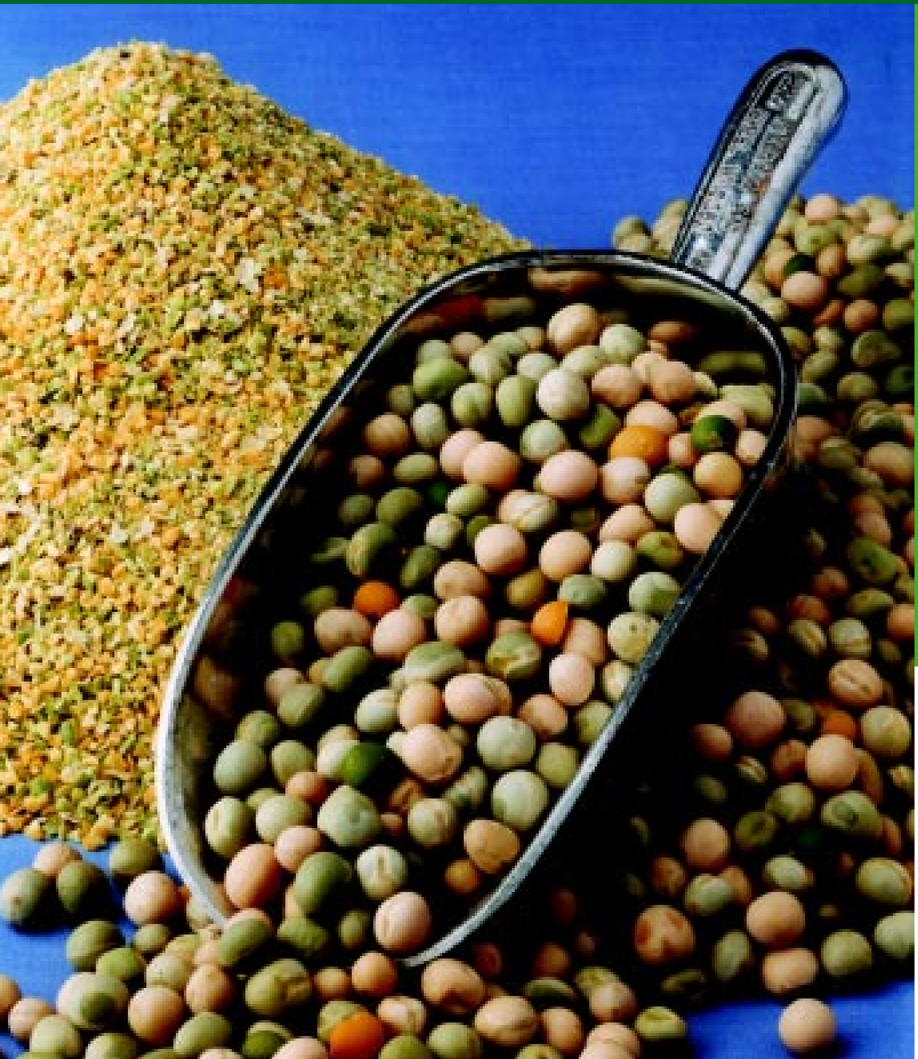
Canadian Feed Peas Industry Guide



Written by:
Dave Hickling, Ph.D.
Third Edition, 2003

Published by:
Pulse Canada
Winnipeg, Manitoba

FEED INDUSTRY GUIDE

INTRODUCTION

This is the third edition of the Pulse Canada technical guide on feeding peas to animals. Since the 1997 edition, there has been increased use and interest in feed peas both in Canada and around the world. There have been many questions about how to properly process peas for feed, detailed questions about pea nutrient composition and questions about practical inclusion levels of peas in commercial diets.

To address these questions, two basic changes have been made to this third edition. The focus has changed—the guide is more of a discussion about feeding peas as opposed to a literature review, although recent research papers are noted. As well the guide has been expanded and contains several areas of new information:

- Update on Canadian feed pea production and markets
- Information on feed pea grading and trading specifications
- Expanded and updated nutrient composition information
- Comparison of nutrient specifications of feed peas from different databases
- New research and practical information about processing peas
- Feeding information about specialty animals—including fish
- Discussion of the relative economic value of feed peas

This publication can also be found on the Internet at: www.pulsecanada.com. As well, Internet users are encouraged to visit the searchable “Pulse–Canola Feed Literature Database Record” at www.infoharvest.ca/pcd.

CONTENTS

FEED PEA INDUSTRY IN CANADA

Pea production in Canada has increased and Canada is now the world's second largest pea producer and the world's largest pea exporter. Canadian peas are used for both direct human consumption and animal feeding. The ratio is about 50:50 but can vary from year to year depending on supply and demand in the food and feed sectors.

The major market for Canadian feed peas is at home in Western Canada. Feed peas are usually sold to feedmills where they are used in a wide variety of animal feeds. There is also significant on-farm feed pea utilization, especially in hog feeds. As well, there are several companies in the business of processing peas for feed use, both as individual ingredients and in combination with other ingredients such as canola meal. These pea-based ingredients are mainly sold to on-farm feed mixers, although there is a feedmill and export market for these products.

The feed industry in many parts of the world has recognized the benefits of feeding peas to animals. This is especially the case in Europe, Canada and Australia. In Europe, peas are widely used in Spain, France, Germany, England, Belgium, Holland and Denmark. In recent years, with increased supply, the use of peas in animal feeds has expanded to several countries in Asia and Latin America. Most feed pea exports from Canada go by bulk shipment, either in full vessel loads or as single compartment loads. There are some container shipments of feed peas when it is economical. Canadian feed pea production and exports in recent years are shown in Table 1.

Table 1 Area, production and exports of peas (both food and feed) in Western Canada, 1998–2004 (AAFC, 2003)

Year	Area, ha	Yield, t/ha	Production, t	Exports, t
1998–99	1,078,000	2.17	2,337,000	1,705,000
1999–00	835,000	2.70	2,252,000	1,417,000
2000–01	1,220,000	2.35	2,864,000	2,196,000
2001–02	1,285,000	1.57	2,023,000	1,401,000
2002–03f	1,050,000	1.30	1,365,000	1,000,000
2003–04f	1,250,000	1.93	2,410,000	1,600,000

Production decreased in 2001 and 2002 due to the drought in Western Canada. This reduced supply, together with overall decreases in world pea production resulted in a greater proportion of the Canadian pea production being used for edible (food) markets.

Pulse Canada is the national organization responsible for research, market development and policy for all pulse crops including feed peas. The grading standards for feed peas are administered by the Canadian Grain Commission (CGC). The grading standard for feed peas is shown in Table 2. Note that foreign material is not a grading specification and is rather a commercially agreed specification.

Canadian feed pea grading specifications (CGC, 2002)

Table 2

Grade Name: Canada Feed Peas

Grading Specifications	Tolerances, %	Grade, if Feed Peas specs not met
Fireburnt	Nil	Feed peas sample
Heated & Binburnt	1.0	Feed peas sample
Pulses other than green and yellow peas	5.0	Feed peas sample
Inert material	1.0	Feed peas sample
Ergot	0.05	Feed peas sample
Excreta	0.02	Feed peas sample

References

AAFC. 2003. Canada: Pulse and Special Crops Supply and Demand. Market Analysis Division. Agriculture and Agri-Food Canada. January 10, 2003. www.agr.gc.ca/mad-dam/e/sd2e/2003e/jan2003sce.htm.

CGC. 2002. Official Grain Grading Guide. Canadian Grain Commission. www.grainscanada.gc.ca.

FEED PEA NUTRIENT COMPOSITION

Canadian feed peas contain both green and yellow varieties. There is no difference in nutrient content between green and yellow peas, but there may be small differences between some pea varieties—mainly due to differences in the size of the pea and the thickness of the hull. Canadian peas are all spring-seeded varieties so nutrient differences between winter- and spring-seeded peas are not an issue. Peas are valued for both their protein and energy content and as such are regarded as a multi-purpose feed ingredient. The basic nutrient composition of feed peas is shown in Table 1. The nutrient values used in this publication have been derived from a number of sources and are believed to be fairly representative of the average nutrient values for the commercial Canadian feed pea.

Table 1 Typical chemical composition of feed peas (10% moisture basis)

Component	Average
Moisture, %	10.0
Crude protein (N x 6.25), %	23.0
Rumen bypass protein, %	22.0
Oil, %	1.4
Starch, %	46.0
Ash, %	3.3
Crude fibre, %	5.5
Trypsin Inhibitor Activity, TIA/mg	3.5
Phytic acid, %	1.2

In reviewing nutrient sources and databases for feed peas, it is apparent that there is considerable variation in published nutrient values. Furthermore, while various references get the information right most of the time, there are also some glaring errors. It is very much a case of "users beware". Some of the main sources of nutrient values used here are: Anderson, 2002; Carrouee and Gatel, 1995; Ewing, 1997; Fan and Sauer, 1999; Fonnesbeck et al., 1984; Gatel, 1994; Igbasan et al., 1997; Marquardt and Bell, 1988; NRC, 1982; NRC, 1994; NRC, 1998; NRC, 2001; Perez et al., 1993; Petterson et al., 1997; Rhone-Poulenc, 1993; Sauer and Jaikaran, 1994; and Stefanyshyn-Cote et al., 1998.

Protein and Amino Acids

Feed pea protein averages 23 percent (as is) and is highly digestible with an excellent amino acid balance. It has especially high levels of lysine, which is good for meat production. As with most crops, environment can affect protein content. Hot, dry growing conditions tend to increase protein content. The standard deviation for protein is fairly high (2.2 percent, Fonnesbeck et al., 1984) for individual field samples, but in commercially blended samples for export shipment it is quite low. This publication uses a value of 23 percent protein, which is typical of blended samples.

Peas have high levels of the important essential amino acids. Peas have especially high levels of lysine and peas are a more concentrated lysine source than soybean meal. Peas, like most pulse crops, have relatively low levels of methionine and cystine. Using peas in combination with canola meal, especially in hog diets, allows the high levels of methionine and cystine in canola meal to complement the lower levels in peas, and the high levels of lysine in peas to complement the lower lysine levels in canola meal. The amino acids in peas are highly digestible by swine and poultry. The digestibility of the amino acids is similar or higher than in grain, and only slightly lower than in soybean meal. In ruminants the protein is highly rumen degradable.

The amino acid content of feed peas is shown in Table 2. Amino acid content is correlated with protein content. Amino acid prediction equations for some key essential amino acids are given in Table 3. The amino acid digestibility for pigs and poultry is shown in Table 4.

FEED PEA NUTRIENT COMPOSITION

Table 2

Amino acid composition of feed peas (23% crude protein basis)

Amino acid	Average, %
Alanine	0.92
Arginine	2.31
Aspartate	2.38
Cystine	0.22
Glutamate	3.68
Glycine	0.95
Histidine	0.72
Isoleucine	1.10
Leucine	1.80
Lysine	1.67
Methionine	0.28
Methionine + Cystine	0.50
Phenylalanine	0.98
Proline	0.97
Serine	0.99
Threonine	0.84
Tryptophan	0.19
Tyrosine	0.73
Valine	1.05

Table 4

Digestibility coefficients of essential amino acids for swine* and poultry **

Amino Acid	Swine true ileal digestibility, %	Poultry true digestibility, %
Arginine	90	90
Cystine	79	74
Histidine	89	87
Isoleucine	85	84
Leucine	86	86
Lysine	88	87
Methionine	84	82
Methionine + Cystine	82	78
Phenylalanine + Tyrosine	87	86
Threonine	83	83
Tryptophan	81	82
Valine	83	81

* NRC Swine, 1998

**Rhone-Poulenc, 1993

Table 3

Regression equations for predicting amino acid levels in feed peas from crude protein levels (Mosse, 1990, as quoted by Gatel, 1994. n=97)

Amino acid, %	Equation	R value
Arginine	% CP X .1555 – 1.497	0.94
Lysine	% CP X .0598 + .358	0.99
Methionine	% CP X .0075 + .065	0.94
Cystine	% CP X .0059 + .220	0.75
Threonine	% CP X .0264 + .297	0.98
Tryptophan	% CP X .0077 – .010	0.91

Oil

The oil, or fat, content of feed peas is relatively low. Average values for ether extract, or oil content, for feed peas is 1.4 percent. The fatty acid profile of the oil in peas is similar to cereal grains, being primarily polyunsaturated. The saturated fat content is approximately 15 percent and the major unsaturated fatty acids are linoleic (50 percent), oleic (20 percent) and linolenic (12 percent), (Carrouee and Gatel, 1995).

Carbohydrates and Fibre

Starch is the largest single carbohydrate component at almost half the total weight of the pea. Starch content shows a strong inverse correlation to protein content. At 23 percent protein, the starch is approximately 46 percent. Since the protein content of peas can vary, a correction for starch and energy content should be made if the peas differ significantly from 23 percent protein. The starch is stored in oval granules and the amylopectin content is approximately 70 percent, which is similar to cereal grains.

Table 5

Carbohydrate components of feed peas (10% moisture basis)

Component	Average, %
Sugars	4.6
Starch	46.0
Insoluble cell walls	12.5
Oligosaccharides	5.0
Crude fibre	5.5
Acid detergent fibre	8.2
Neutral detergent fibre	16.7
Non-starch polysaccharides	12.5
Lignin	0.5

The cell walls are responsible for a significant portion of the fibre, although cellulose and lignin levels are relatively low. Appreciable levels of galactans are found. Peas contain approximately 5 percent oligosaccharides, made up mainly of sucrose (2.0 percent), stachyose (1.0 percent), verbascose (1.5 percent) and raffinose (0.5 percent). Compared to some other pulses such as lupins and beans, the levels of gas producing oligosaccharides are fairly low—not enough to create enough gas production in the hindgut to cause flatulence.

Igbasan et al., (1997) profiled the non-starch polysaccharide content of a number of different Canadian pea varieties. The average was approximately 12.5 percent, predominantly made up of glucose, uronic acids, arabinose, xylose and galactose.

Minerals

Feed peas, like cereal grains, are low in calcium, but contain a slightly higher level of phosphorus at approximately 0.4 percent. Phytic acid, which binds phosphorus so that it is less available to the animal, is present in feed peas, as it is in many other plants. Feed peas contain 1.2 percent phytic acid, which compares favourably with those levels found for soybean at 1.0 to 1.93 percent (Reddy et al., 1982). Marquardt and Bell (1988) reported that the amount of phytic acid phosphorus in peas varied from 28 to 46 percent, which is considerably less than what is found in cereal grains, such as corn, wheat or barley. The level of trace minerals in peas is considered to be similar to those found in cereal grains.

Vitamins

There is only limited data on the vitamin content of feed peas. Levels of vitamins found in peas would appear to be as adequate as those found in cereal grains and other feeds. Feeding trials and on-farm experience would not indicate that any special or abnormal vitamin supplementation is required. Table 7 lists some of the available vitamin data, with levels similar to those found in many of the better cereal grains.

FEED PEA NUTRIENT COMPOSITION

Table 6

Mineral content of feed peas (10% moisture basis)

Mineral	Average*
Calcium, %	0.11
Phosphorus, %	0.39
Available P, %	0.15
Sodium, %	0.04
Chlorine, %	0.05
Potassium, %	1.02
Sulfur, %	0.20
Magnesium, %	0.12
Cobalt, mg/kg	133
Copper, mg/kg	9
Iron, mg/kg	65
Manganese, mg/kg	23
Molybdenum, mg/kg	0.8
Zinc, mg/kg	23
Selenium, mg/kg	0.38

*NRC, 1998

Table 7

Vitamin content of feed peas (10% moisture basis)

Vitamin	Amount*
Biotin, mg/kg	0.15
Choline, mg/kg	547
Folic acid, mg/kg	0.2
Niacin, mg/kg	31.0
Pantothenic acid, mg/kg	18.7
Pyridoxine, mg/kg	1.0
Riboflavin, mg/kg	1.8
Thiamin, mg/kg	4.6
Vitamin E, mg/kg**	0.2

*NRC, 1998
** As alpha-tocopherol

Energy

The energy value of peas for pigs is similar to high-energy grains such as corn and wheat (99 percent of the digestible energy of corn), but the relative energy value for poultry is lower (79 percent of the metabolizable energy of corn). For various reasons, mostly related to carbohydrate digestibility, poultry are not able to extract as much energy from peas as pigs. The result is that peas are more widely used in pig diets than poultry diets.

The net energy value of peas for swine is very high compared to other protein ingredients. This is due to the very high starch levels in peas: approximately 46 percent. This starch is highly digestible and is the main reason for the high biological energy value of peas. Peas have 98 percent the digestible energy (DE) and 101 percent the metabolizable energy (ME) of soybean meal but have 121 percent the net energy (NE) of soybean meal. The practical implications of these factors when peas substitute soybean meal in pig diets, which are positive for peas, are discussed in the chapter, "Feed Peas in Pig Diets".

The ME value for poultry is low, due to the low digestibility of raw legume starch by chickens. If the legumes are heat-treated to the extent that the starch is gelatinized and the cell walls are ruptured, then ME values are much higher.

The energy values for cattle are quite high and are comparable with the cereal grains (NRC, 2001). Ruminants are effectively able to digest all the pea components.

The energy value of peas for various animals is shown in Table 8.

Available energy values* for feed peas (10% moisture basis) Table 8

Animal	Energy type	Average value
Adult chicken	AME_n, kcal/kg	2600
	TME_n, kcal/kg	2640
Growing pig	DE, kcal/kg	3485
	ME, kcal/kg	3240
	NE, kcal/kg	2450
Cattle	TDN, %	78
	DE, Mcal/kg	3.47
	ME, Mcal/kg	3.08
	NEM, Mcal/kg	1.95
	NEG, Mcal/kg	1.33
	NEL, Mcal/kg	1.81

*Values are from NRC publications with modifications based on Ajinimoto, 1996 and Rhone-Poulenc, 1993.

Anti-Nutritive Factors

Pulse crops and other legumes contain a number of anti-nutritional factors, e.g. protease inhibitors, tannins, alkaloids, lectins, phytic acid, saponins and oligosaccharides. In human diets many of these anti-nutritional factors are not a concern because cooking deactivates them. They can be a problem in animal feeds where ingredients are typically not heat processed to the same extent. For peas, the levels of these anti-nutritive factors are quite low and generally no special precautions are required before using them in animal feed.

Most pulses contain protease inhibitors—the main ones being trypsin inhibitor and chymotrypsin inhibitor. Aside from reducing protein digestibility, they may cause pancreatic hypertrophy and reduced growth rate due to endogenous protein loss—both resulting from negative feedback control to induce the pancreas to produce more enzymes. Since they are proteins, they can be deactivated by heat treatment of the pulse. The levels of protease inhibitors in legumes may be very low (e.g. lupins) or very high, (e.g. soybeans). For peas, few special precautions are necessary. The levels of trypsin inhibitor are low enough, usually less than 4 TIU/mg, to not be a practical concern (Liener, 1983; Sauer and Jaikaran, 1994). This is not necessarily true for winter-seeded pea varieties that have higher levels of trypsin inhibitor (>6 TIU/mg) than spring-seeded varieties (Gatel, 1994). Grosjean et al., (2000) have established a clear inverse relationship between the level of trypsin inhibitor and ileal amino acid digestibility in pigs. They found that standard ileal amino acid digestibility decreased by over 0.2 percent for each unit increase in trypsin inhibitor activity per mg of crude protein.

Tannins are phenolic compounds found widely in pulses—mostly concentrated in the seed coat. The condensed tannins cause reduced protein and amino acid digestibility by forming indigestible linkages with protein. They are also bitter and may reduce feed intake. High tannin levels are found in brown peas. Tannin levels are insignificant in green and yellow peas.

Much of the phosphorus in plants is in the form of phytic acid, which is a cyclic compound containing six phosphate radicals. It binds with minerals and is resistant to digestion. It is an anti-nutritional factor in that it interferes with the availability of other minerals in plant sources—especially zinc. Between 50 percent and 80 percent of the phosphorus in pulses is bound up in phytic acid. It is present to the extent of 1 percent to 5 percent of total weight. The phytic acid situation in peas is similar to the phytic acid situation in grain. No special precautions with peas are indicated other than formulating to a standard phosphorous availability of about 30 percent.

There are several oligosaccharides found in pulses. The alpha-galactosides are of interest due to their high levels in some legumes. Monogastrics lack alpha-galactosidase in the intestinal mucosa to break these sugars down. They escape to the large intestine where bacterial galactosidase breaks them down and pro-

FEED PEA NUTRIENT COMPOSITION

duces gas. This causes flatulence and diarrhea, which impairs nutrient digestion and causes nausea, cramps and general animal discomfort. Oligosaccharide levels in peas are relatively low. (See section on Carbohydrates and Fibre).

Varietal Differences

Feed peas are usually marketed as a blend of different varieties—including both green and yellow peas. Canadian feed peas are graded as a combination of green and yellow varieties. As per grade standards, other "pea varieties" such as brown, wrinkled, marrowfat and chick peas can comprise a maximum of five percent of the total.

Only spring-seeded varieties of green and yellow peas are grown in Canada. European research has shown that winter-seeded varieties have higher levels of trypsin inhibitor than spring-seeded varieties. Canadian feed peas, both green and yellow, come from white-flowered varieties. Brown peas come from coloured flower varieties. Brown peas have higher tannin levels, lower starch, higher protein and higher fibre levels than green and yellow peas.

These varietal differences are responsible for much of the variation in nutrient content reported in various nutrient publications and databases. The information in Table 9 compares the nutrient composition of peas as reported in several authoritative publications. There is some variability, but the nutrient values for Canadian peas as reported in this publication are generally in the middle of the range of reported values.

Comparison of feed pea nutrient composition between different literature databases and origins of feed peas

Table 9

Nutrient, 10% moisture basis	Canada, %	UNIP-ITCF 1995*, %	GRDC 1997**, %	Feeds Directory 1997***, %	NRC 1982, %	NRC Poultry 1994, %	NRC Swine 1998, %
Crude protein	23.0	21.6	23.2	23.4	22.5	23.8	22.8
Oil	1.4	1.6	1.1	1.4	1.2	1.3	1.2
Crude fibre	5.5	5.5	5.9	6.3	6.1	5.5	-
Ash	3.3	3.2	2.5	3.2	3.0	-	-
Starch	46.0	46.1	50.0	39.2	-	-	-
ADF	8.2	6.0	9.3	6.8	-	-	7.2
NDF	16.7	10.3	13.3	17.1	-	-	12.7
Calcium	0.11	0.08	0.07	0.09	0.14	0.11	0.11
Phosphorus	0.41	0.41	0.40	0.54	0.39	0.42	0.39
Lysine	1.67	1.61	1.59	1.62	1.54	1.68	1.50
Met + cys	0.50	0.54	0.57	0.50	0.47	0.59	0.52
Threonine	0.84	0.84	0.80	0.81	0.93	0.84	0.78
Tryptophan	0.19	0.18	0.18	0.18	0.22	0.18	1.09

*Carrouee and Gatel, 1995
**Petterson et al., 1997
***Ewing, 1997

Nutrient Comparison with Other Pulses

Peas are the most commonly used pulse crop for feed, although lupins and to a certain extent, lentils, chick peas and faba beans are also used in animal feed. A nutrient comparison is provided in Table 10.

Lupins have higher protein and oil levels than peas; however, the energy value is lower due to the much lower levels of starch and higher levels of fibre. This is illustrated by a comparison of energy values for pigs. Note that the difference in Swine DE between peas and lupins is fairly small; however, there is a much larger difference in Swine NE. This difference is due to the much lower level of starch in lupins.

Much of the digestible energy of lupins by pigs takes place in the hindgut, whereas peas are mainly digested higher up the digestive tract. Lupins are mainly used in ruminant feeds, although when priced right they can be a good source of nutrients in pig diets. They also have low levels of anti-nutrients.

Whereas peas and lupins are often grown intentionally for animal feed, the other major feed pulses such as lentils, chick peas and beans are grown mainly for human consumption. Occasionally they are downgraded for use in animal feeds. They can be good nutrient sources and effective feed ingredients; however, their economic value in feed is lower than feed peas. Relatively high levels of tannins in both lentils and faba beans limit their use in swine and poultry feeds.

Table 10 Nutrient composition of feed peas and other pulses (as fed basis)

Nutrient, as is basis	Feed Peas	Sweet Lupins	Lentils	Faba Beans
Dry matter, %	90	91	90	90
Crude protein, %	23.0	32.0	24.0	24.1
Oil, %	1.4	5.9	0.9	1.2
Crude fibre, %	5.5	15.4	4.4	8.4
Ash, %	3.3	2.7	2.2	2.7
Starch, %	46	10	38	38
Oligosaccharides, %	5.0	4.1	2.4	2.7
Tannins, %	0.4	0.3	0.9	1.0
ADF, %	8.2	19.7	6.0	9.9
NDF, %	16.7	23.5	18.0	12.8
Poultry ME, kcal/kg	2600	2485	2200	2675
Swine DE, kcal/kg	3485	3460	3280	3460
Swine NE, kcal/kg	2450	2060	2265	2150
Ruminant DE, kcal/kg	3455	2870	2950	2870
Lysine, g/16gN	7.26	4 .75	6.30	6.29
Met + cys, g/16gN	2.17	2.01	2.20	2.14

References

Ajinimoto, 1996. Noblet's Net Energy Calculator. Version 1.0. Gentone International Inc.

Anderson, V. 2002. Feeding Field Peas to Livestock. North Dakota State University Extension Service. Fargo. North Dakota.

Carrouee, B and F. Gatel. 1995. Peas: Utilization in Animal Feeding. 2nd Edition. UNIP-TTCF. Paris, France.

Ewing, W.N. 1997. The Feeds Directory. Context Publications, Leicestershire, England.

Fan, M.Z., and W.C. Sauer. 1999. Variability of apparent amino acid digestibility in different pea samples for growing-finishing pigs. Can. J. Anim. Sci. 79: 467-475.

Fonnesbeck, P.V., H. Lloyd, R. Obray, and S. Romesburg. 1984. I.F.I. tables of feed composition. International Feedstuffs Institute, Utah State University. Logan, UT 84322.

Gatel, F. 1994. Protein quality of legume seeds for non-ruminant animals: A literature review. Animal Feed Science and Technology, 45: 317-348.

Grosjean, F., C. Jondreville, I. Williatte-Hazouard, F. Skiba, B. Carrouee and F. Gatel. 2000. Ileal digestibility of protein and amino acids of feed peas with different trypsin inhibitor activity in pigs. Can. J. Anim. Sci. 80: 643-652.

Igbasan, F.A., W. Guenter and B.A. Slominski. 1997. Field peas: chemical composition and energy and amino acid availabilities for poultry. Can. J. Anim. Sci. 77: 293-300.

Liener, I.E. 1983. "Chemistry and biochemistry of legumes", Toxic constituents in legumes. pp. 217-258. Edward Arnold Publishers Limited, London.

Marquardt, R.R. and J.M. Bell. 1988. Future potential of pulses for use in animal feeds. World Crops: Cool Season Food Legumes. Kluwer Academic Publishers.

NRC. 1982. United States–Canadian Tables of Feed Composition. 3rd Revision. National Acad. Press, Washington, DC.

NRC. 1994. Nutrient requirements of poultry. 9th Rev. Ed. National Acad. Press, Washington, DC.

NRC. 1998. Nutrient requirements of swine. 10th Rev. Ed. National Acad. Press, Washington, DC.

NRC. 2001. Nutrient requirements of dairy cattle. 7th Rev. Ed. National Acad. Press, Washington, DC.

Perez, L., I. Fernandez-Figares, R. Nieto, J.F. Aguilera and C. Prieto. 1993. Amino acid digestibility of some grain legume seeds in growing chickens. Anim. Prod. 56: 261-267.

Petterson, D.S., S. Sipsas and J.B. Mackintosh. 1997. The Chemical Composition and Nutritive Value of Australian Pulses. GRDC. Canberra, Australia.

Reddy, M.R., S.K. Sathe, and D.K. Salunkle. 1982. Advanced Food Research. 28: 1-92.

Rhone-Poulenc Animal Nutrition. 1993. Rhodimet nutrition guide. Sixth edition.

Sauer, W.S. and S. Jaikaran. 1994. Amino acid and energy digestibility in peas (pisum sativum) from white-flowered spring cultivars for growing pigs. J. Sci. Food Agric. 64: 249-256.

Stefanyshyn-Cote, B., M. Fleury and L. Ellwood. 1998. Research Summaries: Canola & Peas In Livestock Diets. Saskatchewan Pulse Growers. Saskatoon, Saskatchewan.

FEED PEAS IN POULTRY DIETS

Peas can be used in the diets of all classes of poultry. They are a good source of protein and a moderate source of energy. This nutrient profile usually makes them a very economical ingredient for layers. For birds that have higher energy requirements, e.g. broilers, inclusion levels are usually limited by cost and the availability of other energy-rich ingredients. Peas do have low levels of methionine, cystine and tryptophan, and since poultry generally have a high requirement for these amino acids, it is important to ensure that poultry feeds containing peas are appropriately balanced for these amino acids.

Processing

It is essential to process peas for poultry so that they are able to digest the intracellular starch. Poultry, especially young poultry, have great difficulty digesting unprocessed peas. There are several different methods of processing which are effective, and they are often used in combination.

Peas are usually ground in a hammermill before feeding to poultry. Use a similar screen size as would be used for grinding grain (2.5 to 4.0 mm). As you would expect, there is a difference in digestibility depending on particle size, where digestibility increases with decreasing particle size.

Pelleting improves Apparent Metabolizable Energy (AME) and reduces between pea energy variability—the lower the AME value in mash, the better the improvement with pelleting. Enhancement of AME is also more pronounced with young birds rather than adult cockerels. Some recent studies have looked at alternative heat processing methods such as expansion and micronization. Fasina et al., (1997) determined that expansion increased protein digestibility of a pea/whole canola based diet for broilers, but that there were generally no effects on bird performance. Igbasan and Guenter (1996) determined that micronization increased True Metabolizable Energy (TME) (adult cockerels) and AME (broilers) as well as increased threonine and methionine digestibility but decreased lysine digestibility (cockerels).

The improvements due to heat processing are due to increased starch digestibility (Conan and Carre, 1989). Work by Igbasan and Guenter (1996c) has shown that different pea varieties respond differently to heat treatment: yellow and green varieties responded less than brown varieties. Care should be taken not to overheat the peas to the extent that amino acid digestibility is impaired. The most promising technology lies with using a combination of heat treatment and enzymes. Disruption of the cell walls by heat prior to adding carbohydrase enzymes will markedly increase starch digestibility (Igbasan and Guenter, 1996a).

Longstaff and McNab (1987) found that autoclaving peas resulted in a small (three percent) increase in starch digestibility in adult cockerels. The presence of oligosaccharides in peas has been blamed for their low energy value; however, Trevino et al. (1990) found that oligosaccharides had no effect on growing chick performance and only a small negative effect on starch digestibility. A study by Brenes et al. (1993) looked at the effects of autoclaving and dehulling on the digestibility of different varieties of peas in broilers. Only the high tannin peas were affected by processing: autoclaving increased the energy and protein digestibility (9 percent and 62 percent respectively) of high tannin peas as did dehulling (14 percent and 70 percent for energy and protein respectively). Conan and Carre (1989) found that autoclaving increased the AME of peas fed to three-week-old male broilers by up to 30 percent and increased starch digestibility by up to 25 percent. The increases were greater for winter varieties of peas compared to spring varieties.

Heat treatment of high tannin, and high trypsin inhibitor varieties of peas has increased energy and protein digestibility by as much as 30 percent. Even the low tannin, low trypsin inhibitor varieties of peas show about a 15 percent response in energy and protein digestibility to heat treatment.

The energy value of peas for poultry can also be improved with dehulling. Dehulling increases the energy value for broilers by about 15 percent (Brenes et al., 1993). Igbasan and Guenter (1996a) also determined that dehulling improved broiler performance.

In summary, it is generally recommended to heat process peas when feeding to poultry when economical. In a literature summary by Carre (2002), pelleting and other heat treatment will increase AME for young birds from approximately 2600 kcal/kg to 2950 kcal/kg—an increase of 13 percent. For adult birds, the increase in AME was from 2900 kcal/kg to 3150 kcal/kg—an increase of 9 percent.

Layers

Several studies have shown that peas are effective in egg layer diets. Castanon and Perez-Lanzac (1990) demonstrated that including up to 50 percent peas in short term (eight week) studies with leghorns had no effect on egg production, feed intake or feed conversion. Egg weight increased slightly with increasing levels of peas in the diet. At the 50 percent inclusion level, egg production fell off during the last week of the study for inexplicable reasons. The authors recommend a maximum inclusion level of 33 percent peas in the diets of layers.

The results of a longer term study by Ivusic et al. (1994), using up to 59 percent peas in the diet, are interesting. Compared to a corn/soy diet, there was only an effect on performance in two areas: one, paler egg yolk colour with increasing levels of peas in the diet (reduced levels of corn) and, two, thinner shells on the highest inclusion level of peas. The results indicate equivalent performance can be achieved when layer diets are properly balanced for energy and amino acids.

A series of studies at the University of Manitoba have looked at using peas in layer diets in raw form, after various heat treatments and with enzymes (Igbasan and Guenter, 1997a, 1997b). The results of the second study are summarized in Table 1. Excellent bird performance was attained at the 40 percent pea inclusion level, but similar to the Ivusic et al., study, bird performance decreased at the highest levels. Contrary to the Ivusic study, increasing peas in the diet resulted in darker yolks, however the Ivusic study used corn as the base cereal grain, while in the Igbasan and Guenter study it was wheat.

The feeding of peas to breeding chickens has not been thoroughly investigated. Two studies (Rakphongphairoj and Savage, 1988; Bootwalla et al., 1988) demonstrated that feeding peas had no effect on semen quality of broiler breeder males.

Broiler Chickens

There have been few commercially relevant studies on feeding peas to broilers until recently. Most studies in the past have not looked at full broiler growth periods or have not used commercial-type diets. One of the better studies, Brenes et al. (1989) (Table 2) showed that feeding up to 80 percent peas in the diet had no deleterious effect on performance compared to a corn/soy control. In fact, growth rate was better on the diets containing peas. A high level of supplemental oil was required in the diets containing high levels of peas in order to balance the feeds for energy.

In the mid-1990s, workers at the University of Manitoba conducted a series of feeding studies on starting broilers chicks, looking at the effect of processing, enzymes and varietal differences (Igbasan and Guenter, 1996a,b,c; Igbasan et al., 1997). The results show some improvement on nutrient digestibility with heating although too much heat will impair digestion (Igbasan and Guenter, 1996a). Igbasan et al. (1997) did not find any improvement in broiler performance with enzyme addition.

A series of four commercial-type feeding trials conducted in Saskatchewan (SPCDB, 2000) showed that including peas at up to 20 percent in both pelleted and mash broiler diets provided comparable performance to controls. A recent study in Mexico, (Forat and Garcia, 2001) observed excellent results in a sorghum-based diet in male Ross broilers fed from 10 to 35 days. The results are shown in Table 3.

Table 1 Effect of pea inclusion level on performance in layer diets from 24 to 40 weeks of age (Igbasan and Guenter, 1997b)

Item	Control	20% Peas	40% Peas	60% Peas
Ingredients, %				
Wheat	62	46	30	14
Barley	10	10	10	10
Peas	-	20	40	60
Soybean meal	14	9	5	0
Oil	2.8	3.1	3.5	3.8
Lysine	0.011	-	-	-
DL meth	0.01	0.011	0.013	0.014
Nutrients				
Crude protein, %	18.3	18.3	18.4	18.3
ME, kcal/kg	2820	2820	2820	2820
Lysine, %	0.81	0.82	0.94	1.04
Met + cys, %	0.67	0.66	0.65	0.64
Performance				
Egg production, %	89.8	91.3	89.7	85.3
Feed intake, g/bird	110.0	108.9	110.4	109.7
Feed conv., kg/doz	1.48	1.44	1.48	1.54
Egg mass, g/day	53.6	53.8	53.0	49.7
Egg weight, g	59.7	58.9	59.2	58.2
Shell thickness, mm	0.351	0.343	0.340	0.344
Yolk colour	2.8	4.0	4.6	5.3

Turkeys and Geese

There is limited data on feeding peas to turkeys, although Savage et al. (1986) found that there were no significant differences in growth rate, feed efficiency or meat quality from including peas at levels from 25 percent in the starter feed to 55 percent in the finisher feeds. Geese are able to digest peas well and are capable of digesting more dietary fibre components than chickens.

Table 2

Effect of pea inclusion level on performance in broiler chicken diets from 7 to 28 days of age (Brenes et al., 1989)

Item	Control	60% Peas	80% Peas
Ingredients, %			
Corn	74.2	21.6	1.3
Peas	-	60.0	80.0
Soy protein isolate	17.2	7.0	3.8
Wheat straw	4.5	-	-
Sunflower oil	-	7.1	10.5
L-lysine	0.08	-	-
DL methionine	0.19	0.33	0.38
Nutrients			
Crude protein, %	22.2	22.2	22.2
ME, kcal/kg	3110	3110	3115
Lysine, %	1.12	1.36	1.47
Met + cys, %	0.87	0.87	0.87
Performance			
Body weight gain, g	633	723	772
Feed/gain	1.66	1.67	1.65

Broiler chicken performance at various dietary inclusion levels of feed peas (Forat and Garcia, 2001)

Table 3

Item	Control	4% Peas	8% Peas	12% Peas
Initial body weight, g	208	206	207	205
Final body weight, g	1844	1851	1812	1841
ADG, g	65	66	64	65
Feed consumption, g	103	102	101	104
Feed/Gain	1.58	1.55	1.58	1.60

Practical Considerations of Feeding Peas to Poultry

There are few practical concerns about feeding peas to poultry. They can easily be fed at dietary levels of 20 to 30 percent. Peas also have positive effects on feed pellet quality and as little as 10 to 15 percent peas in the diet will negate the need for pellet binders in most feed formulations.

Peas are often used in combination with canola meal or canola seed. The amino acid balance of the two ingredients complement each other very well. Peas have high levels of lysine and low levels of methionine and cystine. Canola meal has low levels of lysine and high levels of methionine and cystine.

The energy value of peas is high enough for its economical use in layer chicken feeds; however, it is generally too low for use in high energy broiler chicken feeds unless extra oil is added. In Denmark, it is quite common to use a blend of full fat canola seed and peas, (approx. 1/3 canola and 2/3 peas) in high energy broiler feeds. The starch from the peas helps carry the oil in the canola seed. This blend is added at about 30 percent of the diet, so that the total broiler diet contains about 10 percent canola seed and 20 percent peas. The feed is expanded or otherwise heat-processed to increase digestibility of both the peas and the canola.

Table 4 Recommended inclusion levels in poultry diets

Animal type	Recommended pea inclusion level, %
Broiler chickens	20
Layer chickens	30
Turkeys	25
Geese	20

References

Bootwalla, S.M., V.J. Rakphongphairoj and T.F. Savage. 1988. Semen quality of individually caged broiler breeder males fed 16 and 7% crude protein diets containing yellow peas. Nutr. Rept. Intl. 38: 1009-1015.

Brenes, A., J. Trevino, C. Centeno and P. Yuste. 1989. Influence of peas (Pisum Sativum) as a dietary ingredient and flavomycin supplementation on the performance and intestinal microflora of broiler chicks. Brit. Poult. Sci. 30: 81-89.

Brenes, A., B.A. Rotter, R.R. Marquardt and W. Guenter. 1993. The nutritional value of raw, autoclaved and dehulled peas (Pisum Sativum L.) in chicken diets as affected by enzyme supplementation. Can. J. Anim. Sci. 73: 605-614.

Carre, B. 2002. Processing peas for poultry significantly improves energy digestibility. In The Feed Pea Focus. Alberta Pulse Growers. Edmonton, Alberta. September 2002.

Castanon, J.I.R., and J. Perez-Lanzac. 1990. Substitution of fixed amounts of soyabean meal for field beans (Vicia faba), sweet lupins (Lupinus albus), cull peas (Pisum sativum) and vetchs (Vicia sativa) in diets for high performance laying leghorn hens. Brit. Poult. Sci. 31: 173-180.

Conan, L. and B. Carre. 1989. Effect of autoclaving on metabolizable energy value of smooth pea seed (Pisum sativum) in growing chicks. Anim. Feed Sci. Tech. 26: 337-345.

Fasina, Y.O., G.L. Campbell and R.T. Tyler. 1997. Whole canola/pea and whole canola/canola meal blends in diets for broiler chickens 1. Evaluation of steam-pelleting or extrusion processing. Can. J. Anim. Sci. 77: 185-190.

Forat, M. and E.M. Garcia. 2001. Performance of broilers from 10 to 35 days fed 3 dietary inclusion levels of feed peas. Instituto Internacional de Investigacion Animal. Queretaro, Mexico.

Igbasan, F.A. and W. Guenter. 1996a. The enhancement of the nutritive value of peas for broiler chickens: an evaluation of micronization and dehulling processes. Poult. Sci. 75: 1243-1252.

Igbasan, F.A. and W. Guenter. 1996b. The feeding value for broiler chickens of pea chips derived from milled peas (Pisum sativum L) during air classification into starch fractions. Anim. Feed Sci. Tech. 61: 205-217.

Igbasan, F.A. and W. Guenter. 1996c. The evaluation and enhancement of the nutritive value of yellow-, green- and brown-seeded pea cultivars for unpelleted diets given to broiler chickens. Anim. Feed Sci. Tech. 63: 9-24.

Igbasan, F.A. and W. Guenter. 1997a. The influence of micronization, dehulling, and enzyme supplementation on the nutritional value of peas for laying hens. Poult. Sci. 76: 331-337.

Igbasan, F.A. and W. Guenter. 1997b. The influence of feeding yellow-, green- and brown-seeded peas on production performance of laying hens. J. Sci. Food Agric. 73: 120-128.

Igbasan, F.A., W. Guenter and B.A. Slominski. 1997. The effect of pectinase and alpha-galactosidase supplementation on the nutritive value of peas for broiler chickens. Can. J. Anim. Sci. 77: 537-539.

Ivusic, S.I., L.W. Mirosh and H.S. Nakaue. 1994. Productivity of laying pullets fed diets containing yellow peas (Pisum sativum L. var. Miranda). Anim. Feed Sci. Tech. 45: 205-210.

Longstaff, M. and J.M. McNab. 1987. Digestion of starch and fibre carbohydrates in peas by adult cockerels. Brit. Poult. Sci. 28: 261-285.

Rakphongphairoj, V.J., and T.F. Savage. 1988. Effects of cage and floor housing on the reproductive performance of broiler breeder males fed 16% and 7% crude protein diets containing corn-soybean or corn-yellow pea. Nutr. Rept. Intl. 37: 1-9.

Savage, T.F., H.S. Nakaue, Z.A. Holmes and T.M. Taylor. 1986. Feeding value of yellow peas (Pisum sativum L., variety Miranda) in market turkeys and sensory evaluation of carcasses. Poult. Sci. 65: 1383-1390.

SPCDB. 2000. Broiler trials with peas. Saskatchewan Pulse Crop Development Board. Saskatoon.

Trevino, J., C. Centeno, A. Brenes, P. Yuste and L. Rubio. 1990. Effect of dietary oligosaccharides on the digestion of pea starch by growing chicks. Anim. Feed Sci. Tech. 30: 313-319.

FEED PEAS IN PIG DIETS

The primary use of feed peas around the world is in pig diets, and in fact peas are an ideal feed ingredient for pigs. Pigs are able to extract a great deal of energy from peas. Peas have high levels of lysine, which is important for pig growth. Peas are very palatable. Since peas are both a good source of energy and amino acids, they tend to displace both cereal grains and protein ingredients when used in pig feeds. They are often used at high inclusion levels, especially in grower–finisher diets. One note of caution, pea use in the diets of young pigs is limited due to the effects of anti-nutritive components and lower energy digestibility. For young pigs, heat processing has shown some benefit, similar to the situation when using peas in poultry diets.

Starting Pig Diets

For young pigs, the level of trypsin inhibitor in peas may be a problem. Freire et al. (1989) have shown that heat treatment (extrusion) improves the performance of young pigs fed a diet containing 45 percent peas (spring variety), however there was no difference in performance between pigs fed raw or extruded peas at 30 percent of the diet. At these very high dietary inclusion levels, even the spring pea varieties may have enough trypsin inhibitor to cause problems with the young pig. Caution is therefore advised when using winter pea varieties with their higher levels of trypsin inhibitor.

Landblom and Poland (1997) looked at the effect of extruding diets for young pigs containing 20 percent and 40 percent peas (Table 1). There was no benefit to extruding diets containing 20 percent peas in which case both raw and extruded peas provided similar pig performance levels to the control corn/soybean meal diet. The inclusion of 40 percent peas in the diet depressed feed intake and growth rate. Extruding this diet increased pig performance to that of the control and 20 percent pea diets. This experiment used spring varieties of feed peas.

Effect of raw and extruded peas on early weaned pig performance (Landblom and Poland, 1997)

Table 1

Parameter	Corn/Soy	20% Raw Peas	20% Extruded Peas	40% Raw Peas	40% Extruded Peas
Start weight, kg	7.4	7.3	7.3	7.4	7.3
28 day weight, kg	16.8	15.9	16.4	13.9	15.4
ADG, kg	0.33	0.31	0.32	0.23	0.29
Feed intake, kg	0.57	0.54	0.59	0.46	0.54
FCE	1.73	1.74	1.84	2.00	1.86

Grower and Finisher Diets

For growing and finishing pigs, there is no reason to limit pea inclusion levels. Provided that the diets are properly balanced, especially taking into account the low methionine and cystine levels in peas, then high levels of performance can be obtained at dietary inclusion levels of 50 percent. Practical inclusion levels in Canada and other countries where peas are readily available are in the 20 percent to 40 percent range, depending on relative value to other available ingredients.

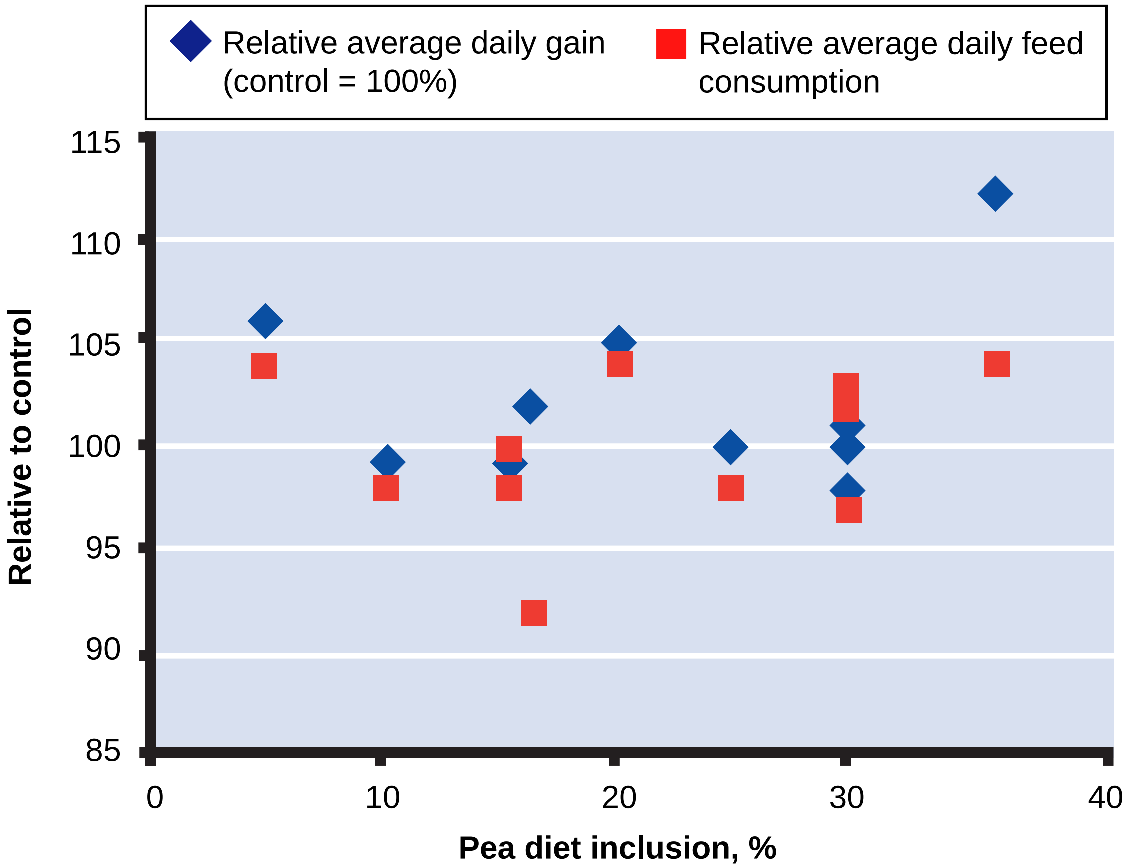
A number of studies have illustrated excellent performance when raw peas are used in growing–finishing pig diets (Bell and Keith, 1990; Gatel and Grosjean, 1990; Cote and Racz, 1991; Kehoe et al, 1991; Castell and Cliplef, 1993; Yacentiuk, 1994; Landblom and Poland, 1998; Brand et al., 2000; Shelton, 2001). The results of the Castell and Cliplef experiment are shown in Table 2. These results are presented because they are typical of pig diets in Western Canada, where it is common to use barley. The results also illustrate the benefit of including canola meal in the diet in combination with peas in order to achieve complementary sources of lysine, methionine and cystine.

Table 2

Performance of growing and finishing swine on barley-based diets containing peas, canola meal and soybean meal (Castell and Cliplef, 1993)

Item	SBM	CM	Blend 1	Blend 2	Peas
Ingredients, %					
Barley	82.4	78.7	70.9	63.0	54.9
Canola meal	-	18.7	12.4	6.1	-
Peas	-	-	14.1	28.3	42.5
Soybean meal	15.0	-	-	-	-
Nutrients					
Crude protein, %	17.7	17.4	16.4	16.2	16.4
DE, kcal/kg	3130	3050	3090	3140	3180
Lysine, %	.74	.73	.73	.76	.81
Meth + cys, %	.64	.70	.60	.54	.50
Threonine, %	.57	.61	.57	.53	.50
Performance					
Avg. daily feed, g	2900	2924	2891	2953	2771
Avg. daily gain, g	821	845	850	880	812
Feed/gain	3.53	3.46	3.40	3.36	3.41
Dressing, %	74.9	72.0	73.0	73.6	73.3
Carcass index	104.7	100.2	103.7	103.2	105.3
Loin muscle fat, %	1.2	1.6	1.3	1.6	2.4

Figure 1 Performance of pigs fed different levels of peas in grower–finisher diets relative to a soybean meal control diet: based on seven different Pulse Canada sponsored feeding trials in China, Chile, Korea, Mexico and the Philippines (1995–2001)



In addition to the previously published studies, Pulse Canada has sponsored a series of feeding trials in growing and finishing hog feeds around the world in recent years—e.g. China, Chile, Korea, Mexico and the Philippines. In all of these studies the attempt was to formulate peas into growing and finishing hog diets at the same energy and digestible amino acid levels as the control diets—thereby expecting to achieve equivalent performance to controls. In most cases, the peas were ground through a hammermill and fed raw in a mash form. These results are summarized in Figure 1. The results generally show equivalent performance, however it should be noted that there is a tendency to improved performance on pea diets especially with regard to feed consumption.

A few studies have recently looked at extruder or expander heat processing of peas as well as the addition of enzymes, with the objective of enhancing digestibility and grower–finisher pig performance. O'Doherty and Keady (2000) determined that extruder processing of peas at the 40 percent dietary inclusion level improved digestibility of organic matter, nitrogen and energy, but had no effects at 20 percent pea inclusion levels. In similar experiments with expander processing (O'Doherty and Keady, 2001) they found no benefits from expanders.

Attempts to improve grower–finisher pig performance with the use of enzymes has also been met with minimal success. Thacker and Racz (2001) found that the addition of commercial enzymes (with carbohydrase and protease activity) did not improve digestibility or performance. Landblom et al., (2002) did find a small improvement in average daily gain when xylanase and phytase enzymes were added to the diets. Another study, Baucells et al., (2000) did observe an improvement in average daily gain, feed conversion efficiency, digestibility of dry matter and crude protein, as well as a decrease in fermentable substrate flowing to the large intestine when alpha-galactosidase was supplemented to diets of growing–finishing pigs. It is unclear whether the response was in the peas or the other ingredients in the diet.

In recent years it has become more important to look at the effects of dietary ingredients on meat quality, since there are significant premiums for lean and flavourful pork meat. Most researchers have found no significant or consistent effect of feeding peas on meat quality. Landblom and Poland, (1998) suggested that feeding peas in corn-, barley- or hulless oat-based diets had no effect on backfat thickness but may increase intra-cellular fat (marbling). The results of a comprehensive study by Robertson et al. (2000) are shown in Table 3. In these wheat-based diets, typical in Western Canada, there was no effect on either growth performance, meat yield or meat quality when either peas alone or in combination with canola meal replaced soybean meal and wheat.

Breeding Swine Diets

The high protein quality and digestible energy of peas make them particularly useful in lactating sow diets. Research in Europe by Gatel et al. (1987) showed no differences in wheat/corn (50:50) based diets when peas substituted all supplemental protein (soybean meal) in both dry sow and nursing sow diets. Pigs weaned per litter were 11.05 and 11.04 for soybean and pea diets respectively. Birth weights were 1.28 and 1.29 kg, lactation growth rate was 210 and 216 g/day and pigs weaned per sow per year were 23.2 and 23.4 respectively for soybean meal and pea diets. Czarnecki et al. (1988) showed no effect on the semen quality of boars fed peas.

Practical Considerations of Feeding Peas to Pigs

It is common to grind peas through a 2.5 or 3.0 mm screen for feeding to pigs. Generally the smaller screen is used for younger animals. For growing and finishing pigs, the objective is to create a product with a mean particle size diameter of approximately 600 microns with a narrow size distribution. Albar et al. (2000) have recommended a smaller particle size (<500 microns) for starter pigs.

Peas are characterized by having a very low water extract viscosity, similar to corn and lower than other cereal grains such as wheat and barley. In pigs, ileal viscosity of digesta is much lower in peas than in cereals and ileal transit time is less for peas than wheat. This may explain the lower response to added dietary enzymes in pea-based diets compared to wheat-based diets. Ileal digestion accounts for a lower proportion of overall digestion for peas than for wheat. The starch in corn is digested more quickly in the ileum (as measured by portal vein glucose flux) than the starch in peas; however, the total digestibility is the same (Van der Meulen et al., 1997).

In northern European countries, such as Denmark, some hog feeders have noted an increase in diarrhea when peas are included in the feed. This effect is not observed in France (the largest feed pea user), in other southern European countries or in Canada. The cause of the diarrhea situation in northern Europe is unknown, but may be related to newly harvested peas and levels of soluble non-starch polysaccharides.

Table 3 Performance of pigs on wheat-based diets using soybean meal, peas and a blend of peas and canola meal (Robertson et al., 2000)

Item	Soy Grower 50–80 kg	Soy Finisher 80–110 kg	Peas Grower 50–80 kg	Peas Finisher 80–110 kg	Pea Canola Meal Grower 50–80 kg	Pea Canola Meal Finisher 80–110 kg
Ingredients, %						
Wheat	71.1	77.1	42.9	55.6	50.1	57.8
Barley	10.0	10.0	10.0	10.0	10.0	10.0
Canola meal	0	0	0	0	11.5	9.0
Peas	0	0	42.5	30.0	23.0	18.0
Soybean meal	15.0	9.0	0	0	0	0
Oil	0.8	1.0	1.5	1.6	2.5	2.5
L-Lysine	0.2	0.15	0.025	0	0.1	0.025
DL-Methionine	0	0	0.06	0.025	0.02	0
Nutrients						
Crude protein, %	16.6	14.6	14.9	13.8	16.0	14.9
DE, kcal/kg	3360	3350	3340	3350	3340	3350
Lysine, %	0.87	0.68	0.88	0.71	0.89	0.73
Dig lys, %	0.78	0.60	0.77	0.61	0.76	0.61
Dig met, %	0.21	0.18	0.21	0.17	0.22	0.19
Dig thr, %	0.47	0.39	0.42	0.38	0.46	0.42
Dig trp, %	0.18	0.15	0.12	0.12	0.14	0.13
Performance						
Avg. daily feed, g	2100	2617	2265	2674	1911	2392
Avg. daily gain, g	851	947	947	907	827	892
Feed/gain	2.48	2.85	2.39	2.98	2.35	2.73
Avg. daily feed, g	2477		2555		2243	
Avg. daily gain, g	912		960		871	
Feed/gain	2.71		2.66		2.60	
Dressing, %	83.1		83.4		83.4	
Carcass index	108		108		107	
Cut out lean, %	58.9		58.9		59.6	
Body cavity fat, %	0.62		0.53		0.58	
Intermuscular fat, %	4.95		4.58		4.71	

European feed manufacturers have also noted that feed intake in grower pigs and sows will sometimes decrease if there is more than 15 percent or 20 percent peas in a mash diet. If the diets are pelleted, then feed intake can be maintained at higher inclusion levels (25 percent or 30 percent). Note that in Europe, there are several by-products such as tapioca commonly used at high inclusion levels, which may have an effect. In Canada, where diets are generally grain-based, much higher (30 percent or greater) inclusion levels of peas are used in mash diets. Generally though, it is preferable to pellet hog diets.

It is useful to comment on the high net energy value of peas (already discussed in the Nutrient Composition chapter) relative to soybean meal since this has a practical effect on formulating diets for growing–finishing pigs. In practical grower–finisher formulas, peas displace corn and soybean meal in approximately a 2/3–1/3 ratio, the overall NE/DE ratio in the feed does not change. In more complicated diets using by-product ingredients, the actual net energy may increase when using peas. The feeds may have the same digestible or metabolizable energy levels but very often the level of net energy is higher in the feed containing the peas. This factor has implications in formulating diets for growing and finishing pigs, which have high net energy requirements. In diets formulated to metabolizable or digestible energy, much of the energy from protein ingredients is theoretically derived from protein catabolism. In well-balanced diets, very little protein is actually catabolized for energy purposes. Therefore, in pea-based diets, more of the energy comes from starch rather than protein, and there may, in fact, be higher levels of productive energy in the diets when peas are substituted for other protein ingredients. When feeds are formulated to minimum digestible energy or metabolizable energy, there is a tendency to overestimate the amount of energy that is actually available to the animal. The net energy system is better because it accounts for feed energy lost as heat. Ingredients high in protein, such as soybean meal, have a considerable heat loss during digestion due to protein catabolism. Users often find that when peas are substituted for soybean meal in hog feeds, pig performance is better than expected.

Peas are also used in lactating sow diets when there are stressful environmental and dietary factors. Since they are palatable, they are used in the summertime to encourage feed intake. They can be used, like cereal grains, to improve feed intake, by improving the taste of feeds which contain high levels of by-product ingredients.

Recommended inclusion levels in pig diets — Table 4

Animal type	Recommended pea inclusion level, %
Starter	10
Grower–Finisher	30
Sow	20

References

Albar, J., F. Skiba, E. Royer and R. Granier. 2000. Effects of the particle size of barley, wheat, corn or pea-based diets on the growth performance of weaned piglets and on nutrient digestibility. 32emes Journees de la Recherche Porcine en France. Paris. Feb 1–3, 2000. 32: 193-200.

Baucells, F., J.F. Perez, J. Morales and J. Gasa. 2000. Effect of alpha-galactosidase supplementation of cereal-soyabean-pea diets on the productive performances, digestibility and lower gut fermentation in growing and finishing pigs. Anim. Sci. 71: 157-164.

Bell, J.M. and M.O. Keith. 1990. Combinations of canola meal and field peas for use in rations for market pigs. Tenth Project Report, Research on Canola Meal, Canola Council of Canada, Winnipeg, MB, Canada, R3B 0T6. pp. 91–100.

Brand, T.S., D.A. Brandt, J.P. van der Merwe and C.W. Cruywagen. 2000. Field peas (Pisum sativum) as protein source in diets of growing-finishing pigs. J. Applied Anim. Res. 18: 159-164.

Castell, A.G. and R.L. Cliplef. 1993. Evaluation of pea screenings and canola meal as a supplementary protein source in barley-based diets fed to growing-finishing pigs. Can. J. Anim. Sci. 73: 129-139.

Cote, B.S. and V.J. Racz. 1991. Feed peas for growing–finishing swine. A.D.F. Research Report. Project #D-0794, Saskatchewan Agriculture Development Fund, Saskatchewan Agriculture, Regina, SK, Canada.

Czarnecki, R., G. Jacyno, R. Lubowicki, K. Petkov and A. Delecka. 1988. Influence of using pea seeds in feeding quantity and quality of semen. Proc. 26th World Conf. Anim. Prod. 5: 604.

Freire, J.B., J.C. Hulin, J. Peiniau and A. Aumaitre. 1989. Effet de la cuisson-extrusion du pois de printemps sur la digestibilité des aliments de sevrage précocé du porcelet et consequences sur les performances jusqu'à l'abattage. Journées Réch. Porcine en France 21: 75-82.

Gatel, F., G. Buron, M. Leuillet. 1987. Utilization of peas as a protein source for gestating and lactating sows. Journées Réch. Porcine en France 19: 223-230.

Gatel, F. and F. Grosjean. 1990. Composition and nutritive value of peas for pigs: a review of European results. Livestock Prod. Sci. 26: 155-175.

Kehoe, C., S.K. Baidoo, S. Jaikaran and F.X. Aherne. 1991. Field peas (Pisum sativa): an effective protein supplement for pigs. 70th Annual Feeders' Day Report, Univ. Alberta. Edmonton, AB, Canada. pp. 59-60, 91.

Landblom, D.G. and W.W. Poland. 1997. Nutritional value of raw and extruded field peas in starter diets of segregated early weaned pigs. Dickenson Research Centre Annual Report. www.ag.ndsu.nodak.edu/dickinso/research/tocreports.htm.

Landblom, D.G. and W.W. Poland. 1998. Supplementing grain energy sources with field peas and full-fat canola seed in swine growing-finishing diets. Dickenson Research Centre Annual Report. www.ag.ndsu.nodak.edu/dickinso/research/tocreports.htm.

Landblom, D.G., R.I Harrold, W.W. Poland and K.A. Dawson. 2002. Effects of Fibrozyme and phytase enzymes on growing-finishing pig performance in field pea-canola meal supplemented diets. J. Anim. Sci. 80: Suppl. 1.

O'Doherty, J.V. and U. Keady. 2000. The nutritive value of extruded and raw peas for growing and finishing pigs. Anim. Sci. 70: 265-274.

O'Doherty, J.V. and U. Keady. 2001. The effect of expander processing and extrusion on the nutritive value of peas for pigs. Anim. Sci. 72: 43-53.

Robertson, W.M., M.E.R. Dugan, S.J. Landry, K. Erin, G. Clayton and S. Jaikaran. 2000. Evaluation of live performance, carcass composition and meat quality of market hogs fed diets with various combinations of peas, canola meal and soybean meal with wheat or corn as the cereal base. Agriculture and Agri-Food Canada. Lacombe Research Centre. Lacombe, Alberta.

Shelton, J.L. 2001. Effects of different protein sources on growth and carcass traits in growing-finishing pigs. J. Anim. Sci. 79: 2428-2435.

Thacker, P.A. and V.J. Racz. 2001. Performance of growing/finishing pigs fed hulled and dehulled peas with and without dietary enzymes. Asian. Austral. J. An. Sci. 14: 1434-1439.

Van der Meulen, J., J.G.M. Bakker, B. Smits and H. de Visser. 1997. Effect of source of starch on net portal flux of glucose, volatile fatty acids and amino acids in the pig. Br. J. Nutr. 78: 533-544.

Yacentiuk, M. 1994. A look at the Somerset pea feeding trials. Proc. Manitoba Swine Seminar. Manitoba Agriculture. Winnipeg, MB, Canada. 8: 135-137.

Rumen Degradability

Peas have a highly rumen degradable protein and more slowly rumen degradable starch. Pea protein is highly soluble with a rumen bypass of 22 percent. Approximately 40 percent of the protein in peas is soluble (Aguilera et al., 1992). The remaining insoluble protein has a degradation rate somewhat slower than soybean meal (Aguilera et al., 1992). In that study, the pea protein disappearance rate was approximately 1.6 percent per hour compared to 4.5 percent for soybean meal after six hours of rumen incubation time. This relatively slow rate of degradation has been observed in other studies (Lindberg, 1981). Degradation rates from 6 to 12 hours appears to be similar to soybean meal. This may be advantageous in providing a more sustained release of nitrogen needed for rumen microbial growth.

Approximately half of the starch in peas is soluble. The non-soluble, rumen degradable fraction of starch is characterized by its slow degradation rate (Walhain et al., 1992; Robinson and McQueen, 1989). In high concentrate diets the ruminal degradation rate of pea starch is similar to corn and much slower than wheat, oats or barley (Table 1). A slow starch degradation rate would help control rumen pH, especially in animals that are fed large amounts of grain. Fibre digestion is depressed at a rumen pH below 6.0 which contributes to reduced dry matter intake, butter fat depression and increased digestive disturbances. This may also explain why high producing cows fed high grain diets tended to have higher butterfat percentage in their milk when peas comprised a significant proportion of the concentrate (Corbett et al., 1995).

Ruminal degradability characteristics of starches from selected feed ingredients (Robinson and McQueen, 1989)

Table 1

Grain	Total starch, % DM	Soluble starch, % DM	Rumen degradation rate, %/hour: 2/3 Hay: 1/3 Concen.	Rumen degradation rate, %/hour: 1/3 Hay: 2/3 Concen. Slow	Rumen degradation rate, %/hour: 1/3 Hay: 2/3 Concen. Fast
Barley	56.1	41	22.4	21.3	34.2
Oats	61.6	91	14.2	14.6	22.6
Corn	67.6	22	3.5	2.7	8.2
Wheat	66.6	41	22.6	17.2	23.2
Peas	41.8	51	13.4	3.9	5.3

FEED PEAS IN CATTLE DIETS

Processing

Peas do require processing when fed to ruminants and processing methods which minimize fines should be used. Coarse grinding or rolling are the most common processing methods currently employed.

Inclusion of peas in pelleted concentrates generally improves pellet quality, resulting in more durable pellets with less fines produced with mechanical handling (de Boer et al., 1991). Steam flaking of peas (Focant et al., 1990) has been shown to have no effect on degradability of protein or on the gelatinization of the starch. Steam processing of cereal grains usually causes the starch to gelatinize resulting in increased extent and rate of starch degradation in the rumen.

Likewise, extruding peas gelatinizes the starch and this increases its ruminal degradation (Aguilera et al., 1992). Extrusion has also resulted in a 50 to 75 percent reduction in protein solubility, and its ruminal degradation rate (Aguilera et al., 1992). An extrusion temperature of 140°C appears to be adequate as higher temperatures failed to result in further improvements in protein degradation characteristics. Total tract digestibility of pea protein was not changed by extrusion. Goelema et al., (1999) looked at toasting, expansion and pelleting as heat treatments for peas for dairy cattle. They found that toasting decreased rumen protein degradability but also decreased total protein digestibility. Expander treatment and pelleting generally had little effect on the rumen degradability and digestibility of protein and starch. Toasting has the potential to do more nutrient damage to peas than other heat treatments.

Calves

A number of studies have demonstrated the effectiveness of feeding peas to calves. De Boer et al. (1991) fed Holstein calves 50 percent peas in a barley-based diet. Peas replaced barley, canola meal and soybean meal from the control diet. The calves were one to four weeks post-weaning at the beginning of the experiment. Average daily gain, dry matter intake of concentrate and hay, and feed conversion efficiency were not different for the control and pea-based concentrates. The results show that peas can be used as a replacement for other protein sources in the diets of young calves. There does not appear to be an upper limit on the amount of peas that can be fed in practical rations.

In a study with creep feeding of beef calves, Anderson et al., (1999) found that peas could completely substitute for wheat middlings (Table 2). Generally feed intake increased with increasing peas in the diet, but this was accompanied by poorer feed conversion efficiency at the highest pea intake levels. Optimum economical performance was achieved at the 67 percent pea level.

Beef creep feeds with increasing levels of feed peas (Anderson, 1999)

Table 2

Performance	0% Peas	33% Peas	67% Peas	100% Peas
Initial weight, kg	164	160	164	162
Final weight, kg	235	239	245	243
DM intake, kg	2.67	2.92	3.46	3.96
ADG, kg	1.28	1.41	1.44	1.44
FCE	2.09	2.07	2.40	2.75

Beef Cattle

There are a few studies using feed peas in growing and finishing beef cattle. Birkelo et al., (1999) looked at feeding whole and rolled peas to yearling steers for the full feedlot cycle. The results are shown in Table 3. Performance was equivalent to the control diet at 10 percent dietary inclusion levels.

Effect of feeding peas on beef steer performance (Birkelo et al., 1999)

Table 3

Item	Control	Whole Peas	Rolled Peas
Ingredients, %			
Corn	72.8	66.6	66.6
Corn silage	20.0	20.0	20.0
Peas	0	10.0	10.0
Soybean meal	4.0	0	0
Nutrients			
Dry matter, %	65.6	65.6	65.6
Crude protein, % DM	12.5	12.5	12.5
Performance			
Initial body weight, kg	416	414	415
Final body weight, kg	605	600	604
Avg. daily gain, kg	1.79	1.77	1.81
Dry matter intake, kg/day	11.01	10.78	10.84
Feed/gain, kg DM/kg	6.18	6.09	5.99
Dress, %	59.0	59.1	58.1
Grade Prime & Choice, %	76.5	82.5	84.3

Dairy Cattle

A number of studies have looked at the use of peas in dairy cattle diets with excellent results. Khorasani et al., (2001) looked at peas as a replacement for soybean meal. The soybean meal diet was formulated to satisfy the nutrient requirements of a Holstein cow weighing 600 kg and producing 22 kg of 3.5 percent fat milk at 200 days in lactation. A Total Mixed Ration (TMR) consisting of 25 percent alfalfa silage, 25 percent brome grass silage and 50 percent concentrate was fed ad libitum twice daily. Four different 18.6 percent crude protein concentrates were used in which pea protein replaced soybean protein at 0, 33, 67 and 100 percent. Barley was the major grain source. Dairy milk production, 4 percent fat corrected milk (FCM) production and dry matter intake were not affected as the level of peas was increased (Table 4).

In a three month feeding study with high yielding Holstein cows, Jackman (2000) fed raw and micronized peas versus soybean meal in barley-based diets. The concentrate to forage ratio was 47 percent/53 percent. The forage component was made up of 75 percent barley silage and 25 percent second cut alfalfa hay. The results are shown in Table 5. Milk production and quality was the same on all diets. The author indicated that micronization did decrease dry matter and protein solubility, however rumen dry matter degradation rate did not change. Pea consumption averaged about 2.7 kg per cow per day. The study confirms that peas can be used at high levels in dairy cattle diets and will support very high levels of milk production.

Table 4

Effect of substitution of pea protein for soybean meal protein on milk production and dry matter intake in late lactation dairy cows (Khorasani et al., 2001)

	Pea protein			
Performance	0%	33%	67%	100%
Milk yield, kg/day	20.7	22.0	21.4	21.7
4% FCM, kg/day	20.2	21.8	21.9	20.7
Dry matter intake, kg/day	21.2	21.5	21.9	21.6

Effect of feeding raw and micronized peas on dairy cattle milk production (Jackman, 2000)

Table 5

Item	Control	Raw peas	Micronized peas
Ingredient, %			
Barley	64.3	48.4	48.4
Soybean meal	13.1	9.0	9.0
Canola meal	13.1	13.1	13.1
Raw peas	0	20.0	0
Micronized peas	0	0	20.0
Nutrients, %			
Crude protein	17.5	16.7	17.4
ADF	21.5	21.1	20.8
NDF	40.6	39.2	38.4
Performance			
Dry matter intake, kg	27.5	27.2	28.1
Milk yield, kg	40.8	41.1	40.8
3.5% FCM, kg	43.1	43.3	41.8
Protein, %	3.13	3.14	3.13

In another processing study, Petit et al., (1997), investigated extrusion as a method for processing peas. In diets based on grass silage and corn, high levels of milk production were achieved on all diets (Table 6).

Table 6 Effect of feeding raw and extruded peas on dairy cattle milk production (Petit et al., 1997)

Item	Control	Raw peas	Extruded peas
Ingredient, %			
Grass silage	43.0	40.2	40.2
Corn	46.4	33.6	33.6
Soybean meal	8.2	3.5	3.5
Raw peas	0	20.2	0
Extruded peas	0	0	20.2
Nutrients, % DM			
Crude protein	16.4	16.9	14.9
ADF	25.0	23.4	21.8
NDF	42.1	40.3	35.7
Performance			
Dry matter intake, kg	19.1	20.6	20.3
Milk yield, kg	33.8	34.3	33.6
4% FCM, kg	31.1	30.6	30.0
Protein, %	2.96	2.97	3.06

Practical Considerations of Feeding Peas to Cattle

Research and practical experience has shown that peas can be a very effective ingredient for ruminants. Processing is required to enhance nutrient digestibility, although in most applications, simple grinding through a hammermill will be sufficient. Since both the protein and starch in peas have different rumen degradabilities from other major ingredients such as cereal grains and protein sources, it is clear that peas can be an effective part of a total dietary mix in order to provide a staged release of protein and energy to the rumen.

Recommended inclusion levels in cattle diets

Table 7

Animal type	Recommended pea inclusion level, %
Beef	25
Dairy	25

References

Aguilera, J.F., M. Bustos and E. Molina. 1992. The degradability of legume seed meals in the rumen: effect of heat treatment. Anim. Feed Sci. Tech. 36: 101-112.

Anderson, V.L. 1999. Field peas in creep feed for beef calves. NDSU Carrington Research Extension Centre Beef and Bison Field Day Proceedings. 22: 1-4.

Birkelo, C.P., B.D. Rops and B.J. Johnson. 1999. Field peas in finishing cattle diets and the effect of processing. 39th Annual Progress Report. SE South Dakota Experiment Farm. South Dakota State University.

Corbett, R.R., E.K. Okine and L.A. Goonewardene. 1995. Effects of feeding peas to high-producing dairy cows. Can. J. Anim. Sci. 75: 625-629.

de Boer, G., R.R. Corbett and J.J. Kennelly. 1991. Inclusion of peas in concentrates for young calves. 70th Annual Feeders Day Report. University of Alberta. p. 41.

Focant, M., A. Van Hoecke and M. Vanbelle. 1990. The effect of two heat treatments (steam flaking and extrusion) on the digestion of Pisum sativum in the stomachs of heifers. Anim. Feed Sci. Tech. 28: 303-313.

Goelema, J.O, A. Smits, L.M. Vaessen and A. Wermmers. 1999. Effects of pressure toasting, expander treatment and pelleting on in vitro and in situ parameters of protein and starch in a mixture of broken peas, lupins and faba beans. Anim. Feed Sci. Tech. 78: 109-126.

Khorasani, G.R., E. Okine, R.R. Corbett and J.J. Kennelly. 2001. Nutritive value of peas for lactating dairy cattle. Can. J. Anim. Sci. 81: 541-551.

Jackman. 2000. The use of peas in dairy rations. Christensen, D.A. and A. Mustafa. 2000. Advances in Dairy Technology. 12: 293-302.

Lindberg, J.E. 1981. The effect of basal diet on the ruminal degradation of dry matter, nitrogenous compounds and cell walls in nylon bags. Swedish J. Agric. Res. 11: 159-169.

NRC. 2001. Nutrient Requirements of Dairy Cattle. 7th Rev. Ed.. National Acad. Press, Washington D.C.

Petit, H.V., R. Rioux and D.R. Ouellet. 1997. Milk production and intake of lactating cows fed raw or extruded peas. J. Dairy Sci. 80: 3377-3385.

Robinson, P.H. and R.E. McQueen. 1989. Non-structural carbohydrates in rations for dairy cattle. Proceedings of the Western Canadian Dairy Seminar. pp. 153-167.

Walhain, P., M. Foucant and A. Thewis. 1992. Influence of extrusion on ruminal and intestinal disappearance in sacco of pea (Pisum sativum) proteins and starch. Anim. Feed Sci. Tech. 38: 43-55.

FEED PEAS IN SPECIALTY DIETS

Sheep

Several studies have confirmed that sheep can effectively digest peas and that peas can support excellent performance. Purroy et al., (1992) determined that dry matter digestibility of peas in diets of 6 to 25-week-old lambs is approximately 80 percent. A series of feeding trials with lambs from approximately 30 to 65 kg body weight were conducted at the University of North Dakota (Loe et al., 2001). One of these experiments is shown in Table 1. The results show that excellent performance can be achieved at up to a 45 percent dietary inclusion level of peas. The peas in this study were dry rolled through a single stage roller mill, and the basal diet was based on dry rolled corn.

Table 1 Use of peas in lamb diets (Loe et al., 2001)

Item	Control	15% Peas	30% Peas	45% Peas
Initial weight, kg	33.5	34.3	32.8	35.0
Final weight, kg	61.3	64.3	62.7	65.7
Dry matter intake, kg	1.59	1.66	1.55	1.62
Avg daily gain, kg	0.31	0.34	0.34	0.34
Feed/gain	5.08	4.87	4.58	4.69

Rabbits

Peas have been fed in diets for growing and breeding rabbits (Seroux, 1984, 1988). Excellent performance was achieved at the highest dietary inclusion levels tested: 20 percent to 30 percent.

Aquaculture

Peas have recently found increased acceptance in aquaculture diets. Generally, they are an economical source of protein and energy, especially for species with intermediate protein and energy requirements. For example, they are more likely to find value in catfish, tilapia and shrimp diets than in trout and salmon diets. It appears that heat treatment will significantly improve the nutrient digestibility of peas for most aquaculture species.

In trout diets, heat treatment of peas has been shown to increase protein digestibility from 84 to 87 percent and energy digestibility from 43 to 53 percent (Pfeffer et al., 1995). Burel et al., (2000) found a similar energy digestibility of peas in trout diets (69 percent). These values are not especially high compared to pea energy digestibility in other animals. Trout and salmon have a limited capacity to digest and metabolize starch, and this will limit the utilization of peas in salmonid diets. Carter and Hauler (2000) did show that pea protein concentrate (starch removed) had high digestibility values in extruded diets for Atlantic salmon.

In diets for silver perch, (Allen et al., 2000; Booth et al., 2001) peas were shown to have similar digestibility values as other commonly used ingredients. Protein digestibility of peas was improved by dehulling.

In shrimp diets, heat treatment by extrusion or micronization will improve nutrient digestibility (Cruz-Suarez et al., 2001). Micronization increases protein digestibility from 77 to 84 percent and extrusion increases digestibility from 77 to 82 percent. As well, extrusion or micronization increased growth rate and improved feed conversion efficiency (Davis et al., 2002). These improvements should justify the expense of heat treatment. Inclusion of peas at 25 percent in shrimp diets will support excellent growth and performance.

There is insufficient information available to make broad recommendations about feed pea usage and inclusion levels in aquaculture diets. Limited information has been collected about nutrient digestibility and effective processing methods. The recommended dietary inclusion levels for aquaculture species in Table 2 are very tentative.

Recommended inclusion levels in specialty diets

Table 2

Animal type	Recommended pea inclusion level, %
Sheep	45
Rabbits	30
Salmonids	15
Other finfish	25
Shrimp	25

References

Allen, G.L., S. Parkinson, M.A. Booth, D.A.J. Stone, S.J. Rowland, J.Frances and R. Warner-Smith. 2000. Replacement of fish meal in diets for Australian silver perch, Bidyanus bidyanus I. Digestibility of alternative ingredients. Aquaculture. 186: 293-310.

Booth, M.A., G.L. Allen, J. Frances and S. Parkinson. 2001. Replacement of fish meal in diets for Australian silver perch, Bidyanus bidyanus IV. Effects of dehulling and protein concentration on digestibility of grain legumes. Aquaculture. 196: 67-85.

Burel, C., T. Boujard, F. Tulli and S.J. Kaushik. 2000. Digestibility of extruded peas, extruded lupins, and rapeseed meal in rainbow trout (Onchorhynchus mykiss) and turbot (Psetta maxima). Aquaculture. 188: 285-298.

Carter, C.G. and R.C. Hauler. 2000. Fish meal replacement by plant meals in extruded feeds for Atlantic salmon, Salmo salar L. Aquaculture. 185: 299-311.

Cruz-Suarez, L.E., D. Ricque-Marie, M. Tapia-Salazar, I.M. McCallum and D. Hickling. 2001. Assessment of differently processed feed pea (Pisum sativum) meals and canola meal (Brassica sp.) in diets for blue shrimp (Litopenaeus stylirostris). Aquaculture. 196: 87-104.

Davis, D.A., C.R. Arnold and I. McCallum. 2002. Nutritional value of feed peas (Pisum sativum) in practical diet formulations for Litopenaeus vannemei. Aquaculture Nutrition. 8: 87-94.

Loe, E.R., M.L. Bauer, G.P. Lardy, J.S. Caton and P.T. Berg. 2001. Field pea (Pisum sativum) inclusion in corn-based lamb finishing diets. In Feeding Field Peas to Livestock. North Dakota State University. 2002. p. 26.

Pfeffer, E., S. Kinzinger and M. Rodehutscord. 1995. Influence of the proportion of poultry slaughter by-products and of untreated or hydrothermally treated legume seeds in diets for rainbow trout, Onchorhynchus mykiss, (Walbaum), on apparent digestibilities of their energy and organic compounds. Aquaculture Nutrition. 1: 111-117.

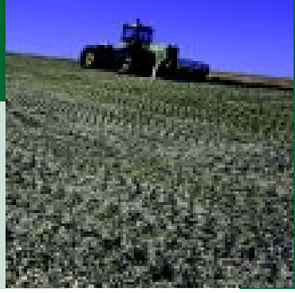
Purroy-A, J-Surra, F-Munoz, E-Morago. 1992. Use of seed crops in the fattening diets for lambs: III. Pea seeds. ITEA,-Produccion-Animal. 1992, 88A: 63-69.

Seroux, M. 1984. Utilization des proteagineux par le lapin a l'engraissement. 3eme Congres Mondial de Cuniculture. Rome. pp. 376-383.

Seroux, M. 1988. Spring peas as a source of protein for doe rabbit. 4th Congress of the World Rabbit Science Association. Budapest. 3: 141-147.

Catfish image on page 31 courtesy of Manitoba Conservation.

ECONOMICS OF FEEDING PEAS



A comparison of the nutrient composition of peas with corn and soybean meal (Table 1) is useful in that these are the most commonly replaced ingredients when peas are added to feed—especially pig feeds. The comparison therefore allows us to analyze the relative value of peas and what are the most economically important nutrients. Peas are an excellent source of energy for pigs and ruminants. The high net energy value of peas compared to protein ingredients has already been noted, but is quite evident in the Table 1 swine energy comparisons between peas and soybean meal. They are a moderate source of energy for poultry. Peas have a moderate protein level, extremely high levels of lysine and low levels of sulfur amino acids. The amino acid digestibility is high and midway between cereal grains and soybean meal.

Table 1 Nutrient content of peas, corn and soybean meal

Nutrient (as fed)	Peas	Corn	Peas % Corn	Soy meal	Peas % Soy meal
Crude protein, %	23.0	8.8	260	46.0	50
Starch, %	46.0	61.9	74	5.2	880
Poultry ME, kcal/kg	2600	3350	78	2455	106
Swine DE, kcal/kg	3485	3500	99	3550	98
Swine NE, kcal/kg	2450	2690	91	2030	121
Ruminant, TDN %	78.0	77.0	101	78.0	100
NE lact, Mcal/kg	1.81	1.77	102	1.81	100
Rumen bypass protein, %	22	50	44	35	63
Lysine, %	1.67	0.21	795	3.06	55
Lys digestibility poultry, %	87	82	106	91	96
Lys digestibility swine, %	84	72	117	89	94
Met + cys, %	0.50	0.30	167	1.42	35
Threonine, %	0.84	0.34	247	1.90	44

When peas are included in a feed, the space they occupy is at the expense of both grain (corn) and protein (soybean meal) ingredients. As mentioned previously, peas typically displace about 2/3 grain and 1/3 protein supplement. A quick estimate of the value of peas can be made by using the “2/3-1/3” rule to quickly approximate the break-even value of peas:

(Corn price X 67%) + (Soybean meal price X 33%) = Opportunity (break-even) price of peas.

For example, if the price of corn is $100 per tonne and the price of soybean meal is $200 per tonne, then, according to the formula, the approximate opportunity price of peas is: ($100 X 67%) + ($200 X 33%) = $67 + $66 = $133 per tonne. At these typical prices for corn and soybean meal it is apparent that approximately half the value of peas come from its energy contribution and the other half comes from the protein.

FEED PEA NUTRIENT COMPOSITION TABLES

Component	Average
Moisture, %	10.0
Crude protein (N x 6.25), %	23.0
Rumen bypass protein, %	22
Oil, %	1.4
Starch, %	46.0
Ash, %	3.3
Crude fibre, %	5.5
Non starch polysaccharides, %	12.5
Oligosaccharides, %	5.0
Insoluble cell walls, %	12.5
Acid detergent fibre, %	8.2
Neutral detergent fibre, %	16.7
Lignin, %	0.5
Trypsin Inhibitor Activity, TIA/mg	3.5
Phytic acid, %	1.2

Mineral	Average
Calcium, %	0.11
Phosphorus, %	0.39
Available P, %	0.15
Sodium, %	0.04
Chlorine, %	0.05
Potassium, %	1.02
Sulfur, %	0.20
Magnesium, %	0.12
Cobalt, mg/kg	133
Copper, mg/kg	9
Iron, mg/kg	65
Manganese, mg/kg	23
Molybdenum, mg/kg	0.8
Zinc, mg/kg	23
Selenium, mg/kg	0.38

Vitamin	Amount, mg/kg
Biotin	0.15
Choline	547
Folic acid	0.2
Niacin	31
Pantothenic acid	18.7
Pyridoxine	1.0
Riboflavin	1.8
Thiamin	4.6
Vitamin E	0.2

FEED PEA NUTRIENT COMPOSITION TABLES

Amino Acid	Total, %	Swine true digestibility, %	Poultry true digestibility, %
Arginine	2.31	90	90
Cystine	0.22	79	74
Histidine	0.72	89	87
Isoleucine	1.10	85	84
Leucine	1.80	86	86
Lysine	1.67	88	87
Methionine	0.28	84	82
Methionine + Cystine	0.50	82	78
Phenylalanine	0.98	87	86
Threonine	0.84	83	83
Tryptophan	0.19	81	82
Valine	1.05	83	81

Animal	Energy type	Average value
Adult chicken	AME_n, kcal/kg	2600
	TME_n, kcal/kg	2640
Growing pig	DE, kcal/kg	3485
	ME, kcal/kg	3240
	NE, kcal/kg	2450
Cattle	TDN, %	78
	DE, Mcal/kg	3.47
	ME, Mcal/kg	3.08
	NEM, Mcal/kg	1.95
	NEG, Mcal/kg	1.33
	NEL, Mcal/kg	1.81

Canadian Feed Peas Industry Guide

Pulse Canada
1212-220 Portage Avenue
Winnipeg, Manitoba
Canada R3C 0A5
Phone: (204) 925-4455
Fax: (204) 925-4454
Email: office@pulsecanada.com
www.pulsecanada.com

Printed in Canada

Pulse Canada