CHEMICAL COMPOSITION OF EXPELLER-EXTRACTED AND COLD-PRESSED RAPESEED CAKE

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ABSTRACT. *Chemical composition of locally produced expeller extracted and cold-pressed rapeseed cake was evaluated. Cold-pressed rapeseed cake was produced at 60 °C and the temperature during processing of expeller extracted cake varied between 98–112 °C.*

It was concluded that cold-pressed rapeseed cake contained less crude protein (30.6 vs. 36.1%), N-free extractives (28.2 and 30.7%, resp.) and crude fibre (11.2 and 12.4%, resp.) but more crude fat (17.8 and 11.6%, resp.) and had higher metabolizable energy content (14.5 and 14.2 MJ/kg). Higher energy content in cold-pressed cake is directly related to its high oil content. There were no big differences in crude ash, calcium and phosphorus content in different cake types. Chemical composition of rapeseed cake is influenced by pressing technology and conditions that are used in particular oil plant. Pressing conditions influence the effectiveness of oil removal and thereby also the nutrient content and nutritional value of produced rapeseed cake.

Keywords: *rapeseed cake, cold-pressed rapeseed cake, nutrients, chemical composition.*

Introduction

The most common animal feed from rapeseed is solvent extracted rapeseed meal. Many articles have been published about chemical composition, nutrient value and feeding solvent extracted rapeseed meal to different animal species. There is not so much information about nutritional value of rapeseed cake produced in different extraction conditions and very little about cold-pressed cake.

Depending on technology used in different oil plants solvent-extracted rapeseed meal, expeller-extracted or cold-pressed rapeseed cake is produced. Technology that is used in Estonian oil plants allow to produce rapeseed cake which is formed after mechanical extraction process. Heating temperature is normally around 100 ºC during the cooking after which the oil is mechanically extracted by screwpress. Solvent-extracted rapeseed meal is produced by using a solvent (hexane) to maximize oil recovery from the seed.

Cold-pressing is a method in which the seeds are directed strait to the mechanical press where the temperature shortly rises to 50–60 degrees.

Most plant protein sources in use contain antinutritional factors that reduce the nutritional value of the feed (Table 1). Glucosinolates which can be hydrolysed to toxic components are most important antinutrients reducing nutritional value in rapeseed. Other antinutrients in rapeseed are phytic acid, tannins and fibre (Lee, Hill, 1983; Bourdon, Aumaitre, 1990).

Table 1. Main antinutritional factors in several protein feeds (Schang *et al.*, 1997)

Protein feed	Antinutritional factors
Soybean	Trypsin inhibitors, lectins, saponins, oligosaccharides (raffinose *etc*)
Rapeseed	Glucosinolates, tannins, phytic acids, fibre
Sunflower	Fibre
Lupine	Alkaloids, fibre
Peas	Lectins, tannins, oligosaccharides, fibre

Both, chemical composition and nutritional value of rapeseed cake are influenced by many different factors which are closely related to the processing technology and conditions (type of the oil press, temperature, humidity during the extraction process *etc*.) used in particular region. Therefore the results from different studies are often controversial and it is difficult to make any general conclusions. The aim of the study was to investigate chemical composition of locally produced expeller extracted and cold-pressed rapeseed cake. In Estonia, nutrient content of rapeseed cake has been previously investigated by Ilus *et al*. (1995) and Pedak (1997).

Material and methods

The samples of rapeseed cake were collected and analyzed during the years 1998–2002. Rapeseed cake was originated from three different commercial oil plant in Estonia – Oru Taimeõlitööstus, Werol Tehased Ldt and small scale farm Kaarli talu.

For each sample approximately 500 g of pooled rapeseed cake was collected and stored in a plastic bag until chemical analysis. A total of 14 different samples were collected and analysed.

Dry matter was determined by drying at 105 °C for 6 hours and crude ash after ignition at 500 °C for 6 hours. Crude protein (N×6.25) was estimated by Kjeldahl method with an analyser *Kjeltec Auto 1030.* Crude fat was determined by ether extraction method using *Soxtec System 1040 Extraction Unit* device. Crude fibre was determined according to W. Henneberg and F. Stohmann.

Content of organic matter and nitrogen free extractives were calculated as follows: organic matter = dry matter – crude ash; nitrogen free extractive = dry matter – (crude ash + crude protein + crude fat + crude fibre).

Gross energy content was calculated by colorimetric coefficients of different nutrients as follows (Oll, Tölp, 1997):

$$BE = (T_1 23.9 + T_2 39.8 + T_3 20.1 + T_4 17.5)/100,$$

where BE – gross energy (MJ/kg),

T_1 – crude protein content (%),
T_2 – crude fat content (%),
T_3 – crude fibre content (%),
T_4 – nitrogen free extractive content (%).

The cleaned and flaked seeds were heated at 100 ºC for 20–25 min and oil was extracted in a screwpress (Allocco S.A., Santa Fe, Argentina) at Werol Tehased Ldt (Figure 1).

The cooker consists from 7 vertically stacked kettles where flaked seeds are heated and steamed if necessary. In the cooker the temperature is rapidly increases from 30 ºC to 80 ºC and further to 100–110 ºC at the end of the process. Moisture content is reduces from 6–9% to 2–3%.

Oil press consists of a rotating screw running in a cylindrical barrel. Output of the press is one ton oil (two tons cake) per hour as an average and the capacity of engine is 150 kW. After leaving the press the cake is transported to a mixer where it is moistured and milled. Prior storage the cake is ventilated with air to cool it to 40–50 ºC.

The cleaned, flaked and preheated (20–30 min) seeds were cooked at 100 ºC for 45–50 min and oil was extracted in a screwpress at Oru Taimeõlitööstus (Figure 1).

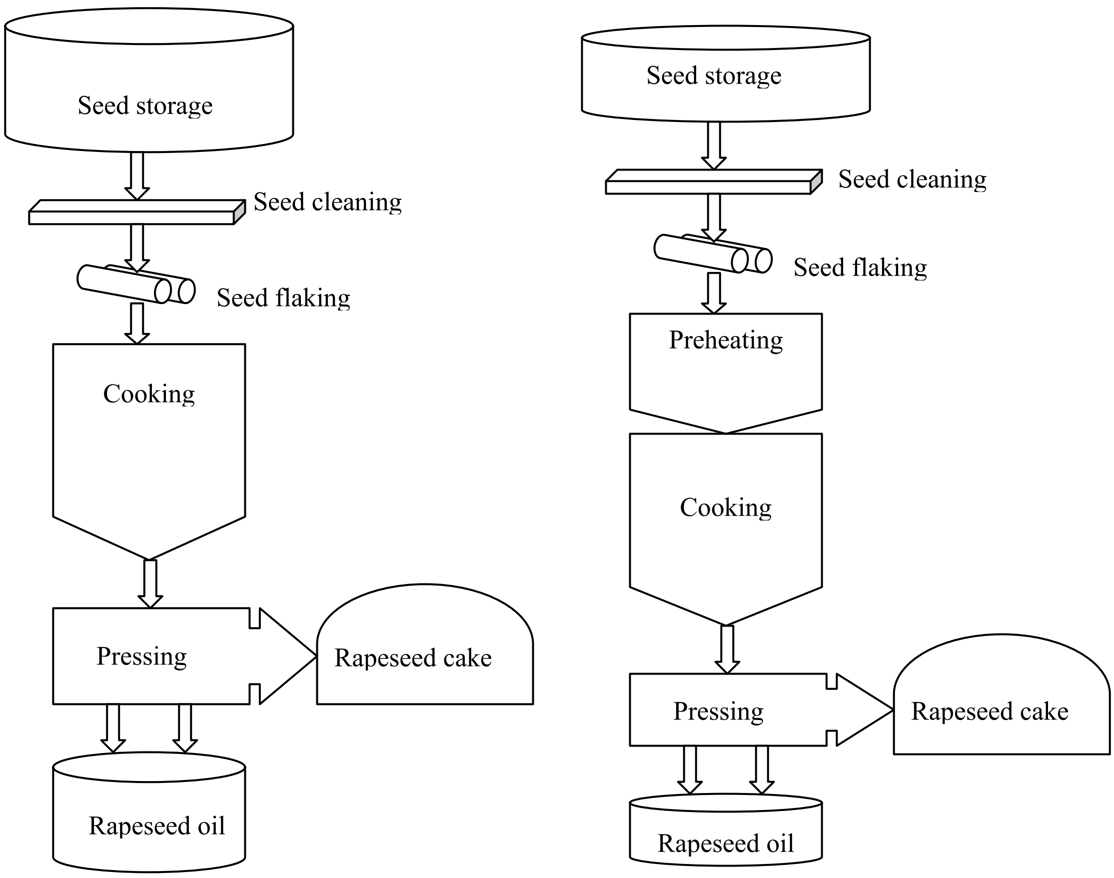

Figure 1. Production of rapeseed cake at Werol Tehased Ldt (left) and Oru Taimeõlitööstus (right)

The cooker in Oru Taimeõlitööstus consists from 3 vertically stacked kettles where rapeseed is heated at 95–105 ºC. During the cooking process the moisture content is reduced from 7–9% to 4–5%. Output of the press EPM (SKET, Magdeburg, Germany) is 80–85 kg of oil (160–170 kg of cake) per hour and the capacity of engine is 40 kW. After pressing the cake is cooled during the transport to storage.

Cold-press (Melrosten OÜ, Kose-Uuemõisa Harjumaa, Estonia) was used in Kaarli talu to produce rapeseed cake (Figure 2). The cleaned seeds were directed strait to the mechanical screwpress where the temperature shortly rises to 50–60 degrees. Rapeseed cake is granulated in nozzle exit (diameter 6,5 mm). Rotation speed of the screw was 40–45 rpm, output of the press was three kg of oil (8–9 kg cake) per hour and the capacity of engine was 1.5 kW

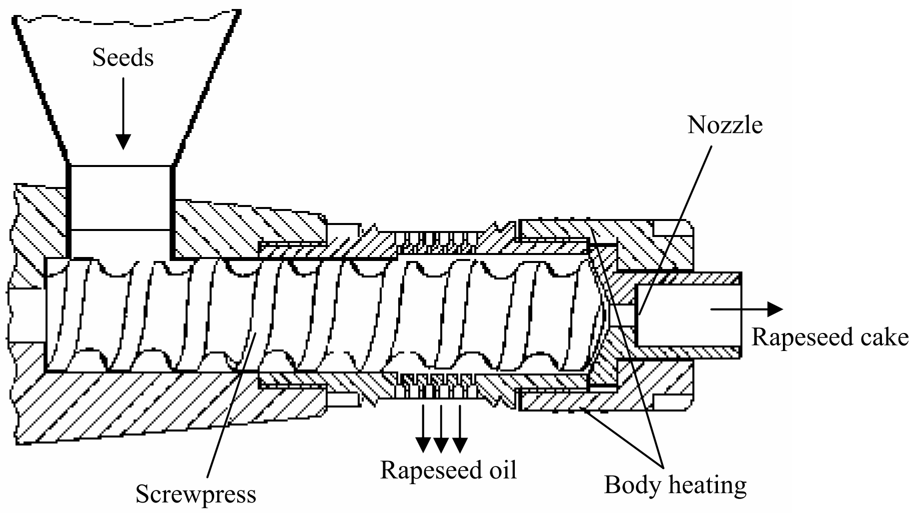

Figure 2. Production of cold-pressed rapeseed cake in Kaarli talu

Results

Chemical composition of expeller extracted rapeseed cake produced in Werol Tehased and Oru Taimeõlitööstus is showed in Table 2.

Despite the small number of samples it was found that there was a great variation in the composition of most nutrients. Average dry matter content of all samples was 95.3% and varied between 89.6% and 98.2%. Compared to other nutrients in rapeseed cake the variation in dry matter content was the largest. The content of crude protein averaged at 36.1% and varied from 30.2% to 37.8% in dry matter. The content of crude fat varied in dry matter of expeller extracted rapeseed cake from 10.3% to 15.1% being 12.2% as an average. Minimum value of crude fibre content was 11.6% and maximum 16.8% in dry matter.

It was determined contrarily to the great variation in most of the nutrients that the content of metabolizable energy was relatively stable. The difference between minimum and maximum value was only 0.4 MJ/kg.

Table 2. Nutrient content and boundary values in dry matter of expeller extracted rapeseed cake (n=13)

Traits	Expeller extracted rapeseed cake			s
	mean	min	max	
Dry matter, %	95.3	89.6	98.2	2.6
Crude protein, %	36.1	30.2	37.8	2.2
Crude fat, %	12.2	10.3	15.1	1.5
Crude fibre, %	13.1	11.6	16.8	1.6
Crude ash, %	7.1	6.5	7.4	0.3
N-free extractives, %	32.2	30.6	34.2	1.2
Phosphorus, %	1.0	0.7	1.2	0.2
Calcium, %	0.7	0.7	0.9	0.1
Gross energy, MJ/kg	21.5	21.2	22.0	0.3
Metabolizable energy, MJ/kg	14.8	14.6	15.0	0.1

The mean value for gross energy was 21.5 MJ/kg varying between 21.2 and 22.0 MJ/kg in dry matter. Variations in nitrogen free extractives, crude ash, phosphorus and calcium composition was the smallest. Differences between minimum and maximum values of these nutrients were 3.6, 0.9, 0.5 and 0.2%, respectively.

Chemical composition of expeller extracted rapeseed cake produced in Werol Tehased and Oru Taimeõlitööstus and cold-pressed rapeseed cake produced in Kaarli talu is compared in Table 3. The content of most nutrients, except for crude fat, was smaller or similar in cold-pressed compared to expeller extracted rapeseed cake. Cold-pressed rapeseed cake contained (as fed basis) less dry matter (91.7% *vs*. 95.3%), crude protein (28.0% *vs*. 34.4%), crude fibre (11.2% *vs*. 12.4%), nitrogen free extractives (28.2% *vs*. 30.7%) and more crude fat (17.8% *vs*. 11.6%). Similarly, cold-pressed cake contained 0.48 MJ more gross energy (21.0 MJ *vs*. 20.5 MJ) and 0.23 MJ metabolizable energy (14.5 MJ *vs*. 14.2 MJ) in kilogram of dry matter.

Table 3. Chemical composition and the difference in nutrient content of cold-pressed (n=1) and expeller extracted (n=13) rapeseed cake

Traits	Cold-pressed at 60 ºC		Expeller extracted		Difference ±	
	as fed	dry matter	as fed	dry matter	as fed	dry matter
Dry matter, %	91.7	100	95.3	100	–3.61	0.00
Crude protein, %	28.0	30.6	34.4	36.1	–6.42	–5.53
Crude fat, %	17.8	19.4	11.6	12.2	6.18	7.18
Crude fibre, %	11.2	12.2	12.4	13.1	–1.26	–0.88
N-free extractives, %	28.2	30.8	30.7	32.2	–2.46	–1.45
Crude ash, %	6.5	7.1	6.7	7.1	–0.25	0.04
Phosphorus, %	1.3	1.5	1.0	1.0	0.32	0.45
Calcium, %	0.9	1.0	0.7	0.7	0.21	0.26
Gross energy, MJ/kg	21.0	22.9	20.5	21.5	0.48	1.33
Metabolizable energy, MJ/kg	14.5	15.8	14.2	14.8	0.23	1.05

When comparing the nutrient content in two types of cake as dry matter basis then the value of crude protein and crude fat have the biggest differences. Cold-pressed rapeseed cake contained 5.5% less crude protein (30.6% *vs*. 36.1%) and 7.2% more crude fat (19.4% *vs*. 12.2%). There was 1.05 MJ (15.8 MJ *vs*. 14.8 MJ) more metabolizable energy in 1 kg dry matter in cold-pressed cake.

Discussion

When comparing the chemical composition of cold-pressed and expeller extracted rapeseed cake then greatest differences are in crude fat and crude protein content (Figure 3).

There is not much information in literature about nutritional value and chemical composition of cold-pressed rapeseed cake which indicates to the fact that this type of cake is not intensively studied in animal nutrition research.

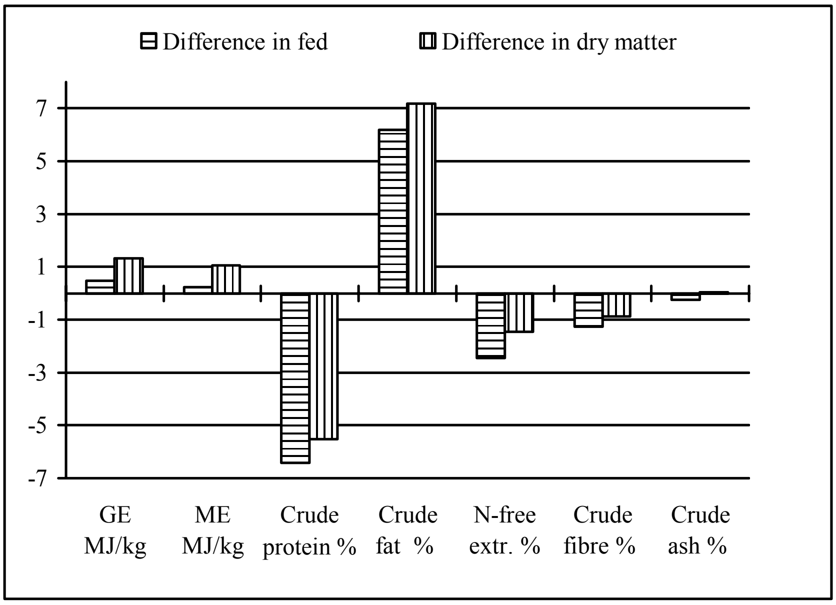

Figure 3. Difference in nutrient content of cold-pressed rapeseed cake (± from corresponding nutrients in expeller extracted rapeseed cake).

The content of dry matter and crude protein in cold-pressed rapeseed cake was similar to the results from study by Barneveld (2000). Apparent differences were seen when comparing the content of all other nutrients. Crude protein content of the cake was 19,4% in present study which was much smaller compared to corresponding results (28%) from Barneveld.

The content of dry matter, crude protein and crude fat in cold-pressed cake analysed in present study were in good correlation with the study results from Alaska investigators (Geier, 2004). The content of dry matter was 91.7% and 91.2%, crude protein 30.6% and 28.3%, crude fat 19.4% and 19.7%, respectively.

Contrarily to fat and energy content in cold-pressed cake, the content of crude protein is much smaller compared to expeller. All major differences in chemical composition between two cake types are most likely connected to the efficiency of oil removal in different extraction methods. The higher is oil content in the cake, the less it proportionally contains other nutrients. However, chemical composition of rapeseed cake is influenced by many other factors. The results of the study demonstrate the great variation in nutrient content of rapeseed cake therefore it is recommended prior diet formulation to evaluate chemical composition of any new batch of rapeseed cake purchased.

Average dry matter and protein content in expeller type cake was in good correlation to the data observed in Australia by Barneveld (2000). However, compared with the results from present study the fat content was higher by 1.5% (13.7% *vs*. 12.2%). Fat content in the cake analysed in present study was found to be similar (12.5% in dry matter) to the results from another Australian investigation (Allan *et al.*, 2000) but were different in protein content (31.8% *vs*. 36.1%). As appears the chemical content can be generally similar if compared with corresponding results from other investigators but there is always a difference in the content of one or more nutrients. Greatest differences are often seen in protein and fat content. These differences are most likely caused by various pressing technologies and conditions that are used in particular oil plant or in particular region. Pressing conditions influence the effectiveness of oil removal and thereby also the nutrient content and value of produced rapeseed cake.

To identify differences in chemical composition that are derived from variety and agrotechnology of rapeseed, it is reasonable to compare nutrient content of the cake in oil-free dry matter. Comparing for instance chemical composition in dry matter of rapeseed cake published by Pedak (1997) with the data from present investigation then apparent differences can be observed in fat and protein content (Table 4). Those differences become very small if the same comparison is made on oil-free dry matter basis and the results from present study are alike to the values reported by Pedak (1997).

Table 4. Comparison of the results from present study and the data reported by Pedak (1997) on chemical composition as in dry matter and oil-free dry matter basis of rapeseed cake

Traits	In dry matter		In oil-free dry matter	
	Pedak (1997)	present study	Pedak (1997)	present study
Dry matter, %	92.9	95.3	–	–
Crude protein, %	33.7	36.1	40.7	39.5
Crude fat, %	17.2	12.2	0	0
Crude fibre, %	12.8	13.1	15.5	14.9
N free extractives, %	30.0	32.2	36.2	36.6
Crude ash, %	6.3	7.1	7.6	8.0
Gross energy, MJ/kg	22.7	21.5	19.2	19.1

Previous investigations have indicated to the correlation between protein and amino acid content in rapeseed meal. Regression equations for predicting amino acid content from crude protein levels in rapeseed meal reported by Beste *et al.* (1992) is one of the options (Table 5).

Table 5. Regression equations for calculating amino acid content (%) from crude protein levels in rapeseed meal (88% dry matter) (Beste *et al.,* 1992)

Amino acid	Equation	Mean value	R
Arginine	%CP × 0.0758 – 0.535	2.25 (2.07–2.48)	0.73
Lysine	%CP × 0.0402 + 0.546	2.02 (1.83–2.16)	0.57
Methionine	%CP × 0.0156 + 0.181	0.75 (0.67–0.79)	0.66
Methionine + cysteine	%CP × 0.0468 – 0.033	1.65 (1.50–1.81)	0.64
Threonine	%CP × 0.0262 + 0.641	1.59 (1.45–1.65)	0.62
Tryptophan	%CP × 0.0215 – 0.294	0.50 (0.46–0.55)	0.79

In Estonia, amino acid content of rapeseed and rapeseed cake has been previously investigated by Pedak (1997). Some differences appear in amino acid content of rapeseed cake when the results from chemical analysis and the values calculated according to regression equations are compared (Table 6). Since the differences are not substantial and precise chemical analysis of amino acids is expensive then using regression equations for calculating amino acid content in rapeseed cake would be a good option for practical purposes. Furthermore, previous investigations have demonstrated similarity of amino acid content in rapeseed meal and in rapeseed cake (Keith, Bell, 1991a; Keith, Bell, 1991b).

Table 6. Amino acid content (% in dry matter) in rapeseed cake as calculated by regression equations (Beste *et al.*, 1992) and results from chemical analysis (protein content 33.7% in dry matter) reported by Pedak (1997)

Amino acid	Calculated according to Beste *et al.* (1992)	From chemical analysis (Pedak, 1997)
Arginine	2.02	2.02
Lysine	1.90	1.68
Methionine	0.71	0.64
Methionine + cysteine	1.54	–
Threonine	1.52	1.75
Tryptophan	0.43	0.54

Regression equations reported by Beste *et al.* (1992) were used for calculating amino acid content in expeller extracted rapeseed cake analysed in present study. The predictional values were calculated from crude protein levels in each particular sample. Calculated content of different amino acids and boundary values in dry matter of expeller extracted rapeseed cake are presented in Table 7. As observed, there were substantial differences between minimum and maximum values. The average contents for all amino acids where closer to the maximum value. For instance, the mean arginine content (2.2%) differed only 0.13% from the maximum value but the difference from minimum was 0.45%. Lysine content (2.0%) differed from the boundary values by 0.07% and 0.24%, respectively. Similarly, the calculated mean contents for methionine, threonine and tryptophan were found to be different from maximum values only by 0.03–0.04%.

Table 7. Amino acid content (% in dry matter) in rapeseed cake (n=13) as calculated from protein level according to regression equations reported by Beste *et al.* (1992)

Amino acid	Content in dry matter %			s
	mean	min	max	
Arginine	2.20	1.75	2.33	0.2
Lysine	2.00	1.76	2.07	0.1
Methionine	0.74	0.65	0.77	0.0
Methionine + cysteine	1.66	1.38	1.74	0.1
Threonine	1.59	1.43	1.63	0.1
Tryptophan	0.48	0.35	0.52	0.0

Amino acid contents as calculated from protein level in expeller extracted rapeseed cake were in good agreement with the values reported in Estonian feed tables and with corresponding data published by Grala *et al.* (1998). Latter similarities, simplicity, cost effectiveness and rapidness of the method are the characteristics that approve using regression equations to calculate amino acid content in rapeseed cake in practical conditions. However, it should be considered that it is a mathematical method and the results may differ substantially from the results of chemical analysis.

Summary

The aim of the study was to evaluate chemical composition of locally produced expeller extracted and cold-pressed rapeseed cake.

Cold-pressed rapeseed cake was produced at 60 ºC and the temperature during production of expeller extracted cake varied between 98–112 ºC. Comparing chemical composition of cake produced at different pressing conditions it was found that cold-pressed rapeseed cake contained less protein, nitrogen free extractives and crude fibre but more crude fat and metabolizable energy. Higher energy content in cold-pressed cake is directly related to its high oil content. Protein content in cold-pressed cake was substantially lower compared to the cake produced at higher temperatures.

There were no big differences in crude ash, calcium and phosphorus content in different cake types. The content of latter nutrients in cold-pressed cake was only 0.04–0.5% higher.

Chemical composition of rapeseed cake is influenced by pressing technology and conditions that are used in particular oil plant. Pressing conditions influence the effectiveness of oil removal and thereby also the nutrient content and value of produced rapeseed cake.

Prior diet formulation it is recommended to evaluate chemical composition and consider pressing technology of any new batch of rapeseed cake purchased. Very few studies have been carried out to investigate the feeding of cold-pressed rapeseed cake in pigs. It is recommended to investigate the presence of different antinutritional substances that can influence the nutritional value and digestibility of cold-pressed rapeseed cake.

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