The University of Manitoba

The Utilization of Canola Meal by Young Growing Pigs

by

Ian Robert Seddon

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ABSTRACT

Four experiments, involving 140 pigs in performance and digestibility studies, were conducted to evaluate canola meal (CM) in comparison to soybean meal (SBM) as a protein supplement for young growing pigs. In experiments 1, 2 and 3, CM replaced 0, 50 or 100% of the SBM supplement on an isonitrogenous basis in isocaloric wheat-based diets for pigs fed from 14 to 32 kg. The effects of different lysine levels (0.74 or 0.84% total lysine) on performance were also studied. Feed intake and daily gains of pigs were reduced ($P<0.05$) when CM replaced 100% of the SBM supplement. Feed to gain ratios were similar ($P>0.05$) for all diets. Pigs fed diets formulated to contain 0.84% total lysine had nonsignificant ($P>0.05$) improved gains compared to pigs fed diets formulated to contain 0.74% total lysine.

In experiment 4, pigs initially weighing 6 kg were fed a prestarter diet until an average final weight of 14 kg. Following this, a starter diet was fed for the weight range of 14 to 32 kg. Four isocaloric diets were formulated for each part of the experiment. CM and synthetic lysine replaced 0, 35, 69 or 82% of the SBM in the prestarter diets whereas CM alone replaced 0, 32, 51 or 100% of the SBM on an isonitrogenous basis in the starter diets. The prestarter diets were formulated to contain similar available lysine levels. Pigs fed the prestarter diets had similar ($P>0.05$) feed intakes, daily gains and feed to gain ratios. However, pigs fed the wheat-SBM starter diet had improved ($P<0.05$) feed intakes

and daily gains compared to pigs fed the CM supplemented diets. Overall, pigs fed wheat-SBM diets from 6 to 32 kg in experiment 4 had improved ($P<0.05$) feed intakes and daily gains compared to pigs fed CM supplemented diets. Feed to gain ratios were similar ($P>0.05$) for all dietary treatments.

Digestibility studies conducted in experiments 3 and 4 indicated there were treatment differences ($P<0.05$) observed for apparent fecal dry matter, nitrogen and amino acid digestibilities. Complete replacement of SBM by CM usually resulted in lower digestibility coefficients but the results were not always consistent since increasing the level of CM in the diets did not always cause reductions in apparent digestibility. In experiment 4, dry matter and nitrogen digestibility coefficients were higher by 3.6 and 2.0% respectively when pigs were fed the starter diets as compared to the prestarter diets indicating an age (adaptation) effect for the young pig.

From these experiments it appeared complete (100%) replacement by CM caused reduced feed intakes and significantly lower gains. However partial (50%) replacement of SBM by CM (i.e. 12% in the diet) did not cause reduced performance thus CM could be included at up to 12% in diets for pigs 14 to 32 kg. The results of the prestarter period in experiment 4 indicated up to 14% CM and 0.5% added lysine could be used to replace 82% of the SBM without reducing performance of pigs over the weight range of 6 to 14 kg. The differences in digestibility coefficients did not help explain the reduced performance of pigs fed the CM supplemented diets.

TABLE OF CONTENTS

Page

Page

List of Tables

List of Appendices

Page

LIST OF ABBREVIATIONS

i) amino acids

Ala	alanine
Arg	arginine
Asp	aspartic acid
Cys	cystine
Glu	glutamic acid
Gly	glycine
His	histidine
Ile	isoleucine
Leu	leucine
Lys	lysine
Met	methionine
Pro	proline
Ser	serine
Thr	threonine
Tys	tyrosine
Val	valine

ii) others

CM	canola meal
d	day
DE	digestible energy
DM	dry matter
g	gram
HCl	hydrochloric acid
kg	kilogram
lysine HCl	lysine hydrochloride
M^2	square metres
ml	millilitre
mg	milligram
mg g^{-1}	milligram per gram
MJ kg^{-1}	megajoule per kilogram

N	nitrogen
NaOH	sodium hydroxide
SBM	soybean meal
ul	microliter
umol g^{-1}	micromole per gram

INTRODUCTION

The nutritive value of canola meal (CM) as a protein supplement in animal feed has increased due to improvements in breeding and processing of the seed (Bell et al., 1981; Youngs et al., 1981). CM can be used as the sole protein supplement for finishing pigs (Bell, 1984; Baidoo and Aherne, 1987b) however the optimum replacement value of CM for SBM in prestarter, starter and grower diets has not been clearly established (Bowland, 1975; McKinnon and Bowland, 1977; Narendran et al., 1981; Baidoo and Aherne, 1987a). When including CM in diets, consideration should be given to nutrient availabilities and digestibilities, especially lysine.

Lysine is considered to be the first-limiting amino acid in pig diets (Kerr et al., 1983). Guidelines have been issued suggesting the optimum levels required for growth (NRC, 1979). Nevertheless, similar to the CM situation, there is considerable disagreement regarding the optimum lysine level to include in diets for young pigs (NRC, 1979; ARC, 1981; Lewis et al., 1981).

The lack of agreement concerning the optimum levels of CM and lysine in diets for young pigs indicates further research is required on this topic. Thus, the present studies were carried out to:

a) to evaluate live performance of pigs (14-32 kg) fed diets formulated to various lysine levels.

b) evaluate the replacement value of CM for SBM in diets of young pigs (6-14 kg);

c) evaluate the replacement value of CM for SBM in diets of young pigs (6-32 kg) based on available supplemental lysine;

All diets included semidwarf wheat (cv. Oslo) as the basal energy source.

LITERATURE REVIEW

Introduction

Early weaning of pigs, most commonly at ages of 21 to 35 days, has become an increasingly common practice in commercial pig production. Consequently, the question of which are the optimum diets for pigs, initially weighing 5 to 10 kg, has resulted in more research investigating the physiological aspects of digestion in the young pig as well as its nutrient requirements. Furthermore, the suitability of various feedstuffs in the young pig's diet has been more extensively investigated. In most studies, the researchers have used young pigs with low initial weights (5 to 10 kg) and have fed them to final weights of 20-30 kg.

In this literature review, the more recent research will be discussed with respect to the following areas:

a) Digestion in the young pig.

b) Nutrients for the young pig - especially lysine.

c) The use of canola meal in growing pig diets, especially for the younger pig.

Digestion in the Young Pig

The trend of weaning pigs at a very young age, 17-35 days, has resulted in a higher incidence of poor postweaning growth encountered for up to 10 days postweaning (Bayley and Carlson, 1970; Owsley et al., 1986b). Suckling pigs receive a highly digestible liquid diet (i.e. sow's milk) containing approximately 25% lactose, 30% protein and 35% fat on a dry matter basis (Nelssen, 1986) whereas weaned pigs are frequently fed a dry cereal-soybean meal starter diet containing approximately 60% carbohydrates, 20% protein and 5% fat. With such a large change in diet-type from nursing to weaning, the ability of young pigs to quickly adapt and digest a cereal-soybean meal diet has been questioned. Therefore, it is important to establish when the early-weaned pig can adapt to a change in dietary ingredients. The following will review changes in digestive enzyme secretions and activities in early life and some of the feeding trial data related to this area.

Digestive enzymes and activities

i) Proteolytic enzymes

Much research has been conducted in recent years studying protein digestion in the young pig. Hartman et al. (1961) and Lindemann et al. (1986) reported low gastric proteolytic activity for the first two weeks of life, followed by a rapid increase.

Lindemann et al. (1986) also reported that pigs weaned at 4 weeks of age had almost twice the gastric peoteolytic activity by 6 weeks of age that comparable nursing pigs had. Thus, they concluded that enzyme production and activity was responsive to the diet.

The activities of pancreatic enzymes increase with the age of the pig (Corring et al., 1978; Efird et al., 1982a,b; Lindemann et al., 1986; Owsley et al., 1986a). Efird et al. (1982a) reported that pigs (3.5 kg) weaned at 16 days of age had significantly higher intestinal activities of chymotrypsin and trypsin by day 22 compared to nursing pigs, whereas the nursing pigs had higher pancreatic activities of the same enzymes. Since total activities of these enzymes were similar for both sow-reared and weaned pigs, Efird et al. (1982a) suggested weaning affects the intestinal and pancreatic enzyme levels. Similar conclusions were reported by Lindemann et al. (1986).

ii) Lactase and amylase

Lactase, an enzyme which hydrolyzes lactose, shows high activity at birth and decreases with age (Nelssen, 1986). Pancreatic amylase has been reported to increase in pigs up to six weeks of age for both nursing and weaned pigs (Corring et al., 1978; Lindemann et al., 1986). The pigs used in these studies had access to either creep feed or sow's feed thus, the increase in amylase secretion and activity was probably due to the need for amylase to digest starch.

iii) Lipase

Corring et al. (1978) and Lindemann et al. (1986) reported an increase in pancreatic lipase up to six weeks of age for nursing pigs, however Lindemann et al. (1986) reported pancreatic lipase activity in weaned pigs, 4 weeks old, significantly decreased by one week after weaning and remained low. The post weaning diet of Lindemann et al. (1986) contained less than 4% fat thus, the decline in lipase activity is not unexpected since lipase secretion and activity is usually adjusted to the dietary fat content.

Feeding experiments

i) Antigenic responses in young pigs

Lindemann et al. (1986) and Owsley et al. (1986a) reported that pigs weaned at 4 weeks of age had sufficient pancreatic enzyme activities to digest typical starter diets however, both reported a decrease in pancreatic amylase, trypsin and chymotrypsin activities during the first week postweaning, followed by a subsequent increase of activity. Reasons for this are unclear, but Newby et al. (1984) suggested early weaned pigs (3 weeks old) may have an antigenic response to their diets at weaning, especially if the pigs receive small amounts of creep feed prior to weaning. Miller et al. (1986) suggested the possibility of an interaction between the gut immune system, activated by absorbed food antigens, and the intestinal

epithelium. Based on this one study, it appears as if absorptive capacity of the intestine is impaired by protein antigens for a period of up to 11 days postweaning (Newby et al., 1984) after which time absorptive function returns to normal. This may partially explain the postweaning lag often associated with early-weaned pigs.

ii) Protein utilization

Walker et al. (1986a, b) reported significantly higher dry matter digestibilities and amino acid availabilities for pigs (5.8 kg) weaned at 21 days fed diets with a milk protein supplement compared to a soy protein supplement. Such differences, especially for lysine, accounted for the significant differences noted in daily gain and feed efficiency for these pigs. The apparent digestibility of SBM increased over time to the extent that differences among SBM and milk diets were nonsignificant by 35 days of age. Similar results were obtained by Wilson and Leibholz (1981 a, b, c, d).

iii) Fat utilization

Many studies have been conducted using a wide range of fats or oils added to diets of young pigs less than 28 days old. Conflicting results have been reported but the most recent evidence seems to indicate that when protein, vitamin and mineral levels of the diet are increased as the energy level of the diet

increases, then pigs weaned at 21 to 35 days appear to utilize energy from fat as well as that of carbohydrates (Leibbrandt et al., 1975a, b; Wolfe et al., 1978; Aherne et al., 1982).

In summary, the current practice of weaning pigs at 17 to 35 days of age in order to improve overall pig productivity has made it necessary to understand the development of digestive function in the young pig so that optimum diet compositions can be obtained for specific weaning ages. Based on enzyme studies and practical feeding trials it appears that a period of 7 to 10 days is required for the digestive system of the newly weaned pig to adapt from a highly digestible liquid diet to a usually lower digestible dry diet.

Nutrients for the Young Pig - Especially Lysine

Young growing pigs require a palatable, highly digestible diet because of the rate of growth that such a young pig can achieve. Compared to older growing and finishing pigs, the young growing pig requires in its diet higher levels of essential amino acids, digestible energy, vitamins and minerals. Among the essential amino acids to be considered in most pig diet formulation, lysine is the first-limiting amino acid. Since 1980, considerable research has been done on the lysine requirement of the young growing pig. Some of the interest in the requirement

was created by the difference in lysine recommendations by NRC (1979) and ARC (1981).

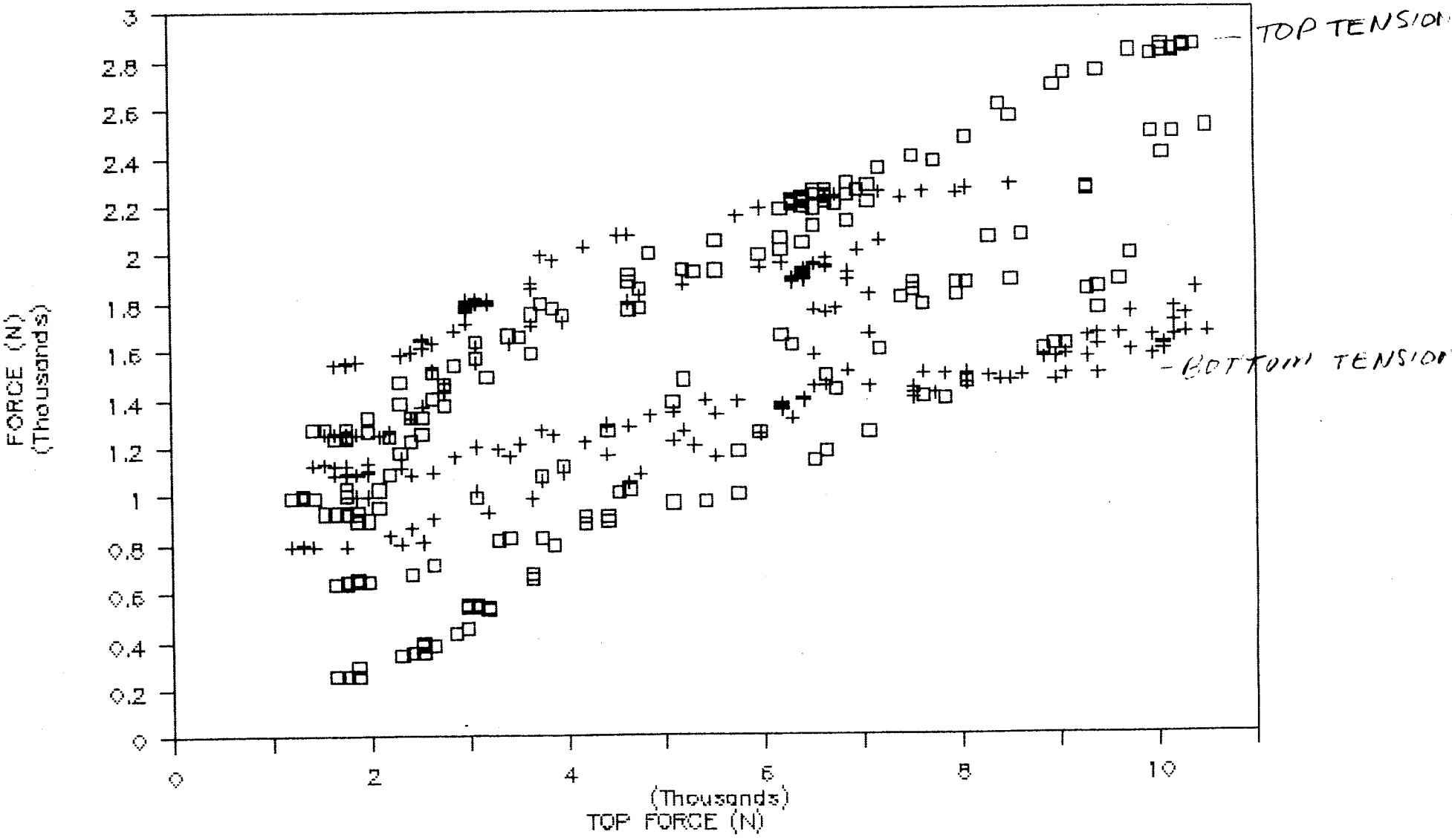
The National Research Council (NRC, 1979) suggested lysine requirements of 0.95% for 5 to 10 kg pigs and 0.79% for 10 to 20 kg pigs. By comparison, the Agriculture Research Council (ARC, 1981) suggested a lysine requirement of 7 g lysine/100 g crude protein or 1.44% of the diet for pigs 3 to 8 weeks of age. Since lysine is the first-limiting amino acid in typical starter and grower pig diets, the establishment of accurate requirement data is of great importance to the swine industry.

Dietary lysine requirement for 5 to 20 kg pigs

Several studies have been reported in recent years suggesting optimum lysine levels for young pigs. Campbell (1977, 1978) suggested that pigs weighing 5 to 20 kg, fed wheat-SBM diets, required a crude protein content of 19 or 20% and 1.01 to 1.10% lysine. Lewis et al. (1981) suggested that pigs weighing 5 to 15 kg, fed corn-SBM diets containing 19% crude protein, required 1.15 to 1.25% lysine. Rosell and Zimmerman (1983, 1984) suggested a minimum lysine requirement of 1.12% for weanling pigs (initial weight 5 kg) fed sorghum-soybean diets; and 1.15 or 1.20% for weanling pigs (initial weight 5 kg) fed corn-soybean or sorghum-soybean diets containing 17 and 18.5% crude protein respectively. Aherne and Neilsen (1983) suggested that pigs weighing 7 to 19 kg, fed wheat-barley-SBM-based diets, required

TEST H PANEL/GRAIN

BULKED DATA



20% crude protein and approximately 1.15% lysine. The above studies reported crude protein levels similar to NRC (1979) and ARC (1981) recommended levels (20 and 20.5% for young pigs respectively). Digestible energy of the diets reported above ranged from 14.1 MJ kg^{-1} (Aherne and Nielsen, 1983) to 14.9 MJ kg^{-1} (Campbell, 1978) which are similar to NRC (1979) and ARC (1981) recommendations of 14.6 and 14.6 MJ kg^{-1} respectively.

Amino acid imbalances and antagonisms in typical starter pig diets

Currently, pig diets are formulated to contain the recommended crude protein and lysine levels. Such formulation may result in other amino acids being present in excess or deficient amounts and, at least one possible antagonism between lysine and arginine has been identified (Southern and Baker, 1984).

Aherne and Nielsen (1983) suggested a lysine requirement of 1.15% for pigs 7-19 kg. A further increase to 1.30% tended to decreased performance. Rosell and Zimmerman (1984) noticed reduced feed intake when adding synthetic lysine to a low protein (17%) starter diet, suggesting a second amino acid may be limiting. If the protein level was increased (to 18.5%), no reduction occurred. However, Lewis et al. (1986) indicated lysine levels between 1.15 and 1.75% in a simple corn-soybean (18.5% protein) diet did not affect feed intake or daily gains regardless of the source of supplemental lysine (either synthetic lysine or SBM). Feed efficiencies increased in response to SBM, between

1.15-1.75% lysine, but not in response to synthetic lysine. These researchers concluded that 6 kg pigs had a lysine requirement of 1.15% and that increasing lysine up to 1.75% did not adversely affect pig performance.

Use of synthetic amino acids in typical pig diets

Supplementing lower protein diets with synthetic amino acids may reduce feed costs. Studies have shown that only lysine is deficient when crude protein levels of starter, grower and finisher diets are reduced two percentage units below NRC (1979) recommendations (Lunchick et al., 1978; Easter and Baker, 1980). However, further reductions in crude protein caused decreased gains in grower pigs even with supplemental synthetic lysine (Kerr et al., 1983) which suggested other amino acids became limiting. Research conducted to date has indicated crude protein levels in starter, grower and finisher diets can be reduced by 4 percentage units in corn-SBM based diets if supplemented with lysine, tryptophan and threonine (Russell et al., 1980; Corley and Easter, 1983; Cromwell et al., 1983).

The lysine requirement of pigs 20-30 kg

As with young starter pigs, there is considerable interest in the lysine requirement of older starter pigs. Baker et al. (1975) suggested a requirement of 0.77% lysine for pigs 18-31 kg. fed a typical corn-soybean diet containing 16% protein. This

requirement was in good agreement with the NRC (1973) suggested level of 0.79% lysine and a 16% protein diet for pigs 20-35 kg, however it is higher than the current NRC (1979) recommendation of 0.70% lysine for the same diet. Henry (1984) suggested a lysine requirement of 0.85% for gilts (17-43 kg) fed a typical corn-soybean diet. Thus, it appears as though current NRC (1979) recommendations are below those necessary for optimum performance.

In summary, considerable research has been conducted to determine the optimum dietary lysine level for young pigs. Reports suggest a level of 1.10-1.20% is necessary for optimum performance of pigs fed from 5-20 kg (Campbell, 1978; Lewis et al., 1981; Rosell and Zimmerman, 1984) and a level of at least 0.77-0.85% for pigs 20-30 kg (Baker et al., 1975; Henry, 1984). Both levels are well in excess of current NRC (1979) recommendations. Crude protein recommendations (NRC, 1979) appear adequate to ensure that the other essential amino acids are present at required levels. Present formulation procedures based on a total lysine and crude protein content tend to result in some amino acids present in excess quantities but such levels do not seem to cause reduced performance.

Canola Meal for Growing Pigs

Soybean meal (SBM) is considered to be the major source of supplementary protein in pig diets in North America (Aherne and Kennelly, 1982). However, alternative protein sources are continually being investigated for their suitability in pig diets in comparison to soybean meal. Canola meal (CM), the residual material following oil extraction of low erucic acid, low glucosinolate cultivars of Brassica napus or B. campestris, would seem to be a logical replacement for SBM in Western Canada where canola is a major crop.

Much interest has been expressed about the use of CM as a protein supplement for starting (7-35 kg), growing (35-60 kg) and finishing (60-100 kg) pigs. Evidence suggests CM can be used as the sole protein supplement for finishing pigs (Bell, 1984; Castell and Spurr, 1984), however there is a lack of consensus regarding the replacement potential of CM for SBM in starter and grower diets (Bowland, 1971; Bowland et al., 1975; Castell, 1977; McKinnon and Bowland, 1977; Baidoo and Aherne, 1987a).

Effect of protein quality and amino acid availability on pig performance

Of the various factors believed to influence pig performance when comparing diets containing CM and SBM, protein quality and amino acid availability are considered extremely important. CM

usually contains 37-38% protein and has a very good balance of amino acids, especially the sulfur-containing amino acids (Table 1). Special attention should be given to the content of lysine, threonine and the sulfur-containing amino acids and their availabilities since they are the first-, second- or third limiting in most pig diets.

Fecal samples have been used extensively for many years to determine amino acid availability (Walker et al., 1986a). However, several reports suggested microbial fermentation in the hind gut alters the amino acid profile and more accurate estimates of amino acid availability may be obtained from digesta collected at the terminal ileum (Hodgson et al., 1977; Sauer et al., 1982). For example, fecal analysis has overestimated threonine availability by as much as 11.6% in CM (Sauer et al., 1982).

Sauer et al. (1982) compared the total and available lysine content of barley-based CM or SBM diets for growing pigs. This study indicated only small differences (2.08 to 0.80%) in total lysine supply existed as the protein level of the diet decreased from 18 to 13% whereas much larger differences (10.01 to 3.65%) were noticed for available lysine supply over the same range of protein levels. These results led to the conclusion that, for grower diets containing 18 and 16% protein, CM should not replace more than half of the supplemental protein from SBM in order to minimize differences in available lysine supply without a reduction in pig performance. Where complete replacement of SBM

TABLE 1

Chemical analysis of canola meal (CM) and soybean meal (SBM)*

	CM		SBM	
	as-fed %	in protein %	as-fed%	in protein%
Proximate analysis				
Dry matter (%)	7.5		11.0	
Crude fiber (%)	11.1		7.3	
Ether extract (%)	3.8		0.8	
Protein (Nx6.25)	38.0		45.0	
Amino acid composition (%)				
Essential				
Arginine	2.32	6.11	2.90	6.44
Histidine	1.07	2.81	1.08	2.40
Isoleucine	1.51	3.98	2.11	4.69
Leucine	2.65	6.97	3.37	7.49
Lysine	2.27	5.98	2.80	6.22
Methionine & cystine	1.15	3.01	0.92	2.05
Phenylalanine	1.52	4.01	2.16	4.80
Threonine	1.71	4.50	1.71	3.80
Tryptophan	0.44	1.16	0.54	1.20
Valine	1.94	5.11	2.25	5.50
Non-essential				
Alanine	1.73	4.56	1.89	4.20
Aspartic acid	3.05	8.03	5.04	11.20
Glutamic acid	6.34	16.69	8.10	18.00
Glycine	1.88	4.96	2.07	4.60
Proline	2.66	7.00	2.20	4.89
Serine	1.67	4.39	2.25	5.00
Tyrosine	0.93	2.46	1.26	2.80

*Adapted from Clandinin et al. (1981).

with CM is desired (for economic reasons), then the crude protein level of a barley-CM diet should be increased relative to a barley-SBM diet, or synthetic lysine could be added, to create equivalent available lysine. Thus, Sauer et al. (1982) concluded the available lysine supply could be a critical factor when using CM as a replacement for SBM in pig diets.

Effect of digestible energy and fiber content in CM on pig performance

CM contains more hulls than SBM (Sauer et al., 1982) which is undoubtedly related to the lower energy and protein digestibility in CM than SBM when fed to pigs. Moreover, canola hulls contain more protein of low digestibility than soybean hulls (Cichon and Sauer, 1980). Thus the higher level of hulls in CM results in CM having a higher fiber content than SBM, helping explain the digestibility differences that may affect pig performance (Sauer et al. 1982; McIntosh et al., 1987).

Castell (1977) suggested the energy content of diets may be affected by including canola meal in the diet. CM and RSM are known to contain less energy per unit than SBM (U.S.-Can. Table of Feed Comp., 1982), thus it seems that CM diets should be formulated to minimize any effect the lower energy may have on pig performance. Narendran et al. (1981) reported growing and finishing pigs (18-105 kg) fed isocaloric CM or SBM-based diets showed similar performance.