Feed additives for swine: Fact sheets – flavors and mold inhibitors, mycotoxin binders, and antioxidants

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This is the third in a series of peer-reviewed practice tip articles, each including two or three fact sheets on feed additives for swine. Previous practice tips included fact sheets on acidifiers and antibiotics in the September-October issue *(J Swine Health Prod.* 2009;17:270-275) and on carcass modifiers, carbohydrate-degrading enzymes, and proteases, and anthelmintics in the November-December issue (*J Swine Health Prod.* 2009;17:325-332).

Future fact-sheet topics will include high levels of copper and zinc; phytase; phytogenic feed additives (phytobiotics-botanicals); and probiotics and prebiotics.

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FACT Sheet: Flavors

Under the conditions of modern swine production, pigs need to be fed a balanced diet that meets their daily nutritional requirement for maintenance, growth, and reproduction. However, nutrient intake is largely determined by voluntary feed intake, which is greatly influenced by the chemical senses of olfaction and taste. Thus, it is essential to make sure that diets being offered to pigs are highly palatable to ensure high feed intake. This is especially important during times when pigs have decreased appetite, such as the first few days post weaning. Therefore, it is believed that enhancement of taste or smell through the use of flavors may help to improve the palatability of diets and, consequently, feed intake.

Factors affecting feed intake

A number of factors have been identified that affect feed intake in pigs. In most cases, feed intake is influenced by the interaction between some or all of these factors, which include the thermal environment, social factors (eg, stocking density), animal factors (eg, genotype), and dietary factors (eg, energy density and palatability).[1] Palatability of a diet refers to its acceptability features, including taste, smell, and texture, that the pig senses before feed is swallowed.

How can palatability of diets be improved?

Palatability of a diet may be measured by comparing the amount of that diet that a pig consumes relative to the amounts consumed of other diets. Palatability can be improved by using ingredients preferred by pigs or by using feed additives, such as flavors, that make the diet more acceptable and encourage greater feed intake. The number of taste buds in pigs are at least three times that found in humans,[2] suggesting that their sense of taste may be more developed and thus more responsive to varying tastes and flavors in their food.

What are flavors?

Flavors are feed additives that attempt to enhance the taste and smell of feed to stimulate feed intake. Taste and smell are the senses associated with feed intake. Because smell is the first sensation detected by the pig, aroma of the diet becomes the initial stimulus that drives the pig to eat.[3] Flavors also mask ingredients that are unpleasant to pigs.

In countries where small-scale pig production is still widespread and producers buy commercially available feed products from distributors, flavors are used by feed manufacturers mainly as a marketing tool to attract feed buyers. Farm owners tend to believe that feed products that smell good to them will also be acceptable to their pigs;[4] however, this may not be the case, as large differences in sense of taste are known to exist between species.[2,5]

At what stage of production are flavors applied or used in pig diets?

Flavors and aromas are primarily used at stages when feed intake is expected to be lower, such as in the postweaning period. During and immediately after weaning, the pig is subjected to significant stress brought about by a number of physical, physiological, and behavioral changes. These include separation from the sow, new environment, and dietary transition from sow's milk to a completely solid food. Identifying and adjusting to the new diet take some time and further contribute to the growth lag experienced by a young pig. Flavors may help improve the performance of pigs during this stage through increased feed consumption by making the feed more attractive and highly palatable.

Fast facts

Flavors are feed additives that attempt to enhance the taste and smell of feed to stimulate intake.

Pigs show preference for certain flavors when given a choice.

Flavors do not improve feed intake when pigs are not given a choice.

This same principle applies to the use of flavors and aromas in creep feed and milk replacers. Some products claim to enhance palatability of creep feed by mimicking the taste of sow's milk. Suckling pigs are stimulated and learn to eat solid food earlier, making the transition to completely solid food during weaning less stressful.

Most sows consume less feed than needed to support the demands during lactation. Thus, flavors may be of some benefit to help increase sow feed intake. However, there is no research data to support this claim.

What flavors are included in commercially available swine-feed additives?

A number of studies[5-9] have been conducted using a wide variety of flavors to identify those most preferred by the pig. Most studies reported a preference for a sweet taste. That is why most products added to the feed as flavoring agents include sweeteners such as saccharin and talin. Others include vanilla and milky or fruity flavors or a combination of these.[4] Acceptability of these flavors to pigs was identified using preference studies[7] wherein pigs were simultaneously offered diets with different tastes. Taste preference was identified in terms of which diet with a particular flavor was consumed the most relative to the total feed intake of the test diets, commonly expressed as a percentage of the total amount of feed consumed.[3,10]

Does the addition of flavors translate to improvement in performance?

Preference for a certain flavor does not necessarily mean that feeding it will result in improvement in feed intake and performance. While a number of studies[6,8,9] have shown that pigs prefer certain flavors when given a choice, using these flavors in performance studies did not necessarily show positive effects when pigs were not given a choice.[6,11]

Growth-performance experiments[12-15] also have shown varying results, with most improvement in feed intake being observed during the first week after weaning.[8] In one recent study,[16] adding an enhanced flavor to creep feed given 3 days before weaning did not affect litter feed intake, the proportion of piglets consuming creep

feed, or preweaning performance. However, exposure to the same enhanced-flavor product was associated with greater postweaning daily gain of pigs fed complex diets, but did not influence performance of pigs fed simple diets.[16]

Summary

Feeding pigs with a well-balanced diet that is highly palatable is essential for optimal growth performance and production efficiency. While the use of flavors may be a useful tool to improve palatability and feed intake under certain conditions, the effectiveness of these feed additives has not been consistently observed in different experiments. In addition, feed intake is regulated by multiple factors, not just taste. Therefore, careful evaluation of commercially available products and consultation with a nutritionist is recommended before a flavor is added to a swine diet.

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FACT Sheet: Mold inhibitors, mycotoxin binders, and antioxidants

In providing a high quality diet to pigs, it is important to ensure that it contains the correct amount and balance of nutrients for optimal productivity and is highly palatable, safe to the animals, and free of substances that may negatively affect their performance. Thus, the addition of feed additives to prolong shelf-life, prevent mold development, or bind mycotoxins present in the feed may be required in certain situations.

Fast facts

Feed ingredients such as grains are prone to mold growth and mycotoxin contamination.

Mold inhibitors such as organic acids are used in diets to prevent mold growth, but they are not effective against mycotoxins.

Mycotoxin binders are added to the diet to prevent pigs from absorbing toxins from contaminated feed.

Common mycotoxin binders are effective against aflatoxins, but have limited activity against other mycotoxins.

It may be feasible to use antioxidants in diets containing ingredients that easily become rancid due to high fat content.

What are mycotoxins?

Mycotoxins are chemical compounds produced by actively growing molds (fungi) as secondary metabolites that can negatively affect pig performance. While not all molds produce toxins, over 300 types of mycotoxins are known to be produced by molds, with aflatoxin, vomitoxin, zearalenone, fumonisin, and ochratoxin generally regarded to be the most significant mycotoxins affecting livestock production (Table 1).[1] Young and breeding animals are generally more susceptible to mycotoxins.

The molds that produce the common mycotoxins found in livestock diets belong to the genera *Aspergillus*, *Claviceps*, *Fusarium*, and *Penicillium*.[2] Feedstuffs may be contaminated before harvest of the main plant source, during post-harvest handling and storage, and during processing into animal-feed products. Grains such as corn, wheat, and barley may be easily contaminated with molds. Molds are categorized into field and storage fungi. Field fungi are those that grow in grains before they are harvested. These commonly include *Fusarium* species, which produce vomitoxin, zearalenone, and fumonisin.[2] Storage fungi, which include molds of the genera *Aspergillus* and *Penicillium*, are significant producers of mycotoxins that commonly affect pigs, such as aflatoxin and ochratoxin.[2] These fungi can grow even at very low moisture levels, unlike the field fungi. *Aspergillus flavus* produces high concentrations of aflatoxin in grains even before harvest. It is important to distinguish between field and storage fungi, since this affects the distribution of mycotoxins. When conditions are favorable for field fungi to produce mycotoxins, grain from a geographic location is expected to be widely affected. Thus, large quantities of grain may be contaminated. In contrast, storage fungi should have a more localized distribution due to specific conditions during storage. In fact, not all grain may be affected evenly within a storage bin. Thus, storage mycotoxins may be difficult to detect without extensive sampling.

With the increase in the availability of distillers grains due to increasing ethanol production, the use of distillers grains in swine diets has also increased. Corn is the major grain product used to produce ethanol. Because most of the starch in the corn is consumed during fermentation, the resulting distillers grains co-product is more concentrated in other proximate components, such as fiber, protein, and fat, than is the source corn. However, if the corn grain used for fermentation has been contaminated with mycotoxins, the resulting distillers grains product may contain as much as three times the concentration of mycotoxins as the source corn.[3]

Table 1: Regulatory limits for the five major mycotoxins in feedstuffs used in swine diets*

Age group	Aflatoxin (ppb)†	Fumonisin (ppm)‡	Vomitoxin (ppm)§	Ochratoxin A	Zearalenone
Young	20	20 (10)	5 (1.0)	NA	NA
Finishing (> 100 lb BW)	200	20 (10)	5 (1.0)	NA	NA
Breeders	100	20 (10)	5 (1.0)	NA	NA

* Source: Food and Drug Administration Center for Veterinary Medicine.[1]

† Action levels. Level indicated for young pigs applies to complete diet and ingredient.

‡ Guidance levels. Not to exceed 50% of the diet as indicated by values in parentheses.

§ Advisory levels. Not to exceed 20% of the diet as indicated by values in parentheses.

NA: not applicable. No FDA action, advisory, or guidance levels established in US feed. Note: A minimum of 0.20 ppm ochratoxin A can cause a reduction in weight gain and mild renal lesions in finishing pigs at slaughter, and a minimum of 1 ppm zearalenone can cause vulvovaginitis and prolapse in prepubertal gilts.[2]

Mycotoxicosis refers to poisoning due to the ingestion of mycotoxins. This condition can cause lower resistance to diseases, increased sensitivity to stress, and damage to vital organs, such as the liver and kidney. Ultimately, this may lead to mortalities and poor production performance.

What are mold inhibitors?

Mold inhibitors are feed additives used to minimize mold contamination and prevent mold growth, thereby minimizing the risk of having mycotoxin-producing molds proliferate in grain or feed. Feed additives commonly used for this purpose include propionic acids and other organic acids. However, even if mold growth has been prevented, mycotoxins may still be present, because mold inhibitors have no effect on mycotoxins already present in contaminated feed.

What are mycotoxin binders?

Mycotoxin binders or adsorbents are substances that bind to mycotoxins and prevent them from being absorbed through the gut and into the blood circulation. When other preventive measures against molds and mycotoxins have failed, the use of mycotoxin binders can be valuable. There also may be instances when feeds and feedstuffs cannot be checked for mycotoxins on a regular basis. Mycotoxin binders are routinely added in such cases as safety measures and as some form of assurance to customers. A variety of substances have the ability to bind mycotoxins. The most commonly used and most researched mycotoxin-binding agents are the aluminosilicates – clays and zeolites. These are natural adsorbents that include hydrated sodium calcium aluminosilicates (HSCAS), bentonite, and zeolite (Table 2).[4,5] Most of these products are efficient binders of aflatoxins. However, they have limited or no activity against other types of mycotoxins. Other substances with toxin-binding capability include cell-wall components of yeasts. Some studies have shown that the cell-wall fraction ß-glucan of yeasts such as *Saccharomyces cereviceae* can be effective in binding a wide range of mycotoxins.[6] Unlike clays, they can be added at low levels and are biodegradable. However, research in pigs documenting their efficacy in mitigating the effects of mycotoxins is limited and has shown inconsistent results.[7-10]

Choosing the appropriate product

In general, the following must be considered when choosing either mold-inhibitor or adsorbent products: efficacy in adsorbing the mycotoxin or inhibiting the mold of interest, and safety to the animal, the handler, and to pork consumers; high stability and ablility to withstand varying conditions during feed mixing; and cost effectiveness. Caution also must be exercised when using clay, because its high adsorptive capacity can limit the bioavailability of minerals. This is most important when diets contain marginal levels of trace minerals. The risk of dioxin contamination associated with the use of natural clays needs to be considered.[6] It is important to know the source of clay products that will be used in swine diets. Dioxins are mainly by-products of industrial processes. Contamination of clay sources can be due to improper disposal or accidental leakage of these by-products into the environment.

What is an antioxidant?

An antioxidant is a product added to animal feeds to prevent oxidation of fat or vitamins.[11] Antioxidants found in commercial products include ethoxyquin, butylated hydroxytoluene (BHT), butylated hydroxyanisole (BHA), and propyl gallate. Combinations of these antioxidants are normally found in commercially available products to take advantage of the different properties of each antioxidant. For instance, an antioxidant-product combination may contain propyl gallate to provide a high level of initial protection and BHA for longer effect. These antioxidants also have an inhibitory effect on mold growth in grains under laboratory settings[12,13] and may have some use as mold inhibitors in pig diets in the future.

When is it advisable to use mold inhibitors, mycotoxin binders, and antioxidants?

The use of mold inhibitors and mycotoxin binders in swine diets may be advisable in geographic areas that are highly conducive to mold growth in grains and where mycotoxin contamination is more likely. Mycotoxin binders should be used when it is suspected that feed ingredients are contaminated with mycotoxins at levels deemed unsafe for pigs (Table 1). The use of these products becomes more important in situations when the moisture content of grains to be used for pig diets is greater than 14% and when storage conditions have a relative humidity that is higher than 85% and a temperature greater than 55°F.[14] Thus, the use of mold inhibitors or mycotoxin binders may also be needed when diets have to be stored for a relatively longer period of time.

Antioxidants are highly applicable in areas where the climate is warm and when high levels of fat are added to the diet. Antioxidants are widely used in areas where by-products high in unsaturated fat (eg, fish meal) are commonly used. Oxidation of unsaturated fatty acids can produce substances that can cause off-flavors

Table 2: Performance of weanling pigs fed aflatoxin-contaminated diets with either bentonite or HSCAS*

		Aflatoxin corn		
Parameter	Normal corn	No additive	Bentonite added†	HSCAS added†
ADG (kg)	0.63	0.52	0.60	0.61
ADFI (kg)	1.29	1.02	1.24	1.20
G:F	0.49	0.51	0.49	0.49

* Adapted from Schell et al, 1993.[5] Data are means from three pens of three pigs per pen.
† Added at a level 0.5% of the diet in place of corn.
HSCAS = hydrated sodium calcium aluminosilicates; ADG = average daily gain; ADFI = average daily feed intake; G:F = gain-to-feed ratio.

and toxic substances that can cause rancidity. These substances can also destroy nutrients like the fat-soluble vitamins.[14] Adding an antioxidant minimizes fat oxidation, keeps the diet highly palatable, and helps prolong the shelf life of the feeds. It should be noted that antioxidants delay, but cannot prevent, fatty-acid oxidation.[15]

Summary

Some species of molds have the ability to produce mycotoxins. Mycotoxin contamination of diets can result in production and financial losses. Mold inhibitors and mycotoxin binders can be effective tools in controlling mold and mycotoxin problems. Antioxidants, on the other hand, can help preserve palatability of feed ingredients or complete diets.

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