Feed Focus: Species Nutrition

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Nutrition by Dr. Mrigen Dutta

Nutritional strategies to improve dairy cow production, reproduction

Providing the correct nutrition is essential for today's high-yielding dairy cows.

FIGURE 1: A comparison of rumen-protected and rumen-stable fats

Rumen-protected fats (Ca soaps)	Rumen-stable fats
Chemically treated, industrial origin of various fatty acids	Physically fractionated triglycerides rich in saturated fatty acids, mainly palmitic acid
Pungent soap taste or aromatised	Neutral odour
Protection depends on rumen pH	Not dependent on rumen pH
Low rumen pH impairs the stability, resulting in to release of the unsaturated fatty acids	Stable at various pH, pass through the rumen almost unchanged

Rumen-stable fats offer a number of advantages over rumen-protected fats.

Over recent decades, genetic improvement and better management practices have dramatically increased dairy cattle milk production but, at the same time, managing fertility and conception rates has been difficult. Managing optimum productivity of dairy cattle in terms of quality milk production and efficient breeding plays a vital role in profitable dairy farming. Nutrition is one of the most important factors in their performance, health and welfare.

Many nutrients are utilised by the body for milk production, and increased nutrient demands for production can negatively impact reproduction in dairy cows.

High-yielding cows require special nutritional care, especially during periods of production stress. Modern, high-yielding animals are either in lactation or in advanced pregnancy, posing a regular metabolic stress to the body.

An adequately nourished cow will be healthy and able to manage the stresses associated with high milk production.

Energy and protein feed ingredients, in addition to many trace elements and vitamins, play important roles in milk production and reproduction. It is not only the quantities of energy and protein source, but also their quality that plays a vital role for optimum production and reproduction.

Energy: supplementation a must

In lactating dairy cattle, milk yield usually peaks at four to eight weeks postpartum, but dry matter intake does not increase proportionately to meet energy requirements until 10-14 weeks postpartum. Consequently, high-yielding cows experience some degree of negative energy balance during the early postpartum period. High-yielding cows have a gap between energy supply and demand. To fulfil the higher energy need for milk production, animals utilize body reserves resulting in impaired health and frequent metabolic disorders.

Energy is the major nutrient required by adult cattle; and inadequate energy intake has a detrimental impact on milk yield and reproduction. Cows under negative energy balance have extended periods of anovulation. Postpartum anestrus, as well as infertility, are magnified by losses of body condition during the early postpartum period.

Strategy to increase energy intake

The extent and duration of postpartum negative energy balance is influenced by genetic potentiality for milk production, dietary energy density and dry matter intake. Nutritional management strategies can be employed to minimize the extent and duration of negative energy balance.

In view of the fact that dry matter intake during the early lactation period goes down, increasing energy density of the ration is the only available option to improve energy intake, which can be achieved through supplementation of grains or fat.

Diets containing high levels of grain may cause metabolic disturbances, such as rumen acidosis, and may ultimately result in low milk and milk fat production.

To avoid these problems, fat can be added to increase the energy density of the diet. Fat supplementation also has other potential benefits, such as increased absorption of fat-soluble nutrients and reduced dustiness of feed. In addition, feeding fat to dairy cows generally improves fertility.

Dietary supplementation with fat

Vegetable oils as such are not recommended for ruminants because the unsaturated fatty acids are toxic to rumen bacteria, especially to fibre degrading bacteria. Unsaturated fat supplementation reduces fibre digestion, thereby defeating the major objective of increasing the availability of energy. Therefore, the supplementation of fat for dairy cows is achieved by means of bypass fats, which pass the rumen without any degradation. Rumen bypass fats can be either rumen-protected or rumen-stable fats. These are inert in the rumen and are

Nutritional strategies

digested in the lower GI tract, hence they are not harmful to rumen bacteria.

Rumen-stable and rumen-protected fats

The protected fats are mostly calcium salts of long-chain fatty acids or saturated fats. Protection does not mean stability; usually protection depends on the conditions of the rumen and its pH. Rumen-protected calcium-soap or calcium salts of long-chain fatty acids were developed to improve milk production. Being a chemical reaction product, they have disadvantages.

Because of the pungent soap taste, there is usually poor acceptance of the feed. A further disadvantage is that larger amounts of feed concentrate, low pH values in feed and in the rumen, impair the stability of calcium soaps resulting in the release of the unsaturated fatty acids. These unsaturated fatty acids may negatively influence milk fat formation and may also disturb ruminal digestion.

A recent development in fat supplementation for dairy cows is rumen-stable fats, which are fractionated triglycerides, rich in saturated fatty acids, mainly palmitic acid. Rumen-stable fats are stable at various pH conditions. Their fatty acids are largely saturated; passing through the rumen almost unchanged. The fats reach the small intestine where they are broken down by enzymes and utilised by the body as an efficient source of energy.

Protein nutrients

Dairy cattle, like other animals, require essential amino acids that must be absorbed from the small intestine. Ruminants obtain amino acids from two sources – microbial proteins and bypass protein, or rumen undegraded protein.

Microbial protein: Microorganisms in the rumen assist in providing the total protein and individual amino acid requirements of ruminants. Rumen microorganisms can synthesize protein and amino acids from non-protein nitrogen compounds, such as urea and ammonia. The microorganisms in the rumen synthesize amino acids by combining ammonia and carbohydrates. These amino acids become part of the microbial protein, which is then digested in the small intestine.

When the digestible energy content of the ration is high enough, one third or more of the total protein needs of many ruminant rations may be supplied by nitrogen from non-protein nitrogen sources. Growing and finishing cattle can effectively use non-protein nitrogen. Microbial protein production depends on the rumen conditions.

Microbial protein synthesis in the rumen depends largely on the availability of carbohydrates and nitrogen in the rumen. Rumen bacteria generally have the ability to utilise the majority of ammonia released in the rumen from deamination of amino acids and the hydrolysis of non-protein nitrogen compounds. However, dietary conditions often occur in which the rate of ammonia release in the rumen exceeds the rate of uptake by ruminal bacteria. The condition may occur because of a surplus of rumen degraded protein or a lack of available energy, resulting in inefficient utilization of fermentable substrates and reduced synthesis of microbial protein.

Bypass protein

High-yielding cows have a higher requirement of amino acids that cannot be fulfilled by rumen microbes, even at high rates of synthesis. The diet of such cows should include proteins of low degradability in the rumen that will escape breakdown until they reach the intestine. This is known as bypass protein or rumen undegraded protein, which is digested in the intestine and the amino acids are used for the synthesis of tissue and milk protein.

Diets for dairy cows should contain rumen-degraded and rumen-undegraded protein, at an ideal ratio of 65:35. Usually, reliance on feed proteins with a high content of digestible RUP is greatest in high-producing cows when most or all of the forage is provided by high-quality grasses and legumes. In these situations, the basal diet often contains adequate or more amounts of RDP, but is deficient in RUP. Protein supplementation should be limited to RUP to avoid excesses of RDP. Milk protein yield can be increased linearly by increasing RUP content in feed.

Chromium

During the phase of negative energy balance, efficient utilization of energy results in higher productivity and better health. Chromium is an essential element that is required for the efficient utilisation of dietary energy. Glucose, produced from carbohydrates, is one of the major sources of energy. Insulin takes major part in the glucose metabolism. Chromium acts biologically as a component of glucose tolerance factor, which enhances tissue sensitivity to insulin and glucose utilization.

The transition period from 21 days prepartum to about 21 days postpartum is a critical period in regard to health and milk production of high-producing dairy cows. Supplementing high-producing dairy cows with chromium during the transition period can increase feed intake and milk production during early lactation. Chromium supplementation can also improve reproductive performance, cell-mediated and humoral-immune responses.

Inorganic forms of chromium are poorly absorbed. Chromium chelated with organic compounds increases its absorption. Chromium nicotinate and chromium picolinate are usually considered the most available sources of supplemental chromium.

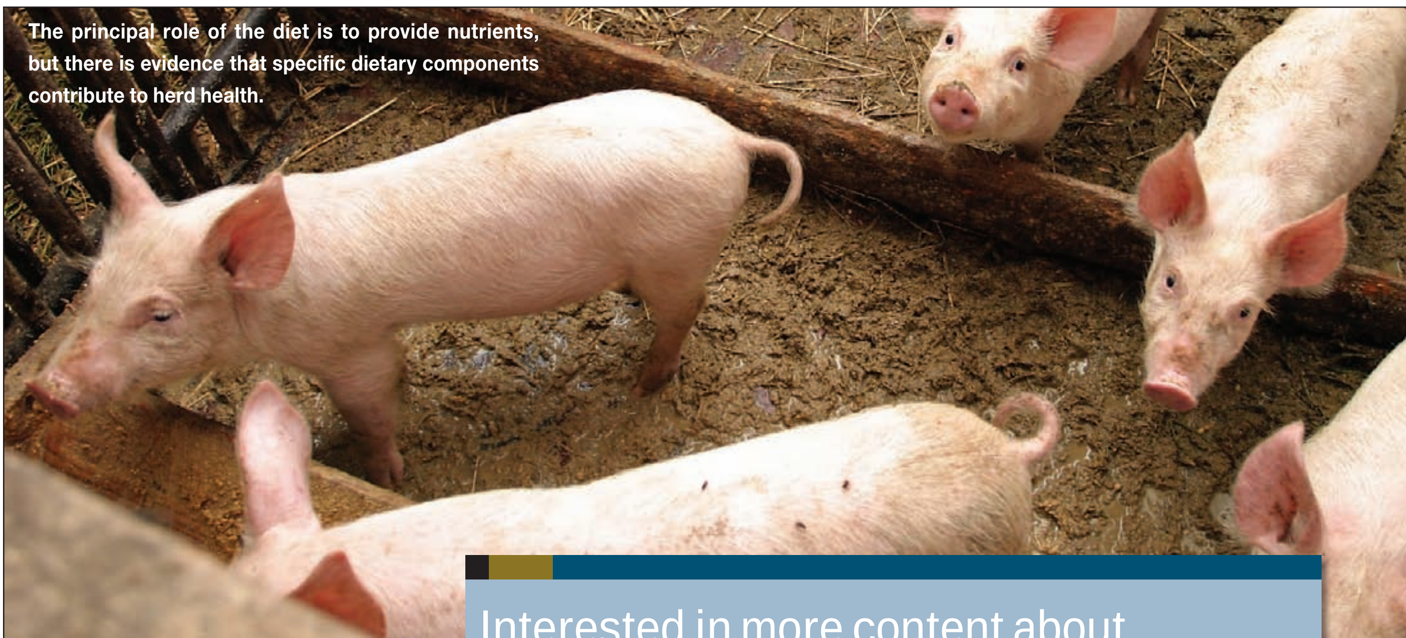
An unhealthy transition period and negative energy balance during early lactation reduces milk production and can lead to metabolic disorders and impaired reproduction. Supplementing cows, especially at early lactation, with rumen-stable fat, bypass protein and chelated chromium can reduce the extent and duration of the negative balance, and improve health, milk production, milk quality and reproduction.

Dr. Mrigen Dutta is business development manager – Corporate, Zydus Animal Health Limited.

[PigNutrition *by J.E. Pettigrew*]

Combating the high cost of pig feed

Nutritionists need to look at all options when considering swine diet.



The principal role of the diet is to provide nutrients, but there is evidence that specific dietary components contribute to herd health.

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The most significant change impacting the pig industry and nutritional practices during recent years has been the dramatic increase in the cost of major feedstuffs, due primarily to droughts and ethanol production. What's more, the cost of special ingredients for nursery diets such as fish meal and milk products has also risen. The combination of these factors has forced swine nutritionists to look thoughtfully and creatively at new and cost-effective options for pig feed.

Pros and cons of DDGS

The pig nutrition community has done an admirable job of learning how best to utilize distillers dried grains with solubles, the dominant co-product of ethanol production. Although the most valuable part of the corn, the starch, is lost during ethanol production, the remainder can be salvaged and put to good use.

Pig nutritionists have learned a great deal about DDGS and its effective use in pig diets. Positive aspects include:

- Its use can often lower diet cost significantly.
- Generally, all components of corn (except starch) are concentrated about three-fold in DDGS.
- The energy value is similar to that of corn, due to high levels of both fiber and fat.
- Phosphorus digestibility in DDGS is quite high.

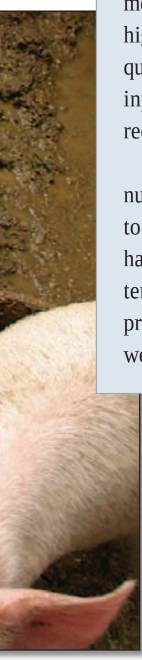
Negative aspects include:

- The digestibility of amino acids, especially lysine, in DDGS is rather low and variable. However, attention to this fact has improved processing conditions. As a result, the extremely low digestibility values reported several years ago are not now generally seen.
- The high levels of polyunsaturated fatty acids can result in soft carcass fat. However, it is still possible to use rather high levels of DDGS without causing carcass fat to be soft enough to cause problems.

Sow nutrition

Besides the inclusion of DDGS, there is another significant reason for changes in sow diets. The last decade or so has brought a startling increase in the number of pigs produced per litter and the amount of milk secreted by the sow. These advances in production increase quantitative nutrient requirements of both gestating and lactating sows, and we continue to struggle to estimate and meet these requirements. This challenge highlights the importance of estimating quantitative nutrient requirements using input-output calculations that relate the requirement to the level of production.

Pig nutritionists continue to seek nutritional contributions to a solution to the reduced piglet birth weights that have accompanied the increase in litter size, and the resulting increase in preweaning mortality and decrease in weaning weight.



•The three-fold concentration of non-starch components of corn in DDGS holds for mycotoxins as well as nutrients. This three-fold concentration of mycotoxins in DDGS created special concerns about DDGS made from the 2009 U.S. corn crop, much of which had damaging levels of mycotoxins because of weather conditions late in the growing season. Mycotoxin binders and other products to reduce the impacts of mycotoxins were used widely.

Other considerations

Phosphorus nutrition. The swine industry has widely adopted the use of phytase to increase digestibility of phosphorus in plant materials, and at higher dietary inclusion levels than used a few years ago. Benefits are in lower diet cost and in reduced phosphorus excretion. There is now a strong trend to formulation on the basis of digestible phosphorus rather than available phosphorus, largely because the measurements of digestible phosphorus are easier, cheaper, and more consistent across laboratories. Some diets containing high levels of both DDGS and phytase do not require additional phosphorus supplementation.

Carbohydrases. The widespread use of DDGS with its high fiber level has spurred interest in increasing fiber digestibility by use of carbohydrase enzymes such as xylanases beyond the previous interest in using such enzymes in lower-fiber diets.

Crystalline amino acids. There has been a continuing increase in the amounts of crystalline amino acids used in swine diets during recent decades. The use of DDGS stimulates even more use of crystalline amino acids because of the relatively poor amino acid balance of the proteins in DDGS.

Other diet components

The principal role of the diet is to provide nutrients, but there is accumulating evidence that specific diet components can contribute to herd health. A few examples:

Spray-dried plasma, besides dramatically increasing the growth rate of pigs soon after weaning, provides a degree of specific protection against enteric infections by *E. coli*.

It also moderates inflammatory responses.

> The pig nutrition community has done an admirable job of learning how best to utilize distillers dried grains with solubles.

A high level of zinc oxide markedly reduces mortality in the face of a severe outbreak of enteric disease in nursery pigs.

Research has shown that insoluble fiber, as found in DDGS, speeds recovery from *E. coli* diarrhea.

Mannan oligosaccharide derived from yeast cell wall causes complex and potentially important changes in immune function, including moderation of inflammation. It partially counteracts the immune suppression caused by a PRRS infection.

Both certain clays and certain plant extracts (essential oils) can reduce diarrhea in pigs infected with *E. coli*.

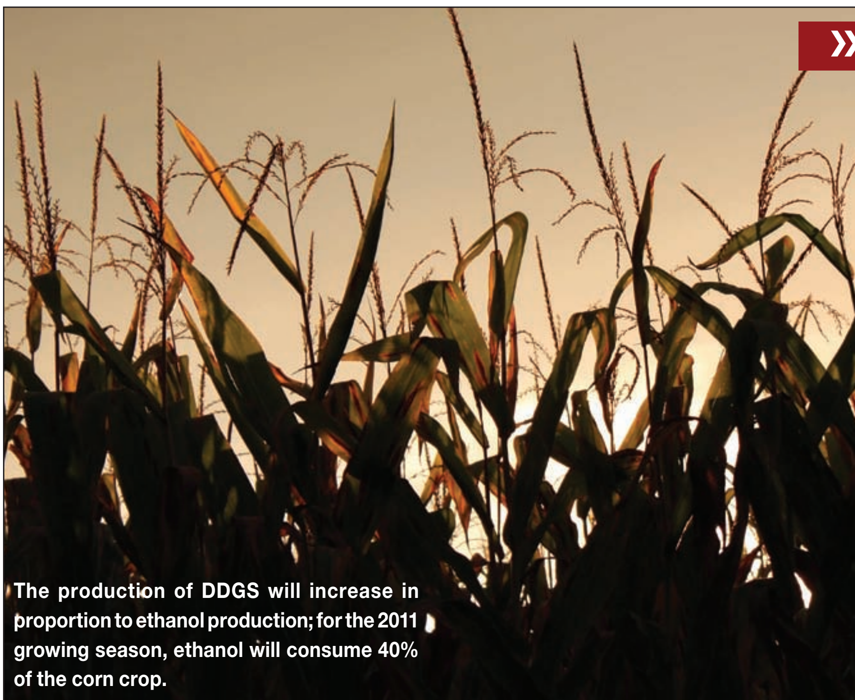
Research is in its early stages in the area of dietary effects on the health of pigs, but there are reasons to believe that specific physiologically active diet components may be quite important for swine herd health. Much more progress is anticipated in coming years. [FM]

J.E. Pettigrew is Professor of Animal Sciences, University of Illinois

[Nutrition *by Sheila Purdum, Ph.D*]

Using more DDGS in poultry feed

With increasing production, DDGS will have to be used to a greater extent by livestock and poultry producers to replace diverted corn



The production of DDGS will increase in proportion to ethanol production; for the 2011 growing season, ethanol will consume 40% of the corn crop.

In 2008, U.S. production of distiller's dried grains with solubles exceeded 23 million tons, with the U.S. poultry industry consuming about 5% of output and swine producers feeding around 20% of available DDGS. The majority of DDGS is fed to ruminants at rates of 75% to 80% of their diets.

The production of DDGS will increase in proportion to ethanol production; for the 2011 growing season, ethanol will consume 40% of the corn crop. With increasing production, DDGS will have to be used to a greater extent by livestock and poultry producers to replace diverted corn and more expensive soybean meal.

Previous research on DDGS in laying hens showed no negative effect on egg production when fed at 10% to 20% of diets. DDGS can contribute as much as one-third of the protein needs of laying hens. The protein concentration in DDGS is approximately three times the level in corn

Table 1. Laying Hen Trial 1. Effect of Various Levels of DDGS on Egg Production Parameters for Phase 1

	DDGS inclusion, %							
Measurements	0	5.0	10.0	15.0	20.0	25.0	S.E	P value
Egg Prod. (%)	92.1	89.2	90.7	89.6	91.2	91.0	1.648	0.82
Feed Intake (g/d)	109.2	110.9	110.3	108.3	108.7	109.2	1.076	0.55
Hen Weight (kg)	1.54	1.57	1.54	1.55	1.53	1.54	0.0155	0.55
Egg Weight (g)	60.6	60.4	60.7	60.0	58.9*	59.3*	0.4873	0.063
Haugh Unit	92.42	92.04	91	92.15	92.89	92.46	0.6822	0.5
Specific Gravity	1.086	1.085	1.086	1.086	1.086	1.086	0.00045	0.13
Yolk Color (Roche)	5.6**	6.2**	6.3**	6.6**	7**	7.2**	0.05257	0.0001
*p<0.1, **P<0.05								

Feeding 25% DDGS to laying hens saved $20.92 and $9.92 per ton for Phase I and Phase II compared to diets devoid of DDGS.

Table 2. Layer production data; egg production, feed intake and feed conversion

Diets								
Ingred.	Enzyme	M.E.	Egg Production (%)	Feed Intake (g/hen/d)	Feed Conversion (g/feed: g egg)	Egg Production (%)	Feed Intake (g/hen/d)	Feed Conversion (g feed: g egg)
DDGS	P[1]	Moderate[3]	91.70	91.69	1.66	84.83	91.98	1.60
DDGS	PAX+P[+]	Moderate[3]	88.81	92.44	1.69	83.52	91.80	1.60
MBM	P1	Moderate[3]	92.79	92.00	1.67	85.73	88.15	1.52
MBM	PAX+P[2]	Moderate[3]	91.86	91.75	1.68	87.48	90.63	1.56
DDGS	P1	Low[4]	92.79	93.60	1.72	86.61	91.92	1.58
DDGS	PAX+P[2]	Low[4]	93.65	93.61	1.70	87.30	93.47	1.61
MBM	P1	Low[4]	90.65	93.44	1.70	85.04	92.89	1.57
MBM	PAX+P[2]	Low[4]	92.19	92.81	1.67	84.61	91.23	1.56
SEM[5]			1.300	1.042	0.019	1.510	1.042	0.238
Main Effects Ingredient								
DDGS			91.64	92.84	1.69	85.57	92.00	1.58
MBM			91.87	92.50	1.68	85.72	90.73	1.55
p-value			0.81	0.62	0.32	0.89	0.12	0.55
Enzyme								
A+P[2]			91.63	92.65	1.68	85.72	91.78	1.58
P1			91.87	92.68	1.69	85.73	91.04	1.56
p-value			0.79	0.96	0.74	0.86	0.39	0.17
M.E.								
Moderate[3]			91.28	91.90	1.68	85.55	90.44	1.56
Low[4]			92.22	93.37	1.69	85.89	92.38	1.58
p-value			0.31	0.04	0.12	0.64	0.03	0.24
SEM[5]			0.007	0.642	0.010	0.757	0.826	0.012
Interactions								
Ingredient x Enzyme			NS	NS	NS	NS	NS	NS
Ingredient x M.E.			0.049	NS	NS	0.036	NS	NS
Enzyme x M.E.			0.077	NS	NS	NS	NS	NS
Ingredient x Enzyme x M.E.			NS	NS	NS	NS	NS	NS
M.E. x Time			NS	0.087	NS	NS	NS	NS
Ingredient x Enzyme x Time			NS	0.0002	NS	NS	NS	NS
Enzyme x M.E. x Time			NS	0.079	NS	NS	NS	NS

[1]=Phyzyme® 5000G XP; Danisco Animal Nutrition, St. Louis, MO 63147
[2]=Avizyme ® 1502 and Phyzyme® 5000G XP; Danisco Animal Nutrition, St. Louis, MO 63147
[3]=Moderate M.E. level, Phase 1 M.E.=2900Kcal/kg; Phase 2 M.E.=2880Kcal/kg
[4]=Low M.E. level, Phase 1 M.E.=2860; Phase 2 M.E.=2800 kcal/kg

Feeding high inclusion rates of DDGS is possible if amino acid balance is achieved.

due to removal of fermentable carbohydrate and starch. DDGS is high in total phosphorous and nitrogen compared to corn, and can consequently reduce the amount of inorganic phosphorous added to hen diets. Inclusion of DDGS does not affect excretion of nitrogen in manure.

Exogenous enzymes such as phytase and combinations of amylase, protease and carbohydrase are incorporated more frequently into poultry diets especially during times of high commodity prices. The majority of research on the efficacy of enzymes has been conducted on corn or wheat-based diets with soybean meal as the major protein source. The action of these enzymes in diets with a high level of DDGS has been a focus of the University of Nebraska-Lincoln research program in poultry diets for the last three years.

Research objectives on DDGS in poultry diets, 2007-2010:

»To evaluate high inclusion of DDGS in

[Using more DDGS in poultry feed]

Table 3. Levels of DDGS by Enzyme interaction

Levels of DDGS	Egg production (%)	Egg weight (g)	Egg mass (g/hen/day)	Feed Intake (g/hen/day)	Feed Price ($/ton)
0%	93.39	53.94	50.40	101.52	251.88
0% Plus SSF	93.37	52.95	49.45	103.11	243.2
10%	93.72	52.87	49.53	102.21	229.88
10% Plus SSF	93.21	53.56	49.92	100.54	222.28
20%	90.41	53.04	47.90	101.47	208.8
20% Plus SSF	90.53	52.36	47.40	101.54	200.8
30%	91.23	53.04	48.38	101.07	187.12
30% Plus SSF	90.91	52.76	48.55	101.88	179.4
40%	88.56	53.19	47.09	103.19	166.72
40% Plus SSF	87.03	52.27	45.44	104.73	166.72
P-Value	0.8185	0.6983	0.7732	0.7615	<0.0001
Standard Error	3.0518	0.6318	0.8768	1.3964	0

Results of the long-term trial indicated a slightly lower level of egg production and egg mass at the 40% level of DDGS inclusion.

feed for laying hens over a production cycle.

» Determining the maximum inclusion rates of DDGS in layer diets supplemental with Alltech SSF

» Examining synergies from DDGS and meat and bone meal with enzyme supplementation in layer diets

Ascertaining the maximum inclusion level of DDGS in layer rations

When DDGS was incorporated in experimental diets, synthetic lysine and a fat blend were added. Dicalcium phosphate was decreased with incremental DDGS levels in diets. Feeding 25% DDGS to laying hens saved $20.92 and $9.92 per ton for Phase I and Phase II compared to diets devoid of DDGS.

In this initial study, results indicated that feeding corn with DDGS at levels of up to 25% had no negative effect on egg production parameters during either Phase. Feeding DDGS at 20% and 25% affected egg weight in Phase I but not in Phase II.

This was due to changing the amino acid balance from fixed lysine and total sulphur-containing amino acids in Phase I to fixed lysine and TSAAs during Phase II.

Feeding high inclusion rates of DDGS is possible if amino acid balance is achieved. In addition, DDGS can replace some dicalcium phosphate in layer diets to reduce feed cost. The reduction in nitrogen and phosphorous excretion were positive benefits of feeding high levels of DDGS.

Effects of feeding DDGS with SSF enzyme

This trial was conducted on laying hens which were fed 0%, 10%, 20%, 30% or 40% DDGS with or without Allzyme SSF (Alltech) enzyme in a factorial arrangement. Diets were formulated to be isocaloric and isonitrogenous. When SSF enzyme was added to the diets, metabolizable energy was reduced by 75 kcal/kg.

Results of the long-term trial indicated a slightly lower level of egg production and egg mass at the 40% level of DDGS inclusion. Diets with SSF enzyme fully supported production equal to hens in the treatments without enzyme supplementation. Adding Allzyme SSF enzyme saved an average of $8.00/ton of feed, and feeding up to 30% DDGS saved $64.00/ton of feed compared to the basal diet devoid of DDGS, based on 2010 ingredient costs.

Previous research on DDGS in laying hens showed no negative effect on egg production when fed at 10% to 20% of diets.

Synergy of feeding DDGS and meat and bone meal with enzyme combinations (Phytase + Avizyme)

The objective was to test the addition of Avizyme 1502, a blend of protease, amylase and xylanase (Danisco UK Ltd.) and a phytase in laying hens fed corn-soy diets containing DDGS, meat and bone meal. Hy-Line W-36 laying hens were used in the study, which was conducted from 24 to 52 weeks of age. There were 12 replicate pens with four hens per pen, with 96 pens in total.

The study consisted of eight dietary treatments arranged in a 2x2x2 factorial design. The factors were: diet (containing DDGS or MBM), metabolizable energy level 2930 Kcal/kg (Phase 1), 2880 Kcal.kg (Phase 2) or 2860 Kcal/kg (Phase 1), 2800 Kcal.kg (Phase 2), and two enzyme levels (0% or 0.0375% Avizyme 1502) to provide protease at 8000 U/g, amylase at 800 U/g, and xylanase at 600 U/g of product. All diets contained Phyzyme at 60 g MT (~300 FTU) and were formulated to contain 0.30%.

The bottom line

DDGS can be included at relatively high levels in diets for pullets and laying hens when formulated to balance amino acid requirements. Addition of exogenous enzymes allows downgrading of dietary specifications for diets containing MBM and DDGS. Exogenous enzyme supplementation can significantly reduce the cost of diets for laying hens.

Adapted from a presentation made at the 2011 Midwest Poultry Federation Convention. [FM]

Nutrition by Peter Best

Piglet nutrition: New targets for amino acids

The latest concepts in feeds for young pigs include formulating to optimise the growth and health of the animal's gut.

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Feeding the young pig both adequately and economically has never been an easy task, but the manufacturer of piglet diets is now being asked to take further factors into consideration. Among these are the birth origins of the animal and even the possibility that part of its feed supply should be for reasons other than body maintenance and growth.

This second aspect was raised in 2010 at the 21st International Pig Veterinary Society Congress, where Dr Douglas Burrin of the US Department of Agriculture's Agricultural Research Service presented a lecture on the role of nutrition and intestinal adaptation in the weaned pig. In his remarks, he introduced the rather novel concept of also formulating to meet gut nutrient requirements.

Fuels for gut function

"Historically, weanling pig diets have been formulated largely to overcome the limitations or immaturity in digestive function in order to maximise growth of the whole animal," he said. "However, with a new understanding of intestinal nutrient utilisation, it is now possible to formulate such diets with the specific goal of optimising the growth, function and health of the gut."

Although most swine nutritionists have an extensive knowledge of the pig's nutritional needs for growth, he told the meeting, research in recent years has extended the whole area of defining requirements so it also now includes nutrients needed specifically for the gut.

"Technical advances have enabled direct estimates of gut nutrient utilisation and the impact on whole animal nutrient metabolism," said Dr Burrin. "A major concept that has emerged from studies with young pigs is that non-essential amino acids are major gut fuels."

The research into intestinal nutrient utilisation has suggested that some of the most promising candidates for manipulation in a new-look formulation strategy are the amino acids glutamine, glutamate and threonine with aspartate. From in-vivo studies in pigs, roughly 70-80% of the glutamate, glutamine and aspartate provided by the animal's diet is taken up by the gut at the first pass and metabolised to carbon dioxide. "Glucose is also quantitatively an important oxidative fuel for the pig intestine. In absolute amounts, the intestinal utilisation of glucose is similar to the combined total from glutamate, glutamine and aspartate. However, the proportional use is lower, such that only about 20-30% of the dietary glucose is metabolised by the gut."

Intestinal metabolism

The implications of the research conducted to date seem to be greatest with regard to the supply and use of amino acids in young pigs, to judge from Dr Burrin's remarks. He described studies with piglets showing that the neonatal intestine played a key role in the metabolism of amino acids involved in the urea cycle, particularly arginine, proline, and ornithine.

There is extensive inter-conversion between these amino acids, he reported. The intestine represents an important site of net arginine synthesis in neonatal pigs. Moreover, the intestinal studies in pigs have demonstrated the extensive metabolism of other essential amino acids, including threonine, lysine, phenylalanine, branched-chain amino acids and methionine.

"It is generally considered that the primary metabolic fate of essential amino acids taken up by the gut is incorporation into tissue proteins. However, studies show that extensive irreversible catabolism and oxidation of amino acids occurs in the gut. Many of these essential amino acids are metabolised to other intermediates involved in intestinal function.

"For example, threonine is believed to be channeled into mucin synthesis and secreted by goblet cells, because mucin peptides are rich in threonine. Methionine may be converted to cysteine or s-adenosyl-methionine used in polyamine synthesis. Cysteine is used as a precursor for glutathione synthesis and maintenance of mucosal anti-oxidant status."

The oxidation of some essential amino acids, such as the branched-chains and lysine, in the gut may be nutritionally significant, Dr Burrin continued. The high essential amino acid utilisation rate by gut tissues can impact significantly on the systemic availability of amino acids for lean tissue growth.

Ideal protein

Current ideas from Europe and North America on the piglet's need for dietary amino acids were summarised at the end of last year in a presentation to the Society of Feed Technologists, SFT, in the UK by Lars Sangill Andersen, feed application manager for Hamlet Protein A/S in Denmark. Amino acid values to supply within a piglet diet tend to be defined according to their relationship to lysine in an ideal protein combination, he pointed out.

Typically, this could mean methionine at 33% relative to lysine or methionine + cystine at 57%. Threonine could be at 65%, tryptophan at 20%, valine at 70%, isoleucine at 58% and histidine at 33%.

Modern formulations in practice consider digestible amino acids per kilogram of feed according to the energy level of the diet and the weight of the piglet. But as Mr Sangill Andersen pointed out, not all requirements have been defined even today and particularly not those for the youngest pigs. The nutritionist therefore must still work mainly from values found for larger growing pigs, despite the certainty that the needs of small piglets will be lower.

From his SFT presentation, accompanying Table 1 sets out some standardised ileal digestible amino acid values at different piglet weights and levels of dietary metabolisable energy. They are based on data established in France, Germany and the US.

As he remarked, however, issues on how to formulate effective feeds for young pigs go beyond the specification of amino acids or other individual nutrients. Among the questions for formulators to answer is whether the right ingredients have been chosen and whether the concentration of crude protein in the early diet might lead to problems of piglet diarrhoea.

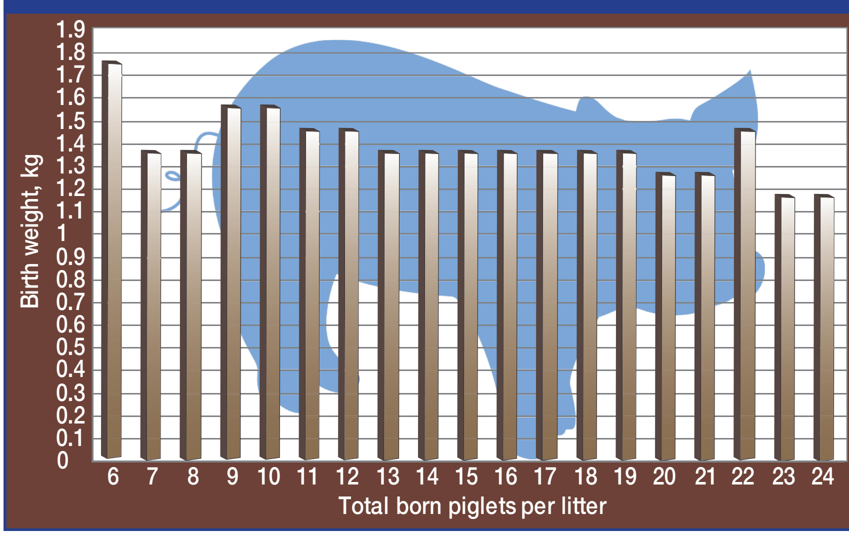
TABLE 1: Standardised ileal digestible amino acid values (grams per kilogram of feed) according to pig weight and dietary energy.

Metabolisable energy	14 MJ ME/kg	13.7 MJ ME/kg	13.5 MJ ME/kg	13.1 MJ ME/kg
Piglet size	6-9 kg	9-20 kg	9-30 kg	20-30 kg
Lysine	13.4	12.2	11.9	11.0
Methionine	4.3	3.9	3.8	3.5
Methionine + cystine	7.2	6.6	6.4	5.9
Threonine	8.2	7.5	7.2	6.7
Tryptophan	2.6	2.4	2.3	2.1
Isoleucine	7.8	7.0	6.8	6.4
Leucine	13.7	12.4	12.1	11.2
Histidine	4.5	4.1	4.0	3.7
Phenyl	7.7	6.9	6.7	6.3
Phenylalanine + Tyrosine	14.9	13.6	13.1	12.2
Valine	9.4	8.5	8.3	7.7
Crude protein (min)	193	176	171	160
Crude protein (max)	207	190	185	173

Source: Sangill Andersen, Society of Feed Technologists 2010, from European and US data.

Standardised ileal digestible amino acid values at various piglet weights and levels of dietary metabolisable energy.

TABLE 2: Danish results for average piglet birth weight when litter size is increased



Larger litters have tended to result in smaller piglets, according to a Danish study.

Classifying ingredients

It is possible to identify certain "good" ingredients in terms of their suitability for piglet starter feeds, he declared, and also some ingredients that can be rated as "bad" in this context. His own list under a classification of good included milk products such as skim milk power, lactose, whey and whey protein concentrate as well as spray-dried blood plasma, fishmeal, cooked cereals and protein concentrates processed from soybeans and potatoes.

Among "bad" ingredients, he indicated, would be soybean meal and raw (uncooked) cereals together with meals from other oilseeds such as rape and sunflower and also full-fat soy, in addition to red blood cells.

These ratings are based on a combination of experience and measurables, Lars Sangill Andersen added. We can measure trypsin-inhibitor levels, for example, besides knowing where a particular ingredient has been ineffectual. But the central issue in each case is one of digestibility.

The first requirement in feeding the pig after weaning is to provide a highly digestible diet because of the animal's still-immature digestive system. When protein is highly digestible, its amino acids are readily available to the pig for use in healthy growth. By contrast, a protein source with poor digestibility not only wastes an expensive input, it also consumes extra energy in its disposal and it sends undigested amino acids into the colon where undesirable gut flora may develop so that the piglet suffers from diarrhoea.

Diet selection for young pigs before weaning must address changing farm productivity

Litter size effect

Diet selection for young pigs before weaning must also address changing circumstances brought by extra farm productivity, according to another Danish speaker to the SFT meeting. Dr Flemming Thorup, pig researcher with Denmark's Agriculture & Food Council, drew attention to data from breeding units showing that modern sows are giving birth to more piglets.

As an example, a research report from Denmark at the start of 2011 commented that the number of pigs born nationally in each farrowing had increased steadily for 15 years and was now at an average of 16.1 pigs per litter.

Although this may be a good basis for greater efficiency in pork production, the report commented, larger litters tend to mean smaller pigs at birth and therefore a bigger risk that they will die prematurely - either during the farrowing process or shortly afterwards.

Dr Thorup's presentation to SFT highlighted Danish investigations of another effect, which is the negative correlation between litter size and the weight of the pigs at weaning. This probe in Denmark found that each additional piglet in the litter was associated with a reduction on 150 grams in the weaning weight at 24 days old.

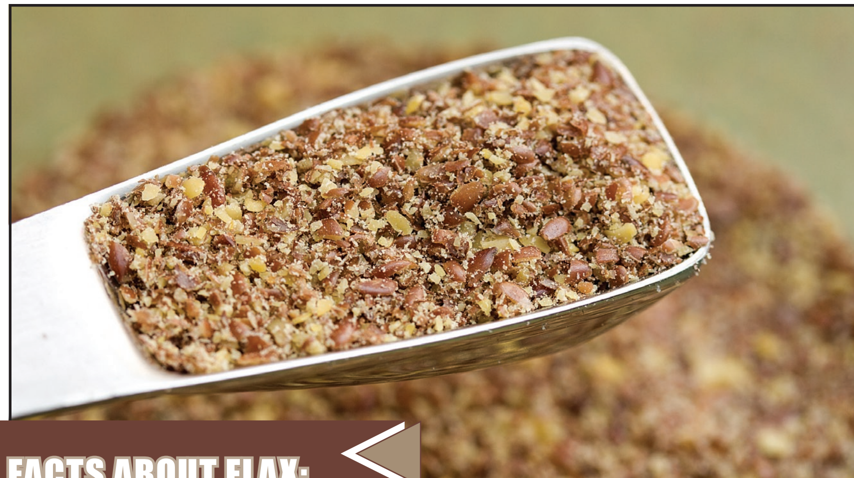
The relationship held true whether the size of the litter went from five pigs to seven or from 13 pigs to 15, he commented.

What is more, supplementary creep feeding of piglets did not seem to compensate for the slower growth of piglets in the larger litters.

Ingredients | by Ioannis Mavromichalis, PhD

Using flax for omega-3 enriched eggs

While a number of ingredients can be used to enrich eggs, flax can offer a number of benefits when used properly.



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Flaxseed is an excellent source of omega-3, but must be treated properly prior to inclusion in diets.

FACTS ABOUT FLAX:

- Excellent source of omega-3 fatty acids
- 22% crude protein
- 6% crude fiber
- 15-18 MJ/kg metabolizable energy (depending on processing)
- A considerable range of anti-nutritional factors
- Grinding recommended

STAY AHEAD:

To learn more about using additives in egg production, read about dietary additives for egg-producing flocks at www.WATTAgNet.com/17599.html

Producing omega-3 enriched eggs is a rapidly expanding niche market. This is because consumers have realized that the health benefits from a diet rich in omega-3 fatty acids outweigh the slight increase in price they are asked to pay for these eggs.

It is highly anticipated that this trend will increase, offering not only an excellent way for consumers to safeguard their health, but also, a new outlet for egg producers to improve their competitiveness and image in the health food sector.

To increase the concentration of omega-3 fatty acids in eggs, it is imperative to provide layers with a diet enriched in the same fatty acids. Like all monogastrics, birds deposit lipids in their body, and consequently in eggs, without changing the form from that ingested through feed.

To this effect, a diet rich in omega-3 fatty acids is the only way to produce such eggs. And, to enrich the layer's feed with omega-3 fatty acids there is only a very limited range of ingredients with a suitable profile and price: fish meal and fish oil, rapeseed and rapeseed oil, and flaxseed and flax oil.

Feeding high levels of fish meal or oil, such as those required to enrich eggs with omega-3 fatty acids is impractical because of ensuing low feed acceptability, risk of 'fishy' smell in eggs, low sustainability of fish meal and oil production, and of course, the high price for fish meal and oil.

Rapeseed meal and oil is indeed a much better choice, but the levels required again are too high due to their intermediate concentration of omega-3 fatty acids. Also with this ingredient, a 'fishy' smell is produced in hens carrying the 'Rhode Island' gene, which is not present only in 'brown' layers. A more suitable ingredient is flaxseed, or flax.

Flaxseed

Flax is grown mainly in areas with a cold climate, such as Canada and northern Europe. The main reason for cultivation is the oil (flaxseed contains 34% total lipids), but some linen varieties are still cultivated in Europe. Flaxseed meal, as a co-product of oil extraction, has limited value (and high fiber content) for feeding to layers. Only full-fat flaxseed is suitable for the purpose of producing omega-3 enriched eggs.

Flaxseed is an excellent source of omega-3 fatty acids: alpha-linolenic acid (the primary omega-3 fatty acid) makes up about 57% of total fatty acids in flaxseed, with linoleic acid, an omega-6 fatty acid, comprising only 16% of total fatty acids. In general, flaxseed contains about 9% saturated fatty acids, 18% monounsaturated fatty acids, and 73% polyunsaturated fatty acids.

From a nutritional point of view, flaxseed contains about 22% crude protein (which increases the requirement for crystalline amino acids when replacing soybean meal), 6% crude fiber, and 15-18 MJ/kg metabolizable energy (depending on thermal processing of feed and flaxseed). Incorporating flaxseed

Using flax

in conventional layer diets does not present major issues from a formulation standpoint, once the above are taken into account.

Inclusion rate

In most markets, enriched eggs are required to contain about 300 mg omega-3 fatty acids. To begin with, a normal egg, produced on a diet based on cereals and soybean meal, contains about 50 mg omega-3 fatty acids. If we accept the rule of thumb proposed by Drs. Leeson and Summers (University of Guelph) in that, 1% inclusion rate of flaxseed results in an increase of 40 mg omega-3 fatty acids in the egg, then we need to add about 6% to reach a minimum of 300 mg in the egg. But, to account for biological variability, both in flax and hens, it is recommended to feed a minimum of 8% and a maximum of 10%.

Issues with flaxseed

Flaxseed contains a considerable range of anti-nutritional factors at significant concentrations, not unlike soybeans.

These factors include: mucilage, trypsin inhibitor, phytic acid, cyanogenic glucosides, and potentially rancid lipids. All these compounds reduce feed acceptance and digestibility of nutrients.

To counter the effects of anti-nutritional factors, heat treatment of seeds and/or whole diets has been shown to vastly improve digestibility and feed acceptance, again not unlike the case with soybeans. Nevertheless, flaxseed should be introduced gradually into diets for young layers, in weekly increments of 2% (or more if flaxseed or the whole diet is heat treated).

Although whole (unground) flaxseed has been used with success, it is generally recommended to grind it before feeding to layers. In a controlled study, grinding increased deposition of alpha-linolenic acid from 13.5 to 16.2 mg/g of yolk. It is, of course, common knowledge that grinding improves nutrient digestibility, but the small size and tough nature of flax make the feeding of unground seeds a tempting option, especially for small operations. To this end, feeding 0.5% grid has been shown to improve digestibility of unground seeds and deposition of omega-3 fatty acids in eggs.

Grinding increases flax's benefits

In some earlier studies, egg production had been reduced when feeding flaxseed. Other observations related to feeding flaxseed included lower egg weight, lower body weight of hens, and reduced eggshell strength. It is now understood that the energy content of flaxseed had been overestimated and the effects of anti-nutritional factors underestimated. Thus, thermal processing, grinding, enzyme supplementation, use of correct metabolizable energy values, and proper balancing of all nutrients are all required to ensure comparable performance in hens fed flaxseed. Indeed, there have been reports where feeding flaxseed actually improved egg production!

Finally, it should be noted that flaxseed has a natural laxative effect; although this should not be of a major concern at levels below 10% in the diet. In addition, the high mucilage concentration creates 'sticky' droppings that reduce the quality of living conditions in hens, and also increase the number of 'dirty' eggs. The use of a beta-glucanase enzyme has been shown to help towards solving this problem, when and if it happens.

After taking into account the natural biological characteristics of flaxseed, and conforming to new findings on how to properly use this ingredient, it is now possible to depend solely on flaxseed to produce eggs enriched in omega-3 fatty acids.

Dr Ioannis Mavromichalis is the owner of consulting firm Ariston Nutrition.