Nutritional and anti-nutritional composition of rapeseed meal and its utilization as a feed ingredient for animal

FENG Dingyuan, ZUO Jianjun

College of Animal Science, South China Agricultural University, Guangzhou 510642, China Email: fengdy@scau.edu.cn

Abtract

Rapeseed cake and meal, a by-product of rapeseed, is one of the most important protein feedstuffs. Quality characteristics of rapeseed meal are given as follows: (1) The energy value of rapeseed meal is at variance, for which it is affected by its residual oil, crust and crude fiber content. (2) Rapeseed meal is an excellent protein source owing to its relatively high protein level (30%-40%), lysine, methionine and tryptophan levels as well as its low digestibility. (3) The calcium, phosphorus, selenium, iron and manganese contents in rapeseed meal are very high, but up to 65% of the P content is abound in P-phytate and thus reducing it bioavailability. (4) High levels of nicotinic acid and choline as well as low carotenoid and vitamin D levels are the main vitamins characteristics of rapeseed meal. Furthermore, variety, squeeze technique, anti-nutritional factors and its levels will also influence the nutritional value of rapeseed meal. While the main anti-nutritional factors in rapeseed meal include glucosinolates, sinapine, sinapic acid, tannin, phytic acid and crude fiber, there are some physical, chemical, biological and crop breeding methods to deal with the toxicity in rapeseed meal, of which the crop breeding is the most successful. Chinese "Double low" rapeseed and Canadian canola are main new varieties. Rapeseed meal has been widely used in the diet of some animals, and the amounts incorporated in diets of poultry, swine and cattle are usually 8%-15%, 3%-15% and 5%-20%, respectively. Presently, the anti-nutritional factors in common rapeseed meal, especially the glucosinolates and sinapic acid, are the main limiting factors for its wider application, while popularization and application for new species will bring into an available approach in solving those problems.

Key words: rapeseed meal, rapeseed cake, nutrients, anti-nutritional factors, utilization

Introduction

Rapeseed is one of the most important oil seeds in China, and it is found in abundant in Hubei, Hunan, Sichuan and Jiangsu provinces of China. It is the raw material for rapeseed cake or meal production. Rapeseed meal, the leftover after crushing and squeezing or permeating with solvent, has three kinds of forms namely powder, patch and granular, and is one kind of protein feedstuffs. Although rapeseed meal is one of the most potential protein sources, the inclusion level is difficult to increase in the diet of animals on grounds of the inherent and excessive levels of anti-nutritional factors (glucosinolates, Sinapine and non-starch polysaccharides, etc) in common *Brassica napus* rapeseed meal. The "Double-low" rapeseed (lower glucosinolates and erucic acid similar to Canola) has been introduced in China since the 1990s, and it is promoting the wilder application of the rapeseed meal as a feed ingredient.

The nutritional characteristics of rapeseed meal

The nutrient composition of rapeseed cake and meal is presented in table1.

Table1 The nutrient composition and its content of rapeseed cake and meal

Nutrients	Rapeseed cake	Rapeseed meal
DM (%)	88.0	88.0
CP (%)	35.7	38.6
EE (%)	7.4	1.4
CF (%)	11.4	11.8
NFE (%)	26.3	28.9
ASH (%)	7.2	7.3
NDF (%)	33.3	20.7
ADF (%)	26.0	16.8
Ca (%)	0.59	0.65
TP (%)	0.96	1.02
Non phytate phosphorus (%)	0.33	0.35
Pig digestible energy (MJ/kg)	12.05	10.59
Pig metabolizable energy (MJ/kg)	10.71	9.33
Poultry metabolizable energy (MJ/kg)	8.16	7.41
Beef cattle digestible energy (MJ/kg)	11.51	11.25
Dairy cow net energy (MJ/kg)	5.94	5.82
Sheep digestible energy (MJ/kg)	13.14	12.05

Source: Feng (2003)

Table 2 shows the nutrients composition of the by-products of the common rapeseed, “Double-low” rapeseed meal and rapeseeds. Compared with soybean meal, the crude protein content in rapeseed meal is 3%-8% lower, while the crude fiber content is about 2 times higher. Similarly, the levels of Ca and total phosphorus (TP) are higher too. The ether extract content of the rapeseed meal after expression is lower than that of the raw rapeseed. However, the levels of the other nutrients are comparatively higher as exemplified by crude protein (13.6%-15.0%), crude fiber (3.9%-4.2%), ash content (3.6%-4.2%), etc. The main reason for the higher nutrient content in rapeseed meal is the removal of oil from the rapeseed (38.84%-39.50%). The crude protein content in the “Double-low” rapeseed and its meal is 4.0%-5.4% higher than that in the common rapeseed and its meal. Moreover, the quality of the crude protein in the common rapeseed meal is better than the common rapeseed cake. Which have shown that crude protein contents in the products from rapeseed are affected by the varieties of the rapeseed and treatment methods. The ether extract content is more influenced by the method chosen to squeeze it. For example, the ether extract of rapeseed cake is 4 times higher than that of rapeseed meal from common rapeseed. The ADF and NDF in the “Double-low” rapeseed meal is affected more by the varieties, whose content vary among different varieties, and the coefficients of variance is reportedly by 29.3% and 30.8%, respectively (Peng and Jiang, 1999).

Table 2 The nutrient composition in the rapeseeds, rapeseed cake and meals(%)

Nutrients	Rapeseed meal and cake			Soybean meal (NY/T2)	Rapeseed	
	Common rapeseed meal	Common rapeseed cake	“Double-low” rapeseed meal		Common rapeseed	“Double-low” rapeseed
DM	90.18±0.77	92.34±0.63	91.88±0.55	-	93.00±0.55	94.38±0.11
CP	37.84±0.89	34.78±0.55	40.26±1.13	43.00	20.00±0.05	25.31±0.88
EE	2.04±0.42	8.62±1.06	3.45±0.06	1.90	39.50±0.70	38.84±0.75
NFE	28.30±0.55	28.06±1.51	-	-	-	-
CF	11.92±0.40	10.35±0.65	11.57±0.36	5.10	7.20±0.00	7.38±0.33
NDF	-	-	31.86±5.48	-	-	-
ADF	-	-	23.40±3.62	-	-	-
Ash	8.40±0.76	8.26±0.72	7.90±0.31	6.00	4.20±0.00	4.29±0.27
Ca	0.65±0.01	0.57±0.10	0.66±0.03	0.32	-	0.46±0.00
TP	0.99±0.03	1.12±0.09	1.04±0.02	0.61	-	0.53±0.01

Source: Xi (2002)

Its crust and the crude fiber content, as well as the technique used in expressing the oil is determined the energy content of the rapeseed meal. Also, the level of residual oil influences it. The higher the residual oil, the higher energy level. The energy level of rapeseed meal for pig was reported to be the highest among the values for pig, cattle and poultry, and that for cattle was higher than that for poultry. The digestibility of protein in rapeseed meal is lower than that of soybean meal, but in general, the rapeseed meal is abundant in all kinds of amino acids. Moreover, which is relatively comparable to what prevailed in soybean meal (see table 3). Although the lysine and tryptophan content in rapeseed meal are higher than that of some other kinds of protein ingredients, the arginine content is the lowest. And the methionine content in the feedstuff is higher and only inferior to gingili meal. The ratio between lysine and arginine is about 100:100, which is lower than the ideal ratio (100:120) in animal ration. The rapeseed meal can be also used to balance the amino acid, for example lysine etc. The Ca and P contents are very high, but up to 65% of the phosphorus content is bound to phytate (P-phytate), which makes the phosphorus availability very low. The Se content is 0.16-0.29 mg/kg, and it is 10 times higher than that in soybean meal. The Fe and Mn contents are also high, about 653-687 mg/kg and 78.1-82.2 mg/kg respectively. The niacin (160 mg/kg) and choline (6400-6700 mg/kg) contents in rapeseed has been reported to be very high (Feng, 2003). On the other hand, carotene and vitamin D contents were deficient, whereas thiamin and riboflavin content were found to be relatively low when compared to other plant meals (Feng, 2003).

Table 3 The amino acids composition and content in the rapeseed meal(%)

Component	Rapeseed cake	Rapeseed meal
DM	88.0	88.0
CP	35.7	38.6
Arginine	1.82	1.83
Histidine	0.83	0.86
Isoleucine	1.24	1.29
Leucine	2.26	2.34
Lysine	1.33	1.30
Methionine	0.60	0.63
Cysteine	0.82	0.87
Phenylalanine	1.35	1.45
Tyrosine	0.92	0.97
Threonine	1.40	1.49
Tryptophan	0.42	0.43
Valine	1.62	1.74

Source: Feng (2003)

Although the protein quality of rapeseed meal matches that of the soybean meal, certain essential amino acids, particularly lysine was observed to have a lower bioavailability than that in soybean meal because of the occurrence of Maillard reaction during rapeseed processing into the cake/meal. Zou *et al*. (1992) investigated the rapeseed processing in Sichuan province and found that the highest protein digestibility for pig in relation to three kinds of rapeseed meal were 74.14%, 66.76% and 63.68% for equipment type 95, tape 200 processed and type 95 solvent extract, respectively. It is shown that higher temperature and longer processing time had adverse effects on the protein quality. Li (1993,1995) determined the amino acid content of rapeseed cakes processed by the type 95, 200 and low temperature to be 1.20±0.35%, 1.51±0.25% and 1.76±0.29% respectively, and the mean of the three processing cakes was reportedly 1.24%, yet the rapeseed meal is 1.32%. The mean amino acid bioavailabilities of rapeseed cake, rapeseed meal and low-temperature processing cake were also found to be 84.02%, 86.29% and 90.82% respectively. The lysine bioavailabilities of low-temperature processing cake, rapeseed meal and high-temperature processing cake were 89.1%, 79.2% and 73.3% respectively.

The quality standard of rapeseed cake and meal as animal feed ingredients established in China is mainly based on the crude protein, crude fiber, ether extract and ash levels (see table 4).

Table 4 The quality standard of rapeseed cake and meal as animal feed ingredient in China

Component	No.1		No.2		No.3	
	Rapeseed cake	Rapeseed meal	Rapeseed cake	Rapeseed meal	Rapeseed cake	Rapeseed meal
CP	⩾37.0	⩾40.0	⩾34.0	⩾37.0	⩾30.0	⩾33.0
CF	<14.0	<14.0	<14.0	<14.0	<14.0	<14.0
EE	<10.0	<5.0	<10.0		<10.0	
ASH	<12.0	<6.0	<12.0	<8.0	<12.0	<8.0

Source: GB (10374-89)

The anti-nutritional factors of rapeseed meal and its detoxification

The anti-nutritional factors, which exert adverse effect on growth, health and general welfare of animal, do so through variety of approach to affect digestion, absorbance and availability of the nutrients in the feedstuffs (Huisman and Tolman, 1992). Although the nutrition value of rapeseed meal is approximate to the soybean meal, the application of rapeseed meal is practically limited due to the high levels of some harmful substance as well as many anti-nutritional factors, such as glucosinolates, sinapine and its derivative, tannin, phytic acid, crude fiber etc. Glucosinolates and sinapine are considered to exert the most effect in terms of the application of rapeseed. Glucosinolates, generally exists in the potassium salts form, which include glucosinolates and glucoside, have no anti-nutrition effect of itself. The products of the hydrolysis of glucosinolates with endogenesis thioglucosidase, particularly oxazolidine thione (OZT), thiocyanate, isothiocyanate (ITC) and nitriles are considered to be more harmful than the intact glucosinolates (Wang and Feng, 2000). Even though thioglucosidase in the raw materials becomes in-anctive when processed, the products of rapeseed will be still possible to produce toxicity to animal because the enzyme from some intestinal microorganism has the same active substance similar to thioglucosidase. On the other hand, glucosinolates can be degradated under acid and alkaline conditions too. OZT and ITC are the important anti-nutritional factors because they affect the iodine absorbance, and result in goiter. OZT, referred to as goitrogen, has a strong anti-thyroxine function. While ITC badly influences the palatability of feedstuffs, as well as destroys the exterior of the digestive system. Isothiocyanate strongly affects the rapeseed meal palatability and has a violent stimulatory function to the mucous membrance, which result in gastroenteritis, scours, even pulmonary edema and goiter in pigs because thyroid follicular sets restrained from condensing with iodine. OZT counteracts the synthesizing reaction of thyroxine in non-ruminant animal, which decreases the thyroxine concentration in the blood, and brings about goiter because of thyroid cell hyperplasia in a bid to promote pituitary to excrete more thyrotropin. Thiocyanate affects the conversion of the iodine and results in goiter in the end. Isothiocyanate and thiocyanate are spicy and thus greatly affect the palatability of rapeseed meal. Nitrile is the other metabolites form of glucosinolates. Its toxicity is 10 times greater than that of OZT, and it can make the liver and the kidney intumescent (Slominski *et al*., 1988). When the content in animal ration exceeds 5 mg/g, glucosinolates will adversely affect the animal performance. In a general way, the duck is more sensitive than the broiler, and the broiler is more sensitive than the pig. High glucosinolates content in rapeseed made the broiler liver hemorrhagic (Campbell *et al*., 1991), and pig liver intumescent (Busato *et al*., 1991). Generally, the mean contents of glucosinolates in common rapeseed, *Brassica napus*, *Brassica rapa*, *Brassica juncea* have been reported to be 3%-8%, 6.13%, 4.04%, 4.85% respectively, or expressed as 50-100 μmol/g for all of them (Bell, 1993). The maximum level of glucosinolates in animal ration cannot exceed 2.5 μmol/g, and the level of glucosinolates and its metabolites under 2.4 mmol/kg could not affect pig performance likewise its thyroid function, when 250 μg/kg iodine was added to the pig ration (Schone *et al*., 1991).

Common rapeseed meal contains a lot of glucosinolates, and the main five kinds are 3-bultylene- glucosinolates, 4-amylene-glucosinolates, 2-hydroxide-3-bultylene-glucosinolates, 2-hydroxide-4- amylene-glucosinolates, and 2-allyl-glucosinolates. Those found in *Brassica napus* meal includes 3-bultylene-glucosinolates and 2-hydroxide-3-bultylene-glucosinolates, while *Brassica rapa* includes 3-bultylene-glucosinolates. The levels of glucosinolates in three different kinds of rapeseed are shown in table 5.

Table 5 glucosinolates content and its products content in rapeseed cake and meals

Item	Common rapeseed cake	Common rapeseed meal	"Double low" rapeseed meal
Total glucosinolates(%)	2.42±0.67	0.69	1.35±0.18
OZT (mg/kg)	2566±612	1458	901±271
Isothiocyanate (mg/kg)	2152±694	1423	1165±84
Nitrile (mg/kg)	420±2520	-	

Source: Xi (2002)

Sinapine (4-hydroxide-3,5-dimethyl cinnamic cholinesterase), an ester product formed from the reaction between erucic acid and cholinergic, and another anti-nutritional factor in rapeseed, is instable and can easily be hydrolyzed without the aid of enzyme to get erucic and cholinergic. Sinapine is bitter, and reduces the palatability as well as generate egg's beany flavor because of the aggregation of TMA in eggs. TMA, a sinapine degraded products, is volatile and give off beany flavor. Another character of sinapine is that it is easily hydrolyzed. Currently, erucic acid has little effect on the performances of animal except that when animals take a lot of it, it induces fat aggregation in cardiac muscle and cardiac muscle putrescence. Sinapine content is only about 1% in common rapeseed meal and is 0.6%-1.8% in "Double low" rapeseed meal (Bell, 1993).

Erucic acid, no sinapine (the product of sinapine hydrolysis), is another anti-nutritional factor that found in crucifer crop, such as rapeseed. The erucic acid content in Chinese common varieties is very high. Erucic acid is composed by 22-carbon atom and the unsaturated fatty acid with 1 double bond. The erucic acid contents are 22%-66% in rape oil from common rapeseed and reduce to 2.6% in "Double low" rapeseed meal (Chen, 2003). As a toxin, erucic acid can slow growth, cause hypogenesis, tumescence of heart, change fat content of the heart, impair cardiac muscle, increase death rate, decrease thrombocyte content as well as reproductive ability. Using male rats, it was shown that these were decrease in spermatogenesis and immaturity of sperms when the erucic acid content in the rat ration was more than 10%.

The mean content of tannin in common rapeseed cake, common rapeseed meal and "Double low" rapeseed meal have been variously but separately reported to be about 0.62% (Wang, 1988; Li *et al*., 1993; Shao *et al*., 1992), 0.52%(Li *et al*., 1993) and 0.65% (Peng, 1999; Qing, 2005) respectively. Tannin tastes saline and affects its palatability. However, tannin in rapeseed meal has little effect on palatability compared to that in sorghum. Moreover, tannin can combine with digestive enzyme, especially pepsin, and decrease the availability of protein in rapeseed meal.

The phosphorous content in rapeseed meal is higher than some other plant feed ingredients, and the total phosphorous content can reach up to about 1%, but the most are phytate phosphorus. The highest contents of phytic acid and phytate phosphorus in common rapeseed meal is up to 2% and 0.67% respectively (Feed Databank in China, 2005). "Double low" rapeseed meal has good effect on decreasing glucosinolates and erucic acid content, and increase phytic acid content as well. In general, total phosphorous content in "Double low" rapeseed meal is 0.94%-1.13%, while phytate phosphorus content reaches 72%-77% of the total phosphorous. Phytic acid cannot be digested in the gut of non-ruminants, which tends to reduce the availability of phosphorus. Thus phytate reduce the digestibility of protein and essential mineral elements because of complexing them, especially Zn which is reduced to 44.1%.

The availability of energy in rapeseed is low, due to its high fibre content. Compared with conventional varieties, "Double low" varieties, with low content of erucic acid and glucosinolates, have a disadvantage owing to the presence of fibre, especially NSP that is considered as an anti-nutrient. The level of NSP, cellulose and other NSP, are 17.9%, 4.9% and 13.8% respectively. Other NSP are usually made up of arabinoxylans, xylose, galactose, uronic acid and mannose, etc (Slominski and Campbell, 1990). Other compositions in fibre are some oligosaccharide. Bell and Hicklin (1999) reported that the contents of NSP, CF, ADF and NDF in rapeseed were 16.1%, 12.0%, 17.2% and 21.2%, respectively. While the levels of CF, NDF, ADF were 1.4%, 33.3% and 26.0% in rapeseed cake, and 11.8%, 20.7% and 16.8% in rapeseed meal respectively (Feed Databank in China, 2005). Peng (2000) indicated that the ADF, NSF, NDSP, AND in four "double low" varieties were 18.6%-22.6%, 24.4%-30.1% and 7.0%-9.1%, respectively. These results show that high content of fibre affects the energy value in rapeseed.

The alexipharmic methods of rapeseed meal are physical, chemical, biological method and crop breeding (Wang and Feng, 2000). Physical methods include inactivation of myrosinase and shelling, and the former consisted of steam heating, roasting, microwave treatment and bulking etc. For the methods cannot stop reaction of enzymes hydrolyzing erucic in animal, physical methods are rarely applied in real production. Milling with water can activate myrosinase to reduce the glucosinolates. Drying enhances volatilization of isothiocyanates, while extraction causes glucosinolates to survive by 40%-80% in rapeseed meal (Schone *et al*., 1996). Heat treatment inactivates myrosinase, and Schone *et al*. (1993) considered that supplementation of enzymes from microorganism was indispensable to hydrolyze glucosinolates. Other investigators held contrary viewpoint that inactivating myrosinase caused glucosinolates to be stabilized which improved the rate of oil yield (Liu *et al*., 1994). Jensen *et al*. (1995) reported that heat treatment at 100°C for 15, 30, 60 and 120 min reduced the level of glucosinolates by 24%, 46%, 70%, 95% respectively, and the solubility of protein as well. In general, heat treatment at 100°C for 30 min was the best.

The simplest method of detoxifying rapeseed meal is by immersion in water. The treatment with water (1:6) for 15-20 min can decrease glucosinolates by 98% and DM by 30% (Fauduct *et al*., 1995). Thacker (1998) reported that microwave treatment of intact rapeseed improved its nutrient values in the diet for pigs, which was attributed to the reduction in the activities of myrosinase. Shelling can reduce the toxin content, and invariably decrease protein content.

Acid and alkaline degradation, metal salts degradation and solvent extractions constitute the chemical method. Acid and alkaline degradation reduced toxicity when H_2SO_4, NaOH, KOH, NH_3, $Ca(OH)_2$ were used, however these treatments require heat treatment, expensive and goes with pollution. The rapeseed meals from acid and alkaline degradation are of poor quality and also affect the palatability of animal. Metal salts degradation catalyze glucosinolates hydrolyzation with metal salts such as iron, copper and so on. The second method only works in reducing glucosinolates content. In the process of solvent extraction, the solvents including ethanol, carbinol, acetone and water etc., decreases lower molecular weight glucosinates.

Biological methods usually include fermentation and hydrolyzation catalyzed by enzyme. In the case of the former, rapeseed meal is fermented with yeast or other microorganism to reduce the toxin. The latter catalyzes the hydrolysis of glucosinolates with activators (such as vitamin C etc.) and enzymes in rapeseed meal.

Crop breeding is one way to develop new varieties with low erucic acid and glucosinolates, which is the most successful among the four methods. “Double low” rapeseed is an excellent protein feedstuff for livestock owing to its high protein content and well-balanced amino acids. In a study by Bell (1993) on Canola, it was shown that the glucosinolates content was below 30 μmol/g based on dry matter-ont-fat, and the erucic acid content was below 2% based on total fatty acid (50-100 μmol/g and 25%-45% in common varieties). However, the biosafety of gene-improved new varieties should be given more attention.

Utilization of rapeseed meal in animal ration

If undetoxified rapeseed meal containing the anti-nutritional agents is used in chicken rations, then severe struma, bleeding of liver may happen. This is shown in most of chicken breeds with the white leghorn showing the most severe response. The common rapeseed meal is not usually used in formulating diets for young chickens. 10%-15% of high-quality rapeseed meals are aptly used in later stage diet for broilers. In order to avoid debasing the quality of chicken, less than 10% of rapeseed meal in diet for broilers should be chosen. As for laying hens, 8% of rapeseed meal in the diet is suitable, and 12% level will reduce egg weight as well as the rate of hatch. Superfluous rapeseed meal results in similar bad smell similar to rotten fish, the reason of which is that microorganism in the gut of chicken will turn sinapine into trimethylamine with the consequent bad smell. Rapeseed meals with high content of glucosinolates lead to iodine deficiency disorders of young chicken on day 9. The energy value of it is much various with animal, mensuration method and so on, which is different with other plant-protein feedstuffs. In different growing phase of broilers, ME values of rapeseed are different, for example 1375 Kcal/kg for young chicken vs. 2265Kcal/kg for adult broiler (Japanese feeding standards, 1975). ME of rapeseed meal for chicken is reported to be 1630 Kcal/kg according to Japanese feeding standards (1975), and 2040 Kcal/kg according to NRC (1984). ME of rapeseed cake and rapeseed meal in Chinese feeding standards is usually 8.16 MJ/kg and 7.41 MJ/kg, respectively.

In recent years, “Double low” varieties have gained much attention by way of the quantities that are planted in China. However, in many cases the presence of glucosinolates in rapeseed meal is still considered as a factor re-stricting its inclusion level in the diet for non-ruminants, owing to both the physiological and anti-nutritional impact. For example, Slominski and Campbell (1991) reported that goiter and liver tumescence were observed in chicken and rat respectively when 30% of rapeseed meal was added to their rations.

Theoretically, complex enzymes including xylanase and α-galactanase can improve nutrient utilization because of the presence of high level of α-galactan (2%-9%) and NSP, especially xylan in rapeseed meal. Some soybean oligosaccharides, raffinose and stachyose about 2.5% are observed in this feedstuff (Slominski and Campbell, 1991). Slominski *et al*. (1994) reported that the digestibility of NSP in Canola meal with low oligosaccharides was higher than that of common Canola varieties. Bedford and Morgam (1995) indicated that xylanase supplemented in diet with canola meal improved the performance of broilers. Feng and Shen (2005) set up the system of “effective nutrients improvement value (ENIV)” to calculate nutrient values of feedstuff supplemented with enzymes. The ENIV values of ME and protein for poultry fed rapeseed meal supplemented with xylanase and cellulase etc are about 120-170 Kcal/kg and 3.5%-5.2%, respectively.

DE values of rapeseed cake and meal for swine are 12.5 MJ/kg and 10.59 MJ/kg respectively. The characteristic of common varieties of rapeseed meal are then not being palatable to swine, which bring thyroid, kidney and liver tumefaction, reduction of growth rate by 30%, decline of reproduction performance of sow. Fitting amount of common rapeseed meal used in diet are 5% for hog, 3% for sow, and that of “Double low” varieties are 15% for hog, 12% for boar, more than 10% for hog without fat softening. Supplemented with premix enzymes containing xylanase and cellulase, the ENIV values of ME and digestible protein in rapeseed meal were 100-135 Kcal/kg and 3.5%-5.2 % (Feng and Shen, 2005).

Though rapeseed meal used in cattle diet reduces palatability and results in goiter, its effect is not much in contrast with non-ruminants. The amounts of this feedstuff used in the diets are 5%-20% for beef cattle and less than 10% for cow with normal milk yield and milk fat. New varieties of rapeseed meal with better feeding effect, can be increased the amount in cattle ration.

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