PELLET QUALITY IN ANIMAL FEEDS

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Introduction

Pelleting costs money, and better pellets cost a little more. Payback comes in the form of convenience in handling the feed and more efficient use of the feed by the animal. Improved efficiency is due in part to heat processing which reduces pathogens and makes starches more digestible. A significant portion of the improvement is related to the physical form of the pellet. Durable pellets reduce waste, reduce segregation, improve palatability, and allow larger meals to be eaten in less time. All these factors contribute to optimized feed efficiency.
This paper will review experiments that have been performed in the U.S. which quantify the benefit of pellet quality in various species. In addition, methods of monitoring pellet quality will be reviewed and compared.

Effect of Quality on Animal Performance

Poultry:

In early pelleting research Reddy (1962) compared the feeding efficiency of mash, pellets, and reground pellets. He found growth response was lost when pellets were reground. Metabolizable energy was not affected by pelleting but the diet fed as intact pellets had approximately 30% more calories of productive energy. Jensen (1962) speculated that the improvement was due to less energy expended in the prehension of feed. He reported that chicks fed mash spent 14.3% of a 12-hour day eating versus only 4.7% with pellet-fed chicks.
In a commercial setting, Rinehart (1981) reported feed conversions (feed/gain) of 2.70, 2.54, and 2.28 for broilers fed mash, reground pellets, and pellets, respectively. He calculated the value of the improved feed conversion to be $26.50 per ton.
Jones (1985) surveyed 36 commercial poultry houses in North Carolina. He ranked them as "good," "mediocre," or "poor" based on productivity during the previous year. He reported that feeds from farms "poor" in productivity had significantly more fines than found on "good" farms. Feed conversions for "good" and "poor" farms were 2.11 and 2.17, respectively.
At North Carolina State University, Zatari (1990) tested pelleted feeds containing 25 and 75% fines. She recorded birds fed the lower level of fines spent less time eating and more time resting. Body weights and feed conversions were also better at the lower level of fines.
It is generally recognized that good pellet quality improves the feeding efficiency, growth, and uniformity of broilers. The level of quality is generally dictated by the economics. When feed is expensive more money can be spent toward pellet quality improvement. When feed is cheap, it may be more economical to allow some of it to be wasted.

Turkey:

Nicholas Turkey's Ken Krueger (1985) advised the National Turkey Federation that "bad management of pellet quality can cost as much as 13% of the grower's conversion ratio." In like manner, Cliff Nixey of British United Turkeys reported an improvement in growth rate and feed conversion of 5% when feed contained a low percentage of broken pellets. Both companies believe good pellet quality is necessary for the turkeys to consume enough feed to achieve their genetic potential for growth and meat development.
In a controlled feeding study at North Carolina State University, Brewer (1989) fed turkeys diets containing 10% and 50% fines. Resulting feed conversions were 2.61 and 2.71, respectively.

Swine:

Jensen (1965) reported four of five trials showed improved feed conversion when young pigs were fed pellets versus mash; feed conversions were 1.52 and 1.72, respectively. Researchers at Texas Tech University (Hamilton, 1978) fed mash versus pellets and found an 8% improvement in feed conversion, going from 3.54 to 3.26. In a follow-up experiment (Trevis, 1979) they fed mash, poor quality pellets, and good quality pellets. Feed conversions were 3.83, 3.81, and 3.31. They emphasized that unless a good quality pellet is produced, little if any benefit will be derived from pelleting.

Stark (1994) reported feed conversion efficiency in nursery pigs to be 1.67, 1.50, and 1.54 when fed mash, screened pellets, and pellets with 25% fines. The effect was even more dramatic in finisher pigs; feed conversions were 2.78, 2.65, and 2.78 for pigs fed mash, screened pellets, and pellets with 20% fines.

Dairy:
Researchers at Ralston Purina (Kertz, 1981) evaluated different forms of feed for dairy cows, comparing pellets, coarse mix, crumbles, and meal. They found that cows consumed the pelleted feed more rapidly than the other forms of feed. When eating time is limited, such as in milking parlor feeding, eating rate may be the most limiting effect on milk production. Although they did not test pellets with fines, the fact that pellets had an advantage over crumbles suggests fines would be detrimental.

Ducks:
Ducks readily eat pellets but vary in their acceptance of mash or fines. Some will refuse to eat fines to the point of starvation and others will accept them with no negative effect. This variation in preference can understandably cause a variation in growth rate. Integrated producers strive for good quality pellets to achieve a uniform duck carcass at harvest time.

Rabbits:
Rabbits do not eat fines. In addition, fines may cause health problems. When eating, the rabbits nostrils are nearly in contact with the feed. Fines generated in high-alfalfa pellets are very dusty. When inhaled by the rabbit they can cause respiratory problems.

Aquaculture: Trout, salmon, and shrimp obviously need good quality pellets. Any fines that are generated en route to the pond will be wasted when thrown into the water. Quality in shrimp pellets goes beyond durability; because they are slow eaters pellets must also have good water stability.

Measuring Pellet Quality

Pellet quality does have economic importance; it should not be left to chance. Fines are generally formed by mechanical action on the pellets during transport. These forces may be classified as impact, compression, and shear. Impact shatters the pellet surface and any natural cleavage planes in the pellet; compression forces crush the pellet; shear forces cause abrasion of the edges and surface of the pellet. A discussion of test methods that measure the combined effects of these forces follows.

Kansas State Method

In an effort to study pellet quality Kansas State University (Pfost, 1962) built a model handling systems consisting of a bucket elevator, a hopper, and a screw conveyor. Fifty pounds of pellets were continuously cycled through this system for 10 minutes. At the end of the test, fines would be screened off from the pellets and the percentage of pellets surviving would be calculated as the Pellet Durability Index (PDI). This test was used as an absolute measure of durability to compare against other model test methods, notably the Stoke's hardness test and the tumbling can method. Correlation with the tumbling can was excellent (.949) and it was officially adopted as a standard method by the American Society of Agricultural Engineers.
In field trials LignoTech compared the level of fines predicted by the KSU Tumbler to actual fines in the feed as it was removed from the farm silo. The relative differences in quality were correctly predicted. The actual level of fines was also very similar to the predicted level. See Figure 1.

The KSU Tumbler has a few short-comings that has led to modification or development of completely new testers. The tumbler was developed using pellets that were primarily corn/soya in make up. When used to evaluate dairy pellets of high durability (PDI>96) the standard test is not abrasive enough to discriminate levels of quality. One simple option to correct this is to add two 3/4" hex steel nuts to the chambers. These provide additional compressive force as they impact against the pellets.

Figures 2a-2c illustrate the ability of three different test methods to measure the affect of temperature change on high-midds dairy pellets. The standard KSU test shows no discrimination at all. When nuts are added to the tester there is some indication that pellet quality improves with increasing temperature. Pellet hardness results seem to be completely random.

Direct Measure of Fines

Measuring fines off the cooler, or from grab or probe samples in storage or transport is unreliable. Fines definitely segregate as the feed is moved (Figure 3). If a single sample is taken the result may be completely misleading. When multiple samples are taken it is possible to calculate an average and a standard deviation.

Measuring fines directly off the die can provide an indication of pellet quality for poultry and turkey feeds (Figure 4). Care should be taken to collect from the same position (quality from the front of the die may be different than the back) and that excess pellets are not allowed to roll off the collection vessel. Of course this method is of little help if there is leakage of meal around the die.

Holmen Pellet Tester

Another shortcoming of the KSU tester is the time required to complete a test. The Holmen Tester, developed in England, provides a level of speed and convenience that is appreciated by those who do durability tests on a regular basis. The Holmen Tester circulates pellets through an air conveyance system for 30 seconds (or up to 2 minutes if needed). Pellets are subjected to both impact and shear in this method that simulates pneumatic rather than mechanical conveyance. Correlation between the Holmen Tester and the KSU Tester is excellent (Figure 5); both are good tools for measuring pellet quality.

Open Screen Tumbler

A variation of the KSU Tumbler replaces the solid cover with a screen which allows fines to exit the compartment during tumbling. The tumbler is surrounded by a case which catches the fines and funnels them down to a tray. In this system it would be possible to weigh the fines and calculate PDI, however, the typical procedure used is to measure the volume of fines. This has some merit as it is simple and it relates directly to what the customer will see upon visual inspection. This method is used by only a few companies.

Tube Tester

The KSU and Holmen Testers offer two types of commercially manufactured machines that have become standards of the industry due to their excellent performance. In spite of these two options, a continuous variety of home-built pellet testers are still found. Of these, the simplest and most effective is the tube tester (Figure 6). It is simply a length of pipe that is rotated end-over-end at a rate which allows the pellets to fall the length of the pipe when it reaches the near-vertical position. Generally the sample size is 100 g of pellets and steel nuts are added to increase pellet degradation. The major force acting on the pellets in this test is shear. Compression and impact will also occur as the pellets and steel nuts strike the end of the pipe. Pipe length varies between 50 and 100 cm. Longer pipes require greater diameter and slower revolution speed. Multiple pipes may be fitted on the same axis. The test period may vary between 5 and 20 minutes. This is an effective test but it is not an industry standard. Specifications would need to be developed in-house.

Pellet Length

Pellet length is a simple way to monitor quality. When samples are collected at the same sampling point, longer pellets indicate greater durability and less fines (Figure 5). When collected at multiple sampling points pellet length can indicate points of destruction in the handling system.

Determining the average length of pellet is not a reasonable procedure. What is actually done is to measure the number of pellets in a weighed sample of feed and calculate the number of pellets per gram. A 10-20 g sample of screened pellets is usually sufficient.

Hardness

Correlation between the KSU pilot plant results and the Stoke's hardness test was not as good as with the tumbling can (.784 vs .949). This could be due to the fact that the Stoke's test measures only compression and ignores impact and shear while destruction in the model handling system was caused primarily by shear and secondarily by impact. The real problem with the Stoke's test is the sample size, the operator must select individual pellets to be tested. It is normal to reject an obviously weak pellet, and by doing so, result are biased. In contrast, the tumbling can method uses a 500 g sample which includes both good and bad quality pellets. Figure 2c illustrates hardness results at different temperatures. Temperature is believed to affect quality but hardness results appear to be random. In another trial hardness had a negative correlation to durability (Figure 7). This is rare but it can occur. It appeared that molasses was added at variable levels during the pelleting run. Addition of molasses can make the pellet soft and gummy; it may even be possible to bend the pellet. Soft pellets can be very durable, making the hardness test an inappropriate method of measuring quality.

Summary

Whenever feed is too expensive to waste, pellet quality begins to have an economic value. Expect your customers to give the quality of your pelleted feed at least a subjective measurement. There are a number of good ways that can be used to objectively measure and record the quality of pellets during the manufacture process. Objective measurement and recording is the first step toward correcting destructive conditions and improving quality. It may also allow opportunity for cost savings when quality is found to be above standard specification.

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