ZESZYTY PROBLEMOWE POSTĘPÓW NAUK ROLNICZYCH 1995 z. 427, 145-150

FACTORS CONDITIONING THE NUTRITIONAL VALUE OF RAPESEED MEAL, PRESS-CAKE AND RAPESEEDS

Z. Zduńczyk

Institute of Animal Reproduction and Food Research, Polish Academy of Sciences, Tuwima 10, 10-718 Olsztyn, Poland

A b s t r a c t. The results of the studies discussed indicate practical possibilities for increasing the nutritional value and range of fodder utilisation of rapeseed products by means of, among others: (i) further lowering GLS content to the level of 3-5 μM, permitting broader application of raw seeds and better utilisation of press cake obtained during cold pressing of oil; (ii) modification of the traditional technology of rapeseed processing, mainly through lowering the temperature of seed conditioning and rapessed meal toasting, which bring about lysine loss and increase the biological value of protein; (iii) reducing fibre content in rapeseed meal (through hulling of seeds, fractioning of rapeseed meal) and selection of '000' cultivars, permitting an increase in energetic value of meal in feeding monogastric animals; (iv) optimisation of cold pressing of oil with regard to the nutritonal value of press-cake.

K e y w o r d s: rapeseed meal, rapeseed cake, glucosinolate, processing

INTRODUCTION

Regression in rapeseed cultivation in Poland in recent years has limited both the industrial and fodder utilisation of this crop. In the best years of rapeseed cultivation and processing the production of rapessed meal was 400 000 t, which covered most of Polish demand for high protein fodders. In the present 1994/5 fodder season the rapeseed meal stock is estimated to be 240 000 t, i.e., less than half the planned import (Fig. 1). This illustrates the scale of the Polish deficit in fodder protein and justifies the necessity of increasing rapeseed cultivation, and improving fodder utilisation of high protein by-products obtained from rapeseed processing. Further discussed results of experiments carried out in recent years in Poland, and abroad, demonstrate good possibilities of inrceasing the nutritional value of rapeseed products.

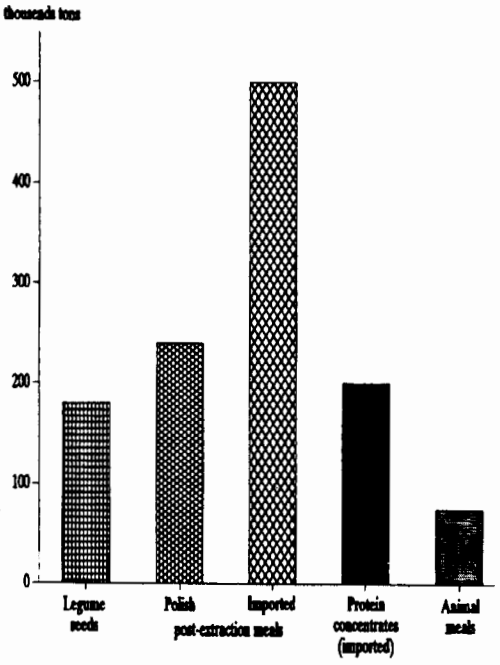

Fig. 1. High-protein fodders in Poland in 1994/5 [32].

GLUCOSINOLATES AS A FACTOR LIMITING FODDER UILISATION OF RAPESEED PRODUCTS

In spite of radically lowering the glucosinolates (GLS) content in the improved rapeseed varieties to 10-20 μM/g, this group of compounds remains an important antinutritional factor, conditioning utilisation of rapeseed products in feeding monogastrics. Glucosinolates have low biological activity, but their side-chains, released during hydrolysis, reveal high antinutritional activity. The endogenous enzyme myrosinase, released during the damage of rapeseeds, hydrolyses GLS to isothiocyanates (ITC, nitrile vinyl-oxazolidinethione (VOT-goitrin) and thiocyanate ion [19] is responsible for the negative effect of rapeseed products on the performance and productivity of animals. From the summary of results of many studies, it follows that the permitted level of GLS in fodder mixes depends on the species and age of animal, and may range from 2 to 4 μM/g in mixes for piglets and pigs, from 0.5 to 1.5 μM/g for poultry, and from 6 to 15 μM/g in mixes for calves and cattle [20-24,29,33]. Higher level of GLS in fodder mixes may result in their diminished intake [20], reduced animal growth and productivity [21], changes in the weight and structure of internal organs [22], and reproductivity [23].

Analyses of 26 batches of 5 rapeseed cultivars grown in Poland in recent years revealed that the GLS content ranged from 8.1 to 15.7 (on average 13.5+3.06) μM/g and complies with the standards of low-glucosinolates varieties. Such amounts of GLS can be sufficient to show them as the factors limiting fodder utilisation of rapeseeds, and press-cake obtained during cold oil pressing [4,8,27]. In raw seeds, and also at too low conditioning temperature, before cold oil pressing, myrosinase retains its activity and hydrolyses GLS to harmful products. Such conclusions follow from the studies by Kozłowski *et al.* [16] who found a highly significant reduction in broiler weight gain, when rapeseed meal from double-improved Jantar rapeseed was replaced with the meal from raw seeds of the same variety (Table 1). Steamed rapeseeds, used in that experiment proved advantageous in relation to the meal from raw rapeseeds, but the effects were not as good as those of toasted rapessed meal. Similar conlusions can be drawn from the experiments by Grala *et al.* [10], partially illustrated in Table 2, where the influence of a different range of rapeseed heat treatment on the nutritive value of the obtained fodder was compared. In the summary of their experiments these authors state that mild toasting of rapeseed meal (100 °C for 10 or 20 min) is necessary, as sole toasting before oil extraction does not ensure the elimination of the harmful effect of antinutritional substances. Also, other authors found that feeding meal from raw rapeseeds brought about worse results in chickens [6] and fatteners [5], compared with other sources of extra energy in mixes.

Table 1. Effect of feeding broilers with concentrate mixture containing raw and variously prepared rapeseed meal [16]

Specification	Experiment group				
	I	II	III	IV	V
High-protein component of diet, %:					
- soybean meal	24.3	-	-	-	-
- raw rapeseed meal	-	26.5	-	-	-
- steamed rapeseed meal	-	-	26.5	-	-
- toasted rapeseed meal	-	-	-	28.5	-
- toasted Canola meal	-	-	-	-	30.0
Broilers weight on day 56	1962^{A}	1541^{B}	1652^{C}	1791^{D}	1870^{E}
Feed intake per kg weight gain	2.96	3.35	3.17	3.14	3.22
Animal loss, %	8.1	10.1	15.3	5.1	10.1

^{A,B,C,D,E} Figures marked with different letters differ significantly at $P \leq 0.01$.

Table 2. Effect of processing stage on the content of glucosinolate and nutritive value of rapeseed products for chickens [10]

	Defatted seed[1]	Oil cake[2]	Post-extraction meal[3]
	Processing stage		
	before heating	after cooking	after toasting
Glucosinolate, μM/g DM	17.7	17.6	4.7
Crude protein, %	40.9	42.4	42.0
Lysine, g/16 g N	6.10	5.77	5.64
Available lysine, g/16 g N	5.08	5.00	4.42
Feed intake, kg/4 weeks	2.01^{B}	2.04^{B}	2.13^{A}
Body weight gain, g/4 weeks	971	960	990
Feed conversion, g/g	2.07^{b}	2.12^{ab}	2.15^{b}
Thyroid, mg/kg BW	217^{B}	284^{A}	93^{C}

[1]Solvent-extracted rape seeds; [2]solvent-extracted expeller cake; [3]rapeseed meal. ^{A,B,C,a,b,c,} Means followed by the same letter or no letter are not significantly different at P>0.01 (capital letter) or P>0.05.

According to Kinal *et al.* [12] with a 5 % inclusion of rapeseeds in the mix feed, a significant difference in the thyroid gland of chickens was found, when rapeseeds contained 4 or 16 μM GLS in 1 g. Thus, it justifies the neccessity of further selecting domestic varieties of rapeseed aimed at lowering the content of GLS to 3-5 μM/g. Such amounts of these compounds (lower than 5) had the recent (very low glucosinolates) of Canadian rapeseed varieties [2]. Further selection of Polish cultivars of reduced (below 5 μM/g) GLS content is economically justified.

EFFECT OF OIL OBTAINING TECHNOLOGY ON THE NUTRITIONAL VALUE OF RAPESEED PRODUCTS

So far, the popularisation of new rapeseed cultivars has not caused significant changes in the technology of obtaining oil adjusted to high GLS content in traditional cultivars. Along with lowering the GLS content, the chemical composition and structure of cell walls of rapeseeds also changed. When compared to traditional processing technology the seeds of improved cultivars are excessively crushed, which deteriorates extraction yield [11]. That is most likely the reason why rapeseed meal contains relatively high amounts of oil (up to 5 % of dry mass).

According to many authors [8-11,25] the basic improvement of the traditional technology of obtaining oil should be the use of improved cultivars allowing, rapeseed meal toasting at a lower temperature of about 100 °C. Too high a temperature of toasting may lower the content and availability of lysine and consequently, the nutritional value of this fodder (Table 3). Grala *et al.* [7,9] reported that toasting temperature alone does not decide the nutritional

Table 3. Effect of testing temperature on GLS and availabile lysine content and of rapeseed meal in feeding pigs (acc. [7, 9])

Specification	Toasting temperature RSM (°C)		
	90	95	100
Glucosinolate, μM/g DM	4.8	0.8	1.5
Lysine, g/16 g N	5.2	4.9	4.3
Available lysine, g/16 g N	4.3	3.8	3.0
Feed intake, kg/day	1.56	1.52	1.40
Body gain, g/day	513^{A}	461^{AB}	434B
Apparent of biological value of protein	48.6^{A}	47.8^{A}	41.9
Thyroid, mg/kg body weight	136	122	141

value of rapeseed meal. Water content during toasting, as well as conditioning and toasting time, play an important role. In the experiment cited, the nutritional value of rapeseed meals from two oil plants was similar, in spite of different toasting temperatures used (90 and 120 °C). According to Grala *et al.* [8] two conditions should be met during toasting: fast temperature increase in roasting plants (but not over 90 °C), and avoidance of water contact on the first shelves of the roasting chamber, so that excessive moisture (over 8 %) does not cause lysine loss. During toasting, temperature should not exceed 100 °C, and the time of removing solvents and GLS breakdown products (ITC, VOT and nitriles) should be maximally reduced (to 20 min). The studies cited indicate that relatively slight changes of the conditions in which rapesseeds are prepared for processing, and limiting of the range of thermal treatment following extraction, can result in a considerable improvement of the nutritional value of rapeseed meal. Results of many works [8,11,25] also indicate that new technological solutions such as expanding, or the enzymatic preparation of seeds, should increase the nutritional value of rapeseed products.

EFFECT OF FIBRE CONTENT ON THE NUTRITIONAL VALUE OF RAPESEED MEAL

A high share of the seed hull (up to 30 %) is the main factor responsible for the relatively low energetic value of rapeseed meal. The value of metabolic energy for pigs in this meal is usually about 12 MJ, whereas in soybean meal it is 14 MJ [4]. Seed coat fibre is characterised by a high content of polysaccharides (pectins, cellulose and hemicellulose) and lignin, which are not digested by the enzymes of the monogastrics alimentary tract [26]. For this reason, attempts are made to defeat rapeseeds in order to lower the fibre content in rapeseed meal (Table 4). Removing the seed coat prior to extraction results in oil of lighter colour, which makes bleaching easier and cheaper [15]. As a result of loss of part of the oil along with the seed coat, and increased oil saturation of rapeseed meal, oil yield decreases. This, as well as technical difficulties, is the reason this technological process has not been broadly applied so far. An alternative solution is the possibility of rapeseed meal fractionation [8]. Using an appropriate set of sieves produces 50 % fractions of elevated nutritional value because of the higher protein and metabolic energy concentration and lower raw fibre content [8]. Another problem is the selection of cultivars of reduced fibre content, so called '000'. Although a few studies [1, 30, 31] brought in some interesting findings, the practical effects of these works seem to be a matter of the future. It can be supposed that the advantage - from the nutritional point of view - of lowering the fibre content in the seed coat, may be lost because of the excessive crushing of seeds and reduced oil yield.

THE NUTRITIONAL VALUE OF RAPESEED PRESS-CAKE AND OIL CAKE

Popularisation of low GLS rapeseed cultivars has made possible a return to simpler

Table 4. Effect of rapeseed dehulling on nutritional value of rapeseed meal [3]

Content in dry matter	Seed batch		Difference (%)
	whole	dehulled	
Crude protein	39.1	45.0	+15.1
Crude fibre	12.7	7.1	-44.1
Digestibility coefficients (pigs):			
- energy	72.5	85.3	+17.7
- protein	80.2	85.1	+6.1
Energy content, MJ (pigs):			
- digestibility	14.02	16.54	+18.0
- metabolitic	12.95	15.22	+17.5

technique of obtaining oil, needing only preconditioning of seeds and pressing in a press. The press-cake obtained contains 10-15 % oil [18,28], which is less than oil cake, obtained as a by-product of rapeseed processing in oil plants. Oil cake used in a few earlier nutritional experiments [13,17,34] contained even more than 20 % raw oil. Thus, the protein to energy ratio of oil cake was closer to rapeseeds, whereas press-cake is closer to rapeseed meal. The nutritional value of press-cake may be affected by three factors: GLS content in seeds, range of hydrothermal preparing (conditioning) prior to pressing, and the amount of remaining oil [4,8,18,27]. Therefore, further reduction of GLS content in Polish rapeseed cultivars (below 5 μM/g) will result in an increase in the nutritional value and range of fodder utilisation of press-cake. Optimisation of seed conditioning, aimed at fast myrosinase inactivation and limiting the range of GLS degradation to harmful products, should serve this purpose. Using low GLS cultivars and optimal technologies, rapeseed press-cake can be a good alternative to soybean and rapeseed meals, and can facilitate the composition of doses of high energetic value and appropriate protein content.

REFERENCES

1. **Bell J.M., Keith M.O.:** Nutritional evaluation of low-mucillage meal for swine. Nutr Rep. Intern., 60(6), 1081-1089, 1989.
2. **Bell J.M., Keith M.O., Hutcheson D.S.:** Nutritional evaluation of very low glucosinolate canola meal. Can. J. Anim. Sci., 71, 497-506, 1991.
3. **Bourdon D., Aumaitre A.:** Low-glucosinolate rapeseeds and rapeseed meals: effect of technological treatments on chemical composition, digestibility energy content and feeding value for growing pigs. Anim. Feed Sci. Technol., 30, 175-191, 1990.
4. **Buraczewski S.:** Rapeseed fodder in feeding of non-ruminantin animals (in Polish). Conf. Mat. 'Rapeseed - present state and perspectives', Institute of Animal Physiol. Nutr. PAS and Comm. Sci. Res., Radzików, 126-136, 1993.
5. **Glapś J., Ziółkowski T., Kozik E.:** The utilization of rappe full seeds in pigs fattenning (in Polish). Roczn., Nauk. Zoot., Mon. i Rozpr., 31, 245-261, 1992.
6. **Fritz Z., Schleicher A., Kinal S., Jarosz L., Jamroz D.:** Concentrate mixtures containing seeds and rapeseed meal of Jantar variety in feeding of broilers (in Polish). Zesz. Nauk. Drobiarstwa, 6, 55-67, 1989.
7. **Grala W., Buraczewska L., Pastuszewska B., Smulikowska S., Gdala J.:** Nutrition value of rapeseed meal obtained from double-improved rapeseed subjected to different temperatures (in Polish). Zesz. Probl. IHAR, Rośliny Oleiste, 175-188, 1991.
8. **Grala W., Pastuszewska B.:** Influence of technological factors on nutritional value of rapeseed products in feeding of monogastric animals (in Polish). Conf. Mat. 'Rapeseed - present state and perspective'. Inst. Animal Physiol. Nutr., PAS and Comm. Sci. Res., 70-79, 1993.
9. **Grala W., Buraczewska L., Gdala J., Pastuszewska B.:** Effect of thermal processing on the protein value of double-low rapeseed products. 1 Effect of toasting temperature on protein value of rapeseed oil meal for pigs. J. Anim. Feed Sci. **3**(1), 33-42, 1994.
10. **Grala W., Pastuszewska B., Smulikowska S., Buraczewska L., Gdala J.:** Effect of thermal processing on the protein value of double-low rapeseed products. 2. Effects of processing stages in the oil plant and toasting in laboratory condition. J. Anim. Feed Sci., **3**(1), 43-55, 1994.
11. **Katzer A.:** Achievements and necessity of researches on oil of rapeseed (in Polish). Conf. Mat. 'Rapeseed - present state and perspective'. Inst. Animal Physiol. Nutr., PAS and Comm. Sci. Res., 55-63, 1993.
12. **Kinal S., Fritz Z., Schleicher A.:** The effect of glucosinolate rape seed varieties Leo and Mar on the performance of Starbro and Vedetta broiler chickens. J. Anim Feed Sci., 3, 207-213, 1994.
13. **Kinal, S., Fritz Z., Dorosz L., Schleicher A.:** Rape seed, partly deffatted seeds, and rapeseed oil meal from var. Jantar in the feeding of broilers (in Polish). Nauk Zoot. Mon. i Rozpr., 28, 251-260, 1990.
14. **Korol W., Jaśkiewicz T., Bartuzi G., Bogusz G., Nieściór H., Grabowski C., Mojek E.:** Chemical composition of rape seed from low glucosinolate varieties grown in Poland. J. Anim. Feed Sci., 3, 57-64, 1994.
15. **Kozłowska H., Nowak H., Zadernowski R.:** Rapeseed hulls fat characteristics. Fat Sci. Technol., 90(6), 216-219, 1988.
16. **Kozłowski M., Faruga A., Mikulski D., Kozłowska H., Rotkiewicz D., Kozłowski K.:** Fattening and slaughter effect of broiler chickens fed diets with rapeseed oil meal from the double improved varieties (in Polish). Acta Acad. Agricult. Techn. Olst. Zoot., 34, 183-193, 1991.
17. **Lipiński K., Tywończuk J., Lewicki C., Rapczyńska I., Sobotka W.:** A utilization of rapeseed meal, rapeseed cake, and rapeseed of the Jantar "00" variety in feeding growing-finishing pigs (in Polish). Acta Acad. Agricult. Techn. Olst. Zoot., 40, 133-144, 1994.
18. **Lipiński K.:** Nutritional value and usability of rapeseed oil cake raftex and rapeseed meal '00' in feeding of fattening pigs (in Polish). ART Olsztyn, PhD Thesis, 1994.

19. **Mawson R., Heaney R.K., Piskuła M., Kozłowska H:** Rapeseed meal - glucosinolates and their antinutritional effects. Part. 1. Repeseed production and chemistry glucosinolates. Die Nahrung, 37(2), 131-140, 1993.
20. **Mawson R., Heaney R.K., Zduńczyk Z., Kozłowska H.:** Rapeseed meal - glucosinolates and their antinutritional effects. Part. II. Flavour and palatability. Die Nahrung, 37(4), 336-344, 1993.
21. **Mawson R., Heaney R.K., Zduńczyk Z., Kozłowska H.:** Rapeseed meal - glucosinolates and their antinutritional effects. Part. III. Animal growth and performance. Die Nahrung, 38(2), 167-177, 1994.
22. **Mawson R., Heaney R.K., Zduńczyk Z., Kozłowska H.:** Rapeseed meal- glucosinolates and their antinutritional effects. Part. IV. Goitrogenicity and internal organs abnormalities in animals. Die Nahrung, 38(2), 178-191, 1994.
23. **Mawson R., Heaney R.K., Zduńczyk Z., Kozłowska H.:** Rapeseed meal - glucosinolates and their antinutritional effects. Part. V. Animal reproduction. Die Nahrung, 38(6), 588-598, 1994.
24. **Mawson R., Heaney R.K., Zduńczyk Z., Kozlowska H.:** Rapeseed meal - glucosinolaes and their antinutritional effects. Part. VI. Taint in end-products. Die Nahrung 39(1), 21-31, 1995.
25. **Mawson R., Heaney R.K., Zduńczyk Z., Kozłowska H.:** Rapeseed meal - glucosinolaes and their antinutritional effects. Part. VII. Processing Die Nahrung, 39(1), 32-40, 1994.
26. **Ochodzki P., Rakowska M.:** Physiological improtance of nondigestible components of rape seeds and ways leaded to decrease their level (in Polish). Rośliny Oleiste, 15, 91-104, 1994.
27. **Pastuszewska B., Smulikowska S., Raj S., Ziołecka A.:** Rapeseed in animal nurition (in Polish). The Kielanowski Institut of Animal Physiology and Nutrition (Ed. B. Pastuszewska), 27, 1992.
28. **Podkówka W., Podkówka Z., Doroszewski P.:** Nuritive value of rapeseed cake obtained by using an extractor 02 PVO (in Polish). Rośliny Oleiste, 15, 179-182, 1994.
29. **Pusztai A.:** Antinutrients in rapeseeds. Nutr Abstr. and Rev. (Ser. B), 59(8), 427-433, 1989.
30. **Simbaya J., Slominski B., Campbell L.D.:** Nutritive quality of dehulled and yellow-seeded canola meals for poultry. Poultry Sci., 71(supp. 1), 14, 1992.
31. **Slominski B., Campbell L.D.:** Non-starch polysaccharides of canola meal: quantification, digestibility in poultry and potential benefit of dietary enzyme supplementation. J. Sci. Food Agric., 53, 175-184, 1990.
32. Fodder situation in 1994/95 (in Polish). Pasze Przemysłowe 7, 4-5, 1994.
33. **Zduńczyk Z.:** Rapeseed glucosinolates - influence on consumption of concentrate mixture, health and productivity of animals and quality of animal products (in Polish). Post. Nauk Rol., 5, 41-54, 1995.
34. **Zduńczyk Z., Lewicki C.:** '00' rapeseed meal with different fat content in concentrates for calves (in Polish). Acta Acad. Agric. Techn. Olst., Zoot., 36, 77-87, 1992.

CZYNNIKI WARUNKUJĄCE WARTOŚĆ POKARMOWĄ ŚRUTY POEKSTRAKCYJNEJ, MAKUCHÓW I NASION RZEPAKU

Na podstawie danych piśmiennictwa scharakteryzowano znaczenie produktów rzepakowych w bilansie paszowym Polski oraz wskazano możliwości zwiększenia wartości pokarmowej śruty poekstrakcyjnej oraz makuchów. W podsumowaniu pracy stwierdzono celowość, m. in., dalszego obniżenia zawartości glukozynolanów w nowych odmianach rzepaku (do poziomu 3-5 μM), zmodyfikowanie tradycyjnej technologii przetwórstwa nasion (obniżenie temperatury kondycjonowania nasion i testowania śruty poekstrakcyjnej) oraz optymalizację techniki tłoczenia oleju w olejarniach rolniczych, celem zwiększenia wartości pokarmowej uzyskiwanego makuchu.

S l o w a k l u c z o w e: rzepak, śruta poekstrakcyjna, makuchy, glukozynolany, wartość pokarmowa.