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Feed manufacturing to lower feed cost

Charles Stark, PhD

Feed Science, Department of Poultry Science, North Carolina State University
Raleigh, North Carolina

Abstract

The recent increase in both the ingredient and energy markets has caused many swine producers to take a closer look at both their formulations and manufacturing processes. Swine producers no longer have access to cheap grain or energy sources, which affects the diet, manufacturing, and delivery cost of the feed. Swine producers should focus on purchasing quality ingredients, manufacturing feed that optimizes profit, and delivering feed as economically as possible. To remain competitive swine producers must systematically evaluate each process within their feed program starting with the purchase of ingredients to the delivery of the feed to the animals on the farm. This evaluation must be a coordinated effort between the purchasing agent, nutritionist, veterinarian, feed mill manager, and animal production team. A company must determine if a least cost diet produces the highest profit margin and how the inclusion level of alternative ingredients will affect animal performance. Additionally, the company must determine a target particle size, the value of feeding pellets versus mash, and their total cost of feed delivery. This paper will focus on the value of least cost formulation, feed processes that improve animal performance, and feed delivery and ordering systems.

Introduction

The traditional role of commercial feed manufacturing has changed as animal production units have increased in size. The buyer-seller relationship is disappearing as companies integrate the feed manufacturing process into their production operation through ownership of feed mills or through toll milling relationships with commercial feed mills. In some cases, a commercial feed mill may have a significant percentage of their production dedicated to a few swine producers through a toll milling arrangement. The toll milling arrangement allows a swine producer to have greater involvement in the selection and pricing of ingredients, manufacturing specifications, and delivery process. The development of a feeding program that is integrated into the animal production system, either through a toll milling arrangement or ownership of a feed mill, is a key component to lowering feed cost and

remaining competitive in the swine industry. A company's operating and management philosophy will define the participation and risk they are willing to assume in the ownership of a mill versus developing toll milling arrangements. Additionally, a swine producer's level of expertise in purchasing ingredients, diet formulation, and feed manufacturing will influence their decision on mill ownership versus purchasing feed. The two most prevalent management philosophies in the feed industry are to lower feed manufacturing cost within the feed mill or use the feed mill as a tool to maximize animal performance and profitability. Modern large scale feed mills have become extremely efficient and have very few variable costs that can be further reduced in order to lower the total cost of the final feed. Although lowering the manufacturing costs is important, producers should not lose sight of the fact that greater cost saving opportunities exist through the use of least cost formulation.

Reducing the cost of production within a company requires the commitment and involvement of all employees. A feed management team that is comprised of individuals from different areas of responsibility within a company can help identify potential savings, develop goals and objectives, and help communicate the company's vision to the other employees. The team must have a mission statement that clearly supports the company's mission, goals, and performance objectives. These objectives will vary based on the company's business philosophy, regardless of the objectives they must be communicated to all employees involved in the production of feed and animals. The first task of the team should be the creation of written procedures that focus on lowering feed costs. Written documents should include standard operating procedures, ingredient specifications, a quality assurance program, and preventive maintenance program. The second step is to implement these procedures and programs through employee training. The final step is to conduct follow-up audits to ensure compliance with the procedures and programs.

Ingredient purchasing and logistics

Alternative ingredient selection

The nutritionist, purchasing agent, and feed mill manager must work as a team to develop an ingredient purchasing strategy that can consistently supply safe high quality feed to their animals. Understanding the constraints or limitations of a feed mill prior to purchasing ingredients will limit truck driver wait times, railcar demurrage, unexpected formulation changes, and negative impacts on animal performance due to constant changes in diet formulation. Communication with the feed mill manager, quality assurance laboratory, and production team prior to the purchase of a new ingredient is essential to minimizing the hidden costs that could be associated with an ingredient change. The team members must recognize that alternative ingredients require added analytical costs in order to develop and maintain matrix values, increased receiving time at the mill, reduced batching times due to additional ingredients, and reduced pellet mill throughput. Additionally, alternative ingredients can change pellet quality, feed density, and palatability. Producers should expect that these challenges will increase as the DDGS market begins to produce products with different levels of fat and protein.

Feed mills that have limited receiving pit capacity or ingredient storage capacity may not be able to consistently include alternative ingredients in all of their formulas. Some feed mills use rail cars as ingredient storage due to their limited bin capacity over their mixing system, which can create demurrage and increase the true cost of the ingredient. The team should also determine if variation in the diets due to the lack of ingredients will have a negative impact on feed consumption, growth rate, and feed conversion. These variations can be extreme especially when the formulas contain high inclusion levels of alternative ingredients. In cases where the mill's ingredient capacity is limited, the inclusion level of ingredients in formulas should be based on the level that will minimize the number of formula changes and provide the greatest profitability for the company.

Ingredient specification sheet

Ingredient specification sheets provide guidance to purchasing agents, suppliers, transporters, and receiving personnel and have always been the cornerstone of producing high quality finished feed, limiting product liability, and lowering the cost of feed. The use of approved suppliers and ingredient specifications sheets will likely become increasingly important as the FDA develops new regulations in response to the new Food Safety Modernization Act that was signed into law on January 4th of 2011 (FDA, 2011). Ingredient specification sheets (Appendix A) should include: a product description, expected nutrient

content, analytical methods, physical characteristics, and the basis for rejection.

Inbound ingredient logistics

Feed mills that have the ability to segregate and manage ingredients based on supplier and/or plant location can capture savings through least cost formulation if they can develop matrix values specific to a supplier or plant location. Simple inexpensive quality assurance tests at the point of receiving can help segregate ingredients based on moisture, protein, fat, and starch content. Equipment such as the grain moisture analyzer, NIR, or moisture balance can be used to rapidly determine the nutrient content of an ingredient prior to its receipt; typically these tests take less than ten minutes. Mycotoxins tests can also be conducted on ingredients prior to unloading if the feed mill suspects a problem based on previous shipments.

Ingredient variation

Ingredient variation exists due to differences in growing conditions, base raw material, and plant processes. The ingredient matrix nutrient values within the least cost program should be based on representative samples collected prior to or during the receiving process. Least cost ingredient matrix values should take into account both supplier and plant variation, ingredients with high variation will normally have a lower value in the program. A nutritionist can manage nutrient variation by applying safety margins to ingredients, which will adjust their estimated nutrient content based on the variation of the ingredient. Adjusting the mean nutrient value by one-half of its standard deviation is a common practice of nutritionists. DDGS is an alternative ingredient that tends to have more nutrient variation as compared to other by-products. Researchers have reported nutrient variation in samples of DDGS obtained from different ethanol plants in the Midwest (Batal and Dale, 2006, Belyea et al. 2010). Belyea et al. (2010) reported that fermentation batches within a plant had a greater effect on product variation than did plant or sampling period. The moisture content of an ingredient significantly changes the value of a product and ultimately affects its inclusion level in a least cost formula. The digestible energy content of corn is reported as 1,600 kcal/lbs. at 11% moisture in the NRC for Swine (NRC, 1998). However, most corn is delivered to feed mills between 13 and 15% moisture, which results in DE values of 1,566 and 1,530 kcal/lbs., respectively. The change in moisture content of corn not only affects its value in the formulation but will influence the final moisture content of the feed delivered to the farm.

Feed manufacturing process

Grinding

Particle size reduction of cereal grains is a small fraction of the overall cost of feed manufacturing. The cost of grinding an ingredient is inversely related to particle size; the cost will increase as the target particle size is decreased. The cost of particle size reduction is dependent on the target particle size, type of equipment (hammermill versus roller mill), and the ingredient being ground. Preventive maintenance of the equipment is essential to achieving and maintaining the target particle size as well as lowering the operating cost of the process. Routinely replacing screens and hammers once the edges become worn will increase maintenance cost but will actually reduce the overall operating cost of the equipment. Anderson (2010) estimated that increasing the preventive maintenance cost of a hammermill by 2.5 times would result in a 24% reduction in total operating cost due to lower energy consumption per ton of ground material. Similarly, maintaining a sharp groove on the rolls in a roller mill and keeping the belts tight will reduce energy costs while maintaining the target particle size. The tendency of a feed mill manager is to reduce maintenance and labor costs by reducing the frequency of hammer, screen, or rolls changes. However, if the particle size of the ground grain in the feed is increased due to these decisions the result could be poorer feed conversion, which could substantially increase the cost of raising the pigs.

The selection of a grinder should be based on the type of grains used in the formulas, target particle size, and the final form of the feed (meal versus pellet). The operating costs (electricity, labor, and maintenance) and capital investment should also be taken into consideration when selecting the type of grinder to purchase for the feed mill. The roller mill is a good option for feed mills that want to produce a granular material and improve the flow characteristics of a meal diet. A roller mill can efficiently grind material to 500 microns but is limited in its ability to effectively grind high fiber ingredients. Conversely, a hammermill can grind fibrous materials and achieve a particle size of less than 400 microns when properly sized with the correct motor, number of hammers, screen openings, and air handling system.

The average particle size of ground material is expressed as the geometric mean diameter (d_{gw}) of the sample as determined by the Method of Determining and Expressing Fineness of Feed Materials by Sieving (ASAE, 2009; ASAE S319.4). The standard method involves the analysis of the material utilizing 15 sieves and a Ro-tap® shaker. Although a standard method exists, researchers, laboratories, and feed mills may use modified methods, which can significantly change the results. The most recent

changes in the method is the inclusion of the statement “For industrial applications, the end-point determination process can be omitted, and the end-point is set to be the sieving time of 15 min”. Additionally, the use of sieving agents and agitators will reduce the estimated particle size result of the sample. Stark and Chewing (2012) reported that the addition of a sieve agent to hammermill ground corn reduced the estimated particle size of the sample from 411 to 332 microns, whereas the addition of the sieve agitators only resulted in a 41 micron decrease in particle size (392 versus 351). However, the addition of both the sieve agent and agitator reduced the reported particle size from 443 to 323 microns. Swine producers should ask their laboratory which method was used to determine their average particle size, which will help them when setting a target particle size and interpreting their results. Managers should determine the average particle size of their ground grains on a routine basis at a company, commercial or university laboratory.

Researchers have demonstrated that a reduction in the particle size of cereal grains will improve animal performance. Ohh et al. (1983) and Healey et al. (1994) reported improvements in the performance of starter pigs when corn was reduced from 1,000 to 500 microns. However, Healey et al. (1994) observed a negative effect on stomach mucosa when the particle size of corn was fed at 300 microns. Lawrence et al. (2003) reported no effect on starter pig performance when the particle size of solvent extracted SBM was reduced from 1,226 to 444 microns. Wondra et al. (1995) reported that reducing the particle size of corn from 1,000 to 400 microns resulted in an 8% improvement in feed/gain (linear effect, $P < 0.01$). Callan et al. (2007) also reported a better feed conversion when finishing pigs were fed a complete diet ground through a 3 mm versus 6 mm hammermill screen. Goodband et al. (2002) developed a regression equation to predict the feed conversion of finishing pigs from 120 to 240 lbs. when fed corn that ranged from 400 to 1,200 microns. The target particle size for each production system must be based on herd health, animal genetics, phase of production (sow, nursery, and grow/finish), electricity cost, capital investment of equipment, and form of the diet (meal versus pellet).

Batching

Reviewing production batch records daily is not only a requirement of the FDA’s current Good Manufacturing Practices (cGMP’s) it also makes economic sense to insure animals are receiving the correct level of nutrients and medications. Feed mill managers should monitor batch reports and look for trends in shrink or gain of ingredients on a daily and weekly basis. Batches of feed that contain ingredients that were weighed less than target (negative variance) will not provide the proper level of nutrients to

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the animals. Conversely, the addition of ingredients above the target weight can significantly increase the cost of the feed. The addition of two pounds of extra fat will add \$0.80 to the cost of a batch of feed (\$0.40/lb.). Depending on the size of the batch the error could cost the feed mill between \$0.10 and 0.40/ton of feed. Feed mill managers should also communicate to the nutritionist the resolution of their scales so that rounding factors can be applied to the least cost formula. As an example, a formula that calls for 3.2 lbs. of lysine per ton and is weighed on a scale with a one pound resolution can only be weighed accurately when a five ton batch of feed is manufactured, all other batch sizes will either add too much or little lysine to the batch of feed. Small difference between the amount listed on the master formula and the actual amount of ingredients weighed on the scales can create a significant inventory deviation over a one year time period.

Mixing

Ingredients should be added to the mixer starting with the discharge of the major scale followed by the minor and micro scales. The dry and wet mix time of the mixer should be established at the time of installation and then checked at least annually but preferable twice a year. The mixer should be tested using a single source ingredient in one batch of feed. Salt or synthetic amino acids are commonly used to test mixer uniformity. Ten samples should be obtained from the mixer by probing the mixer or collecting samples at equally spaced time intervals during the discharge process. The samples should be analyzed for the selected ingredient to determine the uniformity of the mix. The coefficient of variation (CV %) is determined by dividing the standard deviation of the samples by the mean and then multiplying by 100. Herrman and Behnke (1994) provided guidelines for interpretation of mixer uniformity results and potential corrective actions (Table 1). The feed mill should also have established sequencing and flushing procedures that minimize the cross contamination of medicated feed additives.

Pelleting

The pelleting process agglomerates ingredients that have different particle sizes, densities, and flowability.

Pelleting allows nutritionists to formulate diets that include ingredients with poor flow characteristics which includes grain ground to less than 400 microns without affecting the flow characteristics of the finished feed. The effectiveness of the pelleting process is measured by pellet quality as determined by the pellet durability index (PDI) and percent fines at the mill or in the feeder on the farm. Feed mills that have pellet screeners remove the fines after the pellets have been cooled and then re-pellet the fines, thus creating a product with minimal fines when it leaves the feed mill. Integrated operations typically do not remove fines and ship product that has both pellets and fines. This feed may contain from 10 to 50% fines when delivered to the feeder at the farm.

The most common method used in the feed industry to determine pellet quality is the PDI (ASAE, 1997; S269.4), which was developed at Kansas State University. The method is often modified by adding hex nuts to create a more aggressive test, which is more representative of a company's manufacturing and delivery processes. Another method commonly used by the feed industry is the Holmen method, which uses air to create abrasion of the pellets versus the tumbling action that occurs in the metal box of the PDI tester. Regardless of what test is used the pellet quality test should be a predictive model of the manufacturing and handling processes that occur as feed is handled throughout the feed mill and delivery system. Each production system will have unique characteristics that must be taken into account when developing the model. Feed mills that develop a method to estimate pellet quality at the feeder can make the appropriate adjustments to processes within the mill to achieve the desired pellet quality. Additionally, the model can provide feedback to the nutritionist and purchasing agent as to the effect an ingredient or formulation change had on pellet quality.

Stark (1994) reported that feeding pelleted diets, which contained 60% fines resulted in a feed conversion ratio that was similar to feeding a mash diet, thus negating the benefit of pelleting the feed. The consistency of pelleted feed is as important as the actual amount of fines in the feed. Inconsistency in the percentage of pellet fines between

Table 1: Interpretation of mixer uniformity results.

CV	Rating	Corrective action
< 10%	Excellent	None
10-15%	Good	Increase mixing time by 25-30%
15-20%	Fair	Increase mixing time by 50%, look for worn equipment, overfilling, or sequence of ingredient addition
20% +	Poor	Possible combination of all the above Consults extension personnel or feed equipment manufacturer

Feed manufacturing to lower feed cost

feed deliveries will require more feeder management to minimize feed wastage. Establishing a specification for the maximum percent of fines at the feeder will allow the nutritionist, purchasing agent, and feed mill manager to formulate, purchase, and manufacture feed while exploring options to lower the total cost of the feed. Animal production units that specify 100% pellets at the farm can expect higher manufacturing costs. These costs may be significantly higher if the feed mill is attempting to pellet ingredients that have poor pelleting characteristics, which produces more fines that ultimately must be re-pelleted thus decreasing the efficiency of the pellet mill.

Feed ordering and delivery

Feed ordering

The feed ordering system used by an animal production company can impact the cost of feed delivered to a group of animals. Feed ordering systems that rely on human inputs and/or decisions have a greater potential for errors as well as increased costs, lower animal performance, and compromised medication strategies. A feed ordering system that allows an employee to switch feed types without management approval will increase the cost of animal production. The cost will either be due to poorer animal performance or increased feed cost. The delivery of one truck load of a formula that is not on the feed plan and costs an additional \$10/ton will add \$240 to the cost of that delivery and thus \$0.24/pig (1,000 pigs per barn) in feed costs. Manufacturing problems, ingredient delivery issues, and emergency farm orders are often unavoidable; however written policies and procedures for managing these incidences will minimize the added cost associated with shipping the wrong feed to the pigs.

Feed delivery

The cost of feed delivery can increase significantly when trucks are not loaded to the legal weight limit (Table 2). The design and tare weight of the feed delivery equipment will determine the total weight of feed that can be hauled on a load. Selecting the correct type and design of equipment should be based on the condition of the roads, distance to farms, and operating philosophy of the company.

Conclusion

Remaining competitive requires flexibility in both the feed mill and animal production units. Companies must develop a purchasing, manufacturing, and delivery model based on their organizational goals and objectives. The key to lowering feed costs is to understand the interrelationships that exist from the time ingredients are purchased to the time the animal consumes the feed. Feed mills vary in their design, cost structure, and manufacturing efficiency. However, the common denominator in feed mills should be a comprehensive quality assurance program that outlines the purchase of safe high quality ingredients, good manufacturing practices, and standard operating procedures that promote efficient production of animals.

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Table 2: Transportation cost based on tons delivered to a barn.

Item	Tons delivered			
	21	23	25	27
Variable cost/load, \$	100	100	100	100
Delivery cost, \$/ton	4.76	4.35	4.00	3.70
Additional cost, \$/ton	1.06	0.64	0.30	0

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Appendix A

Example Ingredient Specification Sheet

Distillers Dried Grains w/ Solubles

AAFCO PRODUCT DESCRIPTION: Distillers dried grains with solubles is the product obtained after the removal the of ethyl alcohol by distillation from the yeast fermentation of a grain or a grain mixture by condensing and drying at least ¾ of the solids of the resultant whole stillage by methods employed in the grain distilling industry.

AAFCO #27.6

IFN #5-02-843

Typical Nutrient Analysis		Analytical Methods	
Moisture	max 12%	- NFTA 2.2.2.5, Loss on Drying (105C/3 hrs)	
Protein	min 25%	- AOAC 990.03, Protein - Combustion	
Fat	min 8%	- AOAC 945.16, Crude Fat (Pet Ether)	
Fiber	max 10%	- AOAC 978.10, Crude Fiber (F.G. Crucible)	
Ash	5%		
Aflatoxin	max 20 ppb		

Physical Properties

Color: golden to tan color

Odor: sweet odor

Bulk Density: 32 – 36 lbs/ft³

Sieve: 90% through #10 US

Basis for Rejection

1. Transportation method does not meet the FDA Regulations Governing the Transportation of Animal Proteins Prohibited From Use in Ruminant Feed.
2. Product is adulterated or misbranded.
3. Contains product that got wet during shipping.
4. Aflatoxin level above 20 ppb.

