A Reappraisal of Wheat in Swine Rations

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These comments are couched in terms of "reappraisal" since wheat is no newcomer to the swine feeding scene. It has been fed to hogs, to varying extents, for many years and has been subjected to some appraisal as a result of this experience. During this time, however, many changes have occurred: new varieties of wheat have been introduced, cultural practices have varied and, perhaps most significantly, economic conditions have altered, so a reappraisal is due.

As one reviews the literature on wheat feeding, a number of inconsistencies are apparent. These apparently stem, to some extent at least, from lack of definition of the specific wheat used in the feeding comparisons. *Wheat* is far from being a discrete entity—it may be many different things to different people and in different places. Generally speaking, five distinct classes of wheat are grown in the United States: hard red spring, soft red winter, hard red winter, durum and white. Within each of these classes there are a number of species, so that there is a very considerable diversity of base material. Some nutrient values for these different classes of wheat are listed in Table 1, which has been assembled from comprehensive data originating in the U.S. and Canada, by Crampton and Harris (1969).

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Table 1: Nutrient Comparisons* for Major Classes of Wheat

Wheat Class	DM	Ash	CF	E.Ex	NFE	DP**	DE**	Ca	P	B_1	Niacin
	%	%	%	%	%	%	kcal/kg	%	%	mg/kg	mg/kg
Durum	89.5	1.8	2.2	2.0	70.1	12.4	3630	.15	.40	6.3	?
Hard Red Spring	86.5	1.7	3.0	1.9	66.0	12.8	3470	.05	.41	5.2	57.8
Hard Red Winter	89.1	1.8	2.7	1.6	70.0	11.9	3575	.05	.40	6.2	50.9
Soft Red Winter	89.1	1.8	2.2	1.6	72.5	10.1	3614	.09	.29	5.3	57.4
Soft, White	90.1	1.8	2.3	1.7	73.4	9.9	3650	.09	.30	4.8	59.2

*Items listed are, respectively, Dry Matter, Ash, Crude Fiber, Ether Extract, N-Free Extract, Digestible Protein, Digestible Energy, Calcium, Phosphorus, Thiamine and Niacin.
**Determined specifically for swine.

These data (Table 1) are averages of large numbers of samples and within-class variation is obscured. Nevertheless, there are variations of 29% in digestible protein, 5% in digestible energy, 200% in *Ca*, 38% in *P* and 31% in thiamine content between extremes. It would certainly seem possible that feeding comparisons of these different classes of wheat, even against a common standard, such as corn, might yield quite different results.

Much of the original appraisal of wheat as a swine feed was made on economic, rather than nutritional grounds. The feeling was held, particularly during the last century, that wheat was a food for humans and not for hogs. This concept was only partly dispelled by Coburn in 1894 when he exhorted Kansas farmers that, with wheat and corn approximately the same price per bushel, it was "neither unprofitable nor wicked" to feed the wheat to hogs (see Heinemann, W. W., 1957). Through most of the first half of this century demand for wheat for milling kept its price pegged above that of comparable feed grains. One should not dismiss the implications of the human vs. hog food question lightly today, in the shadow of the much-publicized World Food Crisis, even though on this continent, at present, the problem is one of distribution rather than production.

Wheat as a Major Ration Component

It has become conventional, in swine feeding, to use cereal grains as the major ration component, balancing them where necessary with supplementary protein, minerals and vitamins to meet the animals' nutritional requirements. Any evaluation of wheat, then, must compare its effectiveness in supplying the nutritional requirements of swine with that of other cereals, and perhaps other ration components. Along with its nutritional value, of course, the palatability of wheat to hogs must be considered. On this point the literature suggest general agreement. Cunha (1957) states that wheat (type unspecified) is "more palatable than corn

for pigs," while Morrison, (1956) after summarizing a great deal of data, concluded that "wheat of good quality is well-liked by swine." In a few instances where swine have "gone off feed" on predominately wheat rations, the method of preparation or type of feeding practice may have been involved. Numerous authors suggest that fine grinding causes wheat to form a sticky mass of fine, floury particles in the pig's mouth, thereby contributing to unpalatability, (see Carroll and Krider, 1950). Others have suggested that hand-feeding of unground wheat to swine is unsatisfactory because the pigs eat too rapidly and either go off feed or convert the grain inefficiently. This situation can be corrected by either coarse-grinding, rolling or pelleting the wheat, or by introducing a self-feeding system.

It would be convenient indeed, if wheat could be assigned an index value in comparison to corn or other cereal grains, as a major ration component for swine. No single such value is possible, thanks to the diversities already mentioned, and varying figures must be used in the context of the specific situations in which they were obtained. For example, Kentucky workers assigned wheat a value of 95% of corn, when it replaced half the corn in swine grown-finisher rations (Cromwell, Overfield and Hays, 1969) while North Carolina studies gave soft, red winter wheat (Blue Boy) a value of 90% of corn in complete pelleted rations (Clawson and Alsmeyer, 1970). Hollis and Palmer (1970) have provided data suggesting efficiencies of 89% and 87% respectively for Florida-grown wheat and barley as compared with corn in supporting weight gains in swine. It should be noted, however, that use of both wheat and barley permitted lower levels of soybean meal supplementation than did corn in bringing the Florida rations to the desired protein content. Oklahoma studies evaluate local wheat and milo equally in supporting swine gains when each diet had the same protein supplementation (Luce *et al.*, 1969).

North Dakota workers have focused attention on the differences in performance of swine on similar rations formulated with either durum or hard red spring wheats (Dinusson, 1970). While the hard red wheat proved generally satisfactory, the durum required special care in grinding and benefited from mixture with other grains. One may conclude on the basis of available data, that wheat feeding of swine is not seriously limited by consideration of palatability, but the methods of processing some wheats may be critical.

Wheat as an Energy Source

Since the organic matter of wheat, in common with the other cereal grains, is largely carbohydrate, wheat serves as a major source of dietary

energy. There are various ways of evaluating energy, including estimation of total digestible nutrients (TDN) and digestible energy (DE). The relatively straightforward means of determining digestible energy makes it an appropriate criterion of describing energy values of swine ration constituents. Moreover, it has been established (Swift, 1957) that a direct relationship exists between DE and TDN.

Table 2: Comparison of Wheat and Other Cereals as Energy Sources for Swine.*

Cereal and Type	TDN	DE
	%	kcal/kg
Ground wheat	76.7	3322
Ground corn	76.2	3456
Ground barley	69.0	2900
Ground milo	76.8	3313

*Data from Robinson, Prescott and Lewis, (1965).

It is obvious that wheat is a much better source of available energy, measured by both criteria in Table 2 than a fibrous grain, like barley, and a similar comparison might be expected for oats. A more intriguing question is how wheat compares with the other non-fibrous grains commonly fed to swine, like corn and milo. Here the variations among individual lots of wheat become significant, and again the failure to define the specific nature of wheat used in studies such as that shown in Table 2 is regrettable.

There have been a number of studies in which wheat has been compared with other grains as the major energy source in swine rations. Generally, these follow two patterns: either equivalent substitution of the grains, pound for pound, or adjustment to an isonitrogenous basis. Lawrence (1967), in England, fed wheat in comparison with corn, milo and barley in high-level cereal diets (85% in starter, 90% in finisher diets) to pigs from weaning to slaughter at 200 lb. live weight. Contrary to the data in Table 2, he found that digestible energy was highest (and approximately equal) for the wheat and milo diets, and lower for those based on corn and barley. Lawrence attributed the poorer performance on the corn diet to the fact that all diets were fed as wet mashes and apparently this adversely affected palatability of the corn. Digestible energy values were 3557, 3594 and 3378 kcal/kg for the wheat, milo and corn diets, respectively. Nevertheless, weight gains on the corn diet were good, averaging 1.55 lb/day overall, as compared with 1.48 lb. on the wheat and 1.41 lb. on the milo diet. Gill, Oldfield and England (1966) reported somewhat similar comparisons in terms of liveweight gains in pigs when they substituted equal weights of Utah hulless barley, Hann-

chen barley, Oregon H-355 corn and Gaines (a soft white) wheat. Gains were best on the corn diet, next, and approximately equal on the wheat and hulless barley diets and poorest on the regular barley mix. The levels of gains used in these diets were 80% at the start and 85% during the finishing phase.

Bowland (1967) compared wheat (hard red) with hulless barley, barley and rye at 61% levels in starter rations for pigs, when the need for highly available energy is especially critical. The wheat diet was approximately equivalent to the hulless barley and barley diets in terms of feed intake, rate of gain and efficiency of feed conversion and all three were superior to the rye diet. Oregon studies, using soft white wheat or corn as the only grains in creep rations for suckling pigs, with equivalent supplementation in each case, suggested that the wheat-based ration was superior in terms of average 56-day weaning weights (England, 1966). Bowland later investigated the use of wheat in high and low-energy swine rations, where the variation in available energy was accomplished by dilution with oats. Again, the effectiveness of wheat as an energy source was demonstrated. The low-energy diet was apparently less palatable, and the amounts of the two diets eaten were approximately equal, so that growth was significantly better on the high wheat diet.

All of these experiences, (and many more could be cited) suggest that wheat is a very satisfactory energy source for swine. Its somewhat lower energy content than corn, which consequently supports somewhat lower animal gains, may most probably be attributed to corn's higher fat content. This is not an unmixed blessing on the corn side of the ledger. Corn oil is unsaturated and tends to soften the depot fat in the hog carcass somewhat, while wheat feeding has long been known to produce a hard carcass fat (see, for example, Loeffel, 1931).

The data presented have provided some evidence that processing methods may significantly affect animal performance on rations based on wheat or other cereal grains. Several experiments have suggested that pelleting produces greater benefits when applied to relatively high-fiber rations, containing considerable quantities of barley or oats, than when applied to low-fiber grains like wheat, corn or milo (Lehrer and Keith, 1953; Thomas and Flower, 1956). There is evidence, however, that wheat-based rations may also be improved by pelleting. In two separate trials, Hines (1970) has shown that wheat is equal or superior to milo in swine rations, and that both wheat and milo rations may be improved by pelleting. Bowland (1964) has shown with rations in which wheat was combined with some fibrous grains (barley, oats), it could be used successfully under conventional or limited feeding, liquid or dry, or floor versus conventional self-feeder practices. It would appear that wheat is a versatile energy source, without major problems restricting its availability.

Wheat as a Protein Source

Although cereal grains are commonly, and appropriately, considered primarily as contributors of energy, the high levels at which they are used means that they incidentally supply a considerable proportion of the ration protein. Consequently, the suitability of their protein for supporting growth of animals becomes an additional point of importance, for non-ruminant species, along with their values as sources of energy. It is possible that part of the differences in performance of wheat in comparison with other cereals, reported herein, may have been due to the adequacy with which they met protein requirements, particularly in cases where total crude protein in the rations tended to be minimal.

Adequacy of a protein for supporting growth in non-ruminants is generally acknowledged to be a reflection of its amino acid composition, and particularly of the relative proportions of the essential amino acids. It has been known for many years that grains as a class tend to be deficient in lysine and tryptophan and, in some cases, methionine (Osborne and Mendel, 1914). The relative amino acid concentrations in wheat and some other common feed ingredients have been calculated by Altschul (1965) and are listed in Table 3.

Table 3: Amino Acid Patterns of Some Common Proteins.

Protein Source: Amino Acid	Cows Milk	Meat (Beef)	Soybean	Milo	Corn	Wheat
	mg Amino Acid/g N					
Isoleucine	341	323	319	338	225	253
Leucine	620	488	483	594	717	409
Lysine	475	537	429	197	169	174
Methionine & Cystine	214	253	197	354	200	265
Phenylalanine & Tyrosine	599	428	557	525	496	457
Threonine	280	278	269	241	225	192
Tryptophan	81	63	80	88	33	67
Valine	409	321	336	416	263	272

It would appear from Table 3 that the most limiting amino acid in wheat protein is lysine, and Becker (1958) has offered similar data, suggesting that the lysine in wheat represents only 49% of the requirements of this amino acid by the young pig. The decreasing price of commercially-available lysine has encouraged experiments involving its supplementation. Bowland (1960) found that a basal diet for baby pigs consisting of wheat and sugar, minerals, antibiotics and vitamins, could be greatly improved, in terms of growth rate produced, by supplementation with 0.2% L-lysine. Increasing the lysine supplementation to 0.6% improved performance of the animals still further, but not to the same extent as 8% fish meal (added at the expense of wheat). It is noteworthy

that supplementation of the basal ration with 0.1% DL — methionine and 0.07% L-tryptophan, in addition to the lysine, did not improve performance over that attained with 0.6% L-lysine alone. Dinusson (1970) has provided evidence that supplementation of a ration containing 97.7% durum wheat (plus vitamin-mineral supplement) with 0.7% L-lysine increased gains of growing pigs from 0.72 to 1.34 pounds per day.

Further studies at Alberta (Bowland and Grimson, 1968) compared growth performance of pigs from 3 to 9 weeks of age fed diets containing 22% crude protein, or 14% crude protein with and without supplementation with lysine and methionine. All of the test diets contained approximately 60% wheat, which therefore contributed significantly to the dietary protein; however the increased protein in the high-protein diets was achieved largely through addition of herring meal. The lysine and total sulphur-bearing amino acid contents of the high and low-protein diets were 1.16%, 0.69% and 0.70%, 0.48% respectively. These experiments demonstrated that when L-lysine and DL-methionine were added to the low-protein diets, to equal the amounts of these amino acids in the high-protein diet, the growth performance was improved to equal that on the high-protein diet. At currently-prevailing prices, this amino acid supplementation did not produce as economical gains as feeding the higher protein level, however the authors recommended inclusion of cost data for amino acid supplements in future linear-programming of swine rations.

The area of protein quality appears to be one of promise for improvement of wheat rations, particularly those devised for feeding fast-growing young pigs. It is also assuredly one where even minor variations in amino acid patterns may significantly alter the level of growth supported, due to the high levels of wheat commonly fed. Availability of amino acid analyzers in many nutrition laboratories should facilitate accumulation of amino acid data on various types of wheat so that they may be used with increased efficiency as suppliers of dietary protein. For the future, the possibility of breeding wheat types with improved amino acid balances should be pursued. Alexander (1966), among others, has drawn attention to the implications of the development of "opaque-2" corn for the producers of other cereals, including wheat.

Wheat By-Products

Wheat's long acceptance as a human diet staple has made a number of milling by-products available for swine feeding. Thomas and associates (1955, 1956, 1959) have investigated the use of wheat millrun ("wheat mixed feed") under varying conditions of supplementation. They reported some lessening of growth rate and reduction of feed-conversion

efficiency as high levels of wheat millrun (50% or more) replaced whole grain, usually barley, in swine grower rations. The fact that the millrun compared unfavorably with a fibrous grain suggested that the difficulty did not lie in the energy-availability area, while equivalent protein supplementation of the various test rations made a protein deficiency imposed by the millrun on the entire ration unlikely. One may speculate that the problem with rations high in wheat millrun is attributable to palatability or acceptability characteristics rather than to nutrient availability, *per se*. Bell (1960) after extensive studies with laboratory animals, is inclined to doubt flavor difficulties in diets containing wheat bran, but points out the effect of this bulky feed upon stomach volume, rate of passage of food and fecal volume.

There have been some indications of growth inhibition in mink and in poultry when fairly high levels of wheat germ meal have been included in their diets. For example, Creek *et al.* (1961) showed, in tests with chicks, that growth was significantly lessened when wheat germ meal was used as either the major energy source or the major protein source. The inhibitory effect was largely eliminated by autoclaving the wheat germ meal, suggesting the presence of a thermolabile inhibitor. It is highly doubtful that economic considerations would allow the use of such high levels (25% or more) of wheat germ meal in swine rations; nevertheless the demonstration of inhibition by this wheat fraction suggests that processing methods might be devised to improve performance on the whole grain.

Summary

Available evidence suggests that wheat is generally satisfactory as a major source of both energy and protein in rations for swine. Where less-than-optimum performance has been obtained on wheat rations, the reason may be in incidental factors such as method of processing or of feeding rather than in deficiency of specific nutrients or direct difficulties with nutrient availability. It has been shown, however, that lysine supplementation enhances growth of young pigs on wheat rations and this supplementation may be provided by appropirate, intact protein, or by L-lysine itself. Although evidence has been provided for existence of a thermolabile growth inhibitor in wheat germ, it is doubtful that this would occur in high enough quantities in whole-wheat rations for swine to cause significant growth depression. Analytical data on wheat show considerable variation among different types, grown under varying cultural conditions. It is strongly recommended that such differences be more extensively and accurately documented and that resulting data be used in computer formulation of swine rations in future.

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