Journal of Animal and Feed Sciences, 3, 1994, 33-42

Effect of the 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

W. Grala, Lucyna Buraczewska, Jolanta Gdala and Barbara Pastuszewska

The Kielanowski Institute of Animal Physiology and Nutrition, Polish Academy of Sciences 05-110 Jablonna, Poland

(Received 26 January 1994; accepted 21 February 1994)

ABSTRACT

The effect of toasting process in the industrial conditions at 90, 95, 100 (Plant 1) and 120°C (Plant 2) on protein value of a double-low rapeseed meal (RSM) for pigs was studied in two experiments. In Experiment 1, the ileal digestibility of RSM was evaluated, and in Experiment 2, the N balance and growth performance trial was carried out.

It was found that raising of toasting temperature from 90 to 95 and 100°C in Plant 1 decreased the total and available lysine contents (5.20, 4.85, 4.33 and 4.28, 3.84, 3.00 g/16 g N, respectively). The apparent ileal digestibility of protein and, in particular, lysine was also reduced (63.7, 65.5, 57.6 and 66.6, 66.8, 49.6, respectively). Feed intake, body gain, feed utilization and N utilization by pigs were decreased ($P \leqslant 0.01$) as toasting temperature increased from 90 to 100°C. The nutritional value of RSM was not reduced when it was toasted at 120°C in Plant 2 and was comparable to the nutritional value of RSM toasted at 90°C in Plant 1.

It was concluded that protein value of RSM for pigs obtained from Polish oil factories using solvent extraction, is highly dependent on the toasting temperature. But other parameters of rape seed processing such as moisture and duration of heating may also affect the nutritional value of RSM for pigs.

KEY WORDS: double-low rapeseed meal, processing, toasting temperature, protein value, ileal digestibility, pigs

INTRODUCTION

Meal from Polish double-low rape seeds (*Brassica napus* L.) is one of the most important protein sources for monogastric animals in Poland. The nutritive value of double-low rapeseed meal depends on the content and availability of nutrients and the presence of anti-nutrients. It is related to the conditions during thermal processing of the seeds.

The rape seed technology used by Polish oil industry is still adapted to the processing of high-glucosinolate rape seed. The conditions of this technology are not very stable and the meal is often thermally over-processed. This may negatively affect the digestibility of protein and availability of amino acids, especially lysine. Studies by Rakowska et al. (1989) and Pastuszewska and Rakowska (1989) demonstrated large variability in the total and available lysine contents in meals derived from either the same or different oil factories.

Chemical composition of rape seed meal is comparable to that of canola meal while its amino acid and protein digestibility and biological value is lower (Campbell et al., 1981; Sauer et al., 1982; Pastuszewska et al., 1987). These differences may be related to the species of rape (canola meal is mainly produced from *Brassica campestris*) and/or to the overheating during toasting after oil extraction. The rape seed protein is very sensitive to high temperature and moisture during seed processing. According to Baudet et al. (1987) the decrease of toasting temperature improves protein digestibility and lysine availability from rapeseed meal.

The objective of the study was to establish the effect of toasting temperature in the industrial conditions on the composition and protein value of double-low rapeseed meal for young pigs.

MATERIAL AND METHODS

Materials

Samples of repaseed meal (RSM) (*Bassica napus* L., var. Jantar) used in Experiments 1 and 2 were obtained from two industrial plants of KZPT Kruszwica. In both plants a solvent extraction processing was used. In Plant 1 flaked seeds were watered during cooking and the meal after extraction was toasted at the temperature increasing from 90 to 95 and 100°C. Since in Plant 1 it was not possible to increase the toasting temperature above 100°C, to over-process the meal at 120°C it was performed in Plant 2, where 120°C was a regular toasting temperature. In contrast to Plant 1, in Plant 2 the flaked seeds were not watered during cooking.

Diet and animals

Experiment 1. It was carried out to determine the apparent ileal digestibility of crude protein (CP) and amino acids (AA) in RSM toasted at 90, 95, 100 and 120°C at industrial conditions.

Six Polish Landrace castrated male pigs of about 30 kg body weight (BW) were fitted with a T-shaped cannula. The cannula was placed in the ileum about

15 cm before the ileo-caecal junction (Horszczaruk et al., 1972). The experiment was designed and carried out according to the method described by Gdala et al. (1992).

The pigs were fed semi-synthetic diets containing 35% of the tested RSM's. Other ingredients expressed in per cent were as follows: wheat starch – 60.3; $CaHPO_4$ – 2.0; min.-vit. mixture "Polfamix T" – 1.0; $CaCO_3$ – 1.0; NaCl – 0.4; Cr_2O_3 – 0.3.

Experiment 2. It was conducted to evaluate the effect of toasting temperature on the nutritional value of RSM for growing pigs.

The experiment was performed on 24 pigs. Each experimental group consisted of six Polish Landrace male pigs of initial BW about 14 kg. The animals were individually fed with barley-wheat diets containing the meals toasted at various temperature (Table 1). The animals were fed at a level of 2.9 times their assumed maintenance energy requirement (2.9 x 0.5 MJ/kg $^{0.75}$; ARC, 1981). Mash wet diets (water : feed = 1:1) were offered to pigs twice daily.

The experiment lasted 11 weeks; faeces and urine for N balance were collected twice over the 5-day periods, in the 2nd and the 7th week of experiment. Blood for determination of serum thyroid hormone was sampled from *vena cava* before slaughter and then thyroid gland and liver were sampled and weighed. Body weight gains (BWG, g/day), feed conversion (FC, kg/kg BWG) and N utilization (CP digestibility, N retention, N retained/N digested) values were measured.

TABLE 1

Composition of diets, % (Experinemt 2)

Item	Diets with rapeseed meal toasted at:			
	90°C	95°C	100°C	120°C
Rapeseed meal	18.5	20.0	20.5	19.5
Barley	45.5	44.0	43.5	44.5
Wheat	30.0	30.0	30.0	30.0
Soya oil (period of 1-4 weeks) or maize starch (period of 5-11 weeks)	2.5	2.5	2.5	2.5
Min.-vit. mixture[1]	3.5	3.5	3.5	3.5
Crude protein, % DM	17.0	17.0	17.2	17.8
Lysine, g/16 g N^2	0.71	0.68	0.65	0.75
Avaialble lysine, g/16 g N^2	0.60	0.57	0.51	0.61
Metobolizable energy[2], MJ/kg DM	12.4	12.4	12.6	12.6
Glucosinolates[2], μM/kg feed	768	132	254	829

[1] minerals and vitamins (% of diet): Polfamix P – 1.5, $CaCO_3$ – 0.7, $CaHPO_4$ – 1.0, NaCl – 0.3

[2] calculated from contents in the components

Analytical procedure

The rapeseed meals, diets and freeze-dried samples of faeces and digesta were analyzed for essential nutrients and amino acids according to methods described by Buraczewska et al. (1987). Available lysine was analyzed according to the Carpenter method modified by Booth (1971), glucosinolates were estimated according to the Youngs-Wetter method modified by Byczyńska (1971). Analyses of triiodothyronine (T_3) and thyroxine (T_4) levels in the blood serum were determined by the radioimmunoassay using commercial laboratory kits RIA-T_3 and RIA-T_4.

Statistical analysis

Results were analyzed statistically using one-way ANOVA test generated by STATGRAPHICS ver. 2.1 statistical package. Differences among treatment means were evaluated using the least significant difference (LSD) test (Expt.1) and the Duncan test (Expt. 2). Single and multiple linear regression analyses were used to evaluate the pattern of response of measured features to the experimental factors.

RESULTS

Protein, amino acids and glucosinolates in RSM

Table 2 shows the content of CP, AA and glucosinolates in RSM's toasted in Plant 1 (90, 95, 100°C) and in Plant 2 (120°C). For comparison, the data of commercial canola meal (CM) which was used in a similar ileal digestibility experiment by Grala et al. (1988) is also presented. The CP content did not differ among experimental RSM's. Increasing the toasting temperature in Plant 1 from 90 to 100°C resulted in decrease of total and available lysine contents ($r=-0.99$, $P\leqslant 0.99$ and $r=-0.98$, $P\leqslant 0.11$, respectively). The reductions at 100°C as compared to 90°C were 20 and 43% for total and available lysine, respectively. The content of other AA was not affected much by temperature changes.

The total lysine content in RSM toasted at 120°C was unexpectedly similar to that in RSM toasted at 90°C in Plant 1 (5.32 vs 5.20 g/16 g N, respectively). The lysine availability in RSM toasted at 120°C was relatively lower than in RSM toasted at 90°C (75 and 82%, respectively).

The content of the glucosinolates in tested RSM's ranged from 0.8 to 5.0 μM/g fat free DM and was not dependent on toasting temperature.

Experiment 1

The effects of toasting temperature on the apparent ileal digestibility of CP and indispensable AA in RSM are shown in Table 3; the apparent ileal digestibility of CP and AA of CM measured in similar experiment by Grala et al. (1988) is included. Higher toasting temperature resulted in lower ($P \leqslant 0.01$) digestibility of CP and AA, but the most marked negative effect of temperature on CP and AA digestibility was observed in Plant 1 (between 95 and 100°C). With growing temperature the largest reduction in the digestibility was found for lysine; digestibility coefficient was decreased from 66.8 to 49.6%. The digestibility of other AA was decreased to a smaller extent.

Unexpectedly, the toasting temperature of 120°C in conditions of Plant 2 did not caused any further significant decrease in the digestibility of CP and AA as compared with 100°C in Plant 1. The digestibility coefficients of cystine were similar even to those obtained for RSM toasted at 90°C.

The CP and AA digestibility values of CM were higher than those found for the meal toasted at 90°C in Plant 1. The greatest differences were found for CP, Lys, Cys and Trp (5.8, 9.9, 10.0 and 7.2 digestibility units, respectively).

Experiment 2

The effect of RSM toasted at 90, 95, 100 and 120°C on pig performance and N utilization by pigs is shown in Table 4. Feed intake decreased as toasting temperature increased from 90 to 100°C in Plant 1 (1.56 and 1.47 kg/day, respectively). Also BWG markedly ($P \leqslant 0.01$) decreased from 513 to 434 g/day, and FC increased ($P \leqslant 0.05$) from 3.05 to 3.40 kg/kg BWG. CP digestibility was reduced from 77.5 to 75.0 by increasing toasting temperature. The values of N retention and N retained/N digested decreased ($P \leqslant 0.01$) from 37.4 to 31.8% and from 48.6 to 41.9% of N intake, respectively.

Growth performance and N utilization by pigs fed the diet containing RSM toasted at 120°C were as good as those in pigs fed the diet with RSM toasted at 90°C.

The thyroid and liver weights as well as T_3 and T_4 levels in blood serum were not differentiated among the experimental groups.

DISCUSSION

The great effect of toasting temperature on pig performance was due to both the reduced content of total and available lysine in meal and to lower apparent ileal digestibility of CP and AA of RSM. The digestibility of the indispensable AA was significantly decreased ($P \leqslant 0.01$) as toasting temperature increased in

Plant 1. The negative effect of higher toasting temperature was related mainly to the lower digestibility of lysine. Similar results were reported by Anderson-Hafermann et al. (1993) for AA digestibility of CM in adult cockerels and by Parsons et al. (1992) for soya bean meal.

The negative effect of heating on total and available lysine concentrations and lysine digestibility in RSM may be largely attributed to Maillard reaction products formed during toasting (Hurrell, 1990; van Soest and Mason, 1991). The extent of protein damage during Maillard reaction depends on time, temperature, moisture and reducing sugar contents and some other constituents which are present in the seeds. In the present study two types of damage could take place. In one, the lysine might become bound in such a form that it was not liberated during digestion *in vivo* and/or by *in vitro* assay (Pickard et al., 1986). In the second type, lysine was irreversibly altered and was not recovered after acid hydrolysis (Pickard, 1986). Both types of damage were reflected in serious losses of total and available lysine contents in RSM and in decreasing its digestibility.

Cystine, lysine and available lysine concentrations in the meal toasted at 120°C in Plant 2 were as high as those observed for the meal toasted at 90°C in Plant 1. The apparent ileal digestibility of lysine and cystine, pig performance, and N utilization by pigs fed these meals were also similar. However, the ileal digestibility of other indispensable AA and protein of the meal toasted at 120°C was as low as noted for the meal toasted at 100°C. It appears that digestibility trial may be not sufficient to establish the nutritional value of thermally over-processed feedstuffs for pigs. Nevertheless, these findings confirm importance of the lysine concentration and availability for the protein value of rape seed.

The inconsistent results of the evaluation of meals produced in the two plants could probably be due to differences in cooking process. In Plant 1, but not in Plant 2, flaked seeds were saturated with water during cooking what supposedly resulted in higher moisture during the processing of seeds. Thus, increasing toasting temperature from 90 to 100°C, after high moisture conditioning of the seeds, induced much more damage to total and available lysine than toasting at 120°C with lower moisture of seeds.

This is in agreement with the earlier observations in which the moisture and height of temperature were found to play essential role in decreasing lysine concentration and availability in RSM (Josefsson, 1975; Rayner and Fox, 1976; Craig and Broderick, 1981; Pickard et al., 1986; Katzer and Mińkowski, 1989). Laboratory studies (Raczyński and Buraczewski, 1973; Hurrell and Carpenter, 1977) also clearly showed that decrease of lysine availability in heated protein is associated with an increase of moisture, in particular in the presence of reducing sugars. The results of reported study correspond with the obseravations by Kozłowska and Nowak (1981) who found that when temperature exceeds 90°C

TABLE 2

Amino acid, protein and glucosinolate contents in rapeseed meal toasted at various temperature (Experiment 1) and in canola meal[1]

Processing plant:	Plant 1			Plant 2	Canola
Temperature (°C):	90	95	100	120	meal[1]
Crude protein, % fDM[2]	43.2	43.1	42.8	42.6	41.9
Lysine[3]	5.20	4.85	4.33	5.32	6.01
Available lysine	4.28	3.84	3.00	3.97	4.71
Methionine	2.19	2.24	2.20	2.30	2.32
Cystine	2.19	2.20	2.12	2.35	2.76
Threonine	4.56	4.51	4.48	4.52	4.43
Tryptophan	1.38	1.37	1.37	1.39	1.43
Isoleucine	4.14	4.02	4.06	4.17	4.10
Leucine	7.33	7.13	7.23	7.26	7.03
Phenylalanine	4.29	3.94	3.98	4.17	4.26
Valine	5.36	5.17	5.16	5.26	5.35
Arginine	6.55	6.38	6.26	6.63	6.45
Glucosinolates, μM/g fDM[2]	4.8	0.8	1.5	5.0	nd[4]

[1] used in the experiment of Grala et al. (1988)
[2] fat free dry matter
[3] the content of amino acids expressed in g/16 g N
[4] nd - not determined

TABLE 3

Apparent ileal digestibility (%) of rapeseed meal toasted at different temperature (Experiment 1) and of canola meal[1] in pigs

Processing plant:	Plant 1			Plant 2	SE[2]	Canola
Temperature (°C):	90	95	100	120		meal[1,3]
Crude protein	63.7^{B}	65.5^{B}	57.6^{A}	58.6^{A}	0.56	69.5
Lysine	66.6^{B}	66.8^{B}	49.6^{A}	64.7^{B}	0.65	76.5
Cystine	66.1^{B}	67.5^{B}	58.4^{A}	63.7^{B}	0.48	76.1
Methionine	78.9^{B}	81.2^{B}	74.3^{A}	74.4^{A}	0.39	80.7
Threonine	63.2^{B}	63.4^{B}	56.3^{A}	56.5^{A}	0.48	65.5
Tryptophan	60.6^{A}	67.0^{B}	59.7^{A}	57.5^{A}	0.57	67.8
Isoleucine	69.7^{B}	71.2^{B}	66.5^{AB}	61.7^{A}	0.72	73.7
Leucine	74.3^{B}	75.4^{B}	69.6^{A}	66.6^{A}	0.53	76.7
Phenylalanine	73.6^{B}	74.9^{B}	68.4^{A}	66.2^{A}	0.47	76.3
Valine	68.0^{B}	68.8^{B}	60.1^{A}	60.3^{A}	0.56	71.3
Arginine	76.4^{AB}	79.9^{B}	72.8^{A}	73.5^{AB}	0.58	82.1

[1] the meal used in the experiment of Grala et al. (1988)
[2] standard error
[3] column excluded from statistical analysis
^{AB} differences in rows significant at $P \leqslant 0.01$

TABLE 4

Effect of toasting temperature of rapeseed meal on pig performance (Experiment 2)

Processing line:	Plant 1			SE[1]	Plant 2
Temperature (°C):	90	95	100		120
Feed intake, kg/day	1.56	1.52	1.47	0.03	1.53 ± 0.08
Body gain, g/day	513[A]	461[AB]	434[B]	5.48	502
Feed conversion	3.05[a]	3.31[ab]	3.40[b]	0.04	3.05
Crude protein digestibility, %	77.5	75.4	75.0	0.42	79.5 ± 2.4
N rentention, % of intake	37.4[A]	36.4[A]	31.8[B]	0.34	39.6 ± 2.6
N retained/N digested, %	48.6[A]	47.8[A]	41.9[B]	0.41	50.0 ± 2.2
Thyroid, mg/kg body weight	136	122	141	6.70	158 ± 34
Liver, g/kg body weight	24.0	23.1	22.3	0.80	20.9 ± 2.7
T_3, pg/100 ml blood serum	695	828	992	46.3	798 ± 151
T_4, ng/100 ml blood serum	40.0	61.7	52.1	4.60	40.1 ± 23.2

[1] standard error

[ab] differences in rows significant at $P \leq 0.05$

[AB] differences in rows significant at $P \leq 0.01$

and when water content in the seeds exceeds 8%, the Maillard reaction rapidly increases resulting in lysine losses and in deep denaturation of rape seed protein during cooking. These findings were confirmed in another study by Grala et al. (1994) who found that lysine content of rape seeds was reduced during cooking in Plant 1 from 6.10 to 5.77 g/16gN.

Thus, it seems that the protein value of RSM in the present study might have been affected not only by toasting temperature, but also by moisture during cooking.

The comparison of the experimental meals with canola meal (Tables 2 and 3) showed a superiority of the latter in respect to the lysine concentration and availability as well as to CP and AA digestibility. That may prove that the conditions of the canola processing in Canadian (solvent extraction processing) plants are better suited to double-low varieties than procedures used in Poland.

CONCLUSIONS

The results of our study showed that toasting temparature is very important technological factor affecting the protein value of double-low RSM during the industrial processing. Comparison of results for different technological procedures (Plant 1 vs Plant 2) indicated that other processing parameters (moisture, duration of heating) may modify the effect of temperature and influence the protein quality of rapeseed meal.

REFERENCES

Anderson-Hafermann J.C., Zhang Y., Parsons, C.M., 1993. Effects of processing on the nutritional quality of canola meal. Poultry Sci. 72, 326-333

Baudet J., Bourdon D., Evrard D.J., Lessire M., 1987. Influence des conditions de cuisson des tourtaux de colza sur leur valeur nutritionelle chez le poulet de chair et le proc à l'engrais. Proc. 7th Intern. Rapeseed Congress, Poznań, Poland, Vol. 7, 1767-1772

Booth V.H., 1971. Problems in the determination of FDNB-available lysine. J. Sci. Food Agric. 22, 658-666

Buraczewska L., Schulz E., Schröder H., 1987. Ileal digestibility of amino acids in pigs fed barleys differing in protein content. Arch. Anim. Nutr., Berlin 37, 861-867

Byczyńska B., 1971. The isothiocyanates and oxazolidienthiones determination in rape seeds. Biuletyn IHAR 5, 57-61 (in Polish)

Campbell L.D., Eggum B.O., Jacobsen I., 1981. Biological value, amino acid availability and true metabolizable energy of low-glucosinolate rapeseed meal (Canola) determined with rats and roosters. Nutr. Rep. Intern. 24, 791-797

Craig W.M., Broderick G.A., 1981. Effect of heat treatment on true digestibility in the rat, *in vitro* proteolysis and available lysine content of cottonseed meal protein. J. Anim. Sci. 52, 229-301

Gdala J., Buraczewska L., Grala W., 1992. The chemical composition of different types and varieties of pea and the digestion of their protein in pigs. J. Anim. Feed Sci. 1, 71-79

Grala W., Buraczewska L., Gdala J., 1988. Ileal and total digestibility of protein of double improved rapeseed in fattening pigs. Proc. 7th Intern. Symp. On Amino Acids, Brno, Czechoslovakia, p. 27

Grala W., Pastuszewska B., Smulikowska S., Buraczewska L., Gdala J., 1994. Effect of thermal processing on the protein vaule of double-low rapeseed products. 2. Effects of temperature and time of heating and of processing stages on protein value of rapeseed products. J. Anim. Feed Sci. 3, 43-55

Horszczaruk F., Żebrowska T., Dobrowolski W., 1972. Permanent intestinal fistulae for the study of digestion in pigs. III. Establishment of simple fistulae of the small intestine. Rocz. Nauk rol., B-94, 99-105 (in Polish; English Summary)

Hurrell R.F., 1990. Influence of the Maillard reaction on the nutritional value of foods. In: P.A. Finot, H.U. Aeschbacher, R.F. Hurrell (Editors). The Maillard Reaction in Food Processing, Human Nutrition and Physiology. Birkhaüser Verlag, Basel, Switzerland, pp. 245-258

Hurrell R.F., Carpenter K.J., 1977. Mechanism of heat damage in proteins. 8. The role of sucrose in susceptibility of protein foods to heat damage. Br. J. Nutr. 38, 285-297

Josefsson E., 1975. Effects of variation of heat treatments conditions on the nutritional value of low-glucosinolate rapeseed meal. J. Sci. Food Agric. 26, 157-164

Katzer A., Mińkowski K., 1989. Observations of the commercial double-low rape seeds processing. Tłuszcze jadalne 37 (4), 20-30 (in Polish)

Kozłowska H., Nowak H., 1981. Conditions of the inactivation of myrosinase in whole and flaked rape seeds. Przem. spoż. 31, 23-25 (in Polish)

Parsons C.M., Hashimoto K., Wedekind K.J., Han Y., Baker D.H., 1992. Effect of overprocessing on availability of amino acids and energy in soybean meal. Poultry Sci. 71, 133-140

Pastuszewska B., Grala W., Gdala J., 1987. Evaluation of chemical composition and biological value of protein of double-zero rapeseed meal. Biul. inf. Przem. pasz. 26 (3), 3-9 (in Polish; English Summary)

Pastuszewska B., Rakowska M., 1989. The improvement of the nutritional value of double-low rapeseed oil meal by the proper technology of production. Zesz. probl. IHAR, Rośl. Oleiste, T. 1, 350-362 (in Polish)

Picard M.D., Youngs C.G., Wetter L.R., Boulter G.S., 1986. Processing of canola seed for quality meal, In: D.R. Clandinin (Editor). Canola Meal for Livestock and Poultry. Canola Council of Canada, Publ. 59, 3-4

Raczyński G., Buraczewski S., 1973. The effect of heating of proteins with glucose on their digestion and utilization by rats. Acta Physiol. pol. 24, 855-862

Rakowska M., Kupiec R., Sawicki J., 1989. Available lysine content as an indicator of changes of biological value of double-low rapeseed protein. Zesz. Probl. IHAR, Rośl. oleiste, T. 1, 100-109 (in Polish)

Rayner C.J., Fox M., 1976. Amino acids digestibility studies of autoclaved rapeseed meals using an *in vitro* enzymatic procedure. J. Sci. Food Agric. 27, 643-648

Sauer W.C., Cichon R., Misir R., 1982. Amino acid availability and protein quality of canola and rapeseed meal for pigs and rats. J. Anim. Sci. 54, 292-301

Van Soest P.J., Mason V.C., 1991. The influence of the Maillard reaction upon the nutritive value of fibrous feeds. Anim. Feed Sci. Technol. 32, 45-53

STRESZCZENIE

Wpływ procesów termicznych na wartość pokarmową białka pasz z rzepaku podwójnie ulepszonego. 1. Wpływ temperatury tostowania na wartość białka poekstrakcyjnej śruty rzepakowej dla świń

Określono wpływ termicznych warunków procesu technologicznego odolejania rzepaku podwójnie ulepszonego na wartość odżywczą białka śruty poekstrakcyjnej. W warunkach przemysłowych zbadano wpływ temperatury tostowania (Zakład 1: 90, 95 i 100°C; Zakład 2 : 120°C) na wartość biologiczną białka dla świń. Kryteriami wartości odżywczej białka była zawartość lizyny ogólnej i lizyny dostępnej, zawartość glukozynolanów, strawność białka i aminokwasów do końca jelita cienkiego świń oraz wyniki doświadczenia wzrostowo-bilansowego.

Stwierdzono, że warunki technologiczne mają istotny wpływ na skład i wartość odżywczą białka śruty rzepakowej. W warunkach przemysłowych o wartości pokarmowej śruty rzepakowej decyduje nie tylko temperatura tostowania, o czym świadczy fakt, że wartość pokarmowa śruty tostowanej w temperaturze 90°C w Zakładzie 1 była zbliżona do wartości śruty tostowanej w 120°C w Zakładzie 2. Porównanie przebiegu procesów odolejania w obu zakładach pozwala sądzić, że innymi ważnymi parametrami technologicznymi są zawartość wody w czasie prażenia masy rzepakowej oraz czas stosowania wysokiej temperatury (prażenie, tostowanie).