COMPARISON OF FEEDING VARIOUS SOURCES OF ENERGY AND PROTEIN ON PERFORMANCE OF BROILER CHICKS WITH AND WITHOUT AN ANTHELMINTIC

by

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INTRODUCTION

The nutrients required of poultry must be supplied in rations by ingredients available in sufficient quantity, at economical prices. Ingredients vary in the nutrients they contain and in the availability of these nutrients to poultry. Some attention must be given to ways in which their potential usefulness for a poultry ration can be determined.

Grains are used in poultry feeds primarily as a source of energy. They contain relatively low amounts of poor quality protein that is particularly low in the essential amino acids lysine and tryptophan. Poultry rations made up largely of grains must be supplemented with suitable sources of protein. Grains are also deficient in minerals, particularly sodium, calcium and available phosphorus.

Of the grains fed to poultry, corn and grain sorghums are used in greatest amounts for broilers with the remainder made up of wheat and barley.

Corn has the highest metabolizable energy value of the common grains. Wheat and grain sorghum are only slightly lower. The choice of grains used in feeding poultry is based primarily on relative cost per unit of metabolizable energy provided. Corn is used extensively because of its high energy value, large supply and relatively low cost. Use of a certain grain also depends on the area of the country.

By-products of wheat milling, such as wheat standard middlings or flour middlings, are used in chick feeding to a limited extent. They contain more protein and are lower in energy value than the original wheat. The protein in these by-products is of poor quality and cannot be used to supply a large portion of the protein needed in a chick's feed.

Considerable quantities of fats are used in broiler feeding, primarily as potent sources of energy. Fats normally contain two to three times as much metabolizable energy per unit of weight as grains. The main limitation on the use of fats in feeding, other than cost, is the physical nature of the ration containing fat. The major fats available for feeding are the animal fats produced as by-products of the meat packing industry.

Since all grains and grain by-products are deficient both in amount and quality of protein, it is necessary to supply protein to chick rations from other sources. The common ingredients for this purpose are the oil seed meals and certain animal protein concentrates. The choice of a specific protein supplement used in a feed will depend upon its relative cost and its amino acid composition. The combination of protein sources contained in the diet must adequately meet the amino acid needs of the chick.

The sources of animal protein most commonly used in chicks feeding are meat and bone meal and fish meals. The plant sources of protein are obtained chiefly from certain oil-bearing seeds, such as cottonseed, peanut, and soybean, as well as from by-products of corn milling, such as corn gluten meal.

The control of diseases caused by parasitic worms in domestic animals involves not only the use of anthelmintics, but also methods such as grazing management and the control of intermediate hosts. Within recent years a number of synthetic compounds have been found to have anthelmintic properties and have been utilized in the field and the number is constantly increasing.

Two experiments were conducted in order to test the effect of feeding different sources of energy and different sources of protein with and without the anthelmintic supplementation (pyrantel tartrate) on weight gain and feed utilization of noninfected, battery-reared birds from 0 to 8 weeks of age.

REVIEW OF LITERATURE

On the basis of the productive energy value of Fraps (1946), barley is given a value of approximately 70% that of corn. Bearse (1952) has indicated that barley can replace up to 50% of the corn in a high-energy broiler diet with almost comparable growth, but with considerably less efficiency of feed utilization. Under his experimental conditions about 0.15 to 0.3 of a pound of additional barley ration was required to produce a pound of broiler weight gain as compared with the corn ration.

Pepper et al. (1953) have shown improvements in feed efficiency and in some cases growth of broilers fed rations containing from 1 to 8% fat derived from either animal or vegetable sources. The use of a concentrated energy source, therefore may serve as an aid in improving the efficiency of utilization of barley fed to broilers.

Matterson et al. (1953) have shown quite clearly that supplementary DL-methionine markedly improved feed efficiency and in some instances growth and feathering of broilers fed high energy-type rations.

Growth depression was observed and a significant increase in feed consumption was noted when 50 and 100% barley was included in the ration. As the barley content of the rations increased, body pigmentation decreased.

Rose and Arscott (1962) reported improved chick performance from barley rations fed in pelleted form containing water treated barley or supplemented with crude amylolytic enzymes. From these studies it is evident that barley rations supplemented with amylolytic enzymes or containing water treated barley improved chick growth, feed conversion and "sticky droppings" conditions normally associated with untreated barley rations. Ten percent barley malt added to a mash ration resulted in improved growth and "sticky dropping" condition similar to that obtained with the enzyme. However, feed conversion was not reduced.

Arscott (1963) showed that replacing barley with 1/8 to 1/4 corn in the ration was as effective in reducing the adverse effects noted on growth and accumulated droppings from barley as was an amylolytic enzyme supplement. These results confirm the observation of Rose and Arscott (1962) involving the replacement of barley with 1/2 corn. These results show that using small quantities of corn in barley type rations may serve as a means for increasing the value of barley as do amylolytic enzymes.

Willingham (1964) recorded increased water consumption and decreased feed intake of birds receiving barley-based rations, the former being significant with enzymes addition or water treatment of barley. Feces moisture was significantly decreased by enzyme supplement or grain treatment. A higher percentage body fat was determined for the birds, receiving the enzyme supplemented or water-treated barley diets. A small reduction in percentage carcass moisture was also noted when enzyme supplemented diets or water-treated barley diets were fed.

Arscott et al. (1965) reported decreased body weights when barley replaced corn. This could be partially corrected by an amylolytic enzyme supplement. A significant enlargement of the pancreas was observed in the presence of the barley containing diet. Feed conversion was adversely affected, accumulated droppings were greater in the presence of the barley than was noted with chicks fed either corn or the enzyme.

Berg (1961) found that supplementation of barley-containing rations for Leghorn pullets, with crude fermentation products containing enzymes, increased growth rate from 0 to 8 weeks of age; however, during the period 8-21 weeks these products did not improve rate of gain, but did reduce litter moisture.

Burnett (1966) concluded the poor nutritional value of growth depressing barleys was related to the glucan and B-glucan hemicellulose components which give rise to stable highly viscous gels in the small intestine.

Adams and Naber (1969) indicated the nutritive value of barley was not significantly improved when the grain was partially germinated. It was noted during the experiment that fecal material from birds fed the untreated barley adhered to the wire screen floors in the batteries. This condition improved when the diets contained the water-treated barley.

Petersen (1969) reported the results of a broiler feeding trial using diets containing 40% corn, sorghum, wheat, barley and oats with all the diets having the same ratio of metabolizable energy (ME) to digestible protein. Equal gain in weights were observed with chickens fed corn, sorghum or barley. More feed consumption was noted by birds fed wheat, barley and oats.

Novacek and Petersen (1967) indicated that all anatomical parts of the barley kernal, except endosperm, responded slightly to both water and enzyme treatment. Petersen and Sauter (1968) reported an increase in ME of barley of 18 and 22% by enzyme or water treatment. These investigators concluded the increase can be attributed to significantly increased digestibility of the protein and fat and apparent increased digestibility of the nitrogen-free extract.

Petersen (1969) showed that gains were highly correlated with the energy intake, but not with the metabolizable energy (ME) per kilogram of the diet. The results indicated that chickens preferred some types of grain to others, and for this reason the ME intake varied from one treatment to another. There was still a great variation in the fat content of chicken meat due to the various diets, even when these were adjusted for average energy and protein intake.

Garlich et al. (1976) reported that on a dry matter basis the treated high moisture corn with acetic acid and propionic acid had the same metabolizable energy value for broiler chickens as untreated dried corn. There was no significant difference observed in growth rate or feed-gain ratio. This indicates the digestibility and utilization of protein and amino acids were not impaired by treatment with acetic or propionic acid.

Moran et al. (1974) indicated that growth rate of chicks and efficiency of diet utilization are, under some conditions, influenced by the moisture content and physical properties of the cereal grains in the diet.

Summers et al. (1972) postulated that stage of maturity of corn at harvest may affect energy availability for poultry. A change in corn composition with maturity has been reported. It has been noted that sugar levels decrease and starch levels increase with maturity of corn; conversely, the higher sugar levels are associated with immaturity and lower ME values.

Gipp et al. (1968) indicated that energy of normal and opaque-2 corn is equally metabolizable (3.70 and 3.66 KCal./gm, respectively); whereas floury-2 corn possesses lower ME (3.20 KCal/gm).

Cromwell et al. (1968) compared the value of opaque-2, floury-2 and normal corn for chicks. They reported that floury-2 was superior to normal corn and opaque-2 was inferior when no methionine supplement was used. The authors concluded their results were due to the high lysine and methionine content of floury-2 corn and to the high lysine content of the opaque-2 corn. Therefore opaque-2 corn produced faster and more efficient weight gains as compared with normal corn only after a deficiency of the first limiting amino acid was corrected by supplementation with methionine.

Sharby et al. (1973) reported that chicks fed experimental diets showed a significant reduction in weight gain and feed efficiency when fed moldy corn that had been incubated for 4, 6 and 8 weeks. Percent dry matter digestibility was reduced by chicks fed the moldy corn diets. Problems associated with mycotoxins usually relate to the storage of grain or other plant products.

Arscott (1968) reported that chick growth was improved to a greater extent when a fermentation residue (vigofac) was added to a wheat-base diet than to one composed of corn.

Fernandez et al. (1973) showed that growth response to antibiotic supplements was greater with the diets containing rye or beans as compared with those based on corn.

Sloan et al. (1971) indicated that processing yellow corn or sorghum grain by expansion-extrusion before incorporating it into chick diets to replace 50% or 100% of the unprocessed grain had no significant effects on chick growth, but showed a trend toward improvement in feed utilization. Since extrusion results in rupture of the cell wall, this may allow for greater ease of digestion of the cereal grain.

Adams and Naber (1969) showed that nutritive value of corn was significantly improved when the grain was partially germinated, dried and then included in the diet for chicks. Water and acid soaking treatments of commercial corn and wheat starches were not effective in improving growth rate.

Jensen et al. (1976) indicated the percent fat and total fat per liver increased as the proportion of corn increased in diets when compared to barley.

Using chicks and adult hens Sibbald et al. (1960) found no significant differences between ME values of corn. Some studies showed that mature hens are able to utilize a greater percent of the total energy of many feed ingredients than three to four week old chicks.

Ratcliff et al. (1959) reported xanthophyll from yellow corn to have a higher pigmenting capabilities in the skin and shank of the chickens, than xanthophyll from either alfalfa or corn gluten meal.

Sanford (1963) indicated excellent growth and feed conversion have been obtained by feeding a ration combining 35 parts of sorghum grain with 30 parts of corn to supply the grain portion of a practical-type 21% protein broiler ration. Nonsignificant differences in feed consumption were found when sorghum grain or yellow corn were used as the source of energy.

Featherston et al. (1975) reported that chicks fed diets in which high lysine sorghum provided all the dietary protein grew approximately three times more rapidly and required almost 50% less feed per unit weight gain than chicks fed the diets in which normal sorghum provided all the dietary protein. Therefore, the nutritional quality of high lysine sorghum grain is markedly superior to that of commercial sorghum grain.

Bornstein and Bartov (1967) did not find any difference between the effects of sorghum grain and corn on growth rate or feed/gain ratio.

Fuller et al. (1966) reported that grain sorghum with high tannin content had reduced feeding value. They also reported that grain sorghum varieties which had a brown seed color and open heads were characteristically high in tannin and had reduced feeding value. Feed consumption was depressed.

Halloran and Maunder (1971) found that yellow and bronze sorghums gave slightly higher gains and poorer feed conversions. The red sorghum had slightly lower gains and poorer feed conversions.

Peischel et al. (1976) found that weight gains and feed conversions were not significantly different among sorghum grain varieties. Chicks fed the 100% sorghum grain diet exhibited poorest growth. Combination of sorghum grain/corn (50/50) resulted in superior growth as compared to 100% sorghum grain.

Ozment et al. (1963) concluded that corn and sorghum grain were of equal nutritive value in broiler diets when used on an equivalent nutrient intake basis.

Kohne and Biellier (1969) concluded that a concentrate and whole grain sorghum grain feeding system can be used effectively in reducing the cost of feeding turkeys raised in confinement or on range.

Deaton and Quinsenberry (1964) reported that the choice of corn or grain sorghum as the dietary cereal grain source depends upon their relative costs as well as their effects upon such performance traits as body weight and feed efficiency.

Weber et al. (1969) showed that metabolizable energy (ME) content of grain sorghum for chicks was increased from 2.68 KCal/gm to 3.21 by the steam processing treatment. Pressure cooking improved the ME of another sample from 3.00 to 3.45 KCal/gm. There appeared to be little correlation between the tannin content and the resulting ME when fed to chicks.

Lee et al. (1972) concluded that within the same caloric and protein level birds fed the carbohydrate diets consumed more feed and had higher body weights than the birds fed diets in which fat was the principal energy source.

Bornstein and Lipstein (1972) found that corn contains a higher level of oil than sorghum grain, and corn oil more linoleic acid than sorghum grain oil. These differences are reflected in the fatty acid composition of the diets into which these grains are incorporated. Petersen (1969) reported that sorghum grain resulted in the highest fat deposition compared with other types of grains for broilers.

Jensen (1964) found that grilled birds fed the grain sorghum diet had the poorest flavor, and the aroma scores were significantly lower in the case of the birds fed sorghum than for those fed any other cereal. The variation in the chemical composition of the chicken meat due to the type of grain fed or to high or low level of tannin in the diet was not a result of different ME and protein intake, so there was still a great variation in the fat content of chicken meat due to the various diets, even when these were adjusted for average energy and protein intake.

Bragg et al. (1966) indicated no difference in aspartic acid, tyrosine, phenylalanine and lysine between sorghum grain and corn. However, threonine, serine, proline, glycine, histidine and arginine were highest in corn, and glutamic acid, alanine, valine, isoleucine and leucine were highest amino acids in sorghum grain.

Shoup et al. (1969) reported that weight gain produced from the diets containing low protein grain sorghum was slightly higher than gain obtained with high protein sorghum grain.

Fuller et al. (1967) have shown that additions of methionine, choline and other methyl group donors helped overcome the growth depression caused by dietary tannic acid, the extent of the improvement being related to the level of dietary tannic acid.

Armstrong et al. (1973) showed that 0.15% supplemented DL-methionine improved the performance of chicks fed bird resistant sorghum grains up to that of nonresistant sorghum grain diets at a sub-optimal level of protein.

Baptist (1954) found that sorghum was low not only in lysine but also in methionine and tryptophan. Protein content of sorghum grain is affected by such factors as location, hybridization and nitrogen fertilization. Protein variation results in amino acid variation in the grain.

Strain and Piloski (1972) suggested that wheat provided more energy than barley. Since lysine was the most limiting factor in these diets, the amount of energy per unit of lysine was considerably higher in the wheat diets. This resulted in a decrease in feed intake and slower rate of gain.

Adams and Naber (1969) found a significant improvement in growth occurred when chicks were fed diets containing wheat soaked in water or 0.1 normal HCl. Steam expansion of wheat was ineffective in improving the nutritive value of the grain; however, partially germinated grain was effective.

Naber and Touchburn (1969) concluded that water treatment probably increased the susceptability of starch to enzymatic degradation and thereby promoted increased energy utilization by the chick.

Singsen (1948) reported that autoclaving wheat bran resulted in more of the phytin phosphorus being made available for bone ash purposes and suggested the autoclaving treatment had broken down some of the phtin phosphorus into the inorganic form.

Sibbald (1976) found that pelleting increased the true metabolizable energy values of the wheat (3.5%) and barleys (0.9%) but decreased the values of the oats (3.5%). It is postulated that palatability affected feed intake and therefore, reduced some of the apparent metabolizable energy (ME).

Kim et al. (1970) found that diets containing Gaines wheat for broiler type chicks supported growth and feed efficiency to 4 weeks of age equal to results obtained with corn. Fat level did not influence the relative value. These results suggest that ME values do not necessarily indicate true comparative feeding values of grains.

Cave et al. (1965a) found that certain wheat milling fractions gave relatively low ME values and poor protein utilization when they constituted an important part of chick diets. They also showed that steam pelleting wheat bran increased its ME in chick diets by 30% over unpelleted mash. An increase of 17% was found for steam-pelleted wheat shorts over unpelleted material. They also found that some wheat by-products resulted in poor performance when used at high levels in a ration because of their fineness and/or gluten content which causes pasting of the beaks and hence reduced feed intake.

Lee et al. (1972) indicated that within the same caloric and protein level, the birds fed carbohydrate diets consumed more feed, had higher body weights and laid more eggs than the birds fed diets in which fat was the principal energy source.

Schumaier and McGinnis (1967) found that metabolizable energy was affected by the source of supply of wheat, mixed feed and by addition of screenings. The type of wheat from which the wheat, mixed feed was obtained did not influence metabolizable energy value.

Sibbald (1975) indicated that energy voided as excreta increased in a linear manner as the intake of wheat increased.

Bragg and Akinwande (1973) reported that chicks showed no significant response in body weight from adding individual or amino acid combinations to the wheat-lysine diet. However, diets containing threonine consistently supported a growth rate slightly better than other combination which indicated that threonine is probably the second limiting amino acid in wheat for chick growth.

Bragg et al. (1971) concluded that low protein wheat-soya or wheat-lysine diets provided normal growth and development of White Leghorn pullets; whereas, growth was inadequate for normal development in chicks fed the unsupplemented wheat diet. They found the addition of lysine to the wheat protein diet maintained growth equal to that of a wheat-soya diet containing equal dietary protein. It was also demonstrated that wheat supplied less than 50% of the lysine required for normal growth. Bragg and Biely (1971) concluded that growth rates were further improved by the addition of L-threonine and a combination of threonine-valine to the wheat-lysine diet. Feed intake increased in a similar pattern to the increase in body weight of broiler breeders.

Manoukas et al. (1968) concluded that for the hen, niacin availability in yellow corn, dehulled soybean meal and wheat middlings was 30, 100 and 36 percent, respectively. Tryptophan can be converted to niacin by the hen, and it was calculated that it requires 187 mg. of tryptophan to supply 1 mg. of niacin.

Frigg (1976) reported that biotin contained in wheat gave no significant growth response, its bio-availability being low, in a range without practical value. The feed conversion values also closely reflected the intakes of available biotin with the investigated cereals.

Schumaier and McGinnis et al. (1968) found that additional increments of protein in the form of corn, wheat or sesame meal improved chick growth at a greater rate than fish meal protein. This may be due to improved amino acid balance or by some other undetermined factor.

Fernandez et al. (1973) reported that chicks grew equally well on the corn and wheat diets. Chicks fed wheat diets ate significantly more feed than did those on the other diets. Chicks fed the corn diet had significantly better feed efficiency than those on the wheat diet.

Waldroup et al. (1967) found that wheat supported significantly greater weight gains than did corn when fed to turkey poults in mash form. Pelleted diets containing wheat were significantly superior to pelleted diets containing corn. Pelleting significantly reduced the feed/gain ratio for each grain tested.

Waldroup et al. (1968) reported that glandless cottonseed meal can be used to replace part or all of the solvent extracted soybean meal in practical type broiler diets. Lysine supplementation appeared necessary only when more than 75% of the soybean meal was replaced by glandless cottonseed meal, the amount of lysine required to maintain optimum growth and feed utilization appeared to be no more than 1.20% of the diet.

The phytin in cottonseed meal has been shown to interfere with the utilization of various minerals, particularly zinc (Lease and Williams, 1967), calcium, and phosphorous (Pensack et al., 1958).

Forbes and Kastelic (1961) reported poor growth, poor efficiency of feed utilization, and high mortality in chicks fed cottonseed meal as a sole protein. Eggs from laying hens may develop abnormal yolk and albumen discoloration, especially when stored.

Davenport et al. (1969) indicated that weight gains of broilers decreased as gossypol levels were increased. Addition of iron as ferrous sulfate to yield iron (gossypolmolar rations) was effective in partially alleviating the toxic effect; increasing the iron (gossypol ratio to 8:1) resulted in increased weight gains over the no iron ration. Feed conversion results were similar to those of weight gains.

Hopkins et al. (1969) reported that raw glandless cottonseed meals contain a heat-labile growth inhibitor. The heat necessary for the commercial processing of cottonseed by the direct solvent process is sufficient to destroy the growth inhibitor in the glandless cottonseed. Furthermore, direct solvent processed glandless cottonseed meal was superior to commercial pre-press solvent glanded cottonseed meal when fed to chicks in lysine-deficient diet.

Grau (1946) showed that lysine was the first and methionine the second limiting amino acid in the protein of regular cottonseed meal. Fisher (1965) indicated that in addition to lysine and methionine the amino acids leucine, threonine and isoleucine were equally limiting for optimum growth of chicks receiving regular cottonseed meal. Even when sufficient quantities of all five amino acids were added to cottonseed meal, its net protein utilization value (N.P.U.) was still inferior to the value obtained for methionine supplemented soybean meal, while the glandless variety gave far superior N.P.U. value than the regular meal, corresponding in magnitude to those obtained for methionine-supplemented soybean meal.

Galal et al. (1977) showed that gains of chicks fed 1:1 protein mixture of soybean meal (SBM) and cottonseed meal (CSM) were similar to those of chicks fed SBM alone, but gain/feed was less ($P<.05$). Studies indicated that up to two-thirds of the supplemental protein could come from CSM with no loss in rate of weight. Calculation reveals that CSM protein contains about the same concentration of sulfur amino acids, but only 65 to 70% of the lysine that is contained in SBM protein. As CSM replaced SBM, diet intake increased until a 1:2 SBM:CSM protein ratio was reached, at which point it began to decline. Hence, the greater intake of feed resulted in a greater intake of SAA and helped overcome the inherent lysine deficiency when more than 66% of the supplemental protein came from CSM.

Proudfoot et al. (1971) indicated a significant growth response when the level of fish meal in the diet was increased from 4% to 10% or 15%, followed by significant decline in body weight when the fish meal was further increased to 20%. It is not possible to prevent calcium and phosphorous in the diet from rising well above calculated optimum levels. This may be the reason for the growth depression caused by 20% fish meal. Supplementing the finisher diets with activated charcoal for 21 days before slaughter, resulted in increased growth, increased the proportion of grade A carcass weight and increased monetary gain when charcoal cost was considered equivalent to regular feed cost.

Duke et al. (1977) reported that early (0-3 weeks) growth rate was depressed at all levels of fish supplementation, although feed conversion significantly improved. However, by the end of the fourth week, compensatory growth resulted in a significant improvement in body weight of birds fed diets with 2.5 or 5% processed fish. Supplementation of dietary methionine resulted in an improvement in body weight at either 1, 2, 3 or 4 weeks of age.

Hinton and Harms (1972) found a significant response was obtained by the addition of either fish solubles or sodium sulfate to the basal diet with the response from fish solubles being greater than from sodium sulfate. No additional response was obtained by adding sodium sulfate to the diet containing fish solubles. It was interpreted from these data that the major portion of the unidentified growth factor response from fish solubles could be due to its inorganic sulfate content.

Potter et al. (1977) found the majority of the increase in growth obtained by adding 5% menhaden fish meal to the basal ration appears to be directly associated with its selenium content.

Berg (1976) determined that lead in the ash fraction of the scrapfish meal was the factor preventing growth depression. Part of the anti-toxicity factor in the ash would appear to be a calcium-phosphate compound.

Miller and Soares (1972) indicated that fish meal, when fed as sole source protein to chicks, required very low dietary supplements of chloride or none at all to maximize growth. High levels of chloride in dietary mineral mixtures depress chick growth and can be overcome by increasing the sodium level.

Soares et al. (1971) indicated that chicks fed a poor quality herring fish meal consistently execreted more amino acids than chicks fed a good quality protein regardless of environmental conditions. However, there were more significant differences in amino acid digestibility between poor and good fish meal fed to chicks.

Waldroup et al. (1965) reported no significant differences were observed in both weight or fed utilization when 25 and 50% of the soybean meal protein was replaced with fish meal. Replacement of 75% significantly depressed body weight when an open market sample of menhaden fish meal was fed. Schumaier and McGinnis (1968) indicated that supplementation of fish meal protein with other proteins may improve growth rate of chicks by improving amino acid balance or by some other undertermined factor.

Harden and Milligan (1964) suggested the factors producing off-flavor in fish meal are probably associated with the fish oil. Off-flavor in broiler meat was produced by

1.8% dietary stabilized fish oil. While up to 15% solvent extracted fish meal in broiler diets did not produce a fishy flavor in broiler meat. Webb et al. (1973) reported that including DL-a-tocopherol acetate in high-level-fish meal diets reduced the magnitude of severity of off-flavors.

Kelley and Potter (1974) indicated that lysine and methionine were found to be highly available in most fish meals tested. It would appear that amino acids other than lysine and methionine in fish meal must have low availability value as leucine, valine and arginine. Miller (1973) reported growth promoting action by glutamic acid supplementation to chicks fed fish meal diets. Glutamic acid may be used to improve the balance of the nonessential in respect to the essential amino acids which are supplied in excessive amounts by the fish meal.

Atwal et al. (1972) indicated that supplemental biotin is important to the growth of poults and to the pyruvate carboxylase activity in their livers when meat and fish meal were used as the protein supplement in a ration, in comparison to soybean meal as a protein supplement.

Kraybill and Wilder (1947) investigated the feeding value of meat scrap protein and found that some samples of meat scrap were deficient in methionine and tryptophan. Meat scrap in general was a good source of lysine. March et al. (1950) also studied the supplementation of meat scrap with amino acids. They found that lysine was the principal amino acid deficiency in a practical-type ration which contained meat scrap protein. The severity of the deficiency depended upon the batch of meat scrap which was used. It was thought desirable to investigate the value of meat scrap protein for chicks by using it as the only source of protein in the ration.

There was no evidence that any of the samples of meat and bone meal were deficient in lysine, leucine, valine or arginine. In many instances, growth obtained with the supplemented groups was not quite as good as that obtained with soybean oil meal and fish meal protein, which was used as a control. The reason for this slightly poorer performance is not known.

Ten samples of meat and bone meal have been used as the main source of protein in rations for chicks. Tryptophan and either cystine or methionine were effective in improving the growth of chicks fed the meat and bone meal rations.

Grau (1948) reported the lysine requirement of chicks increases with increased protein intake. Skurray and Cumming (1974) studied the digestion of meat meal protein in the small intestine of chicks and showed the amounts of free amino acids and ammonia were higher in the intestine of chicks fed meat meal as compared with chicks fed the freeze-dried raw materials used for meat meal production. This suggested that the accumulation of unabsorbed amino acids may lead to an increase in bacterial deamination and consequential losses of essential amino acids.

Machlin et al. (1952) observed that under their experimental conditions Aureomycin did decrease the protein requirement for early chick growth and increased feed efficiency.

A combination of lysine plus antibiotic gave better results than when used singly. The feeding of an antibiotic did not obviate the need for supplementary lysine.

Horani and Daghir (1975) indicated that chicks were as efficient as laying hens in digesting and utilizing the energy content of the protein supplements (soybean, sesame and poultry by-product meals). This is in agreement with the conclusions of Hill and Renner (1963), but in contrast with previous studies by Sell (1966) who found a significant difference in ME values for ten ingredients, especially those with higher fiber content between chicks and hens. The discrepancy in results among workers may be partially due to differences in the nature of the feedstuffs studied (processing, variety, presence of toxins, etc.).

Scott et al. (1956) reported that soybean meal added to purified diets based on isolated soybean protein increases the bone ash of chicks or poults especially when phosphates of poor biological availability are fed. Hinners and Adeniji (1976) indicated the possibility of using soybean meal up to 71% of the starter ration with only a slight reduction in performance, thus the feasibility of incorporating high levels would depend upon the price relationship of energy bearing ingredients and soybean meal.

Chah et al. (1975) found that feeding soybean fermented with 10 of the 11 species of Aspergilli gave significant

($P<0.05$) improvement in weight gain and feed efficiency. The responses were more pronounced with the low dietary levels of protein. Chemical analyses indicate that chicks fed the fermented soybean diets made better use of dietary nitrogen and dry matter. Carcass composition data showed that diets made with fermented soybeans produced chicks that were significantly ($P<0.05$) higher in protein and ash and lower in total lipids. Amino acid analyses suggest the growth-promoting activity was largely due to a greater supply of essential amino acids. Some vitamin synthesis by the fungi is a possibility.

Nwokolo et al. (1976) determined the amino acid composition for palm kernel meal (PKM), soybean meal (SBM), cotton seed meal (CSM) and rapeseed meal (RSM). These protein sources were fed to broiler chicks to determine the availability of amino acids. Results of amino acid analysis indicated that amino acid concentration was lowest in PKM, intermediate for CSM and RSM with SBM having the highest values. The concentration of amino acids were closely related to protein content with a few exceptions (e.g. arginine was high in PKM and glutamic acid was high in CSM). Soybean meal showed excellent amino acid availability for all amino acids.

Warnick and Anderson (1968) indicated that sulfur-containing amino acids were found to be the most limiting in all soybean meals. Threonine, valine and lysine were the next limiting amino acids in the commercial meals and the meals heated to about the same degree as commercial meal.

Most, if not all, of the essential amino acids in the raw meal were less available to the chicks than they were in the same meals after heat treatment.

Ross and Harms (1970) reported that inorganic sulfate could spare the need for additional sulfur-amino acids in a practical diet, containing corn and soybean meals, with a total methionine and cystine content of 0.79%.

Burgos et al. (1973) concluded there are marked genetic differences in both protein and amino acid content of different soybean varieties. There is also a suggestion that different processing techniques may be required to obtain maximum availability of the various amino acids.

Yen et al. (1973) suggested that benefits of proper heating of soybean protein include destruction of the trypsin-inhibitor factor and the soybean hemmaglutinin, a possible feed intake reducer. Alumot and Nitsan (1961) found no improvement in the digestibility of unheated soybean by the chick up to 6 weeks of age although the digestibility coefficients for the unheated soybean meal were always lower than those of the heat treated meal. Gustafson et al. (1971) determined that microwave heating effectively reduced the urease activity and protein dispersibility of moisturized, unextracted soybean to levels considered to be desirable for chick growth performance. Growth is more rapid than chicks fed the raw soybean diet.

Lepkovsky et al. (1965) showed that ingestion of raw soybean (RS) diets caused greater decreases in proteases and amylase in the chicken pancreas than did ingestion of heated soybean (HS) diets. Those decreases were accompanied by larger amounts of amylase in the intestinal contents. The amounts of proteases in the intestinal contents in the chickens fed RS diets were masked by the complexing of trypsin with the trypsin inhibitors in the RS.

Salman and McGinnis (1968) found that feeding unheated soybean meal, after 16 hours of fasting, resulted in a continuous depletion of the pancreas, as reflected by lower zinc activity. This effect was not observed when autoclaved soybean meal was fed.

Dal Borgos et al. (1968) found that diets containing raw soybean meal produced higher thyroid I^{131} release rates than those containing the autoclaved meal. Release rate of thyroid I^{131} was used to obtain information concerning thyroid activity as affected by the different dietary treatments. No effect of dietary carbohydrate on thyroid function was detected.

Rojas and Scott (1969) indicated that soybean meal produced a rate of growth significantly superior to cottonseed meal. This superior growth effect ranged from 13 to 16%. It could be assumed that one factor associated with the variable performance between cottonseed meal and soybean meal was probably a difference in amino acid composition other than lysine and methionine.

Smith (1968) indicated that availability of amino acids of fish meal and soybean meal was high (greater than 85%).

The exceptions in the case of fish meal were leucine, valine and arginine, and in the case of soybean meal, isoleucine, valine and histidine.

Waldroup et al. (1965) reported that when 100% of the protein supplied by soybean meal was replaced by fish meal protein, a significant decrease in body weight was observed in fish meal sample. This effect was also reflected in an increased amount of feed required for a unit of gain.

Two common ascaridoid nematodes of poultry are *Heterakis gallinorum* and *Ascaridia galli*. They are frequently the cause of unthriftiness particularly in young birds, and in addition, *H. gallinorum* is responsible for the transmission of histomoniasis in turkeys (Bigson, 1975).

Young birds are more susceptible to infection than adult birds or others that have had a previous infection. Dietary deficiencies, such as those of vitamins A, riboflavin and B_{12}, various minerals and proteins, predispose to heavier infections. Chickens over 3 months of age are more resistant to infection and this may be associated with a marked increase in gobelt cells in the gut mucosa about this time (Soulsby, 1968).

Marked lesions may be produced when large numbers of the young parasites penetrate into the duodenal mucosa. This causes hemorrhage and enteritis and the birds become anemic and suffer from diarrhea. The birds become unthrifty, markedly emaciated and generally weak. In heavy infections, intestinal obstruction may occur.

Five studies have been conducted by Bliss (1977) using pyrantel tartrate. Three involved the titration of an efficacious level and two observed possible growth promotion. The five studies were as follows:

1. Pyrantel tartrate was given in water at levels of 12.5 ppm, 25 ppm, or 50 ppm. The water medication was given for a period of 24 hours. All droppings passed for 96 hours beginning with the start of medication were collected in 10% formalin and screened (60 mesh) for worms passed. The birds were killed at the end of this period and the intestinal tract was examined for worms remaining. A dose response was observed. Pyrantel tartrate at a level of 50 ppm removed approximately 52% of the worms (*Ascaridia galli*), but at a level of 12.5 ppm, it was not efficacious.

2. Pyrantel tartrate was given in water at levels of 50, 100, or 200 ppm. The water medication was given for a period of 24 hours. The birds were killed and the intestinal tract was examined for remaining worms. A dose response was observed. Pyrantel tartrate at a level of 50 ppm removed approximately 32% of the *A. galli* and at a level of 200 ppm, the percentage removal was 94%. The efficacy of pyrantel tartrate at 100 ppm was 82%.

3. The treatments were pyrantel tartrate at 200 ppm, and piperazine at 1069 ppm (recommended use level). Results showed that both pyrantel tartrate and piperazine were highly efficacious (100%) against *A. galli*. Water consumption was greater than normal because of the warm weather and a failure

of the air conditioning system.

The next two studies observed possible growth promotion capabilities.

4. The addition of either GS-6970, CP-10, 304 or CP-10, 423-1 (Banminth) at 20 grams per ton to a typical broiler starter ration did not significantly alter 4-week weights. The feeding of Banminth lowered feed efficiency significantly ($P<0.10$) below control chicks.

5. The addition of GS-4990 or GS-8132 at 20 grams per ton to a typical chick broiler starter ration significantly increased 4-week weight ($P<0.01$) and improved feed efficiency ($P<0.05$) above chicks fed only the basal ration.

The 200 ppm ($\cong$182 g/ton) appeared to be most efficacious, and no improvement was seen in feed conversion or daily weight gain without a parasite infection.

MATERIALS AND METHODS

Two separate experiments were conducted at the Kansas State University poultry nutrition laboratory. A total of 480 birds were used in the two experiments. Experiment I, consisting of 240 birds, was initiated on October 18, 1977, and ran until December 13, 1977. The second experiment was conducted from December 6, 1977, to January 31, 1978, and utilized also 240 birds. Male meat-strain Hubbard White Mountain broiler chicks were used in both experiments.

The chicks were randomized into 24 lots of 10 chicks each in both experiments and were individually wing banded. Electrically heated battery brooders were used to rear the birds to four weeks of age, at which time they were transferred to unheated batteries until the end of the experimental period. Feed and water were provided ad libitum.

Grain was ground and all ingredients were mixed at the Department of Grain Science and Industry Feed Mill and the K.S.U. Poultry Research Center.

Eight different broiler basal diets of 24 and 20% protein were used 0 to 4 and 5 to 8 weeks of age, respectively. The first four diets contained different sources of energy, but same source of protein. The second four diets contained different sources of protein and the same source of energy. Various supplements were added to the basal diets. The composition of these diets are given in Tables 1 and 2.

Table 1. Composition of the eight diets used from 0-4 weeks of age in Experiment 1 and 2.

Ration no.	Energy Source	%	Protein Source	%	Other ingredients for all diets
1	Barley	42	Soybean meal	42	Alfalfa meal, 17%
2	Corn	39.5	Soybean meal	45.5	prot.
3	Sorghum grain	40	Soybean meal	45	Animal fat
4	Wheat	44	Soybean meal	41	Salt
5(1)	Corn	45	Cottonseed meal	40	Ground limestone
6(2)	Corn	67.25	Fish meal	24.25	Phosphorus supplement
7(3)	Corn	52	Meat and bone meal	15	
8	Corn	39.5	Soybean meal	45.5	

(1) For Experiment 2, mixed sources of protein were used instead of cottonseed meal and these consisted of cottonseed meal, fish meal, meat and bone meal, and soybean meal.

(2) 6% cottonseed meal was added to the fish meal basal diet to control the calcium and phosphorus levels in that diet.

(3) 24% cottonseed meal was added to the meat and bone meal basal diet to control the calcium and phosphorus levels in this diet.

(4) Trace mineral and vitamin mix (Table 1 cont.).

Table 1 (cont.)

Added per 100 lb. of ration[a]	
Trace mineral mix[b]	23 grams
Vitamin A (10,000 USP units/g)	20 grams
Vitamin D_3 (15,000 ICU/g)	8 grams
B-complex vitamin mix[c]	46 grams
D-L Methionine	23 grams
Vitamin B_{12} (20 mg/lb)	10 grams
Choline chloride, 25% mix	40 grams

(a) Added to all rations

(b) Trace mineral mix supplying by %: Mn 10; Fe 10; Cu 1; Zn 5; I_2 0.3; Co 0.1.

(c) B-complex vitamin mix supplying in mg/lb: riboflavin 8,000; pantothenic acid 14,720; niacin 24,000; choline chloride 80,000.

Table 2. Composition of the eight diets used from 5-8 weeks of age in Experiment 1 and 2.

Ration no.	Energy Source	%	Protein Source	%	Other ingredients for all diets
1	Barley	53.5	Soybean meal	30.5	Alfalfa meal, 17%
2	Corn	55	Soybean meal	34	prot.
3	Sorghum grain	55	Soybean meal	33	Animal fat
4	Wheat	60.5	Soybean meal	27.5	Salt
5(1)	Corn	61.5	Cottonseed meal	29.5	Ground limestone
6	Corn	76.5	Fish meal	22	Phosphorus supplement
7(2)	Corn	65.5	Meat and bone meal	15	
8	Corn	55	Soybean meal	34	

(1) For Experiment 2, mixed sources of protein were used instead of cottonseed meal and these consisted of cottonseed meal, fish meal, meat and bone meal, and soybean meal.

(2) 13.5% cottonseed meal was added to the meat and bone meal basal diet to control the calcium and phosphorus levels in this diet.

Added per 100 lb. of ration

Trace mineral mix	23 grams
Vitamin A (10,000 USP units/g)	20 grams
Vitamin D_3 (15,000 ICU/g)	8 grams
B-complex vitamin mix	46 grams

Table 2 (cont.)

Added per 100 lb. of ration (cont.)

D-L Methionine	23 grams
Vitamin B_{12} (20 mg/lb)	10 grams
Choline chloride, 25% mix	40 grams

Each diet was fed in triplicate to the day-old chicks. One lot for each of the eight diets was supplemented with pyrantel tartrate (200 ppm) to observe influence on growth and feed utilization of noninfected, battery-reared birds. The pyrantel supplemented lots were represented by rations 9, 10, 11, 12, 13, 14, 15 and 16.

A large platform balance was used to weigh macroingredients in pounds; whereas, gram levels of microingredients were weighed on a double pan computagram balance. The microingredients were added to approximately 10 pounds of ground grain and mixed for five minutes in a small electrically operated Hobart mixer. This premix was then blended into the remaining amount of the 100 pounds of macroingredients and mixed for an additional five minutes in the 100-pound horizontal paddle mixer. Each 100 pound diet was divided into three lots, the third lot in each diet was supplemented with the 200 ppm pyrantel tartrate (Table A-3).

All feed was put into paper bags, labeled, and stored in the poultry nutrition laboratory. Feed was weighed into the diet storage cans, the amounts were recorded, and at the end of each two-week period the feed remaining in the feeders was emptied into the storage cans and was weighed back. This amount was then subtracted from the total weighed out to give the kilograms consumed per lot. Feed utilization or kilograms of feed required per kilogram of gain was calculated for each lot of chicks at the end of each eight-week experiment. The feed utilization data appears in Tables A-1 and A-2. Individual body weights were recorded for each two-week period.

RESULTS

Experiment 1

An analysis of variance was run on the 0-2, 2-4, 4-6, 6-8, 0-4, 0-6, 0-8 week chick weight gains and feed utilization. This analysis indicated that performance of birds fed rations 1 (barley), 2 (corn) and 3 (sorghum grain) was not significantly different ($P>0.05$) in weight gain and feed utilization. The same thing was observed for the performance of birds fed rations 2 (corn), 3 (sorghum grain) and 4 (wheat). Rations 2 (corn) and 3 (sorghum grain) showed a better weight gain than ration 1 (barley) for the period 0-8 week. The only significant difference in chick performance ($P<0.05$) was for weight gain between ration 1 (barley) and 4 (wheat) for periods 0-2, 0-6, 0-8, but chicks fed ration 1 (barley) had significantly better feed utilization for the period 0-8 weeks (Tables 3 and 4).

Birds fed rations 1 (barley), 2 (corn), 3 (sorghum grain) and 4 (wheat), that were supplemented with 200 ppm pyrantel, and represented by rations 9 (barley), 10 (corn), 11 (sorghum grain) and 12 (wheat) showed no significant difference in weight gain and feed utilization when compared with the non-supplemented rations for the various experimental periods. However, the pyrantel supplemented rations tended to improve the weight gain and feed utilization for some rations, and to depress others for the periods 0-8 weeks (Tables 3 and 4).

Table 3. Analysis of variance of average weight gain in Experiment 1.

		Mean Squares						
Sources	d.f.	0-2	2-4	4-6	6-8	0-4	0-6	0-8
Treatment	15	9665.22**	43408.15**	53022.58**	57116.07**	92679.09**	276360.73**	575237.80**
Error	8	44.64	564.86	2210.52	2907.13	903.66	2796.31	5996.90

	Means-Weight Gain (grams)						
Treatments	0-2	2-4	4-6	6-8	0-4	0-6	0-8
1 (barley)	265.20^{b}	542.50^{b}	637.60^{ab}	693.65^{a}	807.70^{ab}	1445.30^{b}	2138.95^{b}
9 (barley)	274.80^{b}	51.730^{b}	718.50^{a}	669.10^{a}	792.10^{ab}	1510.60^{ab}	2179.70^{ab}
2 (corn)	273.15^{b}	534.90^{b}	762.80^{a}	686.25^{a}	808.05^{ab}	1564.70^{ab}	2256.20^{ab}
10 (corn)	277.40^{ab}	598.70^{ab}	630.80^{ab}	810.40^{a}	876.10^{a}	1506.90^{ab}	2317.30^{ab}
3 (sorghum grain)	274.60^{b}	576.95^{b}	675.70^{a}	781.05^{a}	853.20^{a}	1528.90^{ab}	2309.95^{ab}
11 (sorghum grain)	268.7^{an}	530.30^{b}	692.30^{a}	760.80^{a}	799.00^{ab}	1491.30^{ab}	2252.10^{ab}
4 (wheat)	294.00^{a}	574.50^{b}	702.99^{a}	714.60^{a}	868.50^{ab}	1598.55^{a}	2341.50^{a}
12 (wheat)	274.30^{b}	624.80^{a}	727.40^{a}	739.10^{a}	895.40^{a}	1622.90^{a}	2379.60^{a}
5 (CSM)	58.60^{f}	84.80^{e}	145.60^{c}	202.80^{c}	145.10^{e}	292.70^{e}	502.55^{d}
13 (CSM)	57.20^{f}	71.10^{e}	134.40^{c}	180.60^{c}	128.30^{e}	262.80^{e}	443.30^{d}
6 (fish meal)	221.05^{d}	431.85^{c}	550.95^{b}	500.65^{b}	652.35^{c}	1193.30^{c}	1685.95^{c}
14 (fish meal)	217.00^{d}	428.80^{c}	571.30^{b}	377.20^{b}	645.60^{c}	1168.90^{c}	1531.40^{c}

Table 3 (cont.)

	Means-Weight Gain (grams)						
Treatments	0-2	2-4	4-6	6-8	0-4	0-6	0-8
7 (M and B meal)	131.75^{e}	348.40^{d}	568.55^{b}	677.30^{a}	475.55^{d}	1044.10^{d}	1694.55^{c}
15 (M and B meal)	143.40^{e}	374.60^{d}	580.80^{b}	633.80^{ab}	520.20^{d}	1154.90^{dc}	1734.80^{c}
8 (soybean meal)	276.15^{b}	618.25^{a}	669.09^{b}	787.60^{a}	894.40^{a}	1563.50^{b}	2351.10^{a}
16 (soybean meal)	242.80^{c}	481.40^{c}	745.10^{a}	676.90^{a}	724.20^{b}	1469.30^{b}	2260.30^{ab}

**Significant ($P<.01$)

Means with the same superscript are not statistically different at ($P<.05$) of probability.

Table 4. Analysis of variance of average feed utilization, Experiment 1.

		Mean Squares						
Sources	d.f.	0-2	2-4	4-6	6-8	0-4	0-6	0-8
Treatments	15	0.7526**	0.9696**	0.1161**	0.3151**	0.9276**	0.4301**	0.4301**
Error	8	0.0262	0.0914	0.0236	0.0488	0.1253	0.0226	0.0268

	Means-Feed utilization (kg feed per kg gain)						
Treatments	0-2	2-4	4-6	6-8	0-4	0-6	0-8
1 (barley)	1.315^{a}	1.775^{a}	2.260^{a}	2.790^{b}	1.620^{a}	1.900^{a}	2.190^{a}
9 (barley)	1.370^{a}	1.780^{a}	2.060^{a}	2.840^{ab}	1.640^{a}	1.840^{a}	2.150^{a}
2 (corn)	1.440^{a}	1.825^{a}	2.090^{a}	2.880^{b}	1.690^{a}	1.940^{a}	2.305^{a}
10 (corn)	1.460^{a}	1.670^{a}	2.350^{a}	2.160^{a}	1.600^{a}	1.910^{a}	1.990^{a}
3 (sorghum grain)	1.600^{a}	1.860^{a}	2.385^{ab}	2.580^{a}	1.805^{a}	2.060^{a}	2.230^{a}
11 (sorghum grain)	1.420^{a}	1.540^{a}	2.440^{a}	2.580^{a}	1.500^{a}	1.930^{a}	2.150^{a}
4 (wheat)	1.340^{a}	1.750^{a}	2.275^{a}	2.935^{b}	1.610^{a}	2.025^{a}	2.475^{b}
12 (wheat)	1.590^{a}	1.610^{a}	2.220^{a}	2.850^{ab}	1.660^{a}	1.910^{a}	2.350^{ab}
5 (CSM)	3.330^{d}	3.950^{c}	3.085^{bc}	3.605^{c}	3.990^{c}	3.590^{c}	3.980^{d}
13 (CSM)	3.150^{d}	4.390^{c}	2.750^{b}	3.320^{bc}	3.840^{c}	3.280^{c}	3.300^{c}
6 (fish meal)	1.740^{ab}	2.075^{a}	2.495^{b}	3.205^{bc}	2.005^{ab}	2.295^{b}	2.615^{b}
14 (fish meal)	1.850^{ab}	2.740^{b}	2.480^{b}	4.420^{d}	2.520^{ab}	2.450^{b}	2.920^{b}

Table 4 (cont.)

Treatments	Means-Feed utilization (kg feed per kg gain)						
	0-2	2-4	4-6	6-8	0-4	0-6	0-8
7 (M and B meal)	2.950^{c}	2.220^{a}	2.490^{b}	2.910^{b}	2.490^{b}	2.490^{b}	2.630^{b}
15 (M and B meal)	2.180^{b}	2.320^{a}	2.350^{a}	2.990^{b}	2.340^{b}	2.520^{b}	2.580^{b}
8 (soybean meal)	1.475^{a}	1.680^{a}	2.320^{a}	2.570^{a}	1.615^{a}	1.915^{a}	2.135^{a}
16 (soybean meal)	1.400^{a}	1.700^{a}	1.940^{a}	2.780^{a}	1.600^{a}	1.770^{a}	2.380^{a}

**Significant ($P<.01$)

Means with the same superscript are not statistically different at ($P<.05$) of probability.

Fed to meat strain chicks, rations 6 (fish meal), 7 (meat and bone meal) and 8 (soybean meal) revealed a significant difference in average weight gain and feed utilization when compared to ration 5 (cottonseed meal) for the various experimental periods (Tables 3 and 4). Chicks fed ration 6 (fish meal) and 7 (meat and bone meal) were found to be significantly poorer in weight gain and feed utilization than ration 8 (soybean meal) but there was no significant difference between them in feed utilization for the period 2-4 weeks. Chicken fed ration 7 (meat and bone meal) showed no significant difference in weight gain for the periods 4-8 and 6-8 weeks in comparison to ration 8 (soybean meal). For the various experimental periods supplementing rations with pyrantel did not make any significant difference in weight gain and feed utilization when compared with the nonsupplemented rations 5 (cottonseed meal), 6 (fish meal), 7 (meat and bone meal), 8 (soybean meal) and those that were supplemented 13 (cottonseed meal), 14 (fishmeal), 15 (meat and bone meal), 16 (cottonseed meal). Feed utilization for ration 5 (cottonseed meal) was significantly different than ration 13 (cottonseed meal) for the period 0-8 weeks.

The data were analyzed by using a one-way analysis of variance testing for significant difference between treatment means for weight gain and feed utilization as described by Snedecor and Cochran (1976).

Experiment 2

In Experiment 2, a slight change was made in ration 5 (cottonseed meal) by using a mixed source of protein instead of one source, which was cottonseed meal in Experiment 1 (Table 1).

Birds fed rations 1 (barley), 2 (corn), 3 (sorghum grain) and 4 (wheat) showed no significant difference ($P>0.05$) in average weight gain and feed utilization for the period 0-8 weeks. Ration 1 (barley) was significantly different than the other three rations 2 (corn), 3 (sorghum grain), 4 (wheat) in weight gain for the periods 0-4, 4-6 weeks. Performance of birds fed ration 2 (corn) was statistically different than rations 1 (barley), 3 (sorghum grain) and 4 (wheat) in weight gain for the period 4-6 weeks (Table 5).

Birds fed rations 5 (mixed source of protein) and 8 (soybean meal) were significantly different than those fed rations 6 (fish meal) and 7 (meat and bone meal) in weight gain for the various periods of the experiment except period 6-8 weeks (Table 5). Birds fed ration 6 (fish meal) were significantly different than birds fed ration 5 (mixed source of protein), 8 (soybean meal), 7 (meat and bone meal) in feed utilization for the period 0-8 week, and statistically different than ration 7 (meat and bone meal) for weight gain for the various periods of the experiment (Tables 5 and 6).

No significant difference appeared among the performance of birds weight gain fed all rations for the period 6-8 week

Table 5. Analysis of variance of average weight gain, Experiment 2.

		Mean Squares						
Sources	d.f.	0-2	2-4	4-6	6-8	0-4	0-6	0-8
Treatments	15	3950.12**	11312.66**	10285.80**	429.22ns	28299.66**	61598.68**	78309.23**
Error	8	152.64	491.46	759.29	2420.45	3308.10	3763.32	9090.44

	Means-Weight Gain (grams)						
Treatments	0-2	2-4	4-6	6-8	0-4	0-6	0-8
1 (barley)	262.70[a]	526.60[ab]	797.85[b]	771.25[a]	713.80[b]	1587.15[a]	2384.40[a]
9 (barley)	288.80[a]	552.20[a]	881.80[a]	711.10[a]	844.00[ab]	1697.20[a]	2399.90[a]
2 (corn)	274.00[a]	595.30[a]	798.90[b]	678.95[a]	873.00[a]	1671.90[a]	2386.60[a]
10 (corn)	288.80[a]	577.00[a]	812.50[a]	671.00[a]	865.80[a]	1678.30[a]	2349.30[a]
3 (sorghum grain)	270.65[a]	565.35[a]	809.50[a]	738.90[a]	821.35[a]	1656.20[a]	2385.55[a]
11 (sorghum grain)	274.80[a]	591.50[a]	819.50[a]	749.50[a]	866.30[a]	1685.80[a]	2435.30[a]
4 (wheat)	273.95[a]	566.50[a]	818.60[a]	717.35[a]	842.75[a]	1682.40[a]	2419.40[a]
12 (wheat)	287.40[a]	582.70[a]	861.10[a]	704.40[a]	870.10[a]	1731.20[a]	2435.70[a]
5 (mixed source of protein)	284.95[a]	598.65[a]	756.30[b]	674.75[a]	883.60[a]	1639.90[a]	2331.15[a]
13 (mixed source of protein)	285.30[a]	577.90[a]	763.10[b]	686.10[a]	863.20[a]	1598.90[a]	2324.10[a]

Table 5 (cont.)

	Means-Weight Gain (grams)						
Treatments	0-2	2-4	4-6	6-8	0-4	0-6	0-8
6 (fish meal)	225.85^{b}	494.10^{b}	676.55^{c}	563.90^{a}	723.70^{b}	1426.25^{b}	2039.45^{b}
14 (fish meal)	271.80^{a}	539.00^{b}	761.20^{b}	627.60^{a}	810.80^{a}	1558.40^{a}	2158.60^{ab}
7 (M and B meal)	126.50^{c}	321.70^{c}	592.85^{cd}	665.90^{a}	448.20^{c}	1062.75^{c}	1731.55^{c}
15 (M and B meal)	128.30^{c}	346.30^{c}	600.60^{c}	672.70^{a}	474.70^{c}	1120.10^{c}	1800.00^{bc}
8 (soybean meal)	249.55^{ab}	604.35^{a}	833.70^{a}	723.65^{a}	851.25^{a}	1684.60^{a}	2412.35^{a}
16 (soybean meal)	239.70^{ab}	572.10^{a}	795.20^{ab}	708.10^{a}	809.90^{a}	1605.10^{a}	2313.20^{a}

ns = nonsignificant.

**Significant ($P<.01$).

Means with the same superscript are not statistically different.

Table 6. Analysis of variance of average feed utilization, Experiment 2.

		Mean Squares						
Sources	d.f.	0-2	2-4	4-6	6-8	0-4	0-6	0-8
Treatments	15	0.0496[ns]	0.1779**	0.0315[ns]	0.1949**	0.0870**	0.0488**	0.1109**
Error	8	0.0342	0.0287	0.0193	0.0235	0.0096	0.0080	0.0198

Means-Feed utilization (kg feed per kg gain)

Treatments	0-2	2-4	4-6	6-8	0-4	0-6	0-8
1 (barley)	1.140[a]	2.385[ab]	2.150[a]	2.495[a]	2.180[b]	2.065[b]	2.305[a]
9 (barley)	1.050[a]	1.980[a]	2.180[a]	3.300[b]	1.660[a]	1.850[a]	2.320[a]
2 (corn)	1.025[a]	1.955[a]	2.090[a]	2.720[a]	1.675[a]	1.875[a]	2.235[a]
10 (corn)	0.950[a]	1.920[a]	2.060[a]	2.700[a]	1.600[a]	1.820[a]	2.070[a]
3 (sorghum grain)	1.035[a]	1.990[a]	2.135[a]	2.655[a]	1.635[a]	1.900[a]	2.210[a]
11 (sorghum grain)	0.970[a]	1.900[a]	2.110[a]	2.560[a]	1.600[a]	1.850[a]	2.070[a]
4 (wheat)	1.000[a]	1.935[a]	1.995[a]	2.665[a]	1.650[a]	1.890[a]	2.270[a]
12 (wheat)	1.050[a]	1.980[a]	2.090[a]	2.730[a]	1.670[a]	1.880[a]	2.120[a]
5 (mixed source of protein)	1.105[a]	1.770[a]	2.375[a]	2.765[a]	1.590[a]	1.945[a]	2.245[a]
13 (mixed source of protein)	1.020[a]	1.940[a]	2.450[a]	2.820[a]	1.640[a]	1.940[a]	2.310[a]

Table 6 (cont.)

Treatments	Means-Feed utilization (kg feed per kg gain)						
	0-2	2-4	4-6	6-8	0-4	0-6	0-8
6 (fish meal)	1.070^{a}	2.160^{a}	2.385^{a}	3.580^{b}	1.850^{a}	2.180^{b}	3.100^{c}
14 (fish meal)	0.950^{a}	1.990^{a}	2.030^{a}	3.510^{b}	1.640^{a}	1.940^{a}	2.470^{ab}
7 (M and B meal)	0.605^{a}	2.910^{b}	2.280^{a}	2.330^{a}	2.260^{b}	2.345^{b}	2.380^{a}
15 (M and B meal)	0.460^{a}	2.850^{b}	2.270^{a}	2.580^{a}	2.200^{b}	2.420^{b}	2.590^{b}
8 (soybean meal)	1.045^{a}	1.835^{a}	2.030^{a}	2.600^{a}	1.645^{a}	1.835^{a}	2.130^{a}
16 (soybean meal)	0.970^{a}	2.020^{a}	2.010^{a}	2.560^{a}	1.750^{a}	1.880^{a}	2.090^{a}

ns = nonsignificant.

**Significant ($P<.01$).

Means with the same superscript are not statistically different.

(Table 5) and in feed utilization for the periods 0-2 and 4-6 weeks (Table 6). The data were analyzed by using the same method of Experiment 1.

DISCUSSION

Results of two experiments using different sources of energy and different sources of protein rations, with and without pyrantel tartrate as an anthelmintic, indicated no significant difference among the rations in weight gain or feed utilization.

A one way analysis of variance for weight gain and feed utilization data are presented as means for the various periods of the experiments (Tables 3, 4, 5 and 6). It is apparent that performance of birds fed rations 1 (barley basal), 2 (corn basal) and 3 (sorghum grain basal) are not statistically different in weight gain and feed utilization. The same is true for rations 2, 3, 4 (wheat basal), for the various periods of the experiment. These results are in agreement with Petersen (1969) who reported the result of a broiler feeding trial using rations containing corn, sorghum, wheat and barley with all rations having the same ratio of metabolizable energy to digestible protein. Likewise Sanford (1963) reported equal gain in weight by chickens fed corn, sorghum grain and barley. Nonsignificant differences in feed consumption were found when sorghum grain or yellow corn were used as the source of energy (Bornstein and Bartove, 1967). They did not find any difference between the effect of sorghum grain and corn on growth rate or feed/gain ratio. Fernandez et al. (1973) reported that chicks grew equally well on the corn and wheat rations. Chicks fed the corn ration had significantly better feed efficiency than those fed the wheat ration. Chicks fed the barley basal ration showed better feed utilization than those fed the corn ration. These results are in contrast with Bearse (1952), who found less efficiency of feed utilization by using barley as a replacement for corn in high-energy broiler diets. Under his experimental conditions, about 0.15 to 0.3 of a pound of additional feed was required to produce a pound of broiler weight gain.

The wheat basal ration supported a significantly better chick weight gain than the barley ration, but the later showed significantly better feed utilization than the former. These results are in contrast to Strain and Piloski (1972), who concluded the higher energy in wheat would account for the poorer performance in wheat than in barley. Since lysine was the most limiting factor in these diets, the amount of energy per unit of lysine was considerably higher in the wheat ration. This resulted in a decrease in feed intake and slower rate of gain.

Rations 9 (barley basal), 10 (corn basal), 11 (sorghum basal) and 12 (wheat basal) that were supplemented with 200 ppm pyrantel showed no significant differences in weight and feed utilization in comparison to the nonsupplemented rations. These results are in agreement with Bliss (1977), who indicated no significant improvement in daily weight gain or feed utilization when using the anthelmintic without parasitic infection.

Rations 6 (fish meal basal), 7 (meat and bone meal basal) and 8 (soybean meal basal) supported weight gain and feed utilization significantly better than ration 5 (cottonseed meal basal). These results are in agreement with the work of Rojas and Scott (1969) who found soybean meal produced a rate of growth significantly superior to cottonseed meal. Forbes and Kastelic (1961) reported poor growth, poor efficiency of feed utilization and high mortality in chicks fed cottonseed meal as a sole protein. Davenport et al. (1969) indicated that weight gain and feed conversion of broilers decreased as gossypol levels increased. It could be assumed that one factor associated with the variable performance between cottonseed meal and soybean meal was probably a difference in amino acid composition, such as lysine and methionine (Grau, 1946). Fisher (1965) indicated, in addition to lysine and methionine, the amino acids leucine, threonine and isoleucine were equally limiting for optimum growth of chicks receiving regular cottonseed meal.

Feeding the soybean meal ration improved weight gain and feed utilization that was statistically significant when compared with the fish meal and meat-bone meal rations. These results are in agreement with Waldroup et al. (1965), who reported a significant decrease in body weight was observed when 100% of the protein supplied by soybean meal was replaced by fish meal protein. This effect was also reflected in an increased amount of feed required for a unit of gain.

Supplemented rations with pyrantel (13, 14, 15 and 16) did not show a significant difference in chicks weight gain in comparison to the nonsupplemented rations (5, 6, 7 and 8), same is true for feed utilization except in the cottonseed meal ration. Pyrantel fed chicks resulted in an improvement in feed utilization that was superior to the nonsupplemented cottonseed meal ration.

In Experiment 2, mixed sources of protein were used (Tables 1 and 2) instead of the cottonseed meal basal. An improvement in weight gain and feed utilization appeared, but no significant differences were found between the mixed source of protein ration (ration 5) and the soybean meal ration (ration 8). These results are in agreement with Galal et al. (1977) who showed that gains of chicks fed 1:1 mixture of soybean meal and cottonseed meal were similar to those of chicks fed soybean meal alone, but gain/feed was less ($P<0.05$). Schumaier and McGinnis (1968) indicated that supplementation of fish meal protein with other proteins may improve growth rate of chicks by improving the amino acid balance or by some other undetermined factor.

No significant difference appeared between ration 1 (barley basal) and ration 4 (wheat basal) for weight gain and feed utilization. Ration 6 (fish meal basal) showed significant depression in feed utilization when compared with ration 14 (fish meal supplemented basal), but weight gain was not significantly different.

SUMMARY AND CONCLUSIONS

Two experiments were conducted to study weight and feed utilization of broiler-strain chicks fed different sources of energy and different sources of protein with and without the anthelmintic pyrantel. A total of 480 male meat-strain Hubbard White Mountain broiler chicks were used in the two experiments. The chicks were kept in electrically heated battery brooders to four weeks of age. At four weeks, they were transferred to unheated growing batteries. Individual body weights and lot feed consumption data were taken at two-week intervals during the eight-week period of the experiments.

Each diet was fed in triplicate to the day-old chicks. One lot for each of the eight diets was supplemented with pyrantel tartrate (200 ppm) to observe influence on growth and feed utilization of noninfected, battery-reared chicks. These supplemented diets are represented by rations 9, 10, 11, 12, 13, 14, 15 and 16.

The following conclusions were drawn from the results of these experiments.

1) There was no significant difference in weight gain and feed utilization between supplemented and nonsupplemented rations, with pyrantel tartrate as an anthelmintic, with noninfected birds.

2) There was no significant difference in weight gain

and feed utilization among the different sources of energy (barley, corn, sorghum grain, wheat) except in case of the wheat ration that produced significantly better weight gain than the barley ration in Experiment 1 only, while barley showed significantly better feed utilization in the same experiment. Under the conditions of these experiments, the weight gains of the chickens did not depend greatly on the energy source of the ration. It is clear that weight gain mainly depended upon metabolizable energy intake per bird. The feed consumption per chicken varied significantly with the type of grain used. The differences in feed consumption were mainly due to the energy content of the rations. The correlation between the dietary energy content and the feed consumption was 0.87.

3) The cottonseed meal ration appeared to be the poorest ration, among others, in weight gain and feed utilization, because it is deficient in some amino acids that are necessary for optimal growth such as lysine and methionine.

4) Use of the mixed source of protein performed as well as soybean meal basal, which was the best ration in weight gain and feed utilization. Superior improvement in performance of weight gain and feed utilization was observed when meat-strain chicks were fed a mixed source of protein ration as compared with the cottonseed meal ration.

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APPENDIX

Table A-1. Average weight gains and feed utilizations, Experiment 1.

Ration no.	Lot no.	Gains in grams 0-8 weeks	Kg. feed per kg. gain 0-8 weeks
1 (barley)	1	2098.6	2.13
	2	2179.3	2.25
9 (barley)	3	2179.7	2.15
2 (corn)	4	2245.6	2.45
	5	2266.8	2.16
10 (corn)	6	2317.3	1.99
3 (sorghum grain)	7	2318.1	2.36
	8	2301.8	2.10
11 (sorghum grain)	9	2252.1	2.15
4 (wheat)	10	2414.4	2.67
	11	2268.6	2.28
12 (wheat)	12	2379.6	2.35
5 (CSM)	13	453.1	3.97
	14	552.0	3.99
13 (CSM)	15	443.3	3.30
6 (fishmeal)	16	1567.4	2.45
	17	1750.5	2.78
14 (fishmeal)	18	1531.4	2.95
7 (M and B meal)	19	1737.3	2.65
	20	1651.9	2.61
15 (M and B meal)	21	1734.8	2.58
8 (soybean meal)	22	2286.2	2.14
	23	2416.0	2.13
16 (soybean meal)	24	2260.3	2.38

Table A-2. Average weight gains and feed utilizations, Experiment 2.

Ration no.	Lot no.	Gains in grams 0-8 weeks	Kg. feed per kg. gain 0-8 weeks
1 (barley)	1	2374.0	2.11
	2	2394.8	2.50
9 (barley)	3	2399.9	2.32
2 (corn)	4	2435.9	2.39
	5	2337.3	2.08
10 (corn)	6	2349.3	2.07
3 (sorghum grain)	7	2354.9	2.18
	8	2316.2	2.24
11 (sorghum grain)	9	2435.3	2.07
4 (wheat	10	2473.8	2.28
	11	2365.0	2.26
12 (wheat)	12	2435.7	2.12
5 (mixed source of protein)	13	2268.2	2.12
	14	2394.1	2.37
13 (mixed source of protein)	15	2324.1	2.31
6 (fishmeal)	16	1889.7	3.08
	17	2189.2	3.12
14 (fishmeal)	18	2158.6	2.47
7 (M and B meal)	19	1709.3	2.38
	20	1753.8	2.38
15 (M and B meal)	21	1800.0	2.59
8 (soybean meal)	22	2467.5	2.13
	23	2357.2	2.13
16 (soybean meal)	24	2313.2	2.09

Table A-3. The level and kind of supplement used in Experiments 1 and 2.

Ration no.	Lot no.	Supplement	Level (ppm)
1	1 and 2 basal	None	-
9	3 basal	Pyrantel	200
2	4 and 5 basal	None	-
10	6 basal	Pyrantel	200
3	7 and 8 basal	None	-
11	9 basal	Pyrantel	200
4	10 and 11 basal	None	-
12	12 basal	Pyrantel	200
5	13 and 14 basal	None	-
13	15 basal	Pyrantel	200
6	16 and 17 basal	None	-
14	18 basal	Pyrantel	200
7	19 and 20 basal	None	-
15	21 basal	Pyrantel	200
8	22 and 23 basal	None	-
16	24 basal	Pyrantel	200

COMPARISON OF FEEDING VARIOUS SOURCES OF ENERGY AND PROTEIN ON PERFORMANCE OF BROILER CHICKS WITH AND WITHOUT AN ANTHELMINTIC

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Two separate experiments were conducted at the Kansas State University, Poultry nutrition laboratory. A total of 480 birds were used in the two experiments.

The chicks were randomized into 24 lots of 10 chicks each in both experiments, and were individually wing banded. Electrically heated battery brooders were used to rear the birds to four weeks of age.

Eight different basal broiler diets of 24 and 20% protein were used 0-4 and 5-8 weeks of age, respectively. The first four diets contained different sources of energy (barley, corn, sorghum, wheat), but the same source of protein. The second four diets contained different sources of protein (cottonseed meal, fish meal, meat and bone meal, soybean meal), and the same source of energy.

Each diet was fed in triplicate to day-old meat-strain Hubbard White Mountain broiler chicks. One lot for each of the eight diets was supplemented with pyrantel tartrate (200 ppm) as an anthelmintic.

Weight gain and feed utilization were obtained every 2 weeks from individual chick weight gain and feed consumed. A one-way analysis of variance was used for testing significant and nonsignificant differences between treatment means for weight gain and feed utilization.

Nonsignificant differences were observed, using pyrantel tartrate as an anthelmintic in weight gain and feed utilization with noninfected birds.

Different sources of energy did not affect the weight gain and feed utilization, except in case of wheat, that showed significantly better weight gain than barley for Experiment 1 only, while barley showed significantly better feed utilization for the same experiment.

Cottonseed meal appeared to be the poorest ration among the other sources of protein in weight gain and feed utilization because of its deficiency in some amino acids that are necessary for optimal growth.

A mixed source of protein which was fed in Experiment 2, replacing cottonseed meal of Experiment 1, showed an improvement in weight gain and feed utilization, and equal to the soybean meal basal, that showed statistically the best weight gain and feed utilization.