defatted	8.1b	15.7a	14.8ab	14.6ab	14.3ab	13.5	3.06
Phytate, %	2.08a	1.84b	1.89ab	1.79b	1.92ab	1.95	1.6
Phytic phosphorus, %	0.57a	0.52b	0.54ab	0.51b	0.54ab	0.55	0.4

values in the same line followed by different letters are significantly different ($P < 0.05$)

The aliphatic glucosinolate content was low and did not exceed 25 μmol/g of defatted matter in all samples (Table 6).The values ranged from 8.1 μmol/g (Bolko) to 15.7 μmol/g (Ceres), ($P \leq 0.05$). Glucosinolate content Y (μmol/g) was correlated with sulphur content X (g/kg) with the respective regression equation:

$$Y = 8.25X - 27.7 \pm 0.76, \quad r = 0.955$$

Mean tannin content was 10.8 ± 1.2 g/kg DM.

Phytate level amounted to 19.5 g/kg DM. Phytic phosphorus, poorly utilized by monogastric animals, comprised 74.8% of total phosphorus content. A ratio of molar content of phytate, expressed as phytic acid, to zinc amounted to 39.6 and was not favourable. At the high inclusion of rape seed in diet, attention should be paid to meeting requirement of animals for zinc. Similar values were obtained in ealier studies (Matyka et al., 1993).

Differences in chemical composition of samples representing each rape variety were rather small, irrespectively of the origin of sample. This indicates the uniformity of the analysed material and shows that the growing conditions in Poland do not affect to a great extent the levels of major nutrients, minerals, and amino acids.

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STRESZCZENIE

Skład chemiczny nasion niskoglukozynolanowych odmian rzepaku uprawianego w Polsce

W 26 próbach nasion 5 odmian niskoglukozynolanowego rzepaku (Bolko, Ceres, Liporta, Libravo i Mar) uzyskanych z terenowych oddziałów „Centrali Nasiennej", reprezentujących obszar całego kraju, oznaczono zawartość podstawowych składników pokarmowych, kwasów tłuszczowych, makro- i mikroelementów oraz substancji antyżywieniowych: glukozynolanów, tanin i fitynianów. Zawartość aminokwasów oraz karotenu i ksantofilu oznaczono w łączonych próbach nasion każdej z odmian. Stwierdzono niewielkie różnice pomiędzy składem nasion każdej z odmian.

Zawartość białka ogólnego wahała się od 19,1 w odmianie Libravo do 22,7% suchej masy w odm. Bolko, lizyny - od 6,48 do 7,30 g/16 g N. Stwierdzono istotne różnice między odmianami w zawartości kwasu erukowego; średnia wartość wynosiła 0,99%. Zawartość alifatycznych glukozynolanów wahała się od 8,1 w odm. Bolko do 15,7 μmol/g masy beztłuszczowej w odm. Ceres i była wysoce skorelowana z zawartością siarki. Fosfor fitynowy stanowił 74,8% fosforu ogólnego.