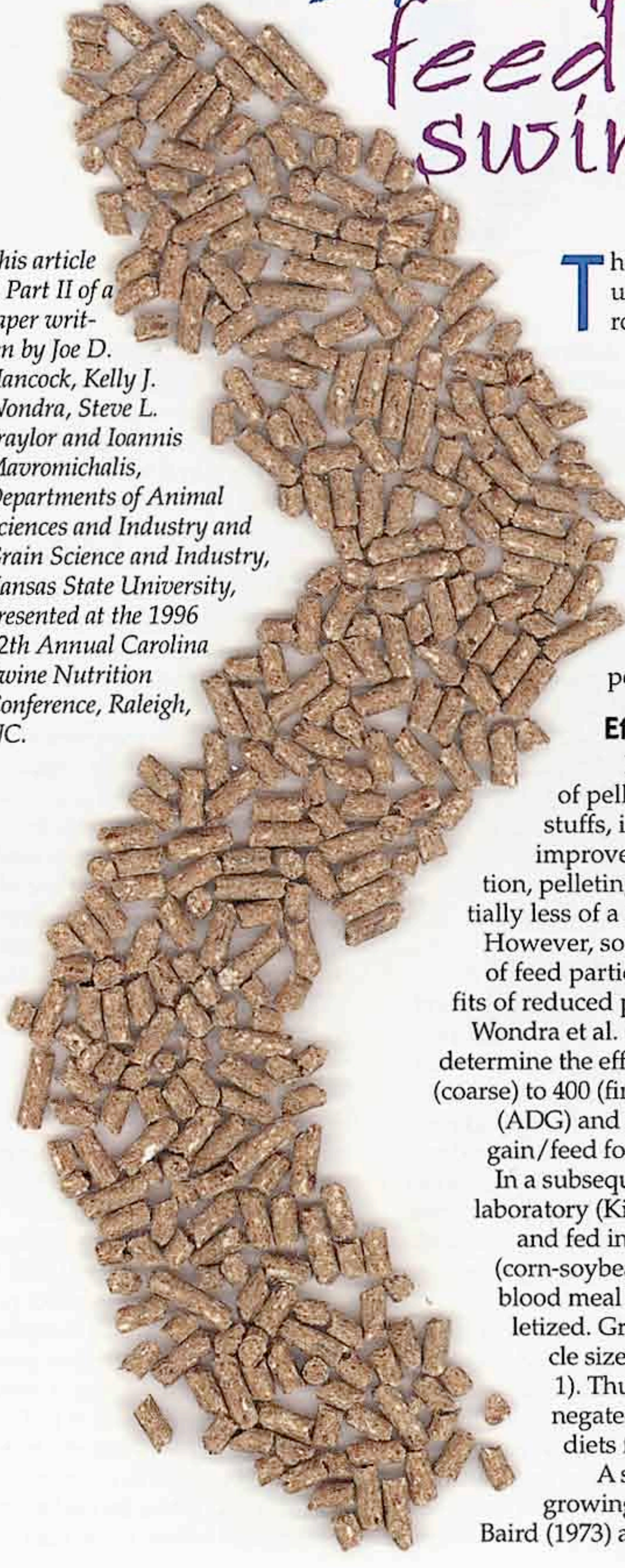
The effects of feed processing on swine production



This article is Part II of a paper written by Joe D. Hancock, Kelly J. Wondra, Steve L. Traylor and Ioannis Mavromichalis, Departments of Animal Sciences and Industry and Grain Science and Industry, Kansas State University, presented at the 1996 12th Annual Carolina Swine Nutrition Conference, Raleigh, NC.

The most common forms of thermal processing used in the feed industry today are pelleting, extruding, roasting and micronizing and steam flaking.

Roasting and micronizing are often used to prepare full-fat soy products (e.g., roasted soybeans), but are not used extensively for processing cereal grains. Steam flaking is used routinely to prepare sorghum for feedlot cattle, but not to prepare diets for swine and poultry. Extrusion is a preferred means to process whole soybeans, but is generally considered cost prohibitive as a means to prepare cereals for commercial pig and poultry diets (except, perhaps, for weanling pigs and lactating sows). This leaves pelleting, a dietary form that has become extremely popular over the last four decades.

Effects of pelleting

From a feed manufacturer's perspective, the benefits of pelleting include decreased segregation of mixed feedstuffs, increased bulk density, reduced dustiness and improved handling characteristics (Skoch et al., 1983). In addition, pelleting can eliminate bridging problems, making it potentially less of a problem to feed diets with finely ground ingredients. However, some nutritionists question whether the agglomeration of feed particles that occurs during pelleting will negate the benefits of reduced particle size.

Wondra et al. (1995b) designed an experiment with finishing pigs to determine the effects of pelleting diets with corn ranging from 1,000 (coarse) to 400 (fine) microns. Pelleting increased average daily gain (ADG) and gain/feed, and reducing particle size improved gain/feed for pigs fed both mash and pelleted diets.

In a subsequent experiment at the Kansas State University (KSU) laboratory (Kim et al., 1995), corn was ground to 1,000 or 500 microns and fed in simple (corn-soybean meal-whey-based) or complex (corn-soybean meal-whey-based with plasma protein, wheat gluten, blood meal and lactose) diets for nursery pigs. All diets were pelletized. Growth and/or efficiency of gain were improved as particle size was decreased in the simple and complex diets (Figure 1). Thus, neither pelleting nor complex diet formulations negated the positive effects of reducing particle size of corn in diets for nursery and finishing pigs.

A summary of the effects of pelleting on performance of growing pigs is given in Table 1 (see p. 20). Hanke et al. (1972), Baird (1973) and Wondra et al. (1995b) reported that pelleted diets

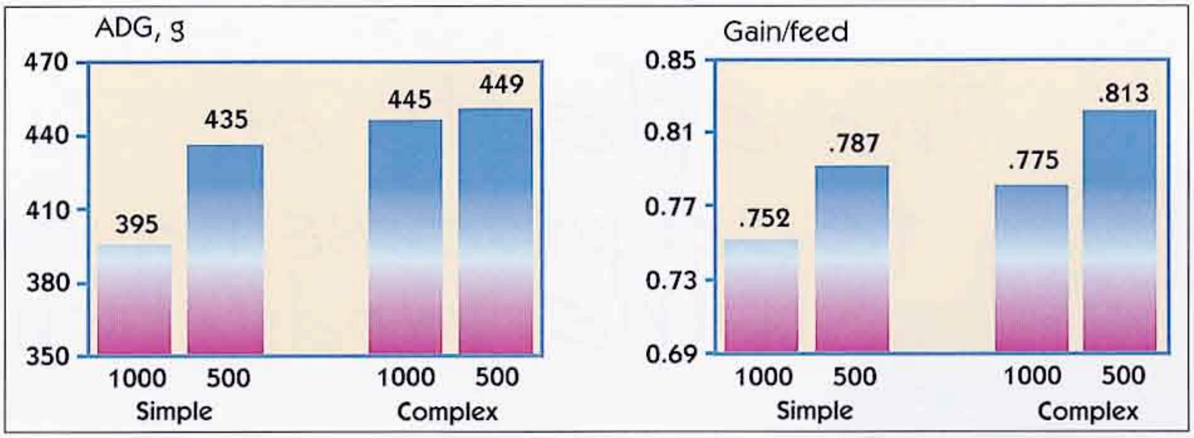


Figure 1. The effects of reducing corn particle size from 1,000 to 500 microns in simple and complex diets for weanling pigs. (From Kim et al., 1995.)

improved ADG. Other scientists, however, reported no significant effects of pelleting on growth rate. Nonetheless, when all of the reports in Table 1 are considered, there is an average improvement of 6% in ADG and a consistent improvement of 6% to 7% in efficiency of gain for growing-finishing pigs fed pelleted diets.

There is little consensus on the reason for increased growth performance of pigs fed pelleted diets. Skoch et al. (1983) suggests that pelleting increases bulk density and reduces dustiness, making the diets more palatable. However, improved palatability is inconsistent with the decreased feed intake generally observed. In experiments from the KSU laboratory (Wondra et al., 1995b,c), DM, N and GE digestibilities were increased by pelleting. Jensen and Becker (1965) suggest that pelleting gelatinizes starch, thus making it more susceptible to enzymatic digestion. Alternatively, many researchers attribute this improved performance of pigs fed pelleted diets to decreased feed waste. This hypothesis would be valid if only efficiency of gain was improved, but is inconsistent with improvements in nutrient digestibility and rate of gain.

Thus, decreased feed waste probably does help improve efficiency of gain in pigs fed pelleted diets, but there is still a factor(s) that enhances nutrient digestibility. It has yet to be determined whether that factor(s) is a change in feeding behavior; a change in the way digestive tracts react to pelleted vs. meal diet form (e.g., altered flow of digest); or a direct effect of thermal processing (e.g., gelatinization of starch and denaturation of proteins). Nonetheless, nutrient excretion from pigs in regions of intensive livestock production is causing environmental concerns. Wondra et al. (1995b) reported 23% and 22% reductions in excretion of DM and N in feces as a result of pelleting. Therefore, grain processing techniques that increase nutrient digestibility and reduce nutrient excretion have value to the swine industry.

Pellet size and quality

From a milling efficiency standpoint, a large-diameter pellet produced with a very thin die would maximize pellet mill output with minimum inputs of time and electricity. However, conventional wisdom dictates that small pigs prefer small pellets and large pigs prefer large pellets; thus, many die sizes are needed to properly process feed.

To address the issue of optimum pellet size for pigs, Traylor et al. (1994) conducted a series of experiments at KSU to determine the effects of pellet size on growth performance in nursery and finishing pigs. For the nursery experiment, 210 weanling pigs (5.4-kg average initial body weight) were used in a 29-day growth assay. The dietary treatments were a corn-based meal control and 2-, 4-, 8- and 12-mm pellets. For day 0 to 5, pelleting improved ADG by 25% and gain/feed by 36% (Table 2). However, pellet size did not affect growth performance. For days 0 to 29, pelleting improved gain/feed by 4% compared to the meal diets, with maximum gain/feed with a 4-mm pellet size.

In the finishing experiment, 80 barrows (58-kg average initial body weight) were fed a corn-soybean meal-based diet with the same pellet size treatments used in the nursery experiment. Rate of gain was not affected by pelleting, but pigs fed pelleted diets tended to have improved gain/feed (Table 3). As pellet size increased, ADG improved, with the 4-mm pellets supporting the greatest gain/feed. Thus, it appears that producing several different pellet sizes for pigs of various sizes is not necessary. Furthermore, a single 4- to 5-mm die size seems adequate.

However, there is still the issue of pellet quality. Reimer (1992) suggests that many factors affect pellet quality, with the largest contributors being diet formulation, particle size and conditioning (Figure 2). Indeed, experiences at KSU confirm that diet formulation can have marked beneficial (e.g., when wheat enters into a formulation) or detrimental (when more than 1%

Table 1. Effects of pelleting on growth performance.[a]

Reference	Pig wt, kg	No. of pigs	Meal ADG	Meal ADFI	Meal G/F	Pellet ADG	Pellet ADFI	Pellet G/F
NCR-42 Committee on Swine Nutrition (1969)	20 to 91	556	.77	-	.31	.78	-	.32
Hanke et al. (1972)	58 to 99	379	.75	-	.29	.80	-	.31
Baird (1973)	15 to 100	120	.69	2.52	.270	.72	2.43	.292
Tribble et al. (1975)	29 to 100	192	.66	-	.265	.68	-	.291
Harris et al. (1979)	70 to 100	98	.61	2.34	.261	.66	2.34	.282
Tribble et al. (1979)	59 to 98	144	.62	2.54	.244	.70	2.56	.273
Skoch et al. (1983)	49 to 98	60	.77	2.39	.323	.84	2.44	.344
Wondra et al. (1995b)	55 to 115	160	.96	3.22	.297	1.00	3.16	.318

[a] *All diets were corn-based except the diets used by Tribble et al. (1975, 1979) and Harris et al. (1979), which were sorghum-based diets.*

Table 2. Effects of pellet size on growth performance of nursery pigs.[a]

Item	Meal	Pellet diameter, mm 2	4	8	12	SE
d 0 to 5						
ADG, g[b]	124	151	148	165	158	12
ADFI, g	153	134	132	162	142	11
Gain/feed[b]	.810	1.127	1.121	1.019	1.113	.061
d 0 to 29						
ADG, g	358	362	371	362	364	7
ADFI, g	537	510	516	541	532	11
Gain/feed[b,c,d]	.667	.710	.719	.669	.684	.012

[a] *A total of 210 pigs with six pens per treatment (from Traylor et al., 1996).*
[b] *Meal vs. pellets (P<.04).*
[c] *Linear effect of pellet size (P<.05).*
[d] *Cubic effect of pellet size (P<.04).*

or 2% fat is added before pelleting) effects on pellet quality. And, in nearly all KSU experiments, pellet durability improved as diet particle size decreased.

In an attempt to define the effects of pellet quality (i.e., percentage fines in the diet) on performance, Stark et al. (1994) conducted a series of experiments with nursery and finishing pigs. In two nursery experiments, a meal control diet was compared to diets with as much as 30% fines. Pelleting improved gain/feed by 12% to 15% compared to the meal control. Compared to the scalped pellets, fines concentrations of 25% to 30% decreased gain/feed by 3% to 4%. For the finishing experiment, pigs fed the screened pellets had 3% greater ADG and 5% greater gain/feed compared to pigs fed the meal diet (Table 4). Pellet fines did not affect ADG, but there was a trend for gain/feed to decrease as the amount of fines increased. Perhaps the most troubling observation was that pigs fed diets with high concentrations of fines were no more efficient than pigs fed the meal control.

These experiments demonstrate that growth performance of nursery and finishing pigs is improved by pelleting diets and pellet die selection. However, if the pelleting process is not done properly, resulting in excessive (as little as 20% to 30%) fines at the feeder, the added benefits of pelleting disappear rapidly.

Diet modifications

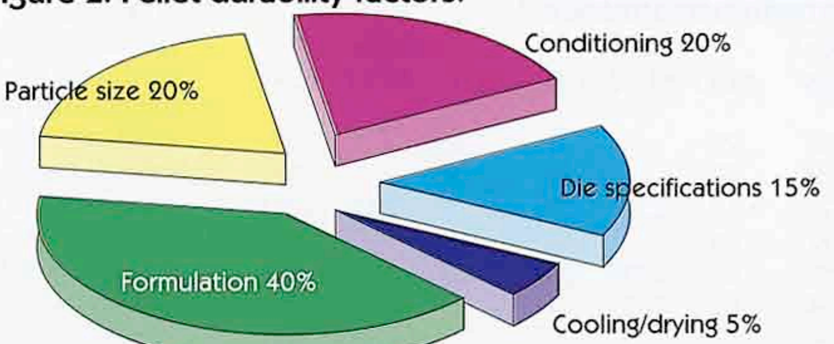
An additional area of research at KSU involves reducing nutrient excesses in diets to minimize production cost. The initial focus (ongoing for the past three years) has been to decrease mineral and vitamin excesses during late finish-

Table 3. Effects of pellet size on growth performance and stomach morphology of finishing pigs.[a]

Item	Meal	Pellet diameter, mm 2	4	8	12	SE
ADG, kg[b]	1.03	.94	1.01	1.02	1.05	.22
ADFI, kg[b,c]	3.01	2.62	2.76	2.85	3.05	.69
Gain/feed[b,c]	.342	.361	.365	.357	.343	.007
Last rib fat depth, mm	24.6	23.2	23.1	23.6	23.4	1.0
Dressing percentage, %	72.4	72.4	72.5	72.5	72.1	.3

[a] *A total of 80 pigs with eight pens per treatment (from Traylor et al., 1996).*
[b] *Linear effect of pellet size (P<.07).*
[c] *Meal vs. pellets (P<.08).*

Figure 2. Pellet durability factors.*



** Adapted from Reimer, 1992.*

ing. Pigs consume roughly one-third of their grow-finish feed during the final portion of the finishing period (from 90 kg market). Feed efficiency is worst in late-finishing, with feed representing 60% to 70% of total pig production cost. Thus, any decrease in diet cost during this stage will markedly increase a swine operation's profitability.

Diets for late-finishing are often overfortified with proteins, vitamins, minerals and other nutrients because allowances are derived from experiments in which pigs were slaughtered at lighter market weights than are common today. Lighter pigs tend to consume less feed, have greater lean growth potential and require greater concentrations of nutrients in their diets. In addition, specifications for such nutrients as Ca and P are set based on the premise that maximum bone strength is needed for replacement gilts selected from the finishing floor. Yet, maximum bone strength is not an issue with the terminal crossbreeding systems often seen today.

In KSU experiments, high-lean (PIC 326 boars x C-15 sows) pigs with good health status were used. Response criteria included growth performance, carcass measurements and muscle quality. In the first experiment, 128 finishing pigs were fed a control diet (corn-soybean meal-based with 0.70% lysine, 0.65% Ca and 0.55% P), or the control diet with the vitamin premix, trace mineral premix or vitamin/trace mineral premixes omitted. Feed and water were consumed ad libitum throughout the 30-day experiment (from 86- to 113-kg body weight). Rate and efficiency of gain, carcass measurements and muscle quality were not affected by deleting vitamin and/or trace mineral premixes.

A second experiment was designed to determine the effects of reducing the inorganic phosphorus (monocalcium phosphate) additions during late-finishing. In this experiment, 128 pigs were used to test the same control diet against omitting one-third, two-thirds or all of the monocalcium phosphate. Limestone concentration was adjusted to keep the Ca:P ratio constant at 1.2:1. Results suggest that omitting up to two-thirds of the monocalcium phosphate (to a total dietary P of 0.4% and daily P intake of 12 to 13 g) had no detrimental effect on growth performance or meat quality/color.

To verify the favorable results of the first two experiments, 160 pigs were fed from 90- to 118-kg body weight. Treatments were the same control diet; the control without the vitamin/trace mineral premixes; the control diet without two-thirds of the monocalcium phosphate; and the control diet without the vitamin/ trace mineral premixes and two-thirds of the monocalcium phosphate. None of the dietary treatments had negative effects on growth performance or carcass measurements, and all of the muscle quality and color determinations were within normal ranges.

Thus, the practice of adding existing vitamin and mineral premixes to finishing diets without thought to whether such premixes are particularly useful to the pig needs reassessment. Not only does this practice increase production costs, but it also increases wasted nutrients that are excreted into the environment. Further research is needed to:

1. determine the consequences of omitting vitamins and minerals in late finishing when "minimum-excess" diets are fed to that point (i.e., diets used in the experiments cited were well-fortified up to late finishing);

2. define a vitamin/trace mineral combination that actually affects some economically important trait in finishing pigs. FG

Table 4. Effects of pellet fines on growth performance of finishing pigs.[a]

Item	Meal	Pellet fines 0%	20%	40%	60%	SE
ADG, kg	.93	.97	.97	.96	.94	.02
ADFI, kg	2.58	2.54	2.66	2.66	2.65	.09
Gain/feed[b]	.362	.379	.360	.361	.355	.008
Backfat thickness, mm	27.8	28.4	27.5	28.0	28.2	.1
Longissimus muscle, cm^2	34.3	34.2	33.8	33.9	35.9	.9

[a] A total of 80 pigs with eight pens per treatment (from Stark et al., 1994).
[b] Linear effect of fines (P<.09).