Evaluation of Twice Decorticated Sunflower Meal as a Protein Source Compared with Soybean Meal in Pig Diets[a]

O. Cortamira*, A. Gallego[1] and S. W. Kim[2]
Instituto Nacional de Tecnologìa Agropecuaria - EEA Pergamino, Argentina

ABSTRACT : A series of four experiments was conducted to compare nutritional values of decorticated sunflower meals against soybean meal, in diets for pigs from weaning (Exp. 1 and 2) to finishing (Exp. 3 and 4). All experimental diets were prepared compensating for the energy content by using vegetable oil and the lysine content was matched using synthetic L-Lysine HCl. Twenty-one day old pigs were fed either corn-soybean meal based diet (CSBM) or corn-twice-decorticated sunflower meal based diet (CDSM) for four weeks (Exp. 1). There was no difference in performances between treatment groups. In Exp. 2, corn-non-decorticated sunflower meal based diet (CNSM) was added to the existing two treatments. Twenty-one day old pigs were fed three experimental diets for four weeks. Pigs fed CNSM had a lower weight gain and feed intake than other treatments ($p<0.05$). There was no difference between pigs fed CSBM and CDSM (Exp. 2). Growth performance of growing pigs was also greater ($p<0.05$) in pigs fed corn starch-twice-decorticated sunflower meal based diet (CSDSM) than pigs fed corn starch-non-decorticated sunflower meal based diet (CSNSM) during the eight week feeding trial (Exp. 3). There was no difference between pig fed corn starch-soybean meal based diet (CSSBM) and CSDSM (Exp. 3). In Exp. 4, growing pigs were fed three experimental diets (CSBM, CDSM, and barley-twice-decorticated sunflower meal based diet; BDSM) until the slaughter. There was no difference in growth performance of pigs during growing and finishing periods among treatments. However, pigs fed CSBM had a higher carcass dressing percentage ($p<0.05$) than pigs fed CDSM and BDSM. Pigs fed BDSM diet had a lower fat tissue percentage than other groups ($p<0.05$). The twice-decorticated sunflower meal can be used as a substitute for soybean meal in pig diets. The performances of piglets and growing-finishing pigs were not affected when soybean meal was replaced by twice-decorticated sunflower meal. This substitution needs the contribution of synthetic lysine and vegetable oil as sources of complementary nutrients to match the nutrient profile. (*Asian-Aus. J. Anim. Sci. 2000. Vol. 13, No. 9 : 1296-1303*)

Key Words : Decorticated Sunflower Meal, Pigs, Carcass, Growth Performance

INTRODUCTION

The pig industry is based on the utilization of vegetable products and their by-products as main sources of nutrients. The cereals or starch products furnish principally the energy and the oil-by-products the proteins to satisfy nutrient requirements.

The concept of nutrient availability has changed the way diets are formulated. Furthermore, Noblet et al. (1989) showed that net energy value for feedstuffs ingredients gives a new evaluation of carbohydrates and lipids content, while protein and fiber content have negative regression coefficients. Thus the diets are formulated by the ideal protein concept (Wang and Fuller, 1989; Chung and Baker, 1992).

These novel stepforwards in animal nutrition changed the concept of using feedstuffs such as soybean meal and sunflower meal, and it allowed their incorporation in to pig diets without lowering animal performances (Mariscal Landin, 1992).

Delic et al. (1964) suggested that sunflower meal has higher levels of tryptophan and methionine, but a lower lysine content than soybean meal. Smith (1968) proposed that the low lysine and high fiber contents limited the use of sunflower meal as an economic alternative replacing soybean meal in pig diets. Seerley et al. (1974) noted that sunflower meal, with more than 20% of fiber, reduced the average daily weight gain and decreased the gain/feed ratio of finishing pigs. Thacker et al. (1984) suggested that depressive effects of sunflower meal can be removed by reducing the fiber content of the meal with decorticating process and adding synthetic amino acid.

With decortication, the fiber content in sunflower meal can be reduced and crude protein content can be increased. Twice-decorticated sunflower meal (SUNECO™, Oleaginosa Moreno, Argentina) contains 25% less fiber and 12% more crude protein than conventional sunflower meal (non-decorticated sunflower meal).

The purpose of this study was to evaluate the nutritional values of a twice-decorticated sunflower meal compared to soybean-wheat bran meal in iso-nutritive diets for pigs from weaning to finishing.

* Address reprint request to O. Cortamira. Tel: +542477-431250, Fax: +542477-432553, Email: ocortamira@pergamino.inta.gov.ar.
[1] Oleaginosa Moreno S. A. Bahia Blanca. Argentina.
[2] Department of Animal Sciences, University of Illinois, Urbana IL 61801, USA.
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MATERIALS AND METHODS

A series of four experiments (Exp. 1 and 2 with nursery pigs, Exp. 3 with growing pigs, and Exp. 4 with growing-finishing pigs) were conducted to evaluate the biological effects of soybean-wheat bran meals substitution by sunflower meal in pig diets.

Exp. 1: Twenty (Landrace × Pietrain) castrated male piglets (initial body weight: 5.3±0.83 kg) from five litters were used to compare the nutritional value of twice-decorticated sunflower meal with soybean-wheat bran meal. Pigs were weaned at 21 days of age and were individually caged in pens, measuring 0.5 × 1.1 m and a full steel-wire floor, in a controlled environment (28℃) using a randomized complete block design. Corn and vegetable oil were major energy sources for both control and treatment diets. Soybean and wheat bran meals were used as a principal plant source protein in the control diet and twice-decorticated sunflower meal replaced its in the treatment diet (table 1). Fishmeal and dried skim milk were added as protein sources for both diets. Pigs were fed either control (CSBM) or treatment diet (CDSM) during the four weeks after weaning.

Exp. 2: Thirty (Yorkshire × Duroc) castrated male piglets (initial body weight: 6.8±0.78 kg) from ten litters were used to compare nutritional value of non-decorticated sunflower meal with twice-decorticated sunflower meal or soybean-wheat bran meals. Pigs were weaned at 21 days of age and were individually caged in pens, measuring 0.5 × 1.1 m and a full steel-wire floor, in a controlled environment (28℃) using a randomized complete block design. The same diets from Exp. 1 were used for the control (CSBM) and twice-decorticated sunflower meal diet (CDSM). Non-decorticated sunflower meal diet (CNSM) was formulated by replacing twice-decorticated sunflower meal by non-decorticated sunflower meal proportionately without balancing for nutritional value (table 1). Pigs were fed experimental diets during four weeks after weaning with a feeding regimen based on a daily consumption of 120 g of food per one kilogram of metabolic weight ($kg^{0.75}$) in order to reduce diet waste and the individual variation for each animal.

Exp. 3: A third experiment was designed where the protein contribution from testing ingredients can be a major source in the experimental diets. Thirty (Yorkshire × Duroc) castrated male pigs (initial body weight: 29.4±4.82 kg) from 10 litter origins were used. Pigs were individually caged in pens, measuring 0.8 × 1.25 m and a full steel-wire floor, in a controlled environment (20℃) using a randomized complete block design. Corn-starch was used instead of corn in order to increase treatment effects by decreasing protein contribution from other ingredients. Soybean-wheat-bran meals were used as a major protein source in the control diet (CSSBM), and twice-decorticated sunflower meal (CSDSM) or non-decorticated sunflower meal (CSNSM) replaced soybean-wheat-bran meal in the treatment diets (table 2). Pigs were fed experimental diets for eight weeks. Diets and water were provided ad libitum.

Exp. 4: Thirty-six (Yorkshire × Duroc) castrated

Table 1. Composition of experimental diets for Exp. 1 and Exp. 2

Ingredient, %	CNSM	CDSM	CSBM
Corn	56.81	56.81	57.04
Sunflower meal			
Non-decorticated	20.00	-	-
Twice decorticated	-	20.00	-
Soybean meal	-	-	20.00
Fish meal	12.18	12.18	10.33
Dried skim milk	5.00	5.00	5.00
Wheat bran meal	-	-	3.00
Vegetable oil	3.25	3.25	1.55
Dicalcium phosphate	0.66	0.66	1.07
Limestone	0.49	0.49	0.57
L-Lysine HCl	0.42	0.42	0.17
DL-Methionine	-	-	0.07
Calcium propionate	0.05	0.05	0.05
Zinc oxide	0.20	0.20	0.20
Vitamin-mineral premix[1]	0.50	0.50	0.50
Flavorings	0.10	0.10	0.10
NaCl	0.35	0.35	0.35
Total	100.00	100.00	100.00
Chemical analysis			
ME, mcal/kg (calculated)	3.19	3.22	3.29
Crude protein, %	19.82	20.70	20.60
Lysine, %	1.34	1.38	1.40
Methionine, %	0.53	0.55	0.50
Calcium, %	1.18	1.18	1.30
Av. phosphorus, % (calculated)*	0.35	0.37	0.39

CSBM: corn-soybean-wheat-bran meal, CDSM: corn-twice decorticated sunflower meal, CNSM: corn-non- decorticated sunflower meal.

* Av. phosphorus = available phosphorus.

[1] Vitamin-mineral premix provided per kilogram of complete diet: Fe, 100 mg; Zn, 100 mg; Cu, 10 mg; Mn, 40 mg; Co, 2 mg; I, 1 mg; retinol 3 mg; cholecalciferol 0.1 mg; DL α-tocopherol acetate, 20 mg; phytilmenoquinone, 1 mg; thiamin, 2 mg; riboflavin, 10 mg; calcium pantothenate, 20 mg; pyridoxine, 10 mg; niacin, 30 mg; ascorbic acid, 40 mg; biotin (1%), 0.2 mg; cyanocobalamin, 0.05 mg; choline, 400 mg, and carbodox, 50 mg.

Table 2. Composition of experimental diets for Exp. 3

Ingredient, %	CSNSM	CSDSM	CSSBM
Corn starch	48.50	48.50	48.60
Sunflower meal			
Non-decorticated	40.00		
Twice decorticated		40.00	-
Soybean meal	-	-	31.00
Fish meal	1.00	1.00	1.00
Wheat bran meal	-	-	14.00
Vegetable oil	5.95	5.95	1.50
Dicalcium phosphate	2.60	2.60	1.70
Limestone	0.70	0.70	1.24
L-Lysine HCl	0.45	0.45	-
DL-Methionine	-	-	0.16
Vitamin-mineral premix[1]	0.50	0.50	0.50
NaCl	0.30	0.30	0.30
Total	100.00	100.00	100.00
Chemical analysis			
ME, mcal/kg (calculated)	3.11	3.16	3.16
Crude protein, %	14.69	16.08	16.01
Lysine, %	0.89	0.96	0.96
Methionine, %	0.29	0.30	0.29
Calcium, %	0.95	0.95	0.95
Av. phosphorus, % (calculated)*	0.42	0.47	0.45

CSSBM: corn starch-soybean-wheat-bran meal, CSDSM: corn starch-twice decorticated sunflower meal, CSNSM: corn starch-non-decorticated sunflower meal.

* Av. phosphorus = available phosphorus.

[1] Vitamin-mineral premix provided per kilogram of complete diet: Fe, 100 mg; Zn, 100 mg; Cu, 10 mg; Mn, 40 mg; Co, 2 mg; I, 1 mg; retinol 3 mg; cholecalciferol 0.1 mg; DL a-tocopherol acetate, 20 mg; phytilmenoquinone, 1 mg; thiamin, 2 mg; riboflavin, 10 mg; calcium pantothenate, 20 mg; pyridoxine, 10 mg; niacin, 30 mg; ascorbic acid, 40 mg; biotin (1%), 0.2 mg; cyanocobalamin, 0.05 mg; choline, 400 mg, and carbodox, 50 mg.

male pigs (initial body weight: 30.3±5.25 kg) from 12 litter origins were used for the fourth experiment. Three dietary treatments were employed in this experiment. The control group was fed a diet with corn as a major energy source and soybean-wheat bran meal as a major protein source (CSBM), and twice-decorticated sunflower meal (CDSM) replaced soybean meal as a major protein source. In addition, barley replaced corn in CDSM diet (BDSM) to test the effect of a different ingredient as a major energy source (table 3). All experimental diets had the same protein (amino acids) and energy levels. Pigs were individually caged in pens, measuring 0.8 × 1.25 m and a full steel-wire floor, in a controlled environment (20℃) using a randomized complete block design. The whole experimental period was divided into growing and finishing periods. Pigs were fed grower diets until 60 kg of live body weight and then were fed finisher diets until 95 kg of live body weight. To reduce diet waste and the individual variation of each animal, diets were provided at a fixed amount of 125 g per one kilogram of metabolic weight ($kg^{0.75}$). Pigs were slaughtered at the end of experiment. After slaughtering, carcasses were stored in a cool room (-4℃) overnight. The left half of the carcass, after removing the head, was weighed and partial dissections were done. Lean and fat percentages were predicted using the equation of Desmoulin et al. (1988). Tissue samples were obtained from internal layers and external layers of backfat at the 5th rib to analyze the composition of fatty acids. Fatty acids were extracted from the sample with petroleum ether (60℃). Fatty acid composition was determined (AOCS, 1998) using gas chromatography (Varian 2700) with a packed column (15% EGSS-XCWAC-DMCS 100/120 2Mx1/8'' SS) and flame-ionized detector.

Statistical analysis of the data of all experiences were performed using the General Linear Model Procedure (PROC GLM) in SAS/STAT software (SAS, 1989). Least-squares means, probability of differences, and variation coefficients were obtained to evaluate differences among treatment means. Due to health problems, one pig from Exp. 1 and two pigs from Exp. 3 were removed.

RESULTS

Exp. 1 and 2 (piglets)

In Exp. 1, pigs had the same feed intake whether they were fed a corn-soybean-wheat-bran meal based diet or the corn-twice-decorticated sunflower meal based diet (table 4). There was no difference in daily weight gain and feed/gain ratio between groups (table 4). Replacement of soybean-wheat bran meal with twice-decorticated sunflower meal plus synthetic lysine and vegetable oil did not alter the performance of piglets.

The same trend was obtained from Exp. 2. Pigs which received corn-twice-decorticated sunflower meal based diet did not show any growth depression compared with pigs that received corn-soybean-wheat-bran meal based diet (table 5). The feed intake and feed/gain ratio were the same between CSBM and CDSM (table 5). However, pigs from CNSM showed lower feed intakes ($p<0.05$) than CSBM or CDSM pigs (table 5). Average daily gain of CNSM pigs was also less than CSBM or CDSM pigs ($p<0.05$). Pigs, which received the CNSM diet, showed lower feed efficiency (feed/gain ratio) than the other groups ($p<0.05$).

Exp. 3 (growing pigs)

The single effect of plant source protein was evaluated in Exp. 3. Additional plant protein sources

Table 3. Composition of experimental diets for Exp. 4

Ingredient, %	Grower			Finisher		
	CSBM	CDSM	BDSM	CSBM	CDSM	BDSM
Corn	53.17	58.56	-	65.06	72.93	-
Barley	-	-	53.88	-	-	66.55
Twice decorticated sunflower	-	30.48	31.00	-	22.66	23.86
Soybean	28.80	-	-	19.16	-	-
Fish	3.00	3.00	3.00			
Wheat bran	8.10	-	-	12.00	-	-
Vegetable oil	3.61	4.35	8.60	0.56	0.59	0.59
Dicalcium phosphate	0.89	1.53	1.48	0.70	1.55	1.48
Limestone	1.78	1.07	1.08	1.87	1.37	1.39
L-Lysine HCl	-	0.36	0.31	-	0.25	0.17
Vitamin-mineral premix	0.40	0.40	0.40	0.40	0.40	0.40
NaCl	0.25	0.25	0.25	0.25	0.25	0.25
Total	100.00	100.00	100.0	100.00	100.00	100.0
Chemical analysis						
ME, Mcal/kg (calculated)	3.13	3.13	3.13	2.99	2.99	2.99
Crude protein, %	18.72	18.91	18.50	15.26	15.20	14.85
Lysine, %	1.00	1.00	1.00	0.73	0.70	0.70
Methionine, %	0.44	0.46	0.45	0.40	0.41	0.39
Calcium, %	0.95	0.95	0.95	0.85	0.85	0.85
Av. phosphorus, % (calculated)*	0.44	0.44	0.45	0.35	0.36	0.36

CSBM: corn-soybean-wheat-bran meal, CDSM: corn-twice decorticated sunflower meal, BDSM: barleytwice decorticated sunflower meal.

* Av. phosphorus = available phosphorus.

[1] Vitamin-mineral premix provided per kilogram of complete diet: Fe, 80 mg; Zn, 80 mg; Cu, 8 mg; Mn, 32 mg; Co, 1.6 mg; I, 0.8 mg; retinol 2.4 mg; cholecalciferol 0.08 mg; DL a-tocopherol acetate, 16 mg; phytilmenoquinone, 0.8 mg; thiamin, 1.6 mg; riboflavin, 8 mg; calcium pantothenate, 16 mg; pyridoxine, 8 mg; niacin, 24 mg; ascorbic acid, 32 mg; biotin (1%), 0.16 mg; cyanocobalamin, 0.04 mg; choline, 320 mg.

were removed in Exp. 3 by replacing corn with corn-starch. Similar to the results from Exp. 1 and 2, pigs fed CSDSM diet had greater ($p<0.05$) average daily gain than pigs fed CSNSM diet (table 6). Feed intake was the same among the three treatment groups (table 6). The feed/gain ratio was lower in CSDSM pigs than CSNSM pigs ($p<0.05$).

Exp. 4 (growing-finishing pigs)

There was no difference in feed intake among treatments during the growing period. The average daily gain of pigs was also the same among treatments. Also, substitution of barley for corn did not affect performance of pigs during the growing period. During the whole experimental period, there were no differences in feed intake, average daily gain, and feed/gain ratio among treatments (table 7).

Dressing percentage of pigs after slaughter was higher ($p<0.05$) in CSBM than CDSM and BDSM (table 8). Body composition was estimated using Desmoulins equations (1988). There were no differences in lean tissue percentage among treatments (table 8). However, carcasses of pigs fed BDSM diet had a lower fat tissue percentage than the other groups ($p<0.05$).

Fatty acids compositions for the internal and external backfat layers are shown in tables 9 and 10. In both layers, a similar profile of fat acids was observed, but there are significant differences caused by experimental treatments. Pigs given the BDSM diet showed a lower percentage of saturated fat acid and a higher percentage of linoleic acid than pigs fed with CSBM or CDSM ($p<0.05$). Only in the internal layer, a higher content of stearic acid was shown in pigs fed the CSBM than in pigs which received CDSM ($p<0.05$).

Table 4. Growth performance of piglets in Exp. 1

	CSBM	CDSM	CV	SS
n	10	9		
Daily feed intak, kg	0.48	0.47	11.46	NS
Average daily gain, kg	0.28	0.27	18.91	NS
Feed/gain ration	1.72	1.75	12.61	NS

CSBM: corn-soybean-wheat-bran meal, CDSM: corn-twice decorticated sunflower meal, n: number of animals, CV: coefficient of variation (%), SS: statistical significance ($p<0.05$), and ns: no difference.

Table 5. Growth performance of piglets in Exp. 2

	CSBM	CDSM	CNSM	CV	SS
n	10	10	10		
Daily feed intake, kg	0.54[b]	0.53[b]	0.50[a]	4.32	P=0.010
Average daily gain, kg	0.31[b]	0.28[b]	0.24[a]	12.40	P=0.001
Feed/gain ratio	1.72[b]	1.85[b]	2.13[a]	10.40	P=0.002

CSBM: corn-soybean-wheat-bran meal, CDSM: corn-twice decorticated sunflower meal, CNSM: corn-non-decorticated sunflower meal, n: number of animals, CV: coefficient of variation (%), and SS: statistical significance, and P: probability of null hypothesis.

[a,b] Within a row, means lacking a common superscript letter differ ($p<0.05$).

Table 6. Growth performance of pigs in Exp. 3

	CSSBM	CSDSM	CSNSM	CV	SS
n	8	10	10		
Daily feed intake, kg	1.78	1.84	1.77	3.56	P=0.061
Average daily gain, kg	0.57[ab]	0.61[b]	0.54[a]	8.35	P=0.014
Feed/gain ratio	3.12[ab]	3.03[b]	3.33[a]	5.51	P=0.008

CSSBM: corn starch-soybean-wheat-bran meal, CSDSM: corn starch-twice decorticated sunflower meal, CSNSM: corn starch-non-decorticated sunflower meal, n: number of animals, CV: coefficient of variation (%), and SS: statistical significance, and P: probability of null hypothesis.

[a,b] Within a row, means lacking a common superscript letter differ ($p<0.05$).

Table 7. Growth performance of growing and finishing pigs in Exp. 4

	CSBM	CDSM	BDSM	CV	SS
Growing period					
n	12	12	12		
Daily feed intake, kg	2.13	2.16	2.17	8.40	P=0.823
Average daily gain, kg	0.78	0.79	0.80	6.43	P=0.343
Feed/gain ratio	2.78	2.70	2.70	6.87	P=0.772
Whole period					
n	12	12	12		
Daily feed intake, kg	2.61	2.65	2.66	7.04	P=0.783
Average daily gain, kg	0.82	0.82	0.82	5.60	P=0.841
Feed/gain ratio	3.22	3.22	3.22	5.78	P=0.834

CSBM: corn-soybean-wheat-bran meal, CDSM: corn-twice decorticated sunflower meal, BDSM: barleytwice decorticated sunflower meal, n: number of animals, CV: coefficient of variation (%), SS: statistical significance, and P: probability of null hypothesis.

Table 8. Carcass performance of finishing pigs after slaughter in Exp. 4

	CSBM	CDSM	BDSM	CV	SS
Slaughter weight, kg	94.4	95.8	95.4	7.24	P=0.876
Carcass weight, kg	75.7	75.4	74.9	7.31	P=0.935
Dressing percent, %	80.3[a]	78.8[b]	78.4[b]	7.55	P=0.003
Lean tissue percentage, %	49.2	49.1	49.4	4.03	P=0.938
Fat tissue percentage, %	28.2[a]	28.4[a]	25.8[b]	8.47	P=0.021

CSBM: corn-soybean meal, CDSM: corn-twice decorticated sunflower meal, BDSM: barleytwice decorticated sunflower meal, n: number of animals, CV: coefficient of variation (%), SS: statistical significance, and P: probability of null hypothesis.

[a,b] Within a row, means lacking a common superscript letter differ ($p<0.05$).

DISCUSSION

The iso-nutritive replacement of soybean-wheat-bran meal (SWM) by twice-decorticate sunflower meal (TDSM) did not affect animal performance. This replacement means that synthetic lysine and vegetable

oil additions are necessary to equal the available amino acid and metabolizable energy contents in the diets. The results correspond with those reported by Wahlstrom et al. (1986) who showed that performance of pigs with 8 kg live weight were not affected by a corn-sunflower meal diet when the levels of essential amino acid were identical to a corn-soybean meal diet.

When TDSM was replaced quantitatively by non-decorticated sunflower meal, feed efficiency was reduced, and a decreased feed intake was observed resulting in a decrease in body weight gain. These results could be due to lysine deficit or a low metabolizable energy, due to a higher content of fiber observed in non-decorticated sunflower meal. The results from Ochetim and Attia (1979) are very similar that of the current study. They reported a decrease in amino acid and energy digestibility when milk powder was totally replaced by sunflower meal in young pig diets. At 50% substitution, the digestibility of sunflower nutrients was similar to the control. These aspects would allow us to explain the reduction of performance animals when fed with non-decorticated sunflower meal in our experiments.

Several workers have proved that the use of synthetic lysine in cereal-sunflower diets is necessary to equal the lysine content of a cereal-soybean meal diet (Russom et al., 1972; Nielsen and Aherne, 1981). However, this results depends on the fiber content of sunflower meal. Our results are coincident with those obtained by Seerley et al. (1974) who observed that lysine supplementation of pig diets with non-decorticated sunflower meal did not compensate for a lower feed efficiency. Moser et al. (1984) found that the high fiber content in sunflower meal reduced the metabolizable energy concentration. According to Hegedus and Fekete (1994), soybean meal could be replaced by sunflower meal, if the levels of lysine and metabolizable energy meet the nutrient requirements of pig. Zettl et al. (1993) concluded that substitution of soybean meal by sunflower meal reduced the digestibility of dry matter and crude protein. According to Thacker et al. (1984), barley-soybean and barley-sunflower diets for finishing pigs have a similar profile of essential amino acid, with the exception of lysine content. However, the diets based on sunflower meal had a higher digestibility of essential amino acids except for lysine than the diets with soybean meal (Kalenyuk, 1991; Mariscal Landin, 1992). These results did not agree with those who measured digestibility of pure raw materials. It could mean that an energy interaction could affect the availability of amino acids in sunflower meal. Therefore, the twice-decorticated sunflower meal, with low fiber content, is a good complement to cereal diets for pigs with supplementation of synthetic lysine as was shown by our results. Wetscherek et al. (1993a) and Vukié et al. (1982) obtained similar conclusions when they studied the substitution of soybean meal by decorticated sunflower meal with 44% crude protein.

Wetscherek et al. (1993b) proposed that the body

Table 9. Fatty acid composition of internal layer of backfat in finishing pigs (Exp. 4)

Fatty acid percentage	CSBM	CDSM	BDSM	CV	SS
Myristic acid (14:0)	1.37[a]	1.47[a]	1.11[b]	10.3	P=0.0001
Palmític acid (16:0)	22.3[a]	22.7[a]	16.8[b]	6.84	P=0.0001
Palmitoleic acid (16:1)	2.90[a]	2.92[a]	2.24[b]	13.8	P=0.0004
Steáric acid (18:0)	10.8[a]	9.46[b]	8.24[c]	14.4	P=0.0011
Oleic acid (18:1)	39.5[a]	39.6[a]	30.6[b]	5.65	P=0.0001
Linoleic acid (18:2)	19.8[a]	20.4[a]	37.6[b]	15.1	P=0.0001

CSBM: corn-soybean meal, CDSM: corn-twice decorticated sunflower meal, BDSM: barleytwice decorticated sunflower meal, n: number of animals, CV: coefficient of variation (%), SS: statistical significance, and P: probability of null hypothesis.
[a,b,c] Within a row, means lacking a common superscript letter differ ($p<0.05$).

Table 10. Fatty acid composition of external layer of backfat in finishing pigs (Exp. 4)

Fatty acid percentage	CSBM	CDSM	BDSM	CV	SS
Myristic acid (14:0)	1.42[a]	1.52[a]	1.10[b]	13.8	P=0.0001
Palmític acid (16:0)	21.6[a]	22.5[a]	16.3[b]	9.18	P=0.0001
Palmitoleic acid (16:1)	2.95[a]	3.11[a]	2.34[b]	15.4	P=0.0006
Steáric acid (18:0)	8.58[a]	7.88[a]	6.81[b]	12.6	P=0.0008
Oleic acid (18:1)	40.9[a]	40.7[a]	32.6[b]	6.47	P=0.0001
Linoleic acid (18:2)	21.0[a]	21.0[a]	37.2[b]	17.9	P=0.0001

CSBM: corn-soybean meal, CDSM: corn-twice decorticated sunflower meal, BDSM: barleytwice decorticated sunflower meal, n: number of animals, CV: coefficient of variation (%), SS: statistical significance, and P: probability of null hypothesis.
[a,b] Within a row, means lacking a common superscript letter differ ($p<0.05$).

composition and the meat quality were not affected by the substitution of soybean meal by decorticated sunflower meal in finishing pig diets. This agrees with our results. However, when cereal source was changed from corn to barley, pigs had a lower content of body fat.

Pigs fed diets either with cornsoybean-wheat-bran meal or corn-TDSM had a similar fatty acid profile. But pigs fed a diet with barley-TDSM presented an increase of linoleic acid and a reduction of saturated fatty acid. These results agree with those obtained by Courboulay and Massabie (1994) when they used full-fat sunflower seed in diets for finishing pigs.

Many studies have proved that dietary lipid affects the composition of the animals body fat (Desmoulin et al., 1983; Mourot et al., 1991). In addition, it is known that there is a high negative correlation between dietary linoleic acid content and firmness of body fat in pigs. The use of high levels of hydrogenous sunflower oil in finishing pig diets increased the firmness of body fat but reduced weight gain (Soumi et al., 1993).

The diets with corn-soybean-wheat-bran meal and corn-twice-decorticated sunflower meal need 0.56 and 0.59% of vegetable oil supplementation, respectively, while barley-twice-decorticated sunflower meal based diet needs 5.9% of vegetable oil supplementation (ten times more) to balance the metabolizable energy in the diets. The high level of vegetable oil in barley-twice-decorticated sunflower meal diet could explain the high linoleic acid and the low saturated fatty acid contents in the backfat of the pig's carcass. Furthermore, the substitution of soybean-wheat-bran meal by twice-decorticated sunflower meal with a low inclusion of oil will not change the back fat composition in finishing pigs.

CONCLUSIONS

The twice-decorticated sunflower meal can be used as a substitute for soybean meal in pig diets. The growth and carcass performances of piglets and growing-finishing pigs were not affected when soybean meal was replaced by twice-decorticated sunflower meal. This substitution needs the contribution of synthetic lysine and vegetable oil as sources of complementary nutrients to match the nutrient profile.

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