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Utilization of Wheat In Turkey Feeding Programs

THOMAS W. SULLIVAN

Introduction

Wheat and wheat by-products have been used for centuries as a food for both animals and humans. Although generally considered as an energy source, wheat must also be recognized and evaluated as a major source of protein and amino acids. The price of wheat relative to other cereal grains restricted its use in animal feeds from the early 1940's until recently.

During the past few years, a steady decline in price has allowed an increasing use of wheat in turkey feeds. In some instances there has probably been too much reluctance or caution in replacing traditional feed grains with wheat. Some caution in this usage of wheat may have been justified, however, because turkeys, turkey feeding programs and varieties of wheat have all changed greatly during the past 25 years.

Data concerning the nutrient composition of wheat has been obtained and reported at a much faster pace in recent years. Also, a number of feeding trials have been conducted with turkeys. McGinnis (1964), Sanford (1966), Harper (1966) and Biely (1969) have reviewed the value of wheat in poultry rations.

This paper will review the pertinent and significant literature relative to the utilization of wheat in turkey feeding programs.

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Table 1. Metabolizable energy values for wheat and other cereal grains.*

Ingredients[1]	Form	Metabolizable energy[2] Kcal./lb. of dry matter	
		range	mean
Corn, yellow all analyses		1580-1800	1740
Corn, yellow	whole	1720-1760	1740
Corn, yellow	ground	1580-1790	1720
Corn, yellow	pelleted	1730-1800	1770
Wheat, all analyses		1340-1800	1540
Wheat, western, feed	whole	1370-1610	1540
Wheat, western, feed	ground	1340-1800	1550
Wheat, western, feed	pelleted	1480-1700	1580
Wheat, Ontario	ground		1530
Wheat, Ontario, sprouted	ground		1520
Wheat, Ontario, sprouted and moldy	ground		1530
Barley, Western, all analyses		1210-1670	1420
Barley, Western	whole	1320-1520	1420
Barley, Western	ground	1210-1470	1380
Barley, Western	pelleted	1450-1670	1520
Oats, Western, all analyses		1050-1720	1360
Oats, Western	whole	1210-1210	1210
Oats, Western	ground	1230-1610	1430
Oats, Western	pelleted	1050-1720	1390

*Sibbald, I. R., and S. J. Slinger. 1962. Poultry Sci. 41: 1612-1613.
[1] Names of ingredients conform to the definitions presented in the Canadian Feeding Stuffs Oct; the term "western" indicates that the ingredient was grown in Western Canada.
[2] The range and mean M.E. values are based on sample values and not on individual determinations.

Nutrient Composition of Wheat

Particular attention has been given recently to the metabolizable energy (M.E.), protein and amino acid contents of various wheats.

Energy. Sibbald and Slinger (1962) reported M. E. values for wheat and other cereal grains commonly used in poultry rations. These values, presented in Table 1, indicate that wheat has a lower energy value (about 90%) than yellow corn. However, the metabolizable energy value of wheat was greater than barley and oats. Hubbell (1968) has reported feedstuff analysis data which are frequently used in formulating turkey feeds. Metabolizable energy values listed by Hubbell are presented in Table 2. These data indicate that the M. E. value of both hard and soft wheats is about 89 percent of the value for yellow corn. It should be emphasized that Hubbell's feed ingredient analysis data were given on an "as fed" and not on a "moisture free" basis.

Certain treatments or processing methods have increased the feeding value and probably the M.E. value of wheat. These treatments will be discussed later in this paper.

Table 2. Metabolizable energy values for wheat and other cerea grains.*

Feedstuff	Metabolizable energy Kcal./lb.	Metabolizable energy % of corn
Yellow corn	1530	100.0
Milo maize	1480	96.7
Oats	1140	74.5
Rice (rough)	1215	79.4
Barley	1190	77.8
Wheat, hard red	1360	88.9
Wheat, soft Western	1360	88.9

*Hubbell, C. H. 1968. Feedstuffs Analysis Table, The Miller Publishing Co., P. O. Box 67 Minneapolis, Minn. 55440.

Table 3. Protein and amino acid composition of experimental whea samples used in milling studies.*

Component	Hard red winter	Hard red spring	White wheat (Gaines)	Soft red winter
	%	%	%	%
Moisture	12.49	12.60	13.00	14.75
Protein[1]	11.73	12.40	9.20	11.75
Amino acids[2]				
Lysine	0.33	0.31	0.32	0.35
Histidine	0.28	0.26	0.26	0.31
Arginine	0.57	0.52	0.55	0.63
Aspartic acid	0.62	0.62	0.57	0.65
Threonine	0.36	0.36	0.32	0.38
Serine	0.61	0.61	0.52	0.63
Glutamic acid	4.01	4.27	3.45	4.27
Proline	1.31	1.35	1.06	1.36
Glycine	0.51	0.52	0.47	0.53
Alanine	0.44	0.45	0.40	0.48
Cystine	0.33	0.32	0.29	0.35
Valine	0.52	0.53	0.48	0.56
Methionine	0.21	0.20	0.16	0.21
Isoleucine	0.43	0.44	0.38	0.44
Leucine	0.84	0.86	0.74	0.88
Tyrosine	0.38	0.38	0.32	0.38
Phenylalanine	0.59	0.59	0.49	0.62

*Deyoe, C. W., D. H. Waggle and E. P. Farrell. 1967. Feedstuffs 39:No. 17, 26-30, 42 & 43.
[1] Percent NX5.7; if the reader wishes to place the value on a factor of 6.25, he should multipl the above protein value by 1.096.
[2] All amino acid values are reported on a 14% moisture basis.

Protein and amino acids. Protein and amino acid composition of whea varies widely and is influenced or determined by genetic and environ mental factors. Wheat breeders today are interested not only in tota yield of protein, but in the amino acid content of the protein. Develop ment of hybrid wheats with high protein and higher lysine contents i now in progress. These high protein wheats should have a definite impac on the formulation of turkey rations in the near future.

Deyoe *et al.* (1967) have reported the protein and amino acid composition of blended samples of four wheats from different areas of the United States. Hard red winter wheats came from north central Oklahoma, southwest Kansas, northeast Kansas 1964, northeast Kansas 1965 and a composite from several Kansas locations. Hard red spring wheats came from northwestern Montana and from southeastern North Dakota; the white wheat sample was Gaines from Pullman, Washington; the soft red winter wheat came from east central Indiana. Protein and amino acid analyses of these four composite samples are presented in Table 3. The authors have presented these analytical data as a reference from which to ascertain the nutritional or feeding value of various wheats; hence, all amino acid values are reported on a 14 percent moisture basis.

Kohler and Palter (1967) studied methods for amino acid analysis of wheat products. These workers have compared their data on the amino acid composition of hard red winter wheat with previously reported values (Table 4). Kohler and Palter (1967) concluded that essentially all of the previously published results on cystine and methionine are too

Table 4. Amino Acid composition (gm/amino acid/16 gm. N) of hard red wheats.*

	Whole wheat		
Component	WRRL[1]	Lyman et al.[2]	Simmonds et al.[3]
Nitrogen (dry basis), %	2.42	2.64	2.56
Recovery of N as amino acids or ammonia, %	96	----	----
Lysine	2.61	2.67	2.71
Histidine	2.29	2.12	2.55
Ammonia	3.92	----	----
Arginine	4.74	4.71	5.06
Aspartic acid	5.06	4.85	----
Threonine	2.98	2.76	3.03
Serine	4.90	5.22	----
Glutamic acid	30.80	29.30	----
Proline	9.46	9.94	----
Glycine	4.03	3.94	----
Alanine	3.49	3.37	----
Cystine	2.31	1.80	----
Valine	4.79	4.69	4.46
Methionine	1.70	1.74	1.32
Isoleucine	3.89	3.78	4.50
Leucine	6.79	6.52	6.48
Tyrosine	3.10	3.19	3.24
Phenylalanine	4.64	4.43	4.92
Tryptophan	----	1.13	1.53

*Kohler, G. O., and R. Palter, 1967. Cereal Chem. 45:512-520.
[1] Western Regional Research Laboratory composite sample of hard red winter wheat (12% protein).
[2] Blend of hard red spring and hard red winter wheats.
[3] Average of five values for red wheat.

Table 5. Amino acid composition of a selected high-protein line and parental varieties of wheat grown in 1966.*

	Wheat variety or line			
Component	Atlas 66	Wichita	Comanche	2500
	gm. of amino acid per 100 gm. protein[1]			
Lysine	3.3	3.2	3.2	3.2
Histidine	2.9	2.7	2.8	2.9
Ammonia	4.6	4.1	4.5	4.3
Arginine	5.6	5.5	5.5	5.4
Aspartic acid	5.7	5.6	6.3	5.5
Threonine	3.4	3.4	3.5	3.2
Serine	5.6	5.0	5.7	5.0
Glutamic acid	36.8	34.2	36.1	36.2
Proline	12.7	12.1	12.6	12.2
Glycine	4.7	4.4	4.6	4.4
Alanine	3.9	3.7	3.7	3.6
½ Cystine	1.8	2.0	1.9	2.0
Valine	4.6	4.3	4.6	4.5
Methionine	1.1	1.6	1.7	1.7
Isoleucine	3.8	3.9	3.9	3.8
Leucine	7.6	7.8	7.5	7.4
Tyrosine	3.8	3.7	3.9	3.8
Phenylalanine	5.3	5.5	5.6	5.4
Protein, % dry wt.	18.0	14.1	15.0	18.3

*Mattern, P. J., Ali Salem, V. A. Johnson and J. W. Schmidt, 1968. Cereal Chme. 45:437-444.
[1] Nitrogen was determined by the Gunning Kjeldahl method. Total N x 5.7 was used to convert nitrogen to protein values.

low, undoubtedly because of oxidative losses during hydrolysis. Also, their values for valine and isoleucine tend to be higher than most previously reported results; it was concluded that vigorous hydrolysis conditions (125°C. for 24 hours) were needed to liberate these two resistant amino acids, valine and isoleucine.

Mattern *et al.* (1968) at the Nebraska Agricultural Experiment Station have reported the amino acid composition of selected high protein wheats. Their amino acid composition data for parental varieties, Atlas 66, Wichita and Comanche, and one selected high-protein line are presented in Table 5. Johnson, Mattern and Schmidt (1969) have recently reported essential amino acid values for 16 high-protein wheats. These average values, presented in Table 6, are very reliable and representative for high-protein wheats, recently produced on an experimental basis.

The protein of wheat, like that of other cereals, is deficient in some of the essential amino acids, such as lysine, methionine and perhaps threonine. Also, wheat contains an excess of other amino acids such as proline and glutamic acid. Wheat breeding research currently in progress is aimed at increasing the protein and amino acid (especially lysine) content of wheat.

Vitamins and minerals. Perhaps the most recent comprehensive data on

Table 6. Average essential amino acid and protein composition of 16 high-protein wheats.*

Component	Gm. of amino acid per 100 gm. protein
Lysine	2.9
Isoleucine	3.7
Leucine	7.1
Methionine	1.6
Phenylalanine	5.2
Threonine	3.0
Valine	4.5
Tryptophan	1.1
Protein, % dry wt.	17.2

*Johnson, V. A., P. J. Mattern, and J. W. Schmit. 1969. Symposium on Plant Breeding, Cambridge, England, June 26-27, 1969.

Table 7. Mineral composition of experimental wheat samples used in milling studies.*

Minerals[1]	Hard red winter	Hard red spring	White wheat (Gaines)	Soft red winter
Ca, %	0.038	0.024	0.024	0.024
P, %	0.38	0.35	0.28	0.41
K, %	0.39	0.32	0.37	0.41
Na, %	0.01	0.005	0.005	0.01
Mg, %	0.11	0.11	0.09	0.10
Zn, ppm.	46.7	37.0	21.0	41.0
Fe, ppm.	27	20.0	30.0	22.0
Mn, ppm.	27.4	36.0	24.0	28.0
Cu, ppm.	7.1	5.2	4.2	4.2
Se, ppm.	0.28	0.50	0.04	0.04
B, ppm.	1.1	1.6	1.8	2.2
Sr, ppm.	0.72	0.69	0.48	0.48
Al, ppm.	5.0	5.0	5.0	5.0
Ba, ppm.	6.7	3.0	3.5	6.2
Co, ppm.	0.13	0.12	0.13	0.10

*Deyoe, C. W., D. H. Waggle and E. P. Farrell. 1967. Feedstuffs 39:No. 17, 26-30, 42 & 43.
[1] All mineral values are reported on a 14% moisture basis.

Table 8. Vitamin composition of experimental wheat samples used in milling studies.*

Vitamins,[1] mcg./gram	Hard red winter	Hard red spring	White wheat (Gaines)	Soft red winter
Niacin	53.1	56.1	46.6	48.4
Pantothenic acid	9.8	9.2	8.4	8.6
Folic acid	0.35	0.43	0.37	0.41
Thiamine	3.70	4.26	4.11	4.11
Riboflavin	1.65	1.50	1.32	1.54
Pyridoxine	2.21	2.66	2.02	1.69
Alpha tocopherol	14.1	13.9	14.5	15.2
Betaine	587.8	1008.4	1026.5	1442.1
Choline	1080.2	1205.6	1139.6	981.2

*Deyoe, C. W., D. H. Waggle and E. P. Farrell. 1967. Feedstuffs 39:No. 17, 26-30, 42 & 43.
[1] All vitamin values are reported on a 14% moisture basis.

the vitamin and mineral content of wheat was reported by Deyoe *et al.* (1967). These data for combined samples of four wheats, previously described, are presented in Tables 7 and 8. The wheat samples analyzed contained from 1.20 percent ash in white wheat to 1.61 percent ash in soft red winter. Considerable variation was evident in the trace mineral contents of different wheats; this was probably due to variations in soil and climatic conditions. Wheat is a fairly good source of certain water soluble vitamins and alpha tocopherol.

Evaluation of Wheat in Turkey Feeding Trials

Poley and Wilson (1939) studied and compared the utilization of corn, wheat, oats and barley by growing and finishing turkeys of the Standard Bronze strain. When judged by the amount of feed required to produce a unit of body weight gain, wheat was practically equal to corn. The feeding value of wheat was 99.0, barley 98.0, and oats 89.3 percent as compared to yellow corn in growing rations. In the finishing rations wheat had a value of 101, barley 87.7 and oats 96.2 as compared to yellow corn.

Slinger *et al.* (1958) concluded that Canadian number 5 wheat was equal in energy value to United States No. 2 yellow corn. These workers suggested that energy values for wheat in the published literature were too low for the Canadian grade of wheat used extensively for feed in that country. Summers *et al.* (1959) reported significantly increased growth rate in poults to four weeks of age, when either an all-wheat diet or a one-half wheat and one-half corn diet was fed as compared to an all-corn diet. Data from this study are presented in Table 9. Dried whey and fish solubles gave a somewhat greater response with diets containing corn than with the "all-wheat" diet. Since the wheat diets contained more

Table 9. Effect of unidentified factor sources on the performance of B. B. Bronze poults fed diets varying in wheat and corn.*

Dietary treatments	4-week data[1]		
	Body wt.	Survival	Feed/gain
	grams		
Corn basal	461	85/88	1.94
Corn basal + 2.5% dried whey + 2.5% fish sol.	515	85/88	1.94
Wheat & corn basal	496	82/88	1.88
Wheat & corn basal + 2.5% dried whey + 2.5% fish sol.	547	86/88	1.87
Wheat basal	525	86/88	1.84
Wheat basal + 2.5% dried whey + 2.5% fish sol.	546	86/88	1.82

*Summers, J. D., W. F. Pepper and S. J. Slinger. 1959. Poultry Sci. 38:922-928.
[1] Duplicate groups of 22 males and 22 females were assigned to each treatment.

Table 10. Influence of grain source on the performance of B. B. Bronze poults.*

Dietary treatment	Average 8-week data[1]	
	Body wt.	Feed conv.
	lbs.	
Corn diet	3.92	2.00
Spelt diet[2]	3.84	2.29
Barley diet	3.78	2.11
Barley diet + 2.5% Dawenzyme	3.75	2.08
Wheat diet	4.12	2.02
L.S.D. ($P<0.05$)	.28	.21

*Arscott, G. H., and J. A. Harper, 1962. World's Poultry Sci. J. 18:278-284.
[1] Duplicate lots of 30 poults per treatment; dietary protein level was held constant at 29.0%.
[2] Spelt, *Triticum spelta*, is a relative of wheat, which resembles barley in appearance.

animal fat, the wheat response may have been due to the higher level of added fat and/or energy.

Sibbald and Slinger (1963) studied the nutritive value of ten samples of Western Canadian grains. These workers suggested that within the ranges studied, bushel weights were of little value in estimating the nutritive worth (M. E. and protein levels) of either wheat or barley. The bushel weights of oats, however, served as a useful guide to M. E. content.

Arscott and Harper (1962) at the Oregon Station have studied and compared the effect of grain sources on poult growth. Data from one experiment are presented in Table 10. These results show that wheat and corn were comparable relative to growth rate and feed efficiency of poults to 8 weeks of age. Harper (1966) has also conducted studies in which Gaines variety wheat replaced one third, two thirds and all of the corn in turkey diets. Data from this study are presented in Tables 11 and 12. Growth rates to eight weeks of age were comparable for poults on all treatments; however, feed conversion was better for the all-corn or partial corn diets. Body weights of both males and females at 20 and 24 weeks decreased as the amount of dietary wheat increased. Also, feed conversion data show a linear increase with increasing level of wheat. The all-wheat diet was 91.0 to 92.6% as efficient as the all-corn ration at 20 and 24 weeks, respectively. This difference in feed efficiency was close to the M. E. value of wheat (89-90%) relative to yellow corn.

Waldroup *et al.* (1967) conducted two trials to determine the comparative feeding value of wheat, corn and milo in turkey diets. When substituted on a pound-for-pound basis in mash diets, wheat and milo supported significantly greater gains in turkeys 11 to 21 weeks of age than did corn. Pelleted diets containing wheat produced significantly greater gains than pelleted corn diets, but there was no difference between pelleted milo and corn feeds. Data from this experiment are presented in

Table 11. Effect of replacing corn with varying levels of wheat in turkey starting diets.*

Dietary treatments[1,2]			4-week data		8-week data	
Corn	Wheat	Sex	Body wt.	Feed conv.	Body wt.	Feed conv.
%	%		lbs.		lbs.	
100.0	0.0	M	1.22	1.73	3.8	2.05
		F	1.09		3.1	
66.7	33.3	M	1.24	1.60	3.7	2.05
		F	1.13		3.2	
33.3	66.7	M	1.25	1.62	3.8	2.27
		F	1.06		3.0	
0.0	100.0	M	1.30	1.77	3.9	2.19
		F	1.10		3.1	

*Harper, J. A. 1966. Feedstuffs, 38: No. 9; 66-67.
[1] Three lots of 30 Medium White poults per treatment.
[2] Diets contained 29.0 to 30.0 percent protein.

Table 12. Effect of replacing corn with varying levels of wheat in turkey growing diets.*

Dietary treatment[1,2]			20-week data		24-week data	
Corn	Wheat	Sex	Body wt.	Feed conv.	Body wt.	Feed conv.
%	%		lbs.		lbs.	
100.0	0.0	M	15.2	3.71	19.2	4.02
		F	10.2		11.4	
66.7	33.3	M	15.4	3.76	19.4	4.06
		F	10.1		11.0	
33.3	66.7	M	15.3	3.85	18.9	4.22
		F	9.7		10.7	
0.0	100.0	M	15.3	4.08	18.5	4.34
		F	9.6		10.7	

*Harper, J. A. 1966. Feedstuffs, 38: No. 9; 66-67.
[1] Three lots of 30 Medium White poults per treatment.
[2] Dietary protein levels were approximately 21.5, 17.5 and 15.0% for 9-12, 13-17 and 18-24 weeks, respectively.

Table 13. Waldroup *et al.* (1967) conducted a second trial in which corn, wheat and milo were compared in linear programmed diets fed to turkeys day-old to 23 weeks of age. All diets fed in this trial were pelleted. There were no significant differences in body weight gain or feed efficiency, which could be attributed to the feed grains used. The 23-week data from this experiment are presented in Table 14. These results would indicate that corn, wheat or milo may be used effectively in turkey feeds, when fed on the basis of their nutrient composition in properly balanced diets.

Table 13. Effect of grain source and pelleting on the body weight gain and feed efficiency of Large White turkeys.[1]

Grain source	Form	11-21 week data	
		Weight gain[2]	Feed/gain
		kg.	
Corn	mash	3.83c	4.35
	pellet	3.99bc	4.10*
	Average	3.91x	4.22
Wheat	mash	4.20ab	4.43
	pellet	4.29a	4.17*
	Average	4.24y	4.30
Milo	mash	4.14ab	4.42
	pellet	4.15ab	3.93*
	Average	4.14y	4.17
	Mash	4.06	4.40
	Pellets	4.14	4.07

[1] Waldroup, P. W., D. E. Greene, R. H. Harris, J. F. Maxey and E. L. Stephenson. 1967. Poultry Sci. 46:1581-1585
[2] Within treatment means or composite averages, values followed by the same letter do not differ significantly ($P < 0.05$).
*Differs significantly from value for mash diet.

Table 14. Final body weight and feed efficiency data for Large White turkeys fed corn, wheat and milo diets in pelleted form[1,2].

Grain source	23-week body wt.	0-23 week feed/gain	Feed consumption
	kg.		kg./bird
Corn	8.38	3.21	27.4
Wheat	8.44	3.23	27.3
Milo	8.49	3.38	28.2

[1] Waldroup, P. W., D. E. Greene, R. H. Harris, J. F. Maxey, and E. L. Stephenson. 1967. Poultry Sci. 46:1581-1585.
[2] Thirty-six male and 36 female poults were assigned to each treatment.

Table 15. Influence of lysine supplementation of wheat-soybean meal rations on body weight gain and feed efficiency of male, B. B. Bronze turkeys[1].

Dietary treatments[2]		24-week	0-24 weeks
M.E. level	added lysine	wt. gain	feed/gain
	%	lbs.	
Medium	0.0	23.7	3.54
Medium	0.10	23.5	3.50
Medium	0.20	22.9	3.68
High	0.0	23.6	3.02
High	0.10	24.6	3.03
High	0.20	24.3	3.08

[1] Sell, J. L. 1964. Dept. of Animal Sci., Univ. of Manitoba, Winnipeg. Research report, Project 702:02.
[2] Two groups of 20 male poults were assigned to each treatment. Medium and high energy levels differed by approximately 100-115 Kcal. of M.E./lb.

Amino acid supplementation of wheat diets. Slinger *et al.* (1953) fed poults a diet containing 21.5 percent ground wheat, 15.0 percent ground corn and 5.0 percent oat groats as grain components. Supplemental methionine levels of 0.025 and 0.05 percent did not increase body weight gain, but did result in small and consistent improvements in feed efficiency.

Sell (1964) investigated the value of supplemental lysine in wheat-soybean meal rations for turkeys 0-24 weeks of age. The final or 24-week data from this trial are presented in Table 15. Addition of lysine to "medium" energy rations failed to increase weight gain or improve feed efficiency. The 0.20 percent level of added lysine reduced weight gain and decreased feed efficiency during the 12-24 week period. These data indicate that lysine was apparently not limiting in the "medium" energy ration, and also illustrate that an excess of this amino acid can adversely affect turkey performance. In contrast, turkeys fed the "high" energy ration responded favorably to lysine supplementation; the 0.10 percent level of added lysine was apparently adequate.

Fat suplementation of wheat diets. Joshi and Sell (1964) studied the effects of including soybean oil, sunflower oil, rapeseed oil or animal tallow in wheat-soybean meal rations for starting poults. Male B. B. Bronze poults were used and the fat sources were tested at 5.0 and 10.0 percent of the ration. Inclusion of soybean oil, sunflower oil or animal tallow stimulated weight gain from day-old to six weeks and improved feed efficiency. However, the addition of rapeseed oil depressed weight gain as compared to the low-fat, basal ration. The magnitude of growth depression was directly related to the rapeseed oil content of the ration.

Factors Which Influence Nutritional Value of Wheat

Origin. The type or variety of wheat, climatic conditions and soil fertility greatly influence the protein and amino acid composition of wheat. The M. E. value and trace mineral contents of wheat are also influenced by variety, climate and soil fertility. Variations in nutrient composition of wheat relative to these factors have been discussed earlier in this paper.

Water treatment and enzyme supplementation. The feeding value of wheat is often improved by water treatment or the addition of enzyme supplements to the diet. Fry *et al.* (1958) reported data from two experiments with starting poults; these data are presented in Table 16. These results show that water treating both barley and wheat gave significantly greater body weight gain.

Adams and Naber (1969a) have reported that water soaking grains improved their nutritive value for growing chicks. This was consistently

Table 16. **Effect of water treating and enzyme supplements on nutritional value of grains for starting turkeys**[1].

Grain	Water treatment	21-day data Wt.	21-day data Feed/gain	Enzyme suppl.	27-day data Wt.	27-day data Feed/gain
		gm.			gm.	
Corn	No	419	1.36	No	646	1.47
Corn	---	---	---	Yes	687	1.49
Barley	No	292	1.64	No	433	1.78
Barley	Yes	408	1.52	Yes	566	1.64
Wheat	No	398	1.42	No	612	1.54
Wheat	Yes	437	1.40	Yes	632	1.50

[1] Fry, R. E., J. B. Allred, L. S. Jensen and J. McGinnis, 1958. Poultry Sci. 37:372-375.

true for wheat and barley and occasionally true for corn. These workers also observed significant improvements in growth when chicks were fed diets containing wheat or barley soaked in 0.1 or 0.2 normal hydrochloric acid. However, in most cases the improved growth response obtained from the acid treatment of grains was no greater than from water treatment alone. Adams and Naber (1969a) also reported that steam expansion of corn or wheat was not effective in improving their nutritive value in chick diets. Supplementation of grain diets with commercial enzyme preparations was not effective in improving the nutritive value of corn, wheat or barley. Adams and Naber (1969a) evaluated partially germinated grains in chick diets; this treatment significantly improved the nutritive value of corn. The response from wheat treated in this manner approached significance, and little or no response was obtained from germinated barley.

Adams and Naber (1969b) reported that water or acid treatment of wheat flour or wheat gluten significantly improved growth rate of chicks, while untreated wheat flour depressed growth due to beak impaction which limited consumption. These workers have indicated that soft wheat did not respond to the water soaking treatment as did hard wheat. According to Naber and Adams (1969b), improved growth response in chicks fed grains subjected to water-soaking and acid treatments may be attributed to increased metabolizable energy values of the experimental diets.

Naber and Touchburn (1969b) have studied the effect of water treatment of components of hard red winter wheat on growth and energy utilization by the chick. They have concluded that water treatment probably increases the susceptibility of wheat starch to enzymatic degradation and thereby promotes increased energy utilization by the chick. An earlier report by Naber and Touchburn (1969a) indicated that water treatment and improved nutritive value of grains probably involve partial hydration and/or gelatinization of starch granules. These changes would apparently contribute to increased energy utilization by the chick.

Fineness of grind and beak impaction. When finely ground wheat or wheat flour is fed in turkey diets, pasting or impaction of the beak and beak necrosis occur. This condition has been observed by the author, by Adams and Naber (1969b) and quite obviously by many other workers. Summers *et al.* (1970) have indicated that this problem is largely overcome by coarse grinding of wheat, and does not occur when the feed is pelleted or crumbled. Therefore, coarse grinding or rolling of wheat is recommended in turkey feeding programs.

Other Considerations

Palatability. Turkeys readily consume wheat when given free-choice access to various cereal grains. Results of several studies have been very consistent and clearly indicate that turkeys prefer and will choose wheat over other grains.

Moldy wheat. Blakely *et al.* (1963) conducted four experiments in which six moldy wheats were incorporated into turkey poult rations for a six-week period. Moldy wheat, used as the sole source of grain in starter diets, significantly depressed body weight gain in only one experiment. Assays of 40 samples of moldy wheat showed that only two (5%) carried *Aspergillus fumigatus,* where as *Candida albicans* was not found in any of them. Mortality was low in all experiments and could not be attributed to the dietary treatments.

Fire and smoke damaged wheat. MacGregor and Blakely (1961) concluded that fire and smoke damaged wheat (21% of kernels charred) was entirely satisfactory for growing turkeys.

Carcass quality. Several studies have indicated that wheat-fed turkeys yield highly acceptable carcasses (Poley and Wilson, 1939; Marsden *et al.*, 1957; Goertz *et al.*, 1961a; Goertz *et al.*, 1961b). Fleshing qualities, meat tenderness, flavor and juiciness of wheat-fed turkeys have been quite satisfactory. The color of dressed carcasses from turkeys fed wheat rations is uniformly light, due to lack of xanthophyll pigment deposition in the skin. This lack of yellow skin pigmentation does not affect the grade or acceptability of turkey carcasses; on the contrary, such carcasses appear more uniform and will generally grade higher than carcasses showing variable yellow pigmentation.

Summary and Conclusions

Extensive studies have demonstrated that wheat performs very well in turkey feeding programs. Turkeys have readily accepted free-choice wheat and will generally select wheat over other cereal grains. Feed formulators and nutritionists should consider the following relative to the inclusion of wheat in turkey feeding programs:

1. Wheat has a metabolizable energy value of 88-92% of that for yellow corn.
2. Water-soaking and partial germination of wheat have improved the nutritive value of wheat for turkeys on an experimental basis. However, neither of these treatments appears commercially and economically feasible at present.
3. The protein content of wheat may vary from a low of about 9.5 percent to a high of 18.5 percent. Variety, climatic conditions and soil fertility largely determine the protein and amino acid composition of wheat. Lysine is apparently the first limiting amino acid in high-protein wheats, while methionine is apparently the first limiting amino acid in low-protein wheats. A high-protein, hybrid wheat with a higher lysine content is the goal of intensive wheat breeding research currently in progress. The achievement of this goal will significantly influence the role of wheat in turkey feeding programs.
4. Wheat should be coarsely ground or rolled for turkey rations; the inclusion of finely ground wheat or wheat flour in turkey rations will cause beak impaction and depressed body weight gains.
5. The carcass quality characteristics of wheat-fed turkeys have been highly acceptable.

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The Use of Wheat In Modern Feeding Programs For Broilers or Replacement Pullets

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The importance of the cereal grains in the formulation of poultry feeds was emphasized by the introduction of high energy rations about 20 years ago. Prior to that time ingredients used in diets were without specific classification. The complex nature of todays' computer formulated feeds balanced in energy, amino acids, minerals and vitamins depends on the cereal grains as the primary source of energy. In this capacity they also serve in a secondary role as sources of amino acids. Thus, both the energy and amino acid content of specific cereal grains must be considered when formulating poultry rations.

Corn is the primary cereal grain used in poultry rations in most of the United States. In the Pacific Northwest and in Canada wheat is the predominant cereal grain. Wheat is also the primary cereal grain used in poultry rations in Australia (McDonald, 1962; Cumming, 1969). Pino (1962) reported that corn, rice and wheat in that order were the energy sources used in the Pacific area.

Whether or not to use wheat in poultry rations is basically a question of availability and/or economics. Where competition with other cereal grains exists, the use of wheat may vary from year to year depending on the availability and price of other grains. Wheat has been fed to poultry since the industry has been in existence (Ewing, 1963). It is usually fed to animals when its price is low compared to corn. However,

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