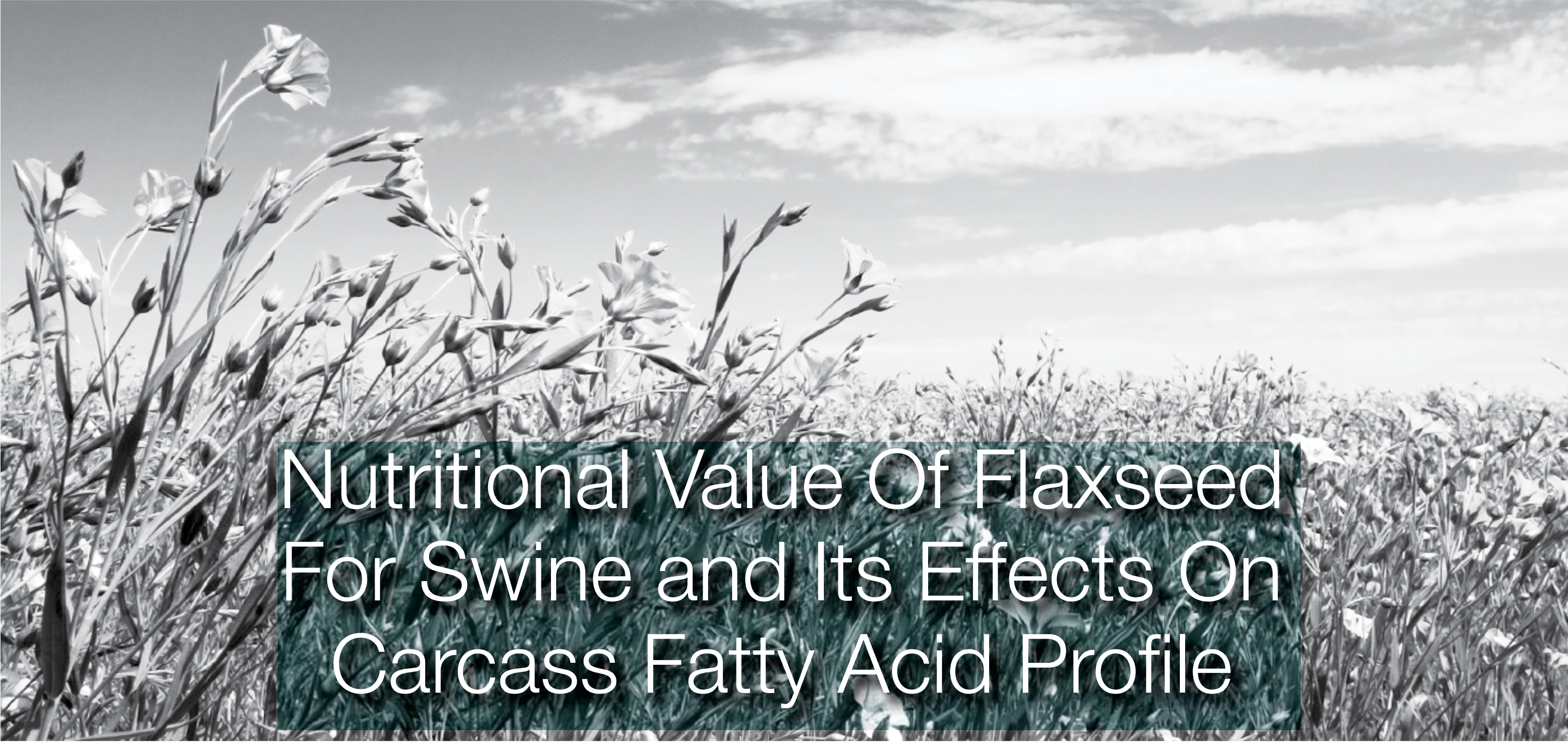

Nutritional Value Of Flaxseed For Swine and Its Effects On Carcass Fatty Acid Profile

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Canada, or more specifically Western Canada, is the largest producer of flaxseed in the world, producing over 0.9 million tonnes last year. Almost 75 % of the crop will be exported, more than 60 % going to Belgium. Flaxseed possesses properties which make it unique as a feed ingredient for swine. One of its nutritional attributes is, of course, the oil (also called linseed oil) which is rich in omega-3 fatty acids. Flaxseed contains 41% oil and the oil contains 57 % omega-3 fatty acids (primarily alpha linolenic acid or ALA) making it the richest plant-based source of ALA.

Prairie Swine Centre, in collaboration with Agriculture and Agri-Food Canada, Lacombe Research Centre, the University of Alberta and the University of Saskatchewan, has conducted a series of experiments examining the use of flaxseed as an ingredient in swine diets. The overall objective of these series of experiments was to develop low-cost feeding protocols which will result in a consistent enrichment of the carcass with ALA without compromising growth or carcass quality.

The first step was to obtain a well-defined nutrient profile of these ingredients, including DE, NE, fatty acid and amino acid digestibility and growth performance. Initial data was also obtained on ALA enrichment of the carcass. This report describes the results from these experiments. Subsequent issues of COS will provide more detailed information on the ALA enrichment of the carcass and effects on carcass and pork quality.

Table 1: Comparison of flaxseed, solvent extracted FSM, press extracted high fat FSM and the co-extruded flaxseed:field pea product (LinPro®) used in these studies (% DM)

	Flaxseed	Solvent Extracted FSM (NRC, 1998)	Press Extracted High Fat FSM (experimental)	LinPro
Crude Protein	25	37	34	24
Ether Extract	37	2	13	21
NDF	25	27	25	20
ADF	15	17	16	12
Calcium	0.25	0.4	N/A	0.2
Phosphorus	0.6	0.9	0.9	0.5
Lysine	0.97	1.38	1.39	1.14
Methionine	0.37	0.67	0.65	NA

Flaxseed Products

We incorporated the flaxseed into the diet using either LinPro®, an extruded flaxseed: pea product produced at Oleet Processing Ltd, Regina, SK, or by using flaxseed meal (FSM). The FSM we used was actually imported from Belgium, (therefore a round trip for this oil!). The Belgium company (Vandeputte S.A.) is seeking export opportunities for this by-product, moreover, demonstration of the benefits of this FSM could assist with the development of a local crushing industry. As a by-product FSM should be less-costly than the full-fat seed, and in European markets is comparable to the cost of soybean meal. The FSM used in these experiments had been produced without a solvent-extraction step, and the meal contains up to 13% oil, therefore it is both a protein and a fat source and can be used

Table 2: Digestibility values and energy content of FSM for growing pigs and gestating sows

	Growing Pigs	Gestating Sows
Digestibility (%)		
Dry Matter	63	65
Ether Extract	59	45
Gross Energy	62	68
Digestible Energy		
(Mcal/kg DM)	3.51	3.54
Net Energy		
(Mcal/kg DM)	2.43	2.44

Table 3: Apparent ileal digestibility and content of amino acids in FSM (DM basis)[1]

Nutrient	AID, % [1]	AID, g/kg[1]
Arginine	86.1	28.2
Histidine	67.3	5.0
Isoleucine	73.6	10.8
Leucine	71.3	14.8
Lysine	61.7	8.6
Methionine	75.3	4.9
Phenylalanine	78.4	12.9
Threonine	58.9	7.5
Tryptophan	25.1	1.0
Valine	71.2	12.3
CP	61.4	222.5

[1]Determined in 40 kg barrows. Data from Htoo et al. 2008. JAS 86:2942-2951.

as a product to enrich the carcass with ALA. A comparison of flaxseed, solvent extracted FSM, high fat FSM and LinPro is shown in Table 1. As expected the amino acid content of flaxseed is less than FSM, due to the dilution with the oil. The lysine contribution from the field peas is reflected in the LinPro.

Experimental Procedure

Flaxseed meal

Two hundred growing pigs (initial weight, 32 ± 4 kg) were used to determine the effects of the FSM inclusion on pig performance. The diets contained 0, 5, 10 or 15 % flaxseed and were phase fed to meet nutrient requirements of the growing pig. Diets were balanced for NE and digestible AA content. At the time of market, 6 pigs per treatment group (total of 24 pigs) were randomly selected from different experimental pens and both backfat (inner and outer layers) and rib-end loin samples (longissimus dorsi) were collected at the slaughterhouse for fatty acid analysis.

Total tract apparent nutrient digestibility was determined in growing barrows, and gestating sows. Standardized ileal amino acid digestibility was determined in growing barrows.

Results

The digestibility values for dry matter, ether extract and gross energy as well as the DE and NE content of FSM are shown in Table 2. Similarly the ileal amino acid digestibilities of FSM are shown in Table 3. Digestibility coefficients were similar in growing pigs and gestating sows, indicating minimal hindgut fermentation or absorption of the nutrients in the FSM. Despite the high oil content, the DE content of the FSM is comparable to soybean meal however, it contains approximately 25 % more NE than SBM. Digestibility of overall DM and most of the AA was lower than is usually observed with oilseeds.

The effects of FSM inclusion on growth performance and carcass fatty acid profiles are shown in Table 4. Average daily gains, ADFI or G:F were not affected by any level of FSM inclusion ($P > 0.05$). Increasing levels of FSM lead to a linear reduction in saturated fatty acid content (palmitic and stearic acids) in the backfat of the pigs ($P < 0.01$) while linearly increasing the ALA content of both backfat and loin samples ($P < 0.001$). Inclusion of 15% FSM lead to an increase in the ALA content from 11 to 47 mg/g backfat tissue and from 5 to 10 mg/g loin tissue.

Table 4: ADG, ADFI, and the fatty acid content of backfat and loins of pigs fed with graded levels of FSM

	Flaxseed meal in diets, %				SEM	P values	
	0	5	10	15	SEM	Linear	Quadratic
ADG, kg/d	0.95	0.94	0.91	0.92	0.02	0.14	0.41
ADFI, kg/d	2.66	2.65	2.79	2.67	6.5	0.55	0.42
G:F	0.36	0.36	0.33	0.35	0.01	0.25	0.34
ALA, mg/g wet tissue							
Backfat	11.1	21.7	34.4	47.4	0.8	< 0.001	0.13
Loin	5.0	6.4	9.3	10.1	0.4	< 0.001	0.48

LinPro

LinPro is an extruded 50:50 field pea:flaxseed product. Initial experiments at the University of Saskatchewan and the Swine Research and Technology Centre at the University of Alberta determined the optimal extrusion conditions to maximize energy, lipid, fatty acid, and amino acid digestibility (Htoo et al. 2008).

Subsequently, the Prairie Swine Centre and Lacombe Research Centre, using the optimally extruded product, conducted a series of experiments designed to provide information which would enable producers to develop feeding programs to efficiently and consistently enrich pork products with ALA without detrimental effects on pork quality. Results reported here are from an experiment designed to determine optimal inclusion rate and length of feeding.

LinPro was included at either 10, 20, or 30 % (5, 10, 15 %) into a wheat, barley, soybean meal based diet and fed for 4, 8 or 12 weeks prior to market. Diets were formulated to be equal in energy and amino acid content. The content of field peas was the same in all diets.

Results

The handling properties of the extruded flaxseed:pea product were superior to full-flax flaxseed. The blend flowed readily through the grinding equipment. Careful control of extrusion conditions were required to obtain an optimal product based on improving amino acid, energy and fat digestibility. Another potential benefit from the heat used in the extrusion, but not examined in these studies, is the inactivation of antinutritional factors in the field peas.

Relative to an unextruded 50:50 flaxseed:field pea blend, extruding increased DE content from 3.70 to 4.35 Mcal/kg or greater than 17% (Table 5). Dry matter and crude protein digestibility were

(Nutritional Value ... continued on page 5

(Nutritional Value ... continued from page 3)

Table 5. Apparent total tract or ileal digestibility of nutrients in coextruded 50:50 flaxseed peas

Item	Control[1]	Extruded
Digestibility, %		
Dry matter	75.0	80.5
Crude protein	79.2	77.3
Gross energy	69.6	80.6
Total fatty acids	70.1	87.2
C18:3 (ALA)	74.1	90.3
Ileal digestibility, %		
Lysine	69.2	84.9
Threonine	64.4	72.7
Leucine	58.9	79.3
Phenylalanine	66.6	82.6
Available lysine, %	0.94	0.97
DE, Mcal/kg	3.70	4.35

[1]Ground but not extruded.

also improved. The apparent ileal digestibility of all the essential amino acids were improved by extrusion (not all are shown), the extent of this improvement varied from 2 to greater than 35 %. This is important because heat processing can damage AA availability, especially lysine. Although determining apparent ileal digestibility does not always determine the availability of the amino acid, a further analysis showed that the content of available lysine was unaffected by the extrusion conditions chosen. The results of the digestibility trial are shown in Table 5.

Similarly, regardless of degree of saturation or chain length, extrusion consistently improved digestibility of the fatty acids. Notably, the digestibility of C18:3 (ALA) increased from 74 to 90 % or by greater than 20 % in the extruded product.

Using the extruded product, flaxseed level in the diet had no effect on growth performance (Table 6), however, feeding the flaxseed for 12 weeks decreased overall gain by about 400 g/day, when averaged over all flaxseed incorporation levels. Feed intake decreased with increasing flaxseed in the diet, and thus there was slight improvement in feed efficiency. There was a linear improvement in the omega-3 (primarily ALA) content of backfat with increasing flaxseed in the diet and length of feeding period prior to slaughter. The greatest enrichment, therefore, was observed with 15% flaxseed fed for 12 weeks (Figure 1).

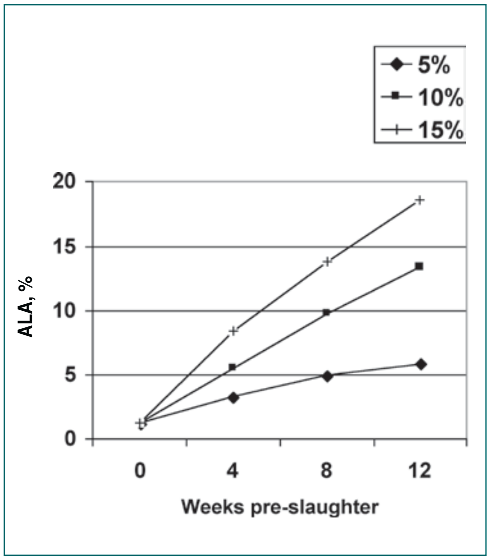

Figure 1. The effect of feeding 5, 10 or 15 % co-extruded flaxseed (10. 20 30 % LinPro) for 4, 8 or 12 weeks preslaughter on the ALA content of backfat.

The Bottom Line

FSM (containing 13 % oil on a DM basis) is a novel protein source that can be incorporated into swine diets. With the exception of its characteristic, low lysine content, the CP fraction of FSM is comparable to that of canola meal in terms of both quantity and quality. Flaxseed meal also contains higher DE and NE values compared to canola meal, thus, making it an attractive alternative to other common protein sources. When diets are properly balanced to meet both the NE and digestible AA requirements of the pigs, FSM can be included into diets without adverse effects on performance while yielding a carcass enriched with ALA.

LinPro, when extruded under optimal conditions, is a good source of energy, omega-3 fatty acids and lysine for swine. Feeding up to 15% LinPro for 8 weeks had no impact on animal performance. The addition of LinPro to the diet provided a highly available source of omega-3 fatty acids, yielding ALA enrichments in backfat which are comparable to diet supplementation with flaxseed (linseed) oil. Feeding higher levels of LinPro for shorter periods versus lower levels for longer periods was more efficient at increasing omega-3 fatty acids in backfat.

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Table 6. Performance of grower-finisher pigs fed different levels of co-extruded flaxseed for 4, 8 or 12 weeks prior to slaughter.

	Control	% flaxseed in diet[1]			Weeks			SEM	P value	
		5	10	15	4	8	12		Diet	Weeks
Initial weight, kg	31.1	30.8	30.9	31.4	30.9	31.2	31.0	1.48	0.31	0.74
Final weight, kg	109.7	114.6	112.9	115.2	115.6	115.7	111.4	2.09	0.36	0.02
ADG, kg/d	0.94	1.00	0.98	1.00	1.01	1.01	0.96	0.01	0.42	0.02
ADFI, kg/d	2.46	2.60	2.50	2.47	2.58	2.55	2.45	0.03	0.01	0.06
Feed efficiency (G:F)	0.38	0.39	0.30	0.41	0.39	0.40	0.39	0.01	0.01	0.80

[1]Equivalent to 10, 20 and 30% LinPro.