INVESTIGATIONS OF GENETIC DETERMINATION AND THE QUALITY OF YELLOW-SEEDED RAPESEED

IWONA BARTKOWIAK-BRODA[1], BŁAŻEJ HERNACKI[1], DANUTA BOROS[2], STEFANIA SMULIKOWSKA[3], JERZY TYS[4]

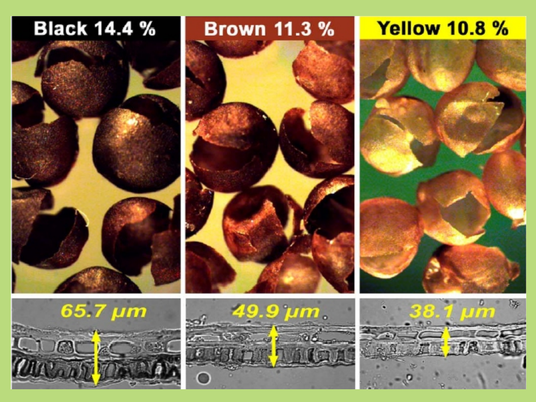
[1] Plant Breeding and Acclimatization Institute – NRI, Department of Genetics and Breeding of Oilseed Crops, Strzeszynska 36, 60-479 Poznan, Poland, ibart@nico.ihar.poznan.pl
[2] Plant Breeding and Acclimatization Institute – NRI, Laboratory of Quality Evaluation of Plant Materials, Radzikow, Poland
[3] Institute of Animal Physiology and Nutrition Polish Academy of Sciences, Jablonna, Poland
[4] Institute of Agrophysics Polish Academy of Sciences, Lublin, Poland

Oilseed rape (*Brassica napus* L.) has become a very important agricultural crop. At present, it is the second oil plant in the world in the production of oil seeds after soybean and the third one in the production of oil after palma- and soybean oil. The total harvest in 2009/2010 was on the level of 61.1 millions tons.

Oil extraction generates large quantities of rapeseed meal and press cake. These in turn may constitute a valuable feedstuff with high protein content (about 40% in oil-free meal) characterized by an excellent amino acid profile, high content of essential minerals (Ca, Mg, P), and vitamins (B4, E).

However, rapeseed meal first of all is used in feeding of ruminants. Its utilization for pigs and poultry is very limited because of the presence in rapeseed seeds antinutritive compounds like: high content of dietary fibre which limits energetic value of meal; too high alkenyl glucosinolates content (also in seeds of canola type); secondary compounds — tannins, sinapine, phytic acid.

The relatively low concentration of metabolisable energy, associated with a high content of dietary fibre, in double low rapeseed cultivars has been considered a major factor limiting the better use of rapeseed meal in the rations for monogastric animals.



The yellow-seed trait in rapeseed is associated with a reduced seed coat thickness, this leads to a reduced contribution of the seed coat to the seedmeal after oil extraction and a consequent lowering of antinutritive crude fibre and phenolic compounds.

Developing cultivars with yellow colour of seeds and noticeably decreased content of dietary fibre has become very important breeding task world-wide, also in Poland.

Several advanced yellow-seeded lines of winter oilseed rape have recently been developed in our Institute, with the yield and quality comparable to that of standard black-seeded double low cultivars.

Source of yellow-seeded genotypes

***Brassica napus* — mutant with lighter seed coat**
(Krzymański 1979)

↓

Segregation of seed colour: light brown, beige

Brassica napus* × *Brassica rapa (Olsson 1960)

↓

Spring line of *B. napus* segregating in seed colour
Seeds with yellow spots
(Canada Agriculture Research Station)

Development of yellow-seeded lines

- Selfpollinating
- Crossbreeding with highly valuable black-seeded lines to improve quality features
- Developing of doubled haploid (DH) lines

The investigations were supported by the Ministry of Science and Higher Education in Poland, Project no. R 12 047 03

The obtained yellow-seeded lines have been investigated in different aspects:

- genetic determination of yellowseedness
- chemical composition of meal and press cake derived from yellow seeds
- nutritional value in feeding of monogastric animals
- physical parameters of yellow seeds

Matherial for these investigations cansisted of:
segregating generations according to the colour of seeds, 3 yellow-seeded winter rapeseed lines (PN 022, PN 036, PN 041) and black-seeded cultivar Bojan

Description of seed colour segregation

Developed lines are characterized by the color of seeds at 1-5 scale:
1 — brown
2 — bright brown
3 — between yellow and brown
4 — in the prevalence of yellow
5 — yellow

Segregation of seed colour in F_3 progeny of hybrids between yellow- and black-seeded DH-lines. Testing accordance of seed colour segregation at the ratio 1 : 15

Number of lines in F_3	Seed colour 5	4	3	2	1	black	χ^2
368	23	33	48	102	42	120	0,0116

Yellow seed colour is determined, at least by two pairs of alleles
Maternal effects — in F_1
Coloration of F_2 is intermediate
The ratio 1 : 15 has been statistically confirmed in F_3 progeny

Genetic investigations using diallel crosses design

6×6 — 3 yellow-seeded lines + 3 black-seeded lines

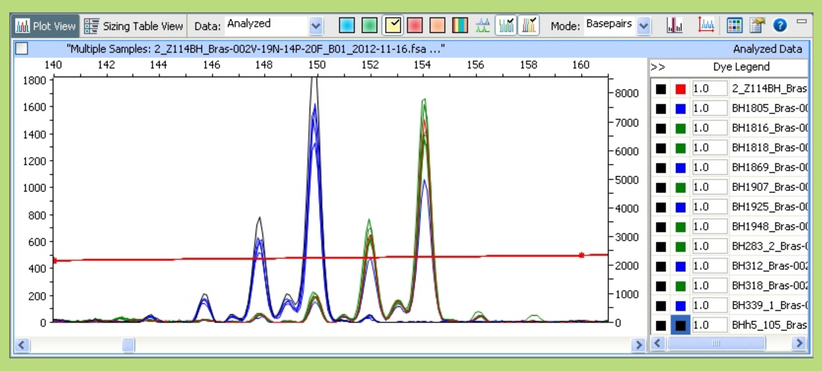
Source of variability	Colour of seeds	NDF	ADF	Protein	Fat
F_1					
Domination	27,52**	5,16**	7,03**	3,10**	3,30**
Additive genes	396,15**	84,07**	116,96**	36,43**	11,14**
F_2					
Domination	5,03**	1,53	1,72	2,00*	3,60**
Additive genes	119,53**	24,18**	24,91**	6,07**	8,59**

NDF — neutral detergent fibre ADF — acid detergent fibre

There was relatively small difference in the contents of gross energy, protein, ash and sucrose between black and yellow types of rapeseed meal. All these components were higher in the yellow-seeded meals. Lignin was the only component considerably differentiating chemically various types of meal. Yellow-seeded meals contained less lignin than its black-seeded counterpart. Lignin content resulted also in the lower content of total dietary fibre in yellow-seeded meals, in comparison to black-seeded meals. There was no big difference in contents of the remaining fibre constituents like nonstarch polysaccharides and uronic acids between two types of rapeseed meal.

Also there is no differences in growth of experimental rats body mass fed with diets containing yellow seeds of rapeseed in comparison to diets containing black seeds.

QTL Searches — responsible for the seed colour differentiation



Example of STR (fluorescently labelled) primers pair — BRAS012 that might candidate as generating seed colour linked markers.

Doubled haploids and their 5-years-average colour of seeds (colorflex 0-5 scale):

Red — DH Z114 — yellow-seeded parental line — 4,8

Black — DH5-105 — black-seeded parental line — 0,6

Green tagged yellow-seeded lines:		Blue tagged black-seeded lines:	
DH 1816	3,6	DH 1805	0,4
DH 1818	4,2	DH 1869	0,4
DH 283	3,4	DH 339	0,6
DH 318	3,9	DH 312	0,6
DH 1907	4,7	DH 1925	0,7
DH 1948	4,0		

Comparison of chemical components of meals from yellow-seeded lines with meals from black-seeded cv. Bojan and soybean [% f.f.d.m.]

Line /cultivar	Gross energy [MJ/kg]	Protein	Ash	Sucrose	Dietery fibre
PN 022	16.55 a	45.5 a	9.1c	9.3 c	36.1 b
PN 036	16.23 b	45.8 a	9.6a	9.7a	35.0 c
PN 041	16.26 b	45.3 a	9.4b	9.7 a	35.7 b
Bojan	16.47 a	43.0 b	8.4d	9.5 b	39.1 a
Soybean meal	16.93	54.0	8.4	7.7	29.8
Means for yellow seeded lines	16.35	45.5	9.4	9.5	35.6

Comparison of dietary fibre and its constituents of meals from yellow-seeded lines with meals from black-seeded cv. Bojan and soybean [% f.f.d.m.]

Line /cultivar	Nonstarch polysaccharides	Oligo-saccharides	Uronic acids	Klason lignin	Dietary fibre*
PN 022	17.9 ab	1.5 b	5.0 b	4.9 c	29.5 b
PN 036	18.6 a	1.6 c	4.9 b	5.7 b	30.4 b
PN 041	17.2 b	1.4 b	5.8 a	4.2 d	28.9 b
Bojan	18.0 ab	1.7 a	5.6 a	11.7 a	36.8 a
Soybean meal	15.1	4.14	3.0	3.3	25.5
Means for yellow seeded lines	17.9	1.5	5.2	4.9	29.6

Growth of rats body mass of parental and first generation — fed with diets containing full fat seeds of black- and yellow-seeded rapeseed [g]

Generations	Wheat + black-seeded rapeseed	Wheat + yellow-seeded rapeseed I	Wheat + yellow-seeded rapeseed II
Parental generation			
Female	91 ± 21	94 ± 17	84 ± 18
Male	161 ± 9	144 ± 6	162 ± 19
Mean value	126 ± 40	119 ± 29	123 ± 45
First generation			
Female	98 ± 5	97 ± 7	95 ± 15
Male	135 ± 6	142 ± 4	143 ± 23
Mean value	116 ± 20	119 ± 24	119 ± 31
Two generations			
Female	95 ± 14	95 ± 12	89 ± 17
Male	148 ± 16	143 ± 5	152 ± 22
Mean value	121 ± 31	119 ± 26	121 ± 38

Mechanical parameters of seeds according to the uniaxial compression test

Material	Quotient of pressure	Modulus of elasticity E [MPa]	Constant of Poisson	Maximum force [N]
Bojan	0,44 ± 0,03	9,1	0,23	16,2
PN 022	0,38 ± 0,02	6,8	0,16	9,8
PN 036	0,39 ± 0,06	6,3	0,15	11,8
PN 041	0,37 ± 0,04	6,6	0,12	10,7

Yellow seeds are more susceplible to distortion in comparison to black seeds.

Conclusion

The results from this study showed that meals derived from yellow-seeded winter rapeseed possess similar but relatively high level of major dietary fibre fraction, which is nonstarch polysaccharides, although its lignin content is much lower. The question remains whether this change in the chemical composition of oilseed rape is satisfactory for the improvement of nutritive value of its meal. It is necessary to investigate which component as a next should be taken into account in the breeding efforts.

The processing and storage conditions should be also determined.