EFFECT OF THE PHYSICAL FORM OF SORGHUM GRAIN ON THE PERFORMANCE OF LARGE-TYPE MARKET TURKEYS

by

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INTRODUCTION

In certain areas of the United States, particularly the Great Plains, sorghum grain has replaced corn as the major cereal grain in poultry diets because it is more adapted to climatic conditions of this region. A common practice among turkey producers in the region is to feed sorghum grain and a protein concentrate on either a complete feed or free-choice basis. Although the grain is fed in the ground, cracked, or whole form in these feeding systems, information is limited concerning the effect of the physical form on weight gain, feed efficiency and market quality of large-type market turkeys.

In some cases, particularly when newly harvested sorghum grain becomes available, some producers switch their birds from an all-mash complete feeding system to concentrate and whole grain. Field observations suggest birds on this system do not digest the whole grain efficiently; as evidenced by the amount of whole grain in the fecal material. Also research work has shown that feeding of whole grains and concentrate during the finishing period produces poorly finished carcasses in market turkeys (Dobson 1963). A possible explanation for these results is that digestive systems of birds on a highly concentrated all-mash ration are not developed sufficiently to utilize whole grains efficiently. This suggests it might be beneficial to feed birds a high-fiber diet prior to switching them to whole grains, since Thomas et al. (1960) reported gizzard weight and intestinal length of pullets were increased by feeding a high fiber-low energy diet.

Any factors which would improve the performance and grade of market turkeys fed sorghum grain would be an economic boost to the industry, since sorghum grain constitutes 30 to 70-percent by weight of turkey diets in this

region. This study was designed to investigate the effect of various physical forms of sorghum grain and the feeding of a high-fiber diet prior to feeding whole sorghum grain on the performance and market quality of large-type market turkeys.

REVIEW OF LITERATURE

The nutritional value of grain sorghum has been the subject of several investigations with chicks, laying hens, and turkeys. Several studies suggest sorghum grain may give inferior performance to yellow corn. Other studies indicate sorghum grain is equal to yellow corn in performance. Waldroup et al. (1967) reported on a study involving large white turkeys fed diets containing three grains (corn, wheat, and sorghum grain) in two physical forms (pelleted and non-pelleted) from 11 through 21 weeks of age. They found sorghum grain to be effective when used as the sole cereal grain in growing turkey diets when adjustments were made on the basis of nutrient composition. Chavez et al. (1966) found no significant differences in production, feed conversion or egg weight of Single Comb White Leghorn pullets fed rations using sorghum grain or corn as the energy source in two comparisons between corn and sorghum grain.

Saxina et al. (1954) reported ground sorghum grain to be equal to ground corn in supporting growth of meat-type chicks when each was fed with a combination of soybean meal and herring fishmeal. It also has been reported by Ewing (1953) that ground sorghum grain, when compared with ground corn as the principal ingredient of broiler rations, satisfactorly replaced an equal weight of corn when adequate carotene was supplied by good quality alfalfa leaf meal. This indicated sorghum grain would give results equal to those given by corn when used in turkey rations as the main source of energy.

PHYSICAL FORMS OF SORGHUM GRAIN

The most common form in which sorghum grain is used in modern poultry rations is the ground form in pelleted all-mash rations. Ground sorghum grain mixed with pelleted concentrate fed free-choice is another feeding system in which the ground form is used. Little research has been conducted on the use of other physical forms (whole, cracked and extruded) or sorghum grain mixed with a pelleted concentrate fed free-choice.

Dobson (1963) conducted an experiment in which turkeys were fed quantities that would be consumed completely every two days of a 32-percent protein pelleted concentrate mixed with whole sorghum grain from 8 weeks to market age. He reported turkeys could be grown satisfactorily on such a feeding system. In a subsequent study Dobson (1963) reported Broad Breasted Bronze and Broad Breasted White hens fed a 33-percent protein pelleted concentrate mixed with whole sorghum grain had significantly less weight gain and required more feed per pound of gain than a similar group fed ground sorghum grain. In both experiments the turkeys fed the whole sorghum grain were downgraded due to a lack of carcass finish. In further studies with whole cereal grains Chamberlin *et al*. (1962) reported significant differences in 8 to 24-week gains of turkeys fed *ad libitum* pelleted all-mash, mash concentrate and whole corn, and pelleted concentrate and whole corn. Feed conversion of the hens was not satisfactory on the pelleted concentrate and whole corn diet. McIntosh *et al*. (1962a) working with pullets fed whole, ground or pelleted wheat as the sole cereal grain on approximately an equal basis with ground corn in balanced diets. He reported neither weight gain nor feed efficiency was significantly reduced in comparison with the other diets when whole wheat was fed as the sole cereal component at levels of 70 to 80-percent from 6 through 15 weeks.

In experiments with White Leghorn pullets Berg and Bearse (1958) reported pullets given free access to a ration containing mash plus whole sorghum grain and barley developed just as rapidly and more efficiently than pullets fed an all-mash ration during the growing period from 8 to 20 weeks of age.

MacGregor and Blakely (1965) compared four forms of growing rations fed to turkeys for a 12-week period; mash, pelleted all-mash, pelleted concentrate mixed with whole wheat, and crumblized concentrate plus ground wheat. These workers found no significant differences in gain and feed to gain rates of turkeys fed pelleted concentrate and whole wheat and those fed crumblized concentrate and ground wheat rations. A comparison of 12-week data of birds fed whole wheat versus ground wheat rations showed texture of the ration had no significant effect on overall gain and feed efficiency. Their results did not support the hypothesis that ground grains should provide better overall energy gains than whole cereal grains.

Massey and Fuller (1962) compared free-choice and limited-choice feeding of all-mash concentrate and grain fed to Broad Breasted Bronze turkeys from 8 through 24 weeks of age. The free-choice feeding of concentrate and grains produced significantly greater weight gains that did feeding concentrate and grains on a limited-choice or feeding an all-mash ration composed of ground grains and concentrate. It was reported by Wyne et al. (1957) that no significant differences were found in live market quality or feed conversion between turkeys fed free-choice, from 8 through 24 weeks of age, all-mash, pelleted all-mash, 24-percent protein mash concentrate plus whole corn and oats fed free-choice, and 24-percent protein pelleted concentrate plus whole corn and oats.

McIntosh et al. (1962b) conducted studies to determine the effects of

grinding, pelleting, dietary balance, and grit feeding on metabolizable energy content of cereal grains, weight gains and feed efficiencies of chickens. Grinding or pelleting of cereal grains resulted in consistent increases in metabolizable energy. However, in two experiments whole wheat was found to yield more metabolizable energy than either ground or pelleted wheat. Grinding or pelleting of barley, oats, or corn exerted no consistent effect on the metabolizable energy values of these grains.

Particle size of the cereal grain in the ration has been reported to have some effect on the performance of poultry. Berg and Bearse (1947) reported decreasing the modulus values (particle size) in various rations resulted in nearly consistent decreases in body weight of Broad Breasted Bronze poults fed, for a period of 8 weeks, rations varying only as to size and shape of particles of wheat, oats, corn and millrun. The coarsest ration had a modulus of 2.96-1:5:4, the finest ration 2.14-0:4:6, with the other rations falling between the coarsest and finest. Davis et al. (1951), in an experiment with White Leghorn chicks, reported the replacement of various amounts of ground corn in a starting mash with finely cracked corn resulted in significantly depressed growth and decreased utilization. This was attributed to the selection of the corn particles to the exclusion of the remainder of the diet.

Yoder Laboratories (1968) found no significant differences in average daily gains for swine fed various grinds of corn. The corn was ground through 1/8, 1/4, 3/8, and 1/2-inch screens using a hammer mill. The corn was mixed with a supplement and self-fed as a complete ration. There was a 3.8 percent improvement in feed efficiency for the 1/8 and 1/4-inch grinds compared with 3/8 and 1/2-inch grinds.

EFFECT OF PROCESSING ON CEREAL GRAIN PERFORMANCE

Research studies show pelleting of cereal grain rations by application of heat and pressure during processing has an effect on the nutrient digestibility and utilization of the pelleted cereal grain ration. Therefore, the treatment of grain by physical (expanding) or chemical methods should improve its nutritive value.

Cowman et al. (1969) reported swine fed cooker-extruded sorghum grain had improved feed utilization. They stated growing-finishing swine may benefit more from partial gelatinization of the cereal grain than from total gelatinization or complete starch damage. Lowered palatability appeared to be a contributing factor as the level of cooker-extruded sorghum grain was increased above the 40-percent level in the ration.

In work with chicks, Deyoe et al. (1967) compared expanded to non-expanded sorghum grain in 17 and 20-percent protein diets supplemented with different levels of lysine and methionine. No significant difference was found in performance of chicks fed either the expanded or non-expanded 20-percent protein diets from 1 to 4 weeks of age. However, the chicks fed the 17-percent protein diets containing expanded sorghum grain did more poorly than the chicks fed the non-expanded sorghum grain.

Naber et al. (1962) reported gelatinization of the starch granules occurred when a slurry of corn starch was heated to 172° F. and the dried product improved growth and feed conversion when fed to chicks. Soaking potato starch in water at 136° F. caused swelling of the starch granules without significant gelatinization. The product improved the diet's metabolizable energy value and the feed conversion when fed to chicks. When gelatinization occurred in water at 160° F., potato starch was comparable to

gelatinized corn starch and produced excellent growth, feed conversion and a diet metabolizable energy value higher than that of the potato starch soaked in water at 136° F.

Influence of steam pelleting conditions on nutritional value of chick diets was studied by Bayley et al. (1968). They conducted an experiment in which 17 and 24-percent protein diets were pelleted at temperatures of 70, 80 and 90° C. and at pressures of 35 and 65 pounds per square inch. All processing treatments improved the performance of the birds on the 24-percent protein diets. Pelleting the 17-percent protein diet caused less improvement in performance.

Arscott et al. (1957) conducted two experiments to determine if pelleting of barley improved growth and feed efficiency when fed to chicks. Pelleting of barley feed resulted in a significant improvement in growth over the unpelleted feed. Regrinding of the pelleted barley feed brought about no improvement in growth. These authors stated failure of the chicks to respond to the reground pellets does not support the reports of some workers, that the pelleting effect may be due in part to a chemical change in feed.

An increase in rate of growth was obtained when chicks were fed both pellets and ground pellets compared to the mash form of the ration as reported by Allred et al. (1956). They concluded the results suggested a large part of the growth response from pelleting was brought about by a chemical change in the feed ingredients. In another experiment chicks fed a ration containing pelleted corn grew faster than those fed rations containing autoclaved, water-soaked or untreated corn. Williamson (1967) reported certain changes occur in the starch portion of cereal grains during heat and moisture treatments of the grains. The grain swells because water has been forced into the

starch granules forcing the starch chains apart. At temperatures of 150° F. and above the structural changes which take place are irreversible and the starch becomes gelatinized.

In studies with pelleted corn, Jensen and Becker (1965) found the starch fraction of pelleted corn was more susceptible to *in vitro* enzymatic digestion than that of unpelleted corn.

Thomas *et al.* (1961) reported chicks fed diets containing ordinary water-treated barley grew significantly faster than chicks fed non-treated barley. Lepkovsky and Furuta (1960) observed wetting of feed with water improved its nutritional value. This improvement persisted in the feeds after they were dried. The improvement consisted of increased feed efficiency and increased palatability when fed *ad libitum* to Single Comb White Leghorn cockerels on a 2-hour basis each day.

In experiments with broiler-type chicks conducted to determine the effect of physiochemical treatment of grains on growth and feed utilization, Adams and Naber (1969) reported soaking grains in water improved their nutritive value for growing chicks. Steam expansion of corn and wheat was ineffective in improving the nutritive value of the grains, when the grains were included in diets for growing chicks. However, soaking the expanded grains in a 0.1 normal HCl solution improved their nutritive value, making them equal or superior to untreated ground corn and wheat.

EFFECT OF PHYSICAL FORM OF RATION ON CARCASS QUALITY

It has been reported by some investigators whole grains or grains in physical forms other than ground produce poorly finished turkey carcasses. Dobson (1963) reported turkeys fed 32 and 33-percent protein pelleted con-

centrates mixed with whole sorghum grain from 8 weeks to market age had very poor finish and were downgraded at processing. The free-choice feeding of concentrate mixed with home-grown ground grains, either in the powdered or pelleted form with whole grains in seperate hoppers, was tested by MacGregor et al. (1953). Concentrate mixed with ground grains fed free-choice, either in pelleted or powdered form, improved the finish of males and significantly improved the finish of females.

Enos et al. (1961) conducted a study to determine the influence of rearing factors on market grade and finish of Broad Breasted Bronze turkey carcasses. An all-mash ration was superior to pelleted all-mash or grain plus concentrate rations in the production of grade A carcasses.

EFFECT OF PRE-CONDITIONING ON TURKEY PERFORMANCE

Investigations on effect of pre-conditioning on market turkeys are limited. Hill and Dansky (1954) investigated the maximum amount of an essentially inert material which could be incorporated in a mash diet without interfering with normal growth. Finely ground oat hulls were incorporated in a mash diet from 0 to 40-percent levels and fed to chicks for a period of 11 weeks. Measurements of gizzard size taken at the end of 11 weeks showed an increase in gizzard size as the level of oat hulls was increased.

Changes in growth, organ size, and reproductive performance of hens fed self-restricting high fiber diets were studied by Thomas et al. (1960). Periodic measurements made on the size and length of certain segments of the digestive tract showed gizzard weight and intestional length were increased by low energy-high fiber diets. This effect persisted in birds after 24 weeks on the laying ration and accounted for slightly better reproductive performance of birds fed the low energy-high fiber diets.

Gleaves (1968) studied the effect of varied dietary densities in the diets of pullets. Sol-ka-Floc and white silica sand were added to rations in varying quantities to provide three estimated daily feed intake weights (112, 127 and 142 grams) with each at three different volume levels (150, 200 and 250 ml.). Mortality, gizzard and large intestine weights were not influenced by either dietary weight or volume. Heuser (1945) reported grains by themselves caused the development of larger gizzards in chickens.

Studies were conducted with White Holland turkeys fed diets that contained 5, 10, 15 and 20-percent fiber supplied principally by oat-huller feed added at levels from 6 to 57-percent in the form of mash and pellets from 10 to 27 weeks of age by Dymsza et al. (1953). At 27 weeks of age all turkeys, except those fed the 20-percent fiber diet as mash, made satisfactory gains and produced carcasses of good quality. Efficiency of feed utilization was best with the 5-percent fiber diets.

Almquist and Merritt (1954) reported Beltsville Small White turkeys varied their grain intake directly with mash fiber level. This was particularly true with sorghum grain (2.2 percent fiber). Both hens and toms ate a higher proportion of whole grain as the fiber level of the mash increased in their diets. He concluded that under a free-choice system, the turkey will vary ratio of grain to mash consumption not only according to mash fiber level, but also according to grain fiber level. Feed to gain ratios began to increase more rapidly in both sexes above a 6.5-percent fiber level.

In a trial with 12-week old White Holland turkeys fed complete diets containing fiber levels of 5, 10 and 15-percent, Dymsza et al. (1955) found the digestion of crude fiber by the turkeys was negligible. Rand et al. (1956)

used crossbred female chicks to study the relationship of protein, fiber, and fat in the diet of growing chicks. Each diet contained graded levels of protein, each with 0, 10 and 19-percent fiber. Ad libitum feeding of 10 percent fiber improved growth where protein was deficient but depressed growth where protein was adequate. Nineteen percent fiber depressed growth in all instances. It was concluded fiber does not seem to have any nutritional role for chick growth since its benefical effect in protein deficient diets can be fully explained by increased consumption of nutrients.

Energy content of diets was found by Mraz et al. (1956) to exert a greater influence on rate of growth than the fiber content within a range of 450 to 900 calories per pound and 5 to 20-percent fiber. The work of Thayer et al. (1967) indicated protein intake per turkey per day was the same regardless of nutrient density as long as feed volume, feed weight, feed energy and feed protein were maintained in proper balance. Studies were conducted with chicks by Dansky and Hill (1951) to determine the effect of energy level and physical nature of the diet on growth and body composition. It was found that large amounts of indigestible, fibrous materials could be incorporated in a diet without affecting weight gains of young birds; although body composition was changed greatly.

Morris et al. (1932), in studies with chickens fed graded levels of crude fiber in the diet, reported the amount of fiber in the diet could be increased to 8 or 9-percent without harmful effects on chick mortality, rate of growth and feed consumption. They also observed that 10 percent fiber did not materially depreciate the coefficient of digestibility of the other nutrients. Mortality showed no relationship to the amount of fiber in the ration. Wilcke and Hammond (1940) reported a diet containing 6 to

7-percent crude fiber from oat hulls increased the rate of growth in chicks when compared to a diet containing 2 to 3-percent crude fiber. Sheeky (1939), with studies on effect of dietary fiber and bulk on chickens, found 7-percent fiber was maximum allowable for growing chicks since higher amounts would retard growth. In experiments concerning the development of an efficient broiler ration, Scott et al, (1947) showed that fiber per se is not required for the physiological well-being of the growing chick. Insko and Culton (1949) fed chicks starting rations containing ground oats, alfalfa meal, and wheat bran, alone and in various combinations, to test the influence of fiber on chick growth. Results indicated maximum growth was obtained on rations containing approximately 5-percent or less fiber from any source.

EXPERIMENTAL METHODS

Four hundred day-old Nicholas Broad Breasted White poults hatched on June 16, 1969 were wing banded and distributed randomly into 10 pens. Each 20 by 20-foot pen contained 40 turkeys (20 males and 20 females). The pens were situated on each side of an aisle which extended north and south the length of a naturally ventilated brooding and rearing house. Each of the five treatments was allotted two replicate pens for the experiment.

The pens were equipped with gas hovers, gallon water fountains and 36-inch metal trough feeders. During the third week the turkeys were gradually switched to automatic plastic cup waterers and tube-type self-feeders. All pens had concrete floors which were covered with 3 to 4 inches of wood shavings. Wet litter was removed and fresh litter added as necessary. The turkeys were debeaked at 4 weeks of age and again at 12 weeks of age to prevent cannibalism. Artifical and natural lighting were used to supply 14 hours of light per day during the experiment.

The turkeys were weighed at the end of each 4-week period throughout the experiment. Records of mortality and feed consumption were maintained. Necessary management practices were performed and management conditions were maintained as nearly alike as possible for all turkeys. At 17 weeks of age infectious sinusitis was diagnosed in the turkeys in some pens. At 18 weeks of age the five pens of birds showing advanced development of the disease were treated with Tylan[1/] injected subcutaneously at the base of the head. Five days later the remaining five pens of birds were injected.

[1/] Tylan - registered trade mark of Tylosin, Elanco Products Company, Indianapolis, Indiana.

All poults were fed the K. S. U. standard 26-percent protein pelleted turkey starter diet (Appendix, Table 1) from 1 to 4 weeks of age. At 4 weeks of age 2 pens were selected randomly and switched to the K. S. U. standard 26-percent protein pelleted turkey starter containing 4 percent sawdust (Appendix, Table 1) for the pre-conditioning treatment. The poults in the remaining 8 pens were continued on the regular starter diet. From 8 weeks to the termination of the experiment the birds were fed a 37.5-percent protein pelleted concentrate (Appendix, Table 2) and various physical forms of sorghum grain.

Ground sorghum grain was whole grain ground in an attrition mill by the impact of the grain kernels against the rotating plates of the mill and by the attrition and shearing action of the plates against the grain kernels. The ground grain had an average particle size of 533 microns. Cracked sorghum grain was whole grain cracked in a 30-inch roller mill by a combined break-up and crushing action of the rollers against the grain kernels. The cracked sorghum grain had an average particle size of 1680 microns. Particle size of the ground and cracked grains was determined according to a procedure reported by Headley and Pfost (1966). Extruded sorghum grain was ground grain exposed to heat-extrusion in a Sprout-Waldron cooker-extruder.[1/] In this process the starch particles are gelatinized by the application of heat, moisture and pressure. Whole sorghum grain was the whole kernel of grain as it appears at harvest plus any broken kernels resulting from mechanical damage. A summary of the experimental treatments is shown in Table 1.

[1/] Sprout-Waldron Pressure Cooker-Extruder, Sprout-Waldron and Company, Muncy, Pennsylvania.

Table 1. Experimental treatments

Treatments	Age in weeks		
	0-4	4-8	8-22
1	Starter	Starter	Ground sorghum grain + concentrate
2	Starter	Starter	Whole sorghum grain + concentrate
3	Starter	Starter	Cracked sorghum grain + concentrate
4	Starter	Starter[1/]	Whole sorghum grain + concentrate
5	Starter	Starter	Extruded sorghum grain + concentrate

[1/] Pre-conditioning--standard 26-percent protein pelleted turkey starter plus 4-percent sawdust.

All diets were mixed in a 1000-pound horizontal Davis mixer. The diets were maintained iso-nitrogenous by varying the ratio of concentrate to grain. Ratios of sorghum grain to concentrate were based on Kjeldahl nitrogen determinations of each physical form of sorghum grain and the concentrate. The protein content of each ration was lowered 3 percent each 4-week period starging with week 9. A summary of the grain to concentrate ratios and grain protein values are shown in Table 2.

Table 2. Percent age of grain and percent age of protein of grain in each diet by 4-week periods

	Period			Period		
	Weeks			Weeks		
	8-12	12-16[1/]	16-22	8-12	12-16[1/]	16-22
Protein in diet (%)	23	20	17	23	20	17
Treatment:	Grain in diet %			Protein in grain %		
1	51.6	54.0	69.3	9.9	8.9	7.9
2	49.6	53.1	70.2	8.8	8.5	8.3
3	49.3	53.9	72.4	8.6	8.9	9.2
4	49.6	53.1	70.2	8.8	8.5	8.3
5	50.7	55.5	74.0	9.4	9.6	9.8

[1/] The average of two batches of grain.

Beginning at the fifth week all turkeys received coarse size turkey grit free-choice to 9 weeks of age. From 10 to 12 weeks of age all turkeys received turkey size grit free-choice. Due to excessive consumption of grit by certain pens of turkeys, turkey size grit was fed on a restricted basis for the balance of the experiment. During this period normal grit consumption was calculated on a weekly basis for each pen according to a standard on turkey grit consumption developed by Heuser (1968), and that amount of grit made available free-choice in each pen.

At 8 weeks of age 4 turkeys from the pre-conditioning pens and 4 from the other pens were selected randomly and sacrificed for measurement of intestinal length and weight and gizzard weight. The intestine was removed intact from each turkey by severing the anterior end at its juncture with

the gizzard and the posterior end at its juncture with the cloaca. The pancreas was removed and the intestine covered with a damp paper towel until measurement. The intestine was extended fully on a damp steel processing table and allowed 30 seconds for resumption of normal length before measurement. Measurements were made by using a 30-millimeter ruler. After the length was determined, the intestine and ceca were opened and the contents removed. The tracts were washed twice in cool water and blotted twice to remove excess moisture. They were then weighted to the nearest 0.1 gram. The gizzard was opened and the contents removed by peeling the lining from the gizzard. It was washed, blotted twice and weighed to the nearest 0.1 gram.

At 22 weeks of age, 16 hens per treatment (8 per pen) were selected randomly for processing. The 80 hens were removed from feed and loaded in crates 8 hours prior to processing. Each turkey was weighed to the nearest 50 grams prior to slaughter. Each turkey was then killed by the standard method of cutting the jugular vein. All turkeys were bled approximately 2 minutes and were scalded at 140° F. for 1 1/2 minutes. The turkeys were picked in a cyclone picker for 45 seconds and immediately placed in cool water until evisceration. Standard evisceration procedures were used. The liver, heart and gizzard were placed in plastic bags along with the corresponding number of the respective turkey. After evisceration the carcasses were placed in slush ice and water.

The following day the carcasses were removed from the ice water and suspended on shackles and allowed to drain prior to scoring. A scoring system of 1 to 5 was used with 5 indicating the most finish (fat covering on the back and in the feather tracts) and 1 the lowest. Prior to scoring, all carcasses were examined and the carcass with the most finish and the one

with the least were selected to serve as standards. After scoring each carcass (including neck) was weighed. The giblets, with excess water removed, were weighed to the nearest 0.1 gram. The gizzard was blotted and weighed separately to the nearest 0.1 gram. The giblet weight of each corresponding carcass was added to the carcass weight to determine dressing percentage.

From these data finish score, dressing percentage, live weight and gizzard weight averages were determined for each treatment.

Live weight and feed consumption data were collected only during weeks 4-20. Live weight data collected during the five, 4-week periods were analyzed independently. Treatment averages were used for each period to analyze for mortality, feed efficiency, finish score, gizzard weight, and dressing percentage. An unequal sub-class analysis of variance was used to analyze the data.

RESULTS AND DISCUSSION

The average weight of the birds for each treatment is shown in Table 3. Analysis of variance (Table 4) shows a significant treatment difference ($P<.01$) for average weight at eight weeks of age. The birds fed the regular 26-percent protein starter diet were significantly heavier than those fed the pre-conditioning starter. This may be explained on the basis that the poults fed the pre-conditioning diet ingested more feed than the other group since feed consumption of poultry is related primarily to its energy requirements. There was a significant ($P<.01$) pen effect as shown in Table 4. A possible explanation for this is a location effect since birds on the east side of the house were heavier than those receiving the same diet but located on the west side. This effect may have been due to lower pen temperatures on the east side of the house due to reduced exposure to radiation from afternoon sunshine.

A significant difference ($P<.01$) among treatments for average body weight was obtained at 12 weeks of age. Turkeys fed whole sorghum grain (pre-conditioning) and extruded sorghum grain and concentrate diets weighed significantly ($P<.01$) less than those fed the cracked and ground sorhgum grain and concentrate diets and were equal in weight to the birds fed the whole sorghum grain and concentrate diet. There was a significant ($P<.05$) pen effect. At 16 and 20 weeks of age treatment and pen differences for average weight were not significant at the ($P<.05$) level. Average weight approached significance ($P<.06$) at 20 weeks of age as shown in Table 4. A significant difference ($P<.01$) was noted among sexes for weight gain.

Table 3. Effect of physical form of sorghum grain on average weight of turkeys[1/] (Kg.)

Treatment[2/]	8 wks.	12 wks.	16 wks.	20 wks.
Ground	2.09[a3/]	4.37[a3/]	6.80	8.82
Whole	2.03[a]	4.20[bc]	6.68	8.59
Cracked	2.09[a]	4.30[ab]	6.75	8.77
Whole (pre-conditioning)	1.94[b]	4.06[c]	6.64	8.73
Extruded	2.03[a]	4.11[c]	6.69	8.59

[1/] Sexes were combined because no significant ($P<.05$) sex x treatment interactions were obtained. Each value represents the average of two replicates.

[2/] Fed from 8 through 22 weeks of age.

[3/] Means with different superscripts differ significantly at the ($P<.01$) level.

It is interesting to note the turkeys fed the regular 26-percent protein starter diet plus 4 percent fiber followed by whole sorghum grain and concentrate weighed significantly less ($P<.01$) at 8 weeks of age than the birds fed the other diets. However, by 16 weeks of age these differences had disappeared. At 20 weeks of age the average difference in body weight between the turkeys fed the ground sorghum grain and concentrate and those fed the whole sorghum grain and concentrate was only 0.1 Kg. This indicates the turkeys which were fed a high-fiber diet prior to receiving whole sorghum grain and concentrate were not affected adversely by the additional fiber in their diet, although their average weight was not equal to that of turkeys fed ground sorghum grain and concentrate. An explanation why there was no increase in weight by the turkeys fed the pre-conditioning diet followed by whole sorghum

grain and concentrate may be because the amount of added fiber to the starter diet was not sufficient to induce a response. This is in agreement with the findings of Rand et al. (1956) who reported chicks fed 10 percent fiber had improved growth when protein was deficient but depressed growth when protein was adequate.

Table 4. Analysis of variance of average weight of turkeys fed various physical forms of sorghum grain

Source of variation	Degrees of freedom	Mean Squares			
		8 wks.	12 wks.	16 wks.	20 wks.
Sex	1	11.83**	84.71**	367.20**	822.92**
Treatment	4	0.31**	1.27**	0.33	0.81
Sex X treatment	4	0.03	0.14	0.27	0.59
Pens	5	0.12**	0.32*	0.26	1.00
Sex X pens	5	0.02	0.10	0.50	0.59
Residual	381	0.03	0.12	0.27	0.47
Total	400				

* Significant at (P<.05)

** Significant at (P<.01)

Turkeys fed extruded sorghum grain and concentrate weighed 0.2 Kg. less than the turkeys fed ground sorghum grain and concentrate at 20 weeks of age. It has been suggested by Deyoe (1969) that extruded grains should be rolled or coarsely ground when fed as a source of energy in poultry rations.

Data on feed conversion are shown in Table 5. Analysis of variance is

shown in Table 6. No significant differences among treatments were observed at 4, 8, 12, and 16 weeks of age. At 20 weeks of age turkeys fed whole sorghum grain (pre-conditioning) had a significantly ($P<.05$) lower feed conversion than the birds fed ground, cracked and extruded sorghum grain and concentrate (non pre-conditioning) and those fed whole sorghum grain and concentrate (pre-conditioning) was not significantly different.

Table 5. Effect of physical form of sorghum grain on feed conversion of turkeys (sexes combined)

Treatment[1]	4 wks.	8 wks.	12 wks.	16 wks.	20 wks.
			(kg. of feed/kg. of wt.)[2]		
Ground	0.95	1.50	2.25	2.80	3.45[c3]
Whole	1.00	1.50	2.30	2.70	3.15[ab]
Cracked	1.10	1.60	2.35	2.95	3.40[bc]
Whole (pre-conditioning)	1.00	1.70	2.15	2.60	3.05[a]
Extruded	1.00	1.55	2.25	2.80	3.35[bc]
LSD					0.24

[1] Fed from 8 through 22 weeks of age.

[2] Each value represents the average of two replicates.

[3] Values with different superscripts differ significantly at the ($P<.05$) level.

Part of the difference among treatments for feed conversion at 20 weeks of age may have been because of less feed wastage by the birds fed whole sorghum grain than those fed the other forms. It was observed there was less feed wastage from the feeders by the turkeys fed whole sorghum grain than those fed ground, cracked and extruded sorghum grain and concentrate. Also

greater mortality of the more efficient or less efficient birds in a treatment may have had an effect on the difference between treatments for feed conversion. No significant difference in feed conversion was found between ground and whole sorghum grain plus concentrate at 12 and 16 weeks of age. These results are not in agreement with the findings of Dobson (1963) who reported turkey hens fed pelleted concentrate and whole sorghum grain required more feed per pound of gain than a similiar group fed ground sorghum grain and concentrate.

Table 6. Analysis of variance of feed conversion of turkeys fed various physical forms of sorghum grain

Source of variation	Degrees of freedom	Mean Squares				
		4 wks.	8 wks.	12 wks.	16 wks.	20 wks.
Treatment	4	0.006	0.014	0.011	0.034	0.059*
Residual	5	0.017	0.005	0.024	0.017	0.008
Total	9					

* Significant at ($P<.05$)

Mortality was not significant among treatments for the entire experimental period (Table 7). Mortality from day-old to 2 weeks of age was due mainly to starve-outs. From 3 to 8 weeks of age mortality was due primarily to leg disorders (perosis). Cannibalism and a pendulous crop condition were the primary causes of mortality from 9 through 20 weeks of age.

Table 7. Effect of physical form of sorghum grain on mortality of turkeys (sexes combined)

Treatment[1/]	Percent mortality[2/]
Ground	8.4
Whole	9.6
Cracked	8.5
Whole (pre-conditioning)	10.8
Extruded	10.8

[1/] Fed from 8 through 22 weeks of age.

[2/] Each value is composed of the average of two replicates.

Gizzard weight was influenced significantly by the physical form of grain as shown in Table 8. The gizzards of birds fed the ground, whole and cracked sorghum grain and concentrate diets were significantly heavier ($P<.01$) than those of the birds fed the whole (pre-conditioning) and extruded sorghum grain and concentrate diets (Table 8). Also there was a significant ($P<.05$) pen x treatment interaction.

Table 8. Effect of physical form of sorghum grain on gizzard weight of turkey hens

Treatment[1/]	Gizzard weight (gm.)[2/]
Ground	146.91[a3/]
Whole	146.05[a]
Cracked	145.97[a]
Whole (pre-conditioning)	131.13[b]
Extruded	124.52[b]

1/ Fed from 8 through 22 weeks of age.

2/ Each value is composed of the average of two replicates (8 samples per replicate).

3/ Mean values with different superscripts differ significantly at the ($P<.01$) level.

These data are not in agreement with those reported by Thomas et al. (1960). They reported gizzard weight of egg production type chickens was increased by low energy-high fiber diets. However, the data do agree with those of Gleaves (1968) who reported gizzard weight of laying hens was influenced by neither dietary weight nor volume.

Table 9. Analysis of variance of gizzard weight of turkey hens as influenced by physical form of sorghum grain

Source of variation	Degrees of freedom	Mean squares
Treatment	4	1643.66**
Pen x treatment	5	655.94*
Live weight	1	2191.97**
Residual	69	262.04
Total	79	

* Significant at (P<.05)

** Significant at (P<.01)

The finish scores of turkeys fed the various rations did not vary significantly among treatments (Table 10). These data do not agree with data reported by MacGregor et al. (1953) who observed that concentrates mixed with ground grains improved the finish of female turkeys significantly when fed free-choice. Also Dobson (1963) reported the carcasses of turkeys fed whole sorghum grain and concentrate were downgraded more at market due to a lack of finish than those of turkeys fed ground grain and concentrate.

The turkeys fed the ground sorghum grain and concentrate diet had the highest finish score (3.3) while the birds fed the cracked and extruded sorghum grain and concentrate diets had the lowest (2.9).

Table 10. Average finish scores of turkeys fed different physical forms of sorghum grain

Treatment[1/]	Average finish score[2/]
Ground	3.3[3/]
Whole	2.8
Cracked	2.9
Whole (pre-conditioning)	3.1
Extruded	2.9

1/ Fed from 8 through 22 weeks of age.

2/ Each value is composed of the average of two replicates (8 samples per replicate).

3/ A value of 5 represents the most finish and a value of 1 the least finish.

Average dressing percentages (Table 11) of the hens processed at 22 weeks of age were very uniform among treatments with no significant difference due to treatment effect.

Table 11. Effect of physical form of sorghum grain on dressing percentage of turkey hens

Treatment[1/]	Average dressing percentage[2/]
Ground	82.0
Whole	83.1
Cracked	83.0
Whole (pre-conditioning)	82.5
Extruded	82.2

[1/] Fed from 8 through 22 weeks of age.

[2/] Each value is composed of the average of two replicates (8 samples per replicate).

The average weights and feed conversions obtained in this experiment are equal and in some instances better than those reported in Scott's (1970) standards for growth rate and feed consumption of turkeys. These data indicate that further study needs to be carried out to determine the economic differences between feeding a pre-conditioning ration and whole grain and concentrate versus grinding the grains. Also the amount of fiber and length of feeding period required to obtain a maximum pre-conditioning effect should be considered.

SUMMARY

Four hundred large type market turkeys were fed free-choice diets consisting of ground, cracked, whole and extruded sorghum grain mixed with a 37.5-percent pelleted protein concentrate from 8 through 22 weeks of age. All turkeys, except two pens, were fed a standard pelleted 26-percent protein starter diet from day-old to 8 weeks of age. These two pens were fed, from 4 to 8 weeks, a pre-conditioning diet consisting of 4-percent sawdust added to the pelleted starter. The turkeys fed the pre-conditioning diet were then fed whole sorghum grain and concentrate from 8 to 22 weeks of age. The turkeys were weighed each four week period to determine the performance of each experimental ration. Under the conditions of this investigation the results of this study show:

1. There was no significant difference in 20-week average weight of turkeys fed the various physical forms of sorghum grain.
2. The turkeys that were fed the pre-conditioning diet, then whole sorghum grain and concentrate had significantly ($P<.05$) better feed conversion at 20 weeks of age than the birds fed ground, cracked and extruded sorghum grain and concentrate.
3. The various physical forms of sorghum grain and concentrate and the pre-conditioning of turkeys which were fed whole sorghum grain had no effect on mortality.
4. Feeding a pre-conditioning diet from 4 to 8 weeks of age, did not increase gizzard size. The turkeys fed whole (pre-conditioning) and extruded sorghum grain and concentrate diets had significantly ($P<.01$) lower gizzard weights than the turkeys fed ground, whole and cracked sorghum grain and concentrate diets.

5. Carcass finish scores and dressing percentages were not affected by the various diets.

These results suggest the physical form of cereal grain used in a particular feeding system will depend largely on the type of equipment available to the producer and facilities available for handling the various forms of grain. Also preference by the producer for a particular form of grain would be a deciding factor.

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APPENDIX

Table 12. Composition of Kansas State University 26-percent protein pelleted turkey starter.

Ingredients	Percentage of ration
Soybean meal, (44% protein)	45.6
Alfalfa meal, (17% protein)	5.2
Ground sorghum grain	14.2
Ground yellow corn	14.0
Wood sawdust	4.0[1/]
Fat	4.0
Ground limestone	3.2
Fish meal (60% protein)	4.2
Distiller dried solubles	2.1
Dicalcium phosphate	2.1
Salt	0.5
Trace mineral mix[2/]	0.05
	Added per 100 lbs.
	gm.
Vitamin D_3 (15,000 IU/gm)	5.2
B-Complex (1233)[3/]	12.0
Vitamin A (10,000 IU/gm)	21.0
Vitamin B_{12}	14.6
Methionine	24.0
Antibiotic supplement[4/]	24.0
Coccidiostat[5/]	24.0
Blackheadstat[6/]	24.0
Ground yellow corn (carrier)	305.4

[1/] Added only to pre-conditioning starter diet, fed from weeks 4 through 8.

[2/] Supplied the following trace minerals: manganese, 10%; iron, 10%; calcium, 14%; copper, 1%; zinc, 5%; iodine, 0.3%; and cobalt, 0.1%.

[3/] B-complex vitamin mix supplying in mg./lb.: riboflavin 2,000; pantothenic acid 2,680; niacin 6,000; choline chloride 20,000.

[4/] Combination of 2 antibiotics: Aurofac-10(R) and Baciferm-10(R) (12 gm. Aurofac-10 and 12 gm Baciferm-10).

[5/] Amprol-25%(R) or equivalent coccidiostat.

[6/] Histostat-50%(R) or equivalent blackheadstat.

(R) = Registered trademark.

Table 13. Composition of the 37.5-percent protein pelleted concentrate

Ingredients	Percentage of ration
Soybean oil meal (44% protein)	66.5
Alfalfa meal (17% protein)	9.3
Fish meal (60% protein)	4.6
Meat and bone scraps (50% protein)	4.6
Distillers dried solubles	4.6
Ground limestone	1.1
Dicalcium phosphate	7.0
Salt	1.1
Premix B[1/]	1.0
	Added per 100 lbs.
	gm.
Trace mineral mix[2/]	22.7
Vitamin D_3 (15,000 IU/gm)	5.0
B-complex vitamin mix (1233)[3/]	11.3
Vitamin A (10,000 IU/gm)	20.0
Vitamin B_{12}	13.8
Methionine	22.7
Antibiotic[4/]	22.7
Blackheadstat[5/]	22.7
Choline chloride	80.0
Antioxidant[6/]	5.7
Ground sorghum grain (carrier)	227.3

[1/] Composed of the above vitamins, minerals and additives.

[2/] Supplied the following trace minerals: manganese, 10%; iron, 10%; calcium, 14%; copper, 1%; zinc, 5%; iodine, 0.3%; and cobalt, 0.1%.

[3/] B-complex vitamin mix supplying in mg./lb.: riboflavin 2,000; pantothenic acid 2,680; niacin 6,000; choline chloride 20,000.

[4/] Antibiotic: TM-10(R)

[5/] Histostat-50%(R) or equivalent blackheadstat.

[6/] Antioxidant: Ethoxyquin(R)

(R) = Registered trademark

EFFECT OF THE PHYSICAL FORM OF SORGHUM GRAIN ON THE PERFORMANCE OF LARGE-TYPE MARKET TURKEYS

by

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Ten pens (20 males and 20 females each) of large-type market turkeys were fed a regular 26-percent protein pelleted starter diet from day-old to 4 weeks of age. From 4 to 8 weeks of age 8 pens were continued on the regular starter and then switched, for the balance of the experiment, to a 37.5-percent protein pelleted concentrate mixed and fed free-choice with the following physical forms of sorghum grain: cracked, ground, whole and extruded. Two pens were fed a pre-conditioning diet consisting of 4-percent sawdust added to the regular starter and then changed to concentrate and whole sorghum grain. All diets were maintained iso-nitrogenous throughout the entire experimental period.

Final average body weight, feed conversion and percent mortality were based on data collected at 20 weeks of age. Gizzard weight, carcass finish score and dressing percentage were based on the averages of 16 hens per treatment processed at 22 weeks of age.

Under the conditions of this experiment it was found the physical form of sorghum grain fed from 8 to 22 weeks of age had no significant effect on final average body weight, percent mortality, dressing percentage and carcass finish score. At 8 weeks of age the turkeys fed the pre-conditioning diet weighed significantly ($P<.01$) less than the turkeys fed the regular starter. At 12 weeks of age turkeys fed whole sorghum grain (pre-conditioning) and extruded sorghum grain and concentrate diets weighed significantly ($P<.01$) less than those fed cracked and ground sorghum grain and were equal in weight to those fed the whole sorghum grain and concentrate diets.

Feed conversion of turkeys fed the pre-conditioning diet followed by whole sorghum grain and concentrate was significantly ($P<.05$) lower at 20 weeks of age than for those fed ground, cracked and extruded sorghum grain.

Turkeys fed the pre-conditioning diet followed by whole sorghum grain and those fed extruded sorghum grain and concentrate diets had significantly ($P<.01$) lower gizzard weights than for those fed ground, cracked and whole sorghum grain and concentrate diets.