TECH NOTES

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Feed Ingredients - Consideration of Alternatives when Facing Increased Price Volatility

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SUMMARY

Market price volatility in raw ingredients for poultry diets increases the pressure to reduce costs and increase efficiency. When the price of dietary raw ingredients dramatically increases, the use of alternative, less traditional, raw ingredients when formulating diets may become more economically attractive. Another consequence of increased feed ingredient prices is that the addition of feed additives and micro-ingredients becomes more economically viable. In particular, an increase in the price of phosphate sources has led to an acceleration in the global use of phytase enzymes.

No raw ingredient should be used in feed formulation without a full understanding of the potentials and limitations of that ingredient when included in poultry diets. These may be different for broilers and breeders.

This document provides information on alternative raw ingredients that could be used during periods of market volatility to provide economic benefits, giving information on both their potential opportunities and potential limitations to maximize productive response.

The raw ingredients covered are:

- Corn
- Sorghum
- Oats
- Distillers Dried Grains with Solubles
- Corn Gluten meal & Corn Gluten feed
- Rice Bran
- Cassava
- Sweet Potato
- Glycerin
- Rapeseed Meal
- Cottonseed Meal
- Sunflower Meal
- Palm Kernel Meal
- Copra Meal
- Phosphates

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The remainder of this article provides more detail on the points summarized on page one.

INTRODUCTION

During the past five years, the industry has experienced increased price volatility in feed ingredients used in poultry diets. Peak prices were recorded in 2008 and 2011, and more recently, record historical prices were set for corn and soybeans. The result is record feed prices for the poultry industry. The proportional contribution of feed in the overall cost of chicken meat production has been seen to rise by up to 70% in recent years. This is clearly of concern to Aviagen® and our customers.

Initially, the greatest rises in price were seen in cereals and higher energy yielding ingredients. This was followed by a rise in the value of protein ingredients led by soybeans. In 2008, a sharp increase in the price of phosphate and various other feed additives used in poultry diets also occurred. One of the primary reasons for market volatility is the global supply versus demand pressure on energy and protein sources. Due to the widespread use of bioethanol and biodiesel, poor weather conditions, and financial investor speculation, the poultry feed industry has been dealt a major blow.

Market volatility has increased the pressure on poultry producers to reduce costs and increase efficiency. The role of nutritionists to achieve these objectives has been to review formulations, both in terms of nutrients specifications and raw material composition, and also to accelerate the implementation of enzymes and other technologies.

In reviewing nutrient specifications, Aviagen has encouraged customers to continue to formulate based on digestible amino acids and energy levels for optimum economic performance.

When reviewing raw materials possibilities, alternative ingredients may become economically more attractive and viable for inclusion. For example, in Western Europe, where wheat is traditionally the economic cereal of choice, the dramatic increase in wheat price resulted in corn and, in many cases, sorghum becoming viable alternative ingredients in broiler feed formulation.

Another consequence of increased feed ingredient prices is that feed additives and micro-ingredients have become more attractive for optimizing economic returns. An increase in the use of synthetic amino acids and enzymes has occurred around the world. An increase in the price of phosphate sources has led to an acceleration in the global implementation of phytase enzymes. Record prices for energy and protein sources have also resulted in increased use of carbohydrase and protease enzymes.

The evolving feed ingredient marketplace demands a deeper understanding of the different ingredient alternatives, their potentials and their limitations for inclusion in poultry diets. This document is an attempt to relay current information regarding the use of alternative feed ingredients, the potential opportunities in their use, and to further strengthen the economic competitiveness of their operations. A table showing the recommended ingredients and their maximum inclusion levels for broilers and breeders is located at the end of this article.

ALTERNATIVE FEED INGREDIENTS

Corn (maize)

Corn is used as the main energy source in poultry feeds in many parts of the world. The standard corn consumed in animal feeds is graded on a scale that considers the physical properties (e.g. density, damaged and broken kernels, and foreign matter). Dent and flint corn are the main classes of corn used worldwide. The physical and chemical difference between them impacts their nutritional value and processing characteristics. Harvesting conditions, processing, and storage will affect the nutritional value of corn, primarily its metabolizable energy content.

When used as a substitute for wheat, special attention must be paid to the following characteristics:

- ***Xanthophylls:*** The concentration is highly variable (5 to 20 ppm) and depends on the origin and class of corn. The degree of yellow skin pigmentation will vary depending on the xanthophyll level. Using corn with lower levels of xanthophylls or restricting its inclusion levels is necessary in markets that demand white-skinned broilers.
- ***Oil:*** Corn has a highly digestible fat, with high unsaturated fatty acids (linoleic acid) content. This must be taken into account when considering the source of any supplemental oil/fat used if effects on carcass fat composition are to be limited.
- ***Amino acid profile:*** Balance of amino acids and digestibility must be considered with corn. Corn has low levels of limiting essential amino acids and, when compared to wheat, the lower protein content will increase the need to use high protein ingredients and synthetic amino acids in corn-based diets.
- ***Starch:*** Corn is composed of over 60% starch and it is of a highly digestible nature. Compared to wheat, a lower degree of gelatinization is achieved so pellet quality tends to be poorer with corn-based diets.
- ***Vitamins:*** Corn has higher levels of vitamin A and biotin compared to wheat.
- ***Toxins:*** Mold growth and mycotoxin(s) production can be of concern with corn. Aflatoxin, T-2, and zearalenone are the most common mycotoxins found. Mycotoxin screening and monitoring is important, and in particular, visual assessment for broken and damaged kernels is key. Broiler breeders should be fed using corn sources low in mycotoxins.
- ***Enzymes:*** Research suggests there may be benefits of using carbohydrases, like amylases and xylanases, to further improve the nutritional value of corn and reduce energy variation due to various factors inherent in corn production.

Sorghum (milo, kaffir)

The world's fifth largest cereal crop, sorghum, is used in many regions as an alternative to corn or wheat as the main energy source in poultry diets. Sorghums cultivars are divided into 3 types based on genotype and tannin content:

- Type I - pigmented testa and tannin-free or low-tannin content (<0.25% condensed tannins).
- Type II - pigmented testa layer and contain condensed tannins (0.5% - 1.5% condensed tannins).
- Type III - ("bird proof") contain tannin both in the testa and pericarp (0.5% - 6.0% condensed tannins).

The negative effects of tannins in poultry feeding include:

1. Depressed feed intake.
2. Reduced amino acid digestibility.
3. Inhibition of digestive enzymes.

The deleterious effect of sorghum is more pronounced with younger birds. When using sorghum in poultry diets the following must be considered:

- ***Nutritional value:*** The nutritional value of sorghum is approximately 95% of corn, and its energy content is higher and more consistent than wheat.
- ***Protein:*** The nutritional quality of protein and the variation in amino acid content and digestibility are of concern with sorghum and should be monitored.
- ***Starch:*** Sorghum has the lowest starch digestibility of all the cereals.
- ***Processing:*** Grain texture, particle size, and pelleting temperatures are factors that can influence pellet quality, and potentially impact broiler performance when feeding sorghum based diets. Achieving effective grinding is very important, to avoid the presence of whole seeds in the feed, which consequently can be found in the excreta.
- ***Pigmentation:*** Contrary to corn, xanthophylls are not present in sorghum so for markets that demand a pigmented carcass, the diet must be supplemented with one of the various pigment alternatives available in the market.
- ***Enzymes:*** Recent studies have shown that the use of dietary enzymes (e.g. xylanase and protease) in sorghum-based broiler diets has the potential to increase protein and starch digestibility.

Oats
Oats are a cold tolerant cereal typically grown in colder areas of the world such as Northern Europe and Canada. Things to consider with oats include:

- ***Energy:*** Oats are the cereal with the lowest energy value, due to the high fiber and lignin levels, and a lower starch content.
- ***Protein:*** The protein composition and availability of oats is the best of all the cereal grains, due to its higher globulin content.
- ***Lipids:*** The oil quality of oats is high due to a high concentration of unsaturated fatty acids (oleic and linoleic). However, if used at high levels, greasy carcasses can become a problem.
- ***Soluble fiber:*** Contains significant β-glucan levels that can lead to digesta viscosity problems.
- ***Enzymes:*** β-glucanases must be added to the diet to take full advantage of the inclusion of oats in the diets.
- ***Naked oats:*** This variety belongs to the same species as "common oats" but have a non-lignified husk which readily becomes detached during harvesting. The absence of the indigestible husk gives it an increased metabolizable energy content for poultry, and a protein content very similar to wheat.

Distillers Dried Grains with Solubles (DDGS)
Exponential growth in the production of ethanol from corn has made DDGS increasingly available to the animal industry, primarily in ruminant feeds. During the process of alcohol production, starch is fermented to obtain ethanol, resulting in the concentration of the other nutrient fractions in corn being increased three-fold.

- ***Variability:*** The DDGS drying process varies from plant-to-plant affecting the quality and digestibility of protein (e.g. lysine digestibility can range from 59 to 84%). Energy values also vary (ME ranges from 2490-3190 kcal/kg), due to variation in final product fat and fiber concentrations, and because of the caramelization of starch during the drying process.
- ***Quality:*** DDGS samples that are darker in color may have a lower amino acid digestibility (especially lysine) than DDGS samples that are lighter in color. Color measurement (colorimetry) is a quick and reliable method of estimating the amino acid quality of DDGS when used as a feed ingredient. Other tests such as near infrared reflectance system (NIRS) and rapid enzyme in vitro analyses may also be used.
- ***Minerals:*** Use of DDGS should account for the higher total and available phosphorus concentrations compared to corn. Also, sodium content should be monitored, as salt is added during the process of DDGS desiccation.
- ***Mycotoxins:*** If mycotoxins are present in the corn prior to ethanol production, DDGS subsequently produced will contain 3 times the concentration of mycotoxins. Monitoring for mycotoxins is critical to ensure the product is not contaminated.
- ***Pellet quality:*** The 'springiness' of DDGS fiber greatly reduces pellet quality.
- ***Handling:*** Bridging and flowability of DDGS can become a major problem in feedmills depending on DDGS particle size.

Corn Gluten Meal
This is a co-product of the corn wet milling process to primarily produce starch and syrup. During the process, the soluble fraction, "corn water", is centrifuged to separate the starch and gluten. The starch is then washed to remove the last traces of protein resulting in high purity (approximately 99.5%). The gluten fraction is dried (to approximately 10% moisture) to yield an approximately 60% protein product called corn gluten meal. Thus, it is a high protein ingredient (ranging from 60 to 70%), with high methionine levels but low levels of lysine and tryptophan. This relatively unbalanced amino acid profile limits its inclusion rate. The high digestibility of its nutritional components gives corn gluten meal a high energetic value. Corn gluten meal also contains significant concentrations of xanthophylls (200–500 ppm) especially when produced from yellow corn. Quality control points to be considered are the moisture of the product, which should not exceed 12%, and its coloration: yellow – orange color.

Corn Gluten Feed
Corn gluten feed is another co-product of the corn wet milling process, being the fraction that remains after the extraction of starch, gluten, and germ. Composed of a soluble fraction called “corn steep water or liquor” and corn bran. Sometimes it may also include corn germ meal which gives a darker color to the product. Chemical composition will vary greatly based on milling process and relative proportions of its components. Corn gluten feed has a significant proportion of fiber (approximately 8.0%), resulting in a lower energy concentration, a moderate protein content (approximately 22%) and approximately 2.5% crude fat. The amino acid composition is low in lysine and tryptophan. This nutritional profile makes the ingredient more appropriate for breeder diets.

Rice Bran (rice pollards)
Rice bran is a co-product of rice production, being a mixture of bran and the germ layers of the rice grain after being polished. Its high oil and starch content make it an important energy ingredient. Typically, there are 2 types of rice bran. Full-fat rice bran contains a high percentage of oil (10-18%). Defatted rice bran has had the oil extracted, so it has a higher concentration of protein and fiber. Defatted rice bran has been reported to have 75% of the metabolizable energy value of the full-fat source.

- ***Variation:*** Processing method, the mixture of rice bran and polishing in the final product and moisture content generates variation in the nutritive value of this ingredient. Also, rice bran can be contaminated with rice husks, greatly affecting its quality; protein levels should be closely monitored for this reason.
- ***Oil:*** Rice bran has a high polyunsaturated fat content and is a good source of linoleic acid. However, the presence of a lipolytic enzyme in the bran, which becomes active during processing, makes rice bran very prone to oxidative rancidity. The oxidative process could interfere with vitamin stability and availability. This limitation can be overcome with the use of an appropriate antioxidant (e.g. ethoxyquin). Storage time and conditions also influence rice bran oxidation risk.
- ***Fiber:*** Rice bran is high in fiber, containing appreciable levels of insoluble and soluble polysaccharides, especially arabinoxylans.
- ***Enzymes:*** Use of enzymes (β-glucanase and xylanase) has been shown to improve the nutritive value of rice bran.
- ***Anti-nutritional factors:*** High levels of phytic acid can interfere with mineral absorption, and the presence of trypsin inhibitors can affect protein digestion.

Cassava (manioc, tapioca)
Cassava is an energy yielding crop produced in tropical regions, Thailand being the main exporter. Dried cassava chips and pellets are the products commonly used in animal feed.

With this ingredient the following factors should be considered:

- ***Anti-nutritional factors:*** Fresh cassava roots contain an anti-nutritional factor called cyanogenic-glucosides (linamarin), which is hydrolyzed into glucose and hydrocyanic acid (HCN) by the action of linamerase enzyme present in the root, and released in the processing stage. Cultivars grown today have lower cyanogenic glysoside concentrations, which is further reduced during the drying process to produce the cassava chips. Good quality chips should contain less than 30 ppm of HCN.
- ***Nutritional value:*** Cassava is mainly a source of energy, with a high starch content (approximately 60-70%) that is highly digestible. Protein level is very low (approximately 2.5%) and of poor balance. Lacks coloring carotenoids, so attention must be paid in markets that demand pigmented birds. Potassium levels should be monitored as they tend to be high (approximately 0.6%).
- ***Feed processing:*** The dustiness and bulkiness of ground cassava needs to be considered with mash feeds. Pellet quality can be poor with cassava-based diets.

Sweet Potato (batata)
Sweet potatoes are an important source of carbohydrates in tropical areas. They are used mainly for human consumption and grown extensively in Asia. The crop is characterized by its high productive efficiency. Sweet potato is a good source of energy due to its high starch content and its high digestibility, but its use as a feed ingredient is limited. Its high moisture content limits its processing to a meal due to the associated high drying cost. Sweet potato has low protein concentrations of average digestibility.

Glycerin

Glycerin is a by-product of biodiesel production. The chemical composition of crude glycerin can vary widely depending on the source (vegetable vs. animal) and the process used in its production. It can be used in poultry feeds as a source of energy, but its use is limited due to the variation in the chemical composition of raw ingredients which makes metabolizable energy content variable. Residual levels of methanol, and content of sodium, potassium, fatty acids, and moisture should be determined before using glycerin. Current official specification recommends that crude glycerin should contain the following for its effective and safe use in animal feeds:

- Not less than 80% glycerin.
- Not more than 15% water.
- Not more than 0.15% methanol.
- Up to 8% salt and 0.1% sulfur.
- Not more than 5 ppm heavy metals.

Rapeseed Meal

Rapeseed meal is an oilseed crop with the second largest worldwide production (including canola). It is also a by-product of oil extraction from rapeseed and is a good source of protein for broiler feeds. Typically, its crude protein content ranges from 34-38%, with a favorable amino acid content compared to soybean meal. The presence of anti-nutritional factors (e.g. erucic acid and glucosinolates) limits its inclusion rate. The improved rapeseed cultivars that are low in erucic acid and glucosinolates, named “canola” or double zero “00”, have become more available and their inclusion in broiler diets can be much higher than standard rapeseed meal. The maximum recommended concentration of glucosinolates in the diet is 4 µmol per gram.

- Good protein source, high in sulphur-containing amino acids but low in lysine.
- Anti-nutritional factors (erucic acid, glucosinolates, tannins and sinapine) limit its use at high levels.
- The use of carbohydrases (cellulase, glucanase, xylanase), and proteases has been shown to improve the nutritive value of this ingredient.
- The oil extraction temperature greatly influences amino acid availability.

The inclusion for rapeseed meal is up to 5%, and for canola meal (solvent extracted) up to 10% in growing broilers. For breeder birds, rapeseed can be used during the rearing cycle up to 5%; however, its use is not recommended for the breeder laying cycle. Up to 5% canola meal can be used in breeder layer diets.

Cottonseed Meal

This is a by-product of cotton oil extraction characterized by its high fiber content which reduces the nutrient density compared to soybean meal. Cottonseed meal is a protein source whose use has been limited in poultry feeds due to its content of anti-nutritional factors - gossypol and cyclopropenoid fatty acids.

- *Gossypol:* Polyphenolic pigment found in the seed. Gossypol binds dietary iron in the diet, in the bloodstream, and in egg yolks, causing iron deficiency problems and formation of discolored yolks. Gossypol has also been found to inhibit pepsin and trypsin action in the gastrointestinal tract. High free-gossypol levels have been correlated with reduced performance and increased mortality. However, free-gossypol levels below 100 ppm in the diet have shown no detrimental effect of cottonseed use. ***For breeders, cottonseed meal with free-gossypol levels below 50 ppm, and with low residual lipid content (to reduce to a minimum the presence of cyclopropenoid fatty acids) is recommended to avoid yolk mottling problems with eggs. The use of ferrous sulphate in ratio 2:1 (iron:gossypol) has been shown to reduce the adverse effects of gossypol.***
- *Protein:* Cottonseed meal has a lower protein content than soybean meal (40-42%), and the first limiting amino acid is lysine. The oil extraction method used affects lysine digestibility, primarily due to the binding of gossypol with lysine. However, adequate lysine supplementation can overcome this limitation.
- *Fiber:* Fiber is a highly variable component which should be closely monitored as it determines the nutritional value of the ingredient. The lower nutritional density due to its fiber content could make it advantageous for use in pullet rearing diets.

Sunflower Meal

The fourth most important oilseed meal, sunflower meal, is derived by the extraction of oil from sunflower seeds. It is widely used in many regions as a protein source and acts as a partial substitute for soybean meal. Sunflower meal can be made from whole or decorticated seeds. Characteristic of the seed and type of oil extraction process affects the quality characteristics of the meal. Sunflower meal is free of anti-nutritional factors.

Points to consider with sunflower meal:
Color of sunflower meal goes from grey to black and depends on the degree of de-hulling (meals with less hulls are lighter in color) and on the oil extraction process.

- Hipro (High Protein content) meal is much more suitable for poultry and should be sourced in preference to standard meal. Its crude protein content varies from 36% to 40%.
- Distinction must be made between Hipro meal and standard meal, and formulation matrix values must reflect the difference.
- Good digestibility of the protein fraction. Rich in methionine, cystine, and tryptophan, but low in lysine.
- Valuable source of calcium, phosphorus and B vitamins.
- Inclusion in broiler diets usually limited to 5% as a result of its high fiber and low energy level.
- No consistent improvement has been found with the use of enzyme complexes in sunflower meal based diets.
- The use of low protein sunflower meal, particularly where crude protein is below 30%, should be severely limited in broiler feeds.

Palm Kernel Meal
During the past decades, palm oil production has undergone a rapid growth in tropical areas. As a result, the availability of palm kernel meal has increased and it has become an alternative ingredient for poultry feeds in some world regions. The oil extraction process used (solvent vs. expeller extraction) affects nutritional value. Its high fiber content severely limits its suitability for use in broiler feeds, however in breeder feeds the lower nutrient density of the ingredient may be beneficial. Palm kernel meal can be a useful source of protein, characterized by its low lysine level but well supplied with sulphur- containing amino acids; however its high fiber level impacts protein digestibility. Its inclusion levels in poultry feeds can be increased with the use of NSP enzyme mixtures (cellulase, glucanase, and xylanase).

Copra Meal (coconut oil meal)
Copra meal is a by-product of the extraction of coconut oil. Copra is the dry kernel of the mature nut of the coconut tree. Flakes or cake is obtained from copra after the removal of oil by either solvent or expeller extraction. The method of extraction used influences the residual oil content (ranging from 1.5% to 14%). Typical crude protein content is around 20%, with low essential amino acid levels of an unbalanced nature. The meal contains very high arginine concentrations and low lysine, methionine, cystine, and tryptophan levels. Digestibility of the protein fraction is low. It has high fiber content, varying from 8% to 16%. The use of enzymes (e.g. mannanase) has been shown to improve the nutritional value of copra meal. A general recommendation is to not use in pre-starter and starter diets due to low energy, high fiber content, and high water holding capacity which could hinder feed intake. It can be used at up to 10% for other poultry diets when enzymes are used. Quality control efforts should be focused on monitoring:

1. Rancidity (dependent on the residual oil content).
2. Mycotoxin levels (during the drying process the product could be susceptible to molds and toxin contamination).
3. Protein, fat, and fiber content, due to their high variability.

Phosphates
Various sources of inorganic phosphorus (P) are currently available in the market. Dicalcium, monocalcium, mono-dicalcium phosphates and defluorinated rock phosphate, are the most common sources of inorganic P. These are derived from the natural rock phosphate that is treated by different chemical processes. When choosing a good source of inorganic P, some quality criteria should be met:

- ***Variability in P content and availability.*** Variations exist between P sources and also within specific P sources, especially with respect to availability. Well conducted analyses are necessary to adjust P supply to the bird's requirements.
- ***Levels of undesirable elements.*** Some rock phosphates contain contaminants that could be of concern to poultry: fluorine, arsenic, cadmium, lead, and mercury. Analyses for these elements must meet international technical standards.
- ***Physical handling properties and feed processing.*** Differences in physical quality exists between products that impact handling, mixing and pelleting of feeds. Pelleting rate can be affected by inorganic P source, with deflourinated rock phosphate being reported to improve pelleting rate.

CONCLUSION

In the current ingredient marketplace, the use of alternative feed ingredients in broiler and breeder diets could provide economic benefits during exposure to market volatility and strengthen financial competitiveness. However, it is important to thoroughly investigate and characterize the ingredients to determine the opportunities and limitations of their inclusion, as it is essential to maximize productive response. The economic fundamentals must remain - maximize productivity at a more competitive production cost.

Table 1: Ingredients recommended maximum inclusion levels for broilers and breeders.

Ingredient	Broilers		Breeders	
	<3 weeks	>3 weeks	Rearing	Production
Corn	None	None	None	None
Sorghum (low tannin)	None	None	None	None
Oats (+ enzymes)	5%	15%	25%	20%
DDGS	6%	15%	15%	15%
Corn gluten meal	5%	10%	10%	10%
Corn gluten feed	3%	5%	10%	10%
Rice bran	5%	10%	15%	15%
Cassava (low HCN)	20%	30%	30%	30%
Sweet potato	15%	20%	20%	20%
Glycerol	5%	5%	5%	5%
Rapeseed meal	5%	5%	5%	*Not recommended*
Canola Meal (solvent extracted)*	5%	10%	5%	5%
Cottonseed meal (low gossypol)	5%	10%	10%	*Not recommended*
Sunflower meal	5%	10%	10%	10%
Palm kernel meal (+ enzymes)	*Not recommended*	10%	15%	10%
Copra meal (+enzymes)	*Not recommended*	10%	10%	10%

**Consider excluding during the last 5 days prior to processing to avoid potential meat processing plant issues.*

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