THE NUTRITIVE VALUE OF TRITICALE IN BROILER CHICK RATIONS

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ABSTRACT

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IN BROILER CHICK RATIONS

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Three feeding trials employing 1550 commercial broiler chicks were conducted to evaluate the nutritive value of triticale. Treatments included three levels of triticale (0, 50, and 100% of the grain), three levels of animal tallow (0, 2.5, and 5.0%), four levels of DL-methionine (.00, .05, .10, .15%) and four levels of L-lysine HCl (.00, .05, .10, .20%). Experimental periods were of 28 day duration. Metabolizable energy was determined for the wheat, wheat-triticale and triticale rations. Weight gain and efficiency of feed utilization was calculated for chicks fed all experimental rations. Amino acid availability (amino acid digestion and retention) from wheat and triticale was determined.

Results showed that triticale was approximately equal to wheat in supporting growth and efficiency of feed utilization with rations containing 2.5% animal tallow. Wheat-triticale combination rations yielded superior chick performance than either grain alone. Triticale rations showed a trend toward poorer chick performance. This was primarily the result of reducing soybean oil meal to maintain isonitrogenous rations. The addition of .10% DL-methionine and .10% L-lysine HCl to triticale rations improved chick performance to that observed with wheat rations. Metabolizable energy was similar for wheat, wheat-triticale and triticale rations. Glutamic acid and cystine were the most available amino acids from both wheat and triticale while glycine was the least available. Glycine and methionine were significantly more available from triticale than from wheat and lysine was approximately equally available from both grains.

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INTRODUCTION

Man has in the past relied heavily upon birds and animals to satisfy his dietary needs. He made use of their ability to convert high energy as well as the low protein more fibrous products of vegetable origin into superior quality readily utilizable animal protein. However, this nutritional tool is being challenged as population pressures increase and patterns of land use change. Efficiency of animal production therefore, must be improved in order that man may enjoy an abundant supply of animal products in the future.

Feed grains will play a major role in achieving this improvement in efficiency. Leisle (1968) suggested that feed grains do not necessarily meet the present standards for baking quality but have excellent nutritional value in terms of protein and available energy which, through greater yield per unit of land, provide an inexpensive source of feed for animal production.

Recently the new grain, triticale, a synthesized hexaploid species combining the genomes of *Triticum durum* and *Secale cereale* was developed (Sell *et al*. 1962). A number of varieties of triticale developed by the plant breeder have indicated in field trials comparable, if not superior, yields to wheat commonly grown in the area. In view of the potential agricultural value of triticale as a feed grain, a series of experimental trials were conducted to determine the nutritive value of this grain in terms of chick performance. The specific variety of triticale designated as 6A-67 and produced during the 1967 growing season was chosen for the chick trials. Experimental trials were conducted during the period from late 1967 to late 1968.

LITERATURE REVIEW

Replacement Value of Cereal Grains:

Numerous studies have been undertaken to evaluate cereal grains (e.g. wheat, barley, oats, and sorghum) in terms of broiler performance. In addition to supplying dietary energy, cereal grains contribute 1/3 to 2/3 of the dietary protein (Carpenter and Clegg, 1957 and Davidson et al., 1962).

Bearse (1948) achieved satisfactory results by replacing 1/2 of the corn in broiler rations with wheat. Biely et al. (1951) substituted wheat for corn in a corn-soybean ration. Substitution was on a pound for pound basis which resulted in no alteration in the growth promoting capacity of rations. However, when the higher protein content of wheat was taken into consideration (isonitrogenous rations), chick growth decreased with wheat-soybean rations. Growth depression also occured with replacement of corn by wheat on a pound for pound basis by changing the protein concentrate from soybean oil meal to fishmeal in chick rations. These studies suggested a difference in the protein composition of grains tested.

Slinger et al. (1958) concluded that Canadian No. 5 wheat was equal in energy value to U.S. No. 2 corn. Sibbald et al. (1960) reported superior weight gains of broilers fed a wheat-soybean ration. These investigators suggested that metabolizable energy (M.E.) of wheat was utilized more efficiently than M.E. of corn. However, M.E. content of wheat was shown to vary between 2.88 and 3.22 kcal./g. on a dry basis (Schumaier and McGinnis, 1967).

McDonald (1964) reviewed the replacement value of grains in poultry rations and concluded that there was no consistent advantage to using either corn or wheat in broiler rations. Inferior growth observed with isonitrogenous wheat rations was due to lowering of protein concentrates (soybean oil meal or fishmeal) of rations and not due to inferiority of wheat. Recent work of Herstad et al. (1966) and Sonne (1967) supported the hypothesis set forth by McDonald (1964).

The nutritive value of barley has received considerable attention during the past 15 years. Bearse (1952) reported that barley can replace 50% of the corn in a broiler ration without adversely affecting growth but feed efficiency was adversely affected. Lindblad et al. (1954) showed that 30% substitution of wheat by barley on a pound for pound basis supported optimum chick performance. Weight gains and feed consumption were reduced with barley substitution beyond 30% even when isocaloric and isonitrogenous rations were employed. These workers suggested that poorer performance was not due to differences in productive energy or digestible protein between barley and wheat rations but to poor palatability of barley rations. Addition of a flavouring material to barley rations resulted in improved feed consumption and weight gains.

Feed utilization of barley rations was improved by addition of 1 to 8% animal tallow (Slinger et al., 1952). Arscott et al. (1955) also observed improved growth and feed efficiency with the addition of fat to barley rations fed to broilers. However, these workers concluded that energy may be limiting but not the only factor responsible for poor performance of chicks. Fry et al. (1956) reported that chicks fed free-choice consumed approximately four times the amount of a corn ration compared to a barley ration. Addition of animal tallow to barley rations resulted in consumption approximately equal to that obtained by feeding corn rations. Therefore, differences in available energy and palatability of corn and barley apparently were the factors responsible for difference in feeding value.

Several methods have been employed to improve the nutritive value of barley. Pelleting improved the performance of chicks fed barley rations but was not the result of increased feed consumption (Lindblad et al., 1955 and Arscott et al., 1958). Water treatment of pearled barley before incorporation into rations improved growth and feed efficiency of chicks (Fry et al. 1957). Supplementation of fungal enzymes to barley rations resulted in growth and feed efficiency equal to that obtained with corn rations (Jensen et al. 1957). Dobson and Anderson (1958) showed improved feeding value of a hulless variety of barley by either water treatment or enzyme supplementation. Leong et al. (1958) observed changes in M.E. of barley with various treatments. Enzyme treatment increased M.E. from 1370 kcal./lb. to 1696 kcal./lb. while water treatment further increased M.E. to 1728 kcal./lb. The elevated M.E. of barley after enzyme supplementation or water treatment was probably due to greater availability of the fat, nitrogen, and nitrogen-free extract due to breakdown of cellular structure (Stutz and Matterson, 1961 and Potter et al., 1965). These results were confirmed by amylase, protease, lipase and cellulase treatment which also improved barley rations (Peterson and Sauter, 1968).

Carpenter and Clegg (1957) studied the relative protein value of Scottish oats, Canadian barley and Argentinian corn for the growing chick. Using isonitrogenous and isocaloric diets, these workers found that nitrogen retention was approximately equal for corn and oats but significantly lower for birds fed a barley ration. However, no difference in nitrogen retention was observed between corn and a mixture of corn, barley and oats. Davidson et al. (1962) showed the efficiency in conversion of dietary protein to body protein in growing chicks fed corn, wheat, oats and barley rations by carcass analysis. Protein of oats was converted better than barley and barley better than corn or wheat to body protein by chicks. These investigators suggested that relative lysine content of the grains tested may account for these results.

A combination of barley and corn or wheat in rations consistently yielded better chick growth and feed efficiency than barley alone (Anderson et al., 1961, Arscott, 1963 and Sonne, 1967). Therefore, it appears that grain combinations provided a better balance of amino acids or greater availability of protein and energy than was observed with a single grain in poultry rations.

Gerry (1958) showed that a ration containing oats resulted in chick growth and feed efficiency inferior to yellow corn rations. However, when James variety of hulless oats was fed, growth rate and feed efficiency were equal to yellow corn. Herstad et al. (1966) confirmed the finding that chick growth was depressed by feeding rations of ordinary oats at a level of 30% or more. McDonald (1964) suggested that inferior chick performance as a result of feeding rations high in oats was due to high fiber in oats. It was also suggested that low fiber of hulless oats was responsible for chick growth improvement.

McClymont (1952) reported that grain sorghum was a satisfactory replacement of wheat up to 28% of the growing chick ration. Harms et al. (1958 a,b) reported an inverse relationship between dietary level of grain sorghum and body weight gain in chicks. Corn rations resulted in significantly heavier body weights than rations containing 25, 50, 75 and 100% replacement of corn by grain sorghum. No attempt was made by these workers to equalize energy and amino acid differences between grain sorghum and corn rations. Later investigations by Hill et al. (1960) reported that M.E. of grain sorghum was 1480 kcal./lb. compared to 1560 kcal./lb. for yellow corn. It would appear that a difference of this magnitude may be sufficient to explain part of the difference observed by Harms et al. (1958 a,b).

Differences in relative amino acid content were shown as another factor involved in varying performance between grain sorghum and corn rations (Black and Weiss, 1956 and Waggle et al.,1967). Energy-protein interrelationships were also shown to affect the performance of poultry rations (Sunde, 1956 and Sibbald et al., 1961).

Ozment (1963) determined the relative nutritive value of four varieties of grain sorghum and yellow corn on an equivalent nutrient intake basis. When used on an equivalent intake basis, grain sorghum and yellow corn were of equal nutritive value for broilers. Bornstein and Bartov (1967) confirmed these results by reporting no difference in feeding value of isonitrogenous corn and grain sorghum rations.

Lysine was shown by Adrain and Sayerse (1957) and Mangay et al. (1957) as the first limiting amino acid in grain sorghum. Waggle et al. (1967) reported that sorghum rations were more limiting in methionine and glycine than lysine for chick growth. It was shown that, with grain sorghum as the only protein source in chick rations, lysine would probably be the first limiting amino acid but not in grain sorghum rations adequately supplied with protein concentrates such as soybean oil meal.

Stephenson et al. (1968) suggested that, due to the high variability in feeding value of grain sorghum, only 50% of the corn should be replaced with sorghum in rations for broiler chicks.

Although limited information is available on the nutritive value of triticale, it appears that triticale may be employed as an energy and protein source for broiler rations. Sell et al.(1962) tested triticale as the principal ingredient of chick starter rations and reported data suggesting that on a pound for pound basis, triticale was approximately equal to wheat but superior to barley in nutritive value for chicks. Ration M.E. were essentially the same between wheat and triticale rations. Rations containing 30 to 67% triticale supported weight gains of chicks through 3 weeks of age equal to that obtained with a wheat ration. Rations containing 30 to 45% triticale significantly improved feed efficiency over that obtained with wheat rations. However, with isonitrogenous wheat and triticale rations, weight gain and feed efficiency were significantly decreased on the triticale ration. These data suggested that protein quality of triticale was inferior to wheat for chick growth in a 20% vegetable protein ration. These investigators also suggested that lysine was the first limiting amino acid in a triticale ration.

Energy-Protein Interrelationships:

Yacowitz(1953) observed slow growth and high incidence of feather picking by increasing fat levels from 2.5 or 5.0% to 10 or 15% respectively with isonitrogenous rations. Hill and Dansky (1954) suggested that feed intake was essentially controlled by energy level of the ration. High energy rations low in protein resulted in depressed chick growth whereas high energy rations high in protein improved growth (March and Biely, 1954). Sunde (1954) suggested that with the addition of fat to a ration, it became necessary to re-evaluate the level of protein required.

Leong et al. (1959) reported that feed consumption was determined by both energy and protein content of the ration. Also, less total protein was required at each energy level provided that amino acids were more adequately balanced. Supplementation of crystalline amino acids was employed in these investigations to improve the dietary amino acid pattern. Twining et al. (1955) and Baldini and Rosenberg (1955) reported that the dietary methionine requirement was increased when dietary energy was increased. Other investigators showed that dietary lysine requirement also increased with an increase in dietary energy (Donovan et al. 1959). The amino acid requirement expressed per 1000 calories of energy was constant at all energy levels. Combs et al. (1964) reported a reduction of 5 to 8% in energy consumption due to improvement in the amino acid pattern of chick rations. It was suggested that high levels of certain amino acids may influence the voluntary consumption of energy by chicks. It was also suggested that voluntary consumption of energy was the result of amino acids, or corresponding metabolite, accumulation in blood. O'Neil et al. (1962) reported that an excess of protein in relation to energy did not adversely affect chick performance, however, there was some evidence to indicate that protein was converted to energy by chicks.

Methionine and Lysine Requirements for Broiler Chicks:

Although methionine and lysine requirements have been broadly established, it is necessary to constantly reassess and refine these requirements due to constant improvements in poultry genetics, nutrition and management.

Methionine:

Almquist (1952) concluded that total sulfur-containing amino acid requirement for the growing chick fed a 20% protein ration was 0.8% of the ration with methionine making up .45% and cystine .35%. As protein in the ration was increased, amino acid requirements, expressed as a percentage of the dietary protein decreased (Grau, 1948 and Almquist, 1952). However, amino acid requirements, expressed as percentage of the ration, increased as protein increased. Baldini and Rosenberg (1955) demonstrated a linear relationship between methionine and energy. Nelson et al. (1960) reported that the sulfur-containing amino acid requirement changed for chicks fed different levels of energy. However, it always remained at a constant 3.51% of protein necessary to balance dietary energy. Combs and Nicholson (1963) and Bornstein and Lipstein (1964) noted that a higher sulfur-containing amino acid requirement was necessary for maximum feed efficiency than for maximum chick growth. Bishop and Halloran (1968) using semi-purified rations demonstrated that average chick weight was closely correlated to the amount of sulfur-containing amino acids consumed. Maximum body weight of 704 grams (g.)

resulted from the consumption of 8.88g. of total sulfur-containing amino acids from one to 28 days of age.

National Research Council (1966) recommended that chick starting rations should contain .40% methionine and .35% cystine. Scott and Dean (1965) confirmed these recommendations for optimum chick growth using a crystalline amino acid diet (i.e. total protein replaced by pure synthetic amino acids).

Although all methionine isomers are utilized by the chick, not all isomers are of equal efficiency in promoting optimum chick performance. Marrett and Sunde (1965) reported that utilization of these isomers by chicks were dependent on the amino acid composition of rations, especially the D-amino acid form. Addition of D-methionine to crystalline L-amino acid rations resulted in more favourable chick growth whereas utilization of this methionine isomer decreased when added to D-amino acid rations. These investigators also reported that mixtures of 2/3 L-methionine and 1/3 methionine hydroxy analogue (M.H.A.) resulted in significantly better chick growth than M.H.A. alone or mixtures of 2/3 M.H.A. and 1/3 L-methionine.

Using purified rations, Bruggemann et al. (1962) reported that D-methionine was inferior to L-methionine in promoting chick growth. However, Tipton et al. (1966) used intact protein and reported L-methionine was only 92.5% as effective as D-methionine in promoting growth. These latter workers suggested that conflicting results with respect to nutritional equivalence of various methionine sources were due to type of ration used (intact protein vs. pure amino acids). Smith (1966)reported the decreasing order in efficiency of utilization as L-methionine, DL-methionine and M.H.A. respectively in crystalline amino acid rations. Tipton et al. (1965) showed that DL-methionine had 1.3 and 1.2 times the biological activity of M.H.A. on an equal weight and equimolar basis respectively. The average performance of M.H.A. treated chicks and DL-methionine treated chicks was equal when 90% M.H.A. was calculated as equivalent to 84.4% DL-methionine (Halloran and Bishop, 1966). Marrett and Sunde (1965) showed .80% L-methionine resulted in greater chick growth than .96% M.H.A. (the calculated equivalence of .80% L-methionine). Creger et al. (1968) reported that relative effectiveness of LMA-50 (methionine hydroxy analogue of 50% L-methionine activity) was equivalent to 50% L-methionine for growth promotion of semi-purified rations.

Many workers have noted a relationship between dietary fishmeal and methionine supplementation. Saxena and McGinnis (1952), Matterson et al. (1953) and Rosenberg et al. (1955) reported enhanced response to methionine supplementation of rations containing fishmeal. Baldini and Rosenberg (1955) interpreted the positive interaction between fishmeal and methionine as part of "methionine-energy dependence" whereby inclusion of fishmeal increased energy of the ration. Guttridge and Morgan (1959) and Evans et al. (1956) however, explained the positive methionine-fishmeal response by a difference in availability of sulfur-containing amino acids in various protein sources.

Bird and Mattingly (1945) reported a beneficial response from .2% DL-methionine supplementation which slightly exceeded the response from 4% fishmeal. Rations containing 5% fishmeal were reported by Romoser et al. (1961) as inadequate to meet the sulfur-containing amino acid requirement of chicks. Borstein and Lipstein (1961) reported no response to dietary methionine supplementation with 6% fishmeal rations unless ration energy was increased. However, these investigators (1964) observed a slight response to methionine supplementation of 9% fishmeal rations. Lower dietary methionine or poor availability of amino acid in feedstuffs were probably the two most important factors responsible for conflicting results obtained with dietary methionine and fishmeal.

Tamimie (1967) reported supplementation of 1.2% L-methionine to a 19% protein corn-soybean chick starter ration resulted in methionine toxicity symptoms. Methionine treated chicks weighed 41% less than untreated chicks and exhibited external deformities such as poor feather development; hock disorders; discoloured shanks, face and eyelids. These symptoms were more pronounced from zero to 4 weeks of age than from 4 to 8 weeks. Griminger and Fisher (1968) also showed growth depression in chicks fed 2.4% DL-methionine. Depression of growth with 2.4% M.H.A., however, was less than observed with excess DL-methionine.

Lysine:

Almquist and Mecchi (1942) were first to study the lysine requirement of chicks and reported that a 20% protein, semi-purified ration should contain .9% lysine. Higher dietary protein levels were later shown to result in a higher dietary lysine requirement for the chick (Grau, 1948). Milligan et al. (1951) reported that during the first six weeks of age, Rhode Island Red chicks fed a 21.1% protein ration required 1.0% lysine for optimum growth. Edwards et al. (1956) observed that the lysine requirement of chicks fed 20.5% protein, semi-purified ration was related to rate of growth. Slow growth required .9% whereas more rapid growth required 1.1% lysine. Donovan et al. (1959) concluded that the lysine requirement of growing chicks was dependent upon the energy content of rations. Optimum growth was observed with an 18.5% protein ration containing 923 kcal. P.E./lb. and 1.04% lysine while chicks fed a ration containing 1018 kcal. P.E./lb. required 1.12% lysine.

Dean and Scott (1965) reported that chicks fed a crystalline amino acid ration equal to 17.69% protein required 1.12% lysine for maximum response. N.R.C. (1966) recommended a lysine level of 1.10% for a 20% protein ration containing 2750 kcal. ME/kg. of ration.

Schwartz et al. (1959) observed no difference in the chick's ability to utilize lysine whether added in the free form or as a part of the protein structure. Although D-lysine was not toxic, Donovan (1957) reported that chicks were unable to utilize the D-isomer of lysine. Feeding levels of DL-lysine equated to L-lysine resulted in response equal to L-lysine. These data indicated that D-lysine was not utilized by the chick.

Chicks fed rations with 1.5 to 2.0% added L-lysine and adequate protein showed toxicity symptoms such as depressed growth, hyperirritability, nervousness, leg tremors and later leg weakness, (Jones, 1960). These data suggest that excess lysine in the tissue prevented development of a normal electrolyte pattern. This investigator stated that physiological immaturity of tissues made the very young chick susceptible to lysine toxicity. Squibb (1968) also reported depressed chick growth with excess levels of dietary L-lysine.

Availability of Amino Acids:

The availability of amino acids in feedstuffs for chicks have been shown to be influenced by a variety of factors. Geiger (1947) established that all essential amino acids must be present simultaneously to insure protein synthesis by the animal. The efficiency in utilization of dietary protein depended upon amino acid balance and the quantities required were determined by the genetic and physiological limitations of the chick (Almquist, 1954). Evans and McGinnis (1947) reported that amino acid availability of soybean oil meal was modified by the method of processing. De Muelenaere et al. (1967b) observed the influences of carbohydrates, amino acid patterns and calorie content of the ration upon lysine availability of corn and rice.

A number of methods have been developed to measure the biological value of protein. Mitchell (1924) used a nitrogen balance method with a nitrogen-free ration to obtain the "metabolic nitrogen" of the feces. The biological value of the protein was calculated as the percent of absorbed nitrogen (initial intake minus fecal nitrogen of dietary origin) that was not eliminated in the urine of rats. A microbiological assay for protein quality using Streptococcus zymogenes was employed by Ford (1960) and (1964) and Waterhouse (1964). Values for a variety of food proteins were found to correlate closely with those obtained in biological tests with rats. Miller et al. (1965b) used chick growth assays to determine available methionine in animal protein concentrates and reported a close correlation between this data and available methionine as measured by S. zymogenes. A chemical method for estimating lysine availability using 2-4-dinitrofluorobenzene was developed by Carpenter and Ellinger (1955). Carpenter (1960) and Miller et al. (1965b) showed that results of the chemical method was very similar to results obtained in chick studies. Price et al. (1953) hydrolyzed chick carcasses, excreta, and rations in determining availability of essential amino acids of the tissue. De Muelenaere et al. (1967b) determined available lysine in cereal products by both growth and fecal analysis methods.

Kuiken and Lyman (1948) determined the availability of amino acids in several foodstuffs for the rat. The availability was the difference between amount of amino acid ingested and the amino acid excreted in the feces. A low level of defatted whole egg protein was fed to obtain the metabolic fecal excretion of amino acids by the digestive system. The availability of ten essential amino acids in wheat ranged from 92.2 to 98.8%.

Ivy (1968) determined the availability of 17 amino acids in different varieties of grain sorghum using both surgically modified and normal broiler chicks. A nitrogen-free ration was fed to determine the metabolic and endogenous nitrogen. The amount of available amino acid was found to be dependent on the sorghum variety fed to chicks. Higher values of availability were generally obtained with surgically modified chicks than with normal chicks. This may be partially explained by the fact that Ivy et al. (1967) reported decreased amino acid excretion by the surgically modified chick following the operation.

EXPERIMENTAL PROCEDURE

Trial I:

Three hundred and sixty day-old straight-run commercial broiler chicks were randomly placed into 45 electrically heated battery pens with eight chicks per pen.

Nine dietary treatments included three levels of triticale (0, 50 and 100% triticale replacement of wheat), and three levels of animal tallow (0, 2.5 and 5.0%). Animal tallow was added at the expense of dextrose. Composition of the nine dietary treatments are shown in Table I. Treatment rations were isonitrogenous and fed *ad libitum* in mash form to chicks from one to 28 days of age. Each dietary treatment was randomly assigned to five pens. A 3 x 3 factorial arrangement of treatments in a randomized block design was employed.

Chick weights were recorded at the beginning of treatment period. Weight and feed consumption were recorded every seven days thereafter, whereas mortality was recorded daily. Individual chick weight gain, efficiency of feed utilization (feed/gain ratio), and incidence of impacted beaks were calculated weekly. Data were tested by analysis of variance (Snedecor, 1956) and multiple range analysis according to Duncan (1955).

Metabolizable energy (M.E.) was determined for basal rations T-0, T-50, and T-100 when chicks were 28 days of age. A representative sample of excreta was collected from four pens per dietary treatment on four consecutive days and immediately frozen. Later the four replicate samples per treatment were pooled, dried at 70°C, ground and stored in sealed plastic bags. The procedure described by Hill *et al.* (1960) was used for deter-

TABLE I. Composition of Experimental Rations[1].

Ingredient	T - 0			T - 50			T - 100		
	I	II	III	I	II	III	I	II	III
Wheat (14.44)	65.5	65.5	65.5	33.0	33.0	33.0			
Triticale (14.91)	-	-	-	33.0	33.0	33.0	66.0	66.0	66.0
SBOM (44)	20.0	20.0	20.0	19.5	19.5	19.5	19.5	19.5	19.5
Meat Scrap (50)	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
Fishmeal (60)	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
Dehyd. Alf. Meal (17)	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Dextrose	5.0	2.5	-	5.0	2.5	-	5.0	2.5	-
Deflur. Rock P.	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
Vit. Premix.[2]	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Min. Premix [3]	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Animal Tallow	-	2.5	5.0	-	2.5	5.0	-	2.5	5.0
Total (%)	100	100	100	100	100	100	100	100	100

1) Rations used in trial I.

2) Vitamin premix supplied the following per pound of ration: Vitamin A, 3250 I.U.; Vitamin D_3, 3721 I.C.U.; Vitamin E, 2.5 I.U.; Vitamin B_{12}, 5 mcg.; Vitamin K(menadione) 0.5 mg.; Riboflavin, 2.5 mg.; Niacin, 7.5 mg.; Pantothenic acid, 5.0 mg.; Choline, 175 mg.; Pen - Strep, 4 mg. and 12 mg.

3) Salt and trace mineral mix supplied the following per pound of ration: Sodium Chloride, 2.1 gm.; Zinc, 5 mg.; Manganese, 37 mg.; Iron, 16 mg.; Copper 3 mg.

mination of metabolizable energy. Chromic oxide in feed and excreta was determined by the method described by Czarnocki et al. (1961). Heat of combustion of feed and excreta was determined with a Parr adiabatic calorimeter. Nitrogen in feed and excreta was determined by macrokjeldahl technique described by the Association of Official Agricultural Chemists (1960). M.E. was calculated by the following formula:

$$M.E. = A(B \times C/D) - 8.22 \left(E - (F \times C/D) \right)$$

where:

A = gross energy of feed (kcal./g.).

B= gross energy of excreta (kcal./g.).

C= chromic oxide content of feed (%).

D= chromic oxide content of excreta (%).

E= nitrogen/g. of feed.

F= nitrogen/g. of excreta.

M.E. of the dietary treatments supplemented with animal tallow were calculated using M.E. values of unsupplemented rations T-0, T-50, and T-100.

Samples of rations T-0, T-50 and T-100 were hydrolyzed by modification of the procedure according to Bragg et al. (1966). Hydrolyzing time was 15 hours and amino acids were eluted with a pH 2.2 sodium citrate buffer. Amino acids were determined by the method of Benson and Patterson (1965).

Trial II:

Five hundred day-old straight-run commercial broiler chicks were placed in electrically-heated battery brooders with raised wire floors. Chicks were fed a 21% protein wheat-soybean ration in mash form for three days. Four hundred and eighty healthy chicks were randomly placed in 48 pens in groups of 10 chicks per pen.

Twelve dietary treatments (Table II) included four supplemental levels of Dl-methionine (.00, .05, .10 and .15%) and three levels of triticale (0, 50 and 100% triticale replacement of wheat). Rations were isocaloric, isonitrogenous and equated for lysine content by appropriate additions of L-lysine HCl. Composition of the three basal rations are shown in Table III. Each treatment ration was fed ad libitum in pellet form to four pens of chicks. A 3 x 4 factorial arrangement of treatments in a randomized block design was employed during an experimental period of 28 days (three days to 31 days of age).

Samples of wheat and triticale were hydrolyzed and amino acid content determined as described in Trial I.

Trial III:

Five hundred and ten day-old straight-run commercial broiler chicks were randomly distributed into an electrically-heated battery. The chicks were divided into 51 experimental pens of 10 birds each.

Sixteen dietary treatments (Table IV) included four levels of DL-methionine (.00, .05, .10 and .20%) and four levels of L-lysine HCl (.00, .05, .10 and .20%) added to 21% protein basal triticale-soybean ration (T-100, Table III). A seventeenth dietary treatment consisting of unsupplemented 21% protein wheat-soybean ration (T-0, Table III) was also included as a control. Treatment rations were fed ad libitum in pellet form to chicks from one to 28 days of age. Each treatment was randomly assigned to three pens in a random block experimental design.

TABLE II. Trial II. Outline of Experimental Treatments.

Ration No.		TREATMENTS[1]	
	Basal	Lysine %	Methionine %
I	T - 0	.00	.00
II	T - 0	.00	.05
III	T - 0	.00	.10
IV	T - 0	.00	.15
V	T - 50	.07	.00
VI	T - 50	.07	.05
VII	T - 50	.07	.10
VIII	T - 50	.07	.15
IX	T - 100	.14	.00
X	T - 100	.14	.05
XI	T - 100	.14	.10
XII	T - 100	.14	.15

1. Lysine and methionine added to basal rations.

TABLE III. Composition of Basal Rations [1]

Ingredient	T - 0	T - 50	T - 100
Wheat (13.27)	65.0	34.5	--
Triticale (14.91)	--	32.5	69.5
Soybean Oil Meal (44)	25.0	23.0	20.5
Fishmeal (60)	3.0	3.0	3.0
Dehyd. Alf. Meal (17)	1.0	1.0	1.0
Deflur. Rock P.	2.0	2.0	2.0
Vitamin Premix [2]	1.0	1.0	1.0
Mineral Premix [3]	0.5	0.5	0.5
Animal Tallow	2.5	2.5	2.5
Total	100.0	100.0	100.0
% Protein (N. x 6.25)	21.73	21.40	22.05

1. Rations employed in Trials II and III.

2. Same as in Trial I.

3. Same as in Trial I.

TABLE IV. Trial III. Outline of Experimental Treatments.

Ration No.	Basal[2]	TREATMENTS[1]	
		Methionine %	Lysine %
I	T - 0	.00	.00
II	T - 100	.00	.00
III	T - 100	.05	.00
IV	T - 100	.10	.00
V	T - 100	.20	.00
VI	T - 100	.00	.05
VII	T - 100	.00	.10
VIII	T - 100	.00	.20
IX	T - 100	.05	.05
X	T - 100	.05	.10
XI	T - 100	.05	.20
XII	T - 100	.10	.05
XIII	T - 100	.10	.10
XIV	T - 100	.10	.20
XV	T - 100	.20	.05
XVI	T - 100	.20	.10
XVII	T - 100	.20	.20

1. Lysine and methionine added to basal rations.
2. Basal rations shown in Table III.

Relative amino acid content of basal rations (T-0 and T-100) was determined prior to beginning the trial as described in Trial I.

Initial chick weight was recorded on a pen basis at the beginning of the trial. Chicks were weighed at seven day intervals throughout the experimental periods for both trial II and III. Feed consumption was recorded weekly for each pen and mortality was recorded daily. Individual chick weight gain and efficiency of feed utilization (F/G) were calculated weekly in both trials.

Data recorded and calculated in trials II and III were subjected to analysis of variance (Snedecor, 1956) and multiple range comparisons were made according to Duncan 1955.

Trial IV:

Amino acid availability of triticale and wheat were determined according to modifications of the procedure described by Ivy (1968). Six chicks at 28 days of age were placed in individual metabolism cages. Centres were removed from caps of 30 ml. plastic bottles resulting in threaded cap rings. Cap rings were sutured to the skin around the vent of each chick so that the centre opening of the ring fitted over the vent.

Chicks at 28 days of age were fed ad libitum a basal 21% protein wheat-soybean ration, containing 0.3% ferric oxide, for 12 hours. They were then fasted for 12 hours and thereafter fed ad libitum a non-protein diet (Table V) for four hours. Excreta collection bottles (30 ml.) were fitted to cap rings around the vent 1½ hours after initiation of non-protein diet. Following a second fasting of two hours, chicks were again fed the basal ration for three hours. Excreta was collected until the red colour of

TABLE V. Trial IV. Composition of Non-Protein Diet.

Ingredient	Percent (%)
Dextrose	75
Cellulose	20
Corn Oil	5
Total	100.0

ferric oxide appeared. Collection bottles were removed and contents transferred to 100 ml. plastic storage containers and frozen.

Following another 12 hour fasting period, procedure was repeated with test protein (wheat) used in place of non-protein diet. Feed consumption of test protein per chick was recorded.

Cap rings were removed and six new 28 day-old chicks were prepared as described above. Feeding and collecting procedure was repeated with triticale as the test protein.

Excreta samples were dried at 60°C and individual dry excreta weight determined. Non-protein excreta was pooled for both test protein trials. Amino acid content of test protein, protein excreta and non-protein excreta were determined according to procedure described in Trial I.

Percent availability to the chick of 17 amino acids from wheat and triticale was calculated by the following formula:

$$\text{\% A.A. Availability} = \frac{A - (B - C)}{A} \times 100$$

where:

A = total amino acid ingested (mg.).

B = total amino acid in protein excreta (mg.).

C = total amino acid in non-protein excreta (mg.).

Data was tested by analysis of variance (Snedecor, 1956) and multiple range comparisons made according to Duncan, 1955.

RESULTS AND DISCUSSION

Trial I.

Weight gain (Table VI) was not significantly different among chicks fed wheat (T-0),wheat-triticale (T-50) or triticale (T-100) rations without animal tallow. There was however, a 9.8 percent depression of weight gain observed by the addition of triticale at the expense of wheat in the T-50 ration and a 9.6 percent depression in the T-100 ration. The addition of a 2.5% dietary animal tallow (medium energy) produced a growth response sufficient to overcome the depression observed with triticale rations. The ration containing 5% animal tallow (high energy) improved chick growth with the wheat-triticale combination which was significantly greater than observed with no animal tallow (low energy T-50). Five percent dietary animal tallow had no effect on weight gain of chicks fed the wheat ration (T-0) but produced a depression ($P < 0.01$) with the triticale ration (T-100) as compared to triticale with 2.5% dietary animal tallow.

Efficiency of feed utilization (feed per gain ratio) was not significantly different between chicks fed wheat (T-0), wheat-triticale (T-50) or triticale (T-100) rations without animal tallow (Table VI). A slight improvement was observed however with the wheat-triticale ration whereas a slight depression occurred with the all triticale ration as compared to the all wheat ration. Addition of 2.5% animal tallow improved feed per gain ratio of chicks fed T-0 and T-100 rations in relation to that of chicks fed T-50 rations. A further increase in dietary animal tallow to 5% of the ration resulted in a further improvement with T-0 and T-50 rations while the feed per gain ratio of chicks fed T-100 ration was significantly depressed in comparison to medium and high energy T-0 and high

TABLE VI. Trial I. Effect of Dietary Triticale and Energy on Chick Performance.

Dietary Treatment	Feed/Gain	Wt. Gain (g.)[2]	Feed Intake (g.)
T - 0 + 0% fat	1.81^{ABC}	504.9^{ABC}	6,882.6
" + 2.5% fat	1.73^{AC}	536.2^{BC}	7,250.4
" + 5.0% fat	1.67^{A}	529.3^{BC}	7,071.0
T - 50 + 0% fat	1.77^{ABC}	455.2^{AC}	6,387.4
" + 2.5% fat	1.78^{ABC}	526.1^{BC}	7,096.8
" + 5.0% fat	1.73^{AC}	549.8^{B}	7,190.6
T - 100 + 0% fat	1.91^{BC}	456.3^{AC}	6,452.8
" + 2.5% fat	1.81^{ABC}	520.7^{BC}	7,348.4
" + 5.0% fat	1.94^{B}	434.9^{A}	6,120.8

1. Means of 5 replicate pens of 8 birds each.
2. Means not having the same superscript are significantly different ($P < 0.01$).

energy T-50.

Maximum weight gain was achieved by chicks fed the combination wheat-triticale ration supplemented with 5.0% animal tallow. It appeared that a combination of the two grains provided a better balance of amino acids or greater availability of protein and energy for growth and efficiency of feed utilization than was provided by either grain alone. This was also observed by Anderson et al. (1961) and Arscott (1963).

Metabolizable energy (M.E.) data (Table VII) revealed little difference in energy between T-0 and T-100 rations which was similar to results reported by Sell et al. (1962) relative to energy in wheat and triticale rations. Although the wheat-triticale combination ration was slightly lower in M.E. compared to wheat or triticale rations, analyzed valued of all three basal rations were within experimental error of procedures employed, eliminating any possibility of a significant difference in M.E. among wheat, triticale or wheat-triticale combination rations.

Therefore differences in chick performance among rations of varying triticale content was not due to M.E. in the rations. Differences in protein content or amino acid patterns of the rations may explain the observed differences in chick performance. These differences would have been accentuated to a critical extent as ration energy was increased resulting in decreased feed intake as suggested by Baldini and Rosenberg (1955) and Nelson et al. (1960).

Variations in amino acid content of the three basal rations (Table VIII) were due in part to variation in amino acids between wheat and triticale used in the rations. In an attempt to make all rations isonitrogenous, soybean oil meal content was reduced 0.5% in T-50 and

TABLE VII. Trial I. Metabolizable Energy and Protein Content of Dietary Treatments.

Dietary Treatment	M.E. kcal./kg.	Protein (%) (N x 6.25)
T - 0 + 0% fat	2810	22.4
" + 2.5% fat	2910	22.0
" + 5.0% fat	3010	21.6
T - 50 + 0% fat	2760	21.1
" + 2.5% fat	2860	22.0
" + 5.0% fat	2960	21.8
T - 100 + 0% fat	2830	21.8
" + 2.5% fat	2930	22.2
" + 5.0% fat	3030	21.1

TABLE VIII. Trial I. Amino Acid Content of Basal Rations.

	PERCENT		
Amino Acid	T - 0	T - 50	T - 100
Lysine	1.047	1.041	1.130
Histidine	.489	.441	.494
Arginine	1.314	1.229	1.396
Aspartic Acid	1.725	1.825	1.738
Threonine	.637	.714	.722
Serine	.941	1.015	.852
Glutamic Acid	6.201	5.785	5.586
Proline	1.664	1.502	1.468
Glycine	.920	.870	.829
Alanine	1.016	.893	.891
Cystine	.183	.165	.172
Valine	.971	.928	.946
Methionine	.355	.333	.282
Isoleucine	.863	.816	.783
Leucine	1.682	1.561	1.499
Tyrosine	.723	.659	.755
Phenylalanine	1.151	1.011	1.119

T-100. This would account for a small amount of variation in individual amino acids. An interesting feature of the amino acid make-up (Table VIII) of T-50 and T-100 basal rations was a decreasing methionine level with increasing dietary triticale which indicated a lower methionine content in triticale.

Poor chick performance on the high energy (5% animal tallow) triticale (T-100) ration may therefore be explained by a reduction in feed consumption (Table VI) to the extent that protein became limiting for chick performance. This ration had the highest energy and lowest protein content of all dietary treatments (Table VII). Methionine in particular was probably limiting at this high energy level, creating an amino acid imbalance. Reduced feed consumption (Table VI) further supports the hypothesis that high energy induced the dietary amino acid imbalance. This concept of a energy-amino acid relationship was demonstrated in the work of Leong _et al_. (1959). Inferior feed per gain ratio of chicks fed the high energy all triticale ration (Table VI) also supports this hypothesis.

Hill and Dansky (1954) reported that feed consumption was essentially controlled by energy content of a ration. Differences in feed consumption (Table VI) were not significant, however chicks receiving the low energy rations generally had the lowest feed intake of all dietary treatments. Addition of 2.5% animal tallow improved feed intake of all three basal rations while addition of 5% animal tallow only slightly decreased feed consumption of T-0 and T-50 rations but very markedly reduced feed intake of T-100 ration. Lippincott and Card (1950) and Heuser (1955) demonstrated that physical condition influenced ration palatability, resulting in decreased feed intake. This was the case with low energy but not high energy rations. The incidence of impacted beaks (Table IX) reflected the physical condition of the experimental rations. There was a significantly greater number of impacted beaks with chicks fed low energy (zero animal tallow) rations. There was also a significantly greater degree of impacted beaks for chicks fed all triticale rations (T-100) as compared to those fed all wheat rations (T-0) which may account for the poor growth observed with T-100 ration fed chicks as compared to chicks fed T-0 rations.

Inferior feed intake of triticale rations compared to several grain rations have been reported for animal species other than poultry. Larter (1968) noted that comsumption of triticale rations was inferior to that of barley rations fed to hogs and cattle. This worker suggested that a low level of ergot contamination in the triticale was responsible for the depressed feed intake. However, Bragg and Salem (1969) observed no reduction in feed intake by broiler chicks fed triticale rations containing ergot at .4% of the ration. The ergot content of the triticale used in the present study was less than .1% of the grain by weight (0.9404 gms. ergot per kg. of triticale). Therefore, reduction in feed consumption observed in this trial was not due to the ergot content of the rations. Reduced feed consumption observed with the unsupplemented all wheat ration further suggested that the depressed feed intake of the unsupplemented all triticale ration was related to physical condition (palatability) rather than ergot contamination.

Metabolizable energy content of the unsupplemented basal ration met the energy requirements recommended by N.R.C. (1966). Therefore, inferior chick performance observed with these rations was not due to low energy but rather to decreased feed intake as a result of the poor physical condition

TABLE IX. Trial I. Effect of Dietary Triticale and Animal Tallow on Incidence of Impacted Beaks[1].

Dietary Treatment	Impacted Beaks[2]
T - 0 + 0% fat	20^{BCD}
" + 2.5% fat	1^{A}
" + 5.0% fat	0^{A}
T - 50 + 0% fat	22^{BD}
" + 2.5% fat	9^{AC}
" + 5.0% fat	2^{A}
T - 100 + 0% fat	30^{B}
" + 2.5% fat	12^{AD}
" + 5.0% fat	1^{A}

1 - Total number of impacted beaks in 5 replicate pens of 8 birds each per dietary treatment.

2 - Totals not having the same superscripts are significantly different ($P < 0.01$).

of the feed. The addition of 2.5% animal tallow improved the physical condition which increased feed intake sufficiently to produce maximum chick performance.

Trial II.

Weight gain (Table X) was not significantly different among chicks fed unsupplemented wheat (T-0), wheat-triticale (T-50) and triticale (T-100) rations. There was, however, an improvement in growth as triticale was substituted at the expense of wheat in the T-50 and T-100 rations as compared to the wheat (T-0) ration. Addition of .05% DL-methionine to the T-0 ration resulted in a growth response that approached significance as compared to unsupplemented T-0 ration. The same addition of DL-methionine to the basal T-100 ration resulted in significant improvement in weight gain as compared to the unsupplemented T-100 ration while addition of .05% DL-methionine to the T-50 ration produced only slight improvement in weight gain. Further additions of DL-methionine to the three basal rations had little effect on weight gain with the exception of a slight depression with .10% DL-methionine added to the T-0 ration as compared to T-0 with .05% and .15% DL-methionine supplementation.

Efficiency of feed utilization (feed per gain ratio) was not significantly different (Table XI) among chicks fed unsupplemented wheat, wheat-triticale and triticale rations. Substitution of triticale for wheat (rations T-50 and T-100) improved the feed per gain ratio with greatest efficiency observed among chicks fed the T-50 ration. Supplementation of the three basal rations with DL-methionine improved, but not significantly, the feed per gain ratio as compared to unsupplemented basal rations. Maximum feed per gain ratio was 1.81, 1.80, and 1.77 for chicks fed T-0 and

TABLE X. Trial II. Effect of Dietary Triticale and DL-Methionine Supplementation on Weight Gain[1].

T - 0		T - 50		T - 100	
Meth %	Wt. Gain (g.)[2]	Meth %	Wt. Gain (g.)	Meth %	Wt. Gain (g.)
.00	528.4^{A}	.00	561.7^{ABC}	.00	536.1^{AC}
.05	565.3^{ABC}	.05	571.1^{BC}	.05	575.6^{B}
.10	534.0^{AC}	.10	560.5^{ABC}	.10	566.4^{ABC}
.15	556.6^{ABC}	.15	565.6^{ABC}	.15	568.1^{BC}

1 - Means of four replicate pens of 10 chicks each.

2 - Means not having the same superscript are significantly different ($P < 0.05$) among methionine levels and triticale levels.

TABLE XI. Trial II. Effect of Dietary Triticale and DL-Methionine Supplementation on Feed Per Gain Ratio[1].

T - 0		T - 50		T - 100	
Meth %	F/G	Meth %	F/G	Meth %	F/G
.00	1.90±.03[2]	.00	1.81±.04	.00	1.85±.02
.05	1.81±.06	.05	1.86±.02	.05	1.82±.04
.10	1.87±.10	.10	1.80±.04	.10	1.81±.05
.15	1.81±.05	.15	1.82±.06	.15	1.77±.06

1 - Means of four replicate pens of 10 chicks each.

2 - Standard deviation of the means.

.05% DL-methionine, T-50 and .10% DL-methionine and T-100 and .15% DL-methionine rations respectively, suggesting a methionine-triticale interaction.

Superior weight gain observed by chicks fed unsupplemented T-50 rations as compared to chicks fed either T-0 or T-100 unsupplemented rations adds further support to the hypothesis suggested in Trial I. Rations composed of combinations of grains provided a more suitable balance of amino acids or greater availability of protein than individual grain rations. The significant response in weight gain of chicks fed ration T-100 supplemented with .05% DL-methionine suggested that basal ration T-100 was limiting in methionine as was also indicated in Trial I. Basal ration T-0 was also limiting in methionine since the weight gain response to addition of .05% DL-methionine approached significance.

Comparative amino acid content of the wheat and triticale used in formulating the dietary treatments is shown in Table XII. It was assumed, on the basis of the amino acid content of a previous sample of triticale, that the lysine content of triticale was lower than that of wheat. Therefore .07% and .14% L-lysine HCl was added to basal rations T-50 and T-100 respectively to equalize the lysine content of all three basal rations. However, it was observed that the lysine content of the wheat and triticale used in this trial was .362% and .439% respectively (Table XII). Therefore the original assumption was erroneous and the lysine content was not equal for all basal rations but was higher in the triticale rations as compared to the wheat rations. Superior chick performance with basal T-50 and T-100 rations compared to basal rations T-0 was no doubt a reflection of the lysine additions and not a reflection of the substitutive ability of triticale for wheat alone.

TABLE XII. Amino Acid Content of Triticale and Wheat [1,2].

Amino Acid	Triticale	Wheat
Lysine	.439	.362
Histidine	.296	.287
Arginine	.710	.604
Aspartic Acid	.879	.687
Threonine	.421	.391
Serine	.621	.609
Glutamic Acid	4.851	5.241
Proline	1.196	1.394
Glycine	.673	.627
Alanine	.465	.394
Cystine	.163	.136
Valine	.578	.543
Methionine	.204	.180
Isoleucine	.461	.436
Leucine	.910	.894
Tyrosine	.417	.384
Phenylalanine	.633	.645
% Protein (N x 6.25)	14.91	13.27

1 - Percent of grain.

2 - Used in Trials II and III.

The data (Tables X and XI) demonstrated a higher methionine requirement for maximum efficiency of feed utilization than for maximum chick growth. Similar observations were reported by Combs (1963) and Bornstein and Lipstein (1964). The methionine-triticale interaction observed with feed per gain data (Table XI) suggested that methionine level either decreased or was not as available to the chick as the triticale in the ration increased. The methionine content of wheat and triticale was found to be .180% and .204% respectively (Table XII). Therefore the need for greater supplementary methionine with increased triticale in the ration was not due to a lower methionine content of triticale compared to wheat. Since the protein content of the wheat used in this Trial was lower than that used in Trial I, the soybean oil meal portion of basal rations T-50 and T-100 was reduced to 23.0% and 20.5% respectively from 25% of ration T-0. This was necessary to make all dietary treatments isonitrogenous. No doubt the methionine content of rations T-50 and T-100 was reduced as a result of reducing the soybean oil meal portion of the rations. McDonald (1964) applied similar reasoning to explain inferior growth with wheat rations made isonitrogenous with corn rations.

Efficiency of feed utilization data (Table XI), which was already shown to be a more sensitive criterion of methionine adequacy than weight gain, suggested that the methionine content in basal rations T-50 and T-100 was lower than in basal ration T-0.

Trial III.

Weight gain (Table XIII) of chicks fed basal T-100 ration was lower than that of chicks fed basal T-0 ration. Although differences were not significant, additions of .10% DL-methionine and .10% L-lysine HCl to the basal T-100 was necessary to improve weight gain to that achieved by chicks fed the basal T-0 ration.

Feed per gain ratio (Table XIV) were almost identical for chicks fed the basal T-0 and basal T-100 rations. Additions of .10% DL-methionine and .10% L-lysine HCl to basal T-100 ration improved the feed per gain ratio, however, differences were not significant.

Methionine and lysine levels in basal ration T-100 was somewhat lower than in basal ration T-0 (Table XV). This was not due to the triticale substitution of wheat since it was shown in Trial II that triticale contained a higher content of lysine and methionine than wheat (Table XII). Reduction of soybean oil meal from 25.0% of ration T-0 to 20.5% of ration T-100 was necessary in both Trials II and III to make all dietary treatments isonitrogenous. This decreased the lysine and methionine levels of T-100 ration to such an extent that these amino acids became limiting for optimum chick performance. Lower weight gain by chicks fed basal T-100 ration as compared to chicks fed basal T-0 ration reflected this amino acid limitation. The addition of .10% L-lysine HCl and .10% DL-methionine increased the lysine and methionine levels of T-100 to that of T-0. Equalization of these two amino acids in both basal rations resulted in approximately equal weight gain but slightly superior feed per gain ratio by chicks fed the supplemented T-100 ration. This latter observation was probably due to a general improvement of the amino acid pattern of supplemented T-100.

TABLE XIII. Trial III. Effect of Dietary Triticale, Lysine and Methionine on Weight Gain.

Meth. Level(%)[3]	Lysine Level (%)[3] .00	.05	.10	.20
.00	506.3±65.6[1]	500.1±36.1	515.4±10.9	507.4±6.3
	537.2±10.8[2]			
.05	511.1±11.1	520.4±15.3	495.7±18.8	515.2±9.3
.10	510.4±23.1	514.9±13.1	530.5±16.1	514.9±19.9
.20	509.0±28.8	513.5±14.6	476.8±26.8	508.4±36.1

1 - Mean and standard deviation of the means of three replicate pens of 10 chicks each.

2 - Basal-wheat - soybean ration (T-0).

3 - Lysine and methionine added to basal rations.

TABLE XIV. Trial III. Effect of Dietary Triticale, Lysine and Methionine of Feed Per Gain Ratio.

Meth. Level (%)[3]	Lysine Level (%)[3] .00	.05	.10	.20
.00	1.91±.09[1]	1.98±.06	1.99±.07	1.94±.03
	1.92±.02[2]			
.05	1.94±.07	1.92±.08	1.98±.13	1.98±.03
.10	1.91±.05	1.91±.02	1.85±.03	1.88±.04
.20	1.95±.03	1.92±.08	1.96±.09	1.96±.13

1 - Mean and standard deviation of the means of three replicate pens of 10 chicks each.

2 - Basal wheat-soybean ration (T-0).

3 - Lysine and methionine added to basal rations.

TABLE XV. Trial III. Amino Acid Content of Basal Rations T - 0 and T - 100.

Amino Acid	T - 0	T - 100
Lysine	1.086	.922
Histidine	.514	.411
Arginine	1.279	1.106
Aspartic Acid	1.846	1.696
Threonine	.776	.692
Serine	1.052	.912
Glutamic Acid	6.439	5.662
Proline	1.515	1.482
Glycine	.919	.822
Alanine	.912	.898
Cystine	.160	.162
Valine	.948	.858
Methionine	.375	.294
Isoleucine	.847	.748
Leucine	1.579	1.426
Tyrosine	.678	.599
Phenylalanine	1.046	.922
% Protein (N x 6.25)	21.93	21.59

Inferior weight gain of chicks fed basal T-100 ration as compared to chicks fed basal T-0 ration in this trial supports the hypothesis given in Trial II that superior weight gain with T-100 compared to T-0 was due to the addition of L-lysine HCl to the T-100 ration. Differences in the analyzed and calculated levels of lysine in triticale accounted for the lysine additions in the previous trial. Growth data of Trial III were in agreement with the analyzed amino acid contents of the basal rations.

Sell et al. (1962) reported that lysine and methionine were limiting for chick growth when chicks were fed a 21% protein triticale-soybean ration. These workers further reported a significant depression in chick performance by chicks fed triticale rations made isonitrogenous with wheat rations. It was suggested that the lysine and methionine content of triticale was inadequate in 21% triticale rations to satisfy the growing chick's requirement for optimum performance.

The results of the present trial were not as conclusive as those reported by Sell et al. (1962) possibly because of the much higher protein content (18.42%) of the triticale employed in their studies. The high protein level would have necessitated drastic reductions in the soybean oil meal content of their triticale rations when made isonitrogenous with rations containing wheat of lower protein levels (14.18%). However, trends observed in the present trial appear to substantiate the results reported by Sell et al. (1962).

Trial IV.

Amino acid availability to the growing chick of wheat and triticale protein was measured for samples employed in Trials II and III. Availability was a measure of digestion and retention of amino acids by the chick.

Percent amino acid available from wheat and triticale is shown in Table XVI. Analysis of variance for these data are shown in Appendix Table IX.

Among the 17 amino acids of wheat studied, glutamic acid and cystine were respectively the first and second most available to chicks. Glycine and methionine were least ($P < 0.01$) available from wheat. Differences in the availabilities of the remaining amino acids of wheat were not significant.

Among the amino acids of triticale studies, cystine showed greatest availability and glutamic acid was the second most available to chicks. Glycine was again found to be the least available, which was significantly lower than that of cystine.

A comparison of amino acid availabilities between wheat and triticale revealed a general similarity with a few exceptions. Glycine of triticale was more ($P < 0.01$) available to chicks than glycine of wheat. Methionine of triticale was more ($P < 0.05$) available than methionine of wheat. Means availability for 17 amino acids in triticale was slightly but not significantly greater than that of wheat. Availability of lysine, which was of particular interest to this investigation, was approximately equal for the two grains. It was also of interest to note that methionine of triticale was more available to the growing chick than methionine of wheat. Differences in chick performance observed in Trials I and III between wheat and triticale rations fed to chicks were therefore not due to methionine availability in wheat and triticale.

Variation among individual chicks or replicates within treatments ($P < 0.05$) was apparently due to greater variation observed with triticale fed chicks than chicks fed wheat. This was suggested by the greater standard deviation (Table XVI) for triticale than wheat.

TABLE XVI. Trial IV. Amino Acid Availability of Wheat and Triticale to Growing Chicks.

Amino Acid	PERCENT[2]	
	Wheat[1]	Triticale[1]
Lysine	94.3^{C}	93.4^{AB}
Histidine	95.5^{C}	95.9^{AB}
Arginine	92.0^{BC}	92.0^{AB}
Aspartic Acid	91.9^{BC}	92.4^{AB}
Threonine	92.7^{BC}	91.7^{AB}
Serine	94.5^{C}	94.7^{AB}
Glutamic Acid	97.5^{C}	97.3^{AB}
Proline	96.6^{C}	97.2^{AB}
Glycine	70.8^{A}	85.2^{A}
Alanine	89.9^{BC}	90.3^{AB}
Cystine	96.1^{C}	98.3^{B}
Valine	92.2^{BC}	92.3^{AB}
Methionine	81.8^{B}	90.9^{AB}
Isoleucine	94.2^{C}	93.0^{AB}
Leucine	95.2^{C}	94.7^{AB}
Tyrosine	94.3^{C}	94.6^{AB}
Phenylalanine	95.8^{C}	95.8^{AB}
Means[3]	92.1 ± 1.90	93.6 ± 4.66

1 - Means of six individual chicks.

2 - Means not having the same superscript are significantly different ($P < 0.01$).

3 - Means of 17 amino acids with standard deviation.

SUMMARY AND CONCLUSIONS

Fifteen hundred and sixty-two commercial type broiler chicks were employed in three feeding trials and a test of amino acid availability to determine the nutritive value of triticale. Weight gain, efficiency of feed utilization and availability of energy and amino acids were the main criteria for the evaluation of triticale.

Results showed that triticale was approximately equal to wheat in supporting growth and efficiency of feed utilization with rations containing 2.5% animal tallow. Wheat-triticale combination rations showed generally better chick performance than either grain alone. Triticale rations showed a trend toward poorer chick performance, which was primarily the result of reducing soybean oil meal in order to maintain isonitrogenous rations. Supplementation of 0.1% DL-methionine and 0.1% L-lysine HCl to triticale rations equalized the lysine and methionine content of wheat and triticale rations resulting in approximately equal chick performance.

Metabolizable energy was similar for wheat, wheat-triticale and triticale rations. Glutamic acid and cystine were the most available amino acids to the growing chick from both wheat and triticale while glycine was the least available from the two grains. Glycine and methionine were significantly more available from triticale than wheat and lysine was approximately equally available from the two grains.

Triticale may replace 100% of the wheat in a 21% wheat-soybean ration without adverse effects on chick performance if palatability is improved with addition of 2.5% animal tallow and appropriate addition of lysine and methionine to compensate for reduced soybean oil meal content of triticale rations.

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A P P E N D I X

APPENDIX TABLE I. Trial I. Analysis of Variance of Weight Gain of Broiler Chicks Fed Different Levels of Dietary Energy and Triticale.

Source	DF	SS	MS	F
Total	44	145,345	--	--
Treatment	8	69,638	8,704.8	4.185**
Triticale	2	22,733	11,366.5	5.465**
Animal Tallow	2	23,393	11,696.5	5.624**
Trit. x An. Tallow	4	23,512	5,878.0	2.826*
Replication	4	9,149	2,287.3	1.100
Error	32	66,558	2,079.9	

* Statistically significant at $P < 0.05$.

** Statistically significant at $P < 0.01$.

APPENDIX TABLE II. Trial I. Analysis of Variance of Feed Per Gain Ratio of Broiler Chicks Fed Different Levels of Dietary Energy and Triticale.

Source	DF	SS	MS	F
Total	44	.751	--	--
Treatment	8	.299	.037	2.763*
Triticale	2	.190	.095	7.030**
Animal Tallow	2	.031	.016	1.163
Trit. x An. Tallow	4	.077	.019	1.430
Replication	4	.022	.006	.407
Error	32	.431	.014	

* Statistically significant at $P < 0.05$.

** Statistically significant at $P < 0.01$.

APPENDIX TABLE III. Trial I. Analysis of Variance of Feed Consumption of Broiler Chicks Fed Different Levels of Dietary Energy and Triticale.

Source	DF	SS	MS	F
Total	44	3,357,146,700	--	--
Treatment	8	7,682,590	960,323	.009
Triticale	2	1,383,492	691,746	.006
Animal Tallow	2	3,361,948	1,680,974	.015
Trit. x An. Tallow	4	2,937,150	734,287	.007
Replication	4	1,920,460	480,115	.004
Error	32	3,562,543,650	111,329,489	

APPENDIX TABLE IV. Trial I. Analysis of Variance of Impacted Beaks of Broiler Chicks Fed Different Levels of Dietary Energy and Triticale.

Source	DF	SS	MS	F
Total	44	253.9	--	--
Treatment	8	193.9	24.2	13.931**
Triticale	2	16.2	8.1	4.649*
Animal Tallow	2	169.4	84.7	48.672**
Trit. x An. Tallow	4	8.4	2.1	1.201
Replication	4	4.4	1.1	.638
Error	32	55.6	1.7	

* Statistically significant at $P < 0.05$.

** Statistically significant at $P < 0.01$.

APPENDIX TABLE V. Trial II. Analysis of Variance of Weight Gain of Broiler Chicks Fed Dietary Levels of Methionine and Triticale.

Source	DF	SS	MS	F
Total	47	29,180	--	--
Treatment	11	10,634	966.69	1.872
Triticale	2	3,107	1,553.46	3.008
Methionine	3	5,425	1,808.38	3.502*
Trit. x Meth.	6	2,102	350.26	.678
Replication	3	1,505	501.78	.972
Error	33	17,041	516.40	

* Statistically significant at $P < 0.05$.

APPENDIX TABLE VI. Trial II. Analysis of Variance of Feed Per Gain Ratio of Broiler Chicks Fed Different Dietary Levels of Methionine and Triticale.

Source	DF	SS	MS	F
Total	47	.167	--	--
Treatment	11	.062	.006	1.807
Triticale	2	.011	.006	1.871
Methionine	3	.012	.006	1.936
Trit. x Meth.	6	.032	.005	1.710
Replication	3	.003	.001	.355
Error	33	.102	.003	

APPENDIX TABLE VII. Trial III. Analysis of Variance of Body Weight Gain of Broiler Chicks Fed Different Levels of Dietary Lysine and Methionine.

Source	DF	SS	MS	F
Total	50	30,816	--	--
Treatment	16	8,570	535.6	.801
Replication	2	838	419.3	.627
Error	32	21,408	669.0	

APPENDIX TABLE VIII. Trial III. Analysis of Variance of Feed Per Gain Ratio of Broiler Chicks Fed Different Levels of Dietary Lysine and Methionine.

Source	DF	SS	MS	F
Total	50	.273	--	--
Treatment	16	.075	.005	.797
Replication	2	.010	.005	.848
Error	32	.187	.006	

APPENDIX TABLE IX. Trial IV. Analysis of Variance of Amino Acid Availability of Wheat and Triticale.

Source	DF	SS	MS	F
Total	203	9,205.9	--	--
Treatment	1	137.0	137.0	5.285*
Amino Acids	16	4,060.5	253.8	9.787**
Replication	5	315.6	63.1	2.434*
Error	181	4,692.8	25.9	

* Statistically significant at $P < 0.05$.

** Statistically significant at $P < 0.01$.