AN ABSTRACT OF THE THESIS OF

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Title: Studies on the Effects of Feeding Yellow Pea (*Pisum sativum L. var. Miranda*) diets With and Without Supplementation to Commercial Broiler Chickens

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Dr. Harry S. Nakaue

Five experiments were conducted with commercial broilers to study the effects of feeding yellow pea (*Pisum sativum L.* var. Miranda) diets with and without supplementation.

Mean body weights and feed conversion for broilers fed 0, 25, 50 and 65% of soybean crude protein (CP) substituted with yellow pea (YP) protein were not significantly different among the dietary treatments at 4 weeks of age (WOA). At the end of 7 WOA broilers fed 50 and 65% YP diets had significantly lower mean male, female and combined sex body weights than broilers fed the 0 (C-S) and 25% YP diet. Feed conversion for broilers fed the 65% YP diets was significantly higher than for broilers fed the 0 (C-S), 25 and 50% YP diets (Experiment 1).

Commercial broiler chicks grown in cages with raised wire floors from day-old to 4 WOA (Experiment 2) and from day-old to 7 WOA (Experiment 3) were fed YP diet without

and with supplementation of either choline (.12%) or dl-methionine (.4%) or a combination of the two. Autoclaved YP was also fed which represented 50% of the CP from soybean meal. Feeding diets containing 25 and 50% YP did not significantly depress either growth rate or improve feed utilization when compared to broilers fed the 0% YP diet. Supplementation of choline (.12%) or dl-methionine (.4%) or the combination of the two to 50% YP diet and feeding autoclaved 50% unsupplemented YP diet did not significantly improve performance.

Broiler chicks were reared on litter floors (Experiment 4) and fed diets containing 0, 25 and 50% YP and 50% YP diets with supplemental l-tryptophan (.045%) to 7 WOA. At 4 and 7 weeks, significant improvements in mean male body weights were observed with supplemental l-tryptophan to the 50% YP diet then with the unsupplemented 50% YP diet. No significant difference was observed in combined body weights, mean female body weights and feed conversion at 4 and 7 WOA among broilers fed 50% YP with and without l-tryptophan supplementation. Performance of broilers fed 0 and 25% YP diets were not significantly different at 4 and 7 WOA.

Supplementations of either l-tryptophan (.01%) or l-threonine (.03%) or l-lysine (.1%) or combinations of two or three amino acids to 50% YP diets were carried out (Experiment 5). At 4 WOA, supplementation of tryptophan and threonine to 50% YP diet significantly improved body weight more than did the unsupplemented 50% YP diet. Supplementations of either tryptophan or threonine to 50% YP diets did not produce significant differences in mean body weights than the 25% YP diet. Lower body weight was observed with lysine supplementation than with other dietary treatments at 4 WOA. At 7 WOA, supplementation of threonine alone or combination of threonine and tryptophan to 50% YP diets produced comparable growth performance with that of broilers fed 0% and 25% YP diets. Lysine supplementation to the 50% YP diet produced lower body weights than the other dietary treatments. No significant differences in body weights were observed among the broilers fed the 50% YP diets supplemented with tryptophan alone or a combination of either lysine with tryptophan or threonine or all three amino acids when compared with 50% YP diet. Feed conversion was not significantly different among the dietary treatments at 4 and 7 WOA.

Feeding of 25% YP diet was not detrimental to broiler growth and feed conversion. Supplementation of either tryptophan or threonine or the combination of the two to the 50% YP diet improved body weights. However, lysine, methionine and choline supplementations did not improve broiler performances.

STUDIES ON THE EFFECTS OF FEEDING YELLOW PEA (*PISUM SATIVUM L.* VAR. MIRANDA) DIETS WITH AND WITHOUT SUPPLEMENTATION TO COMMERCIAL BROILER CHICKENS

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CHAPTER I

INTRODUCTION

The Pacific Northwest (PNW) is considered to be deficient in growing corn and soybean meal, the major ingredients that are used in poultry rations. These feedstuffs are now being imported from the Midwest and other regions thereby greatly increasing the costs on feeds. It is estimated that for the year 1987, PNW poultry producers will use approximately 480,000 tons of corn and 96,000 tons of soybean meal, thereby paying approximately $14 to $15 million more for importing these two grains from the Midwest (Savage and Nakaue, 1987).

Reducing the costs of corn and soybean meal has always been a major concern to PNW poultry producers. Thus, there has been a constant search for alternate grain sources grown locally that possess nutrient profiles which are compatible with that of the broiler's and turkey's requirements and which can successfully replace corn and soybean meal in the poultry rations.

An alternate crop, yellow peas (*Pisum sativum L.* var. Miranda), has been introduced in the PNW as a possible plant protein source for poultry. Approximately one million pounds of peas are being produced in the Willamette Valley in 1987 (C. R. Hayes, personal communication), and the production is expected to be on the increase in subsequent years.

The Miranda variety of yellow pea (*P.sativum L.*) is characterized by having large cream colored seeds produced on plants of dwarf stature with determinate growth habits. Savage *et al*. (1986) have reported that yellow peas (*P. sativum L.* var. Miranda) fed to market turkeys did not cause any detrimental effects. Therefore, a series of experiments were conducted with broilers to study the effects of feeding the Miranda variety of yellow pea diets with and without supplementations.

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CHAPTER II

REVIEW OF LITERATURE

The origin of the word pea came from the Greeks who called the pea "PISOS"; the Romans called it "PISUM"; the English called it "PEASON" which then became "PEASE" and was modified to "PEA" (Sutcliffe and Patte, 1977).

(A). HISTORY:

The history of peas dates back to the Stone Age, particulary the Neolithic period which is more than 20,000 years ago. Peas were brought under cultivation along with wheat, barley, millet and beans (Makashewa, 1983). They were further domesticated about 7000 BC in the mountainous regions of Southwest Asia, particularly Afghanistan and India (Janick *et al*., 1981; Makashewa, 1983) and is now grown worldwide (Hebblethwaithe *et al*., 1985).

The pea was supposedly first sown in North America by Columbus on Isabella Island in 1843. Subsequently, they gained wide distribution in the United States as a grain and vegetable as well as a fodder and green manuring crop (Makashewa, 1983).

The first planting of a pea variety (Austrian winter field pea) in the PNW was made at the Oregon Agricultural Experiment Station in the fall of 1923 (Schoth, 1931). Seeds were supplied by the Bureau of Plant Industry of the

USDA. Its habits of growth were such that possibilities for an increased use were soon recognized and commercial production of the seed began early in 1927.

Much of the present production of this crop is concentrated in the Northern sections of Washington and Oregon. Approximately one millon pounds of peas are being produced in the Willamette Valley in 1987 (C.R. Hayes, personal communication).

(B). CLASSIFICATION:

Peas fall in to the following classification:-

Order: Fabales

Family: Leguminosae

Genus: Pisum

The number of species include sativum, formosum, elatius and arvense, to name a few. The evolution of P. sativum is much debated. Janick et al. (1981) considered P. sativum to be the cross product between two species namely P. humile and P. elatius. However, Makashewa (1983) reported that P. sativum could have evolved as a result of mutation and natural crosses among the different species mentioned in different zones of the world.

The cultivars of peas are often classified into two groups according to the color of seed coat pigment as-light and dark green, by seed coat surface as smooth and wrinkled (Hartman et al., 1981).

(C). IN PRAISE OF PEAS:

The value of peas as a green manuring crop is well known. Pea seeds of high viability are available throughout the year in most parts of the world (Sutcliffe and Patte, 1977). They further reported that pea seeds germinate rapidly; there is no hard seed coat to be removed with sufficient food reserves stored in the cotyledons allowing them to grow for several weeks even at low intensity light; and they have a short life period of 80 - 100 days.

Peas are of great agronomical value as a nitrogen-fixing crop (Makashewa, 1983). Their roots have a high assimilating capacity to utilize soil nutrients having low solubility, and peas (Pisum sativum) grow to a convenient height (40 - 300 cms).

(D). CHEMICAL COMPOSITION OF PEAS (Pisum sativum)

Pea seeds, depending upon the varieties and growing conditions, contain 18-35% protein, 24-60% carbohydrates, 0.6-1.5% lipids, 2-10% cellulose and 2-4% minerals (Makashewa, 1983).

1. Protein and amino acids:

The protein content of 28 breeding lines of peas (P.sativum L.) varied from 21 to 28% (Bajaj *et al*., 1971) which is in close agreement with Reddy *et al*., (1979) who reported that the protein contents of different varieties of yellow peas grown in Washington and Idaho areas were in the range from 20.8 to 23.1%. However, Makashewa (1983) reported the average protein content in the range from 15.5 to 39.7% on a dry weight basis.

This wide range in the protein content could be accounted for with the different strains of peas having different levels of non-protein nitrogen (Bajaj et al., 1971). Further, it has been shown by Ali Khan and Youngs (1973) that total nitrogen varies within pea varieties by the location and year it was grown.

The proteins of *P. sativum* have been separated into two entities: legumin and vicilin, with molecular weights of approximately 331,000 and 196,000, respectively (Doulter and Derbyshire, 1971). The round and the wrinkled peas were also shown to differ in the proportion of the two proteins. The wrinkled varieties averaged less legumin than the round form (Davies and Domoney, 1983).

Amino acid composition has been presented by Doulter and Derbyshire (1971) which is in agreement with Makashewa (1983) who reported different varieties of peas contain amino acids in the following percentages:

Arginine	2.42 - 3.28%
Cystine	0.19 - 0.29%
Histidine	0.52 - 0.58%
Lysine	0.96 - 1.56%
Methionine	0.36 - 0.49%

Tryptophan 0.28 - 0.34%

Tyrosine 0.60 - 0.86%

Asparatic and Glutamic acid 6.76 - 15.34%

Generally arginine, leucine, lysine, aspartic and glutamic acids accounted for 50% of the total amino acids, whereas histidine, methionine, threonine, tryptophan and cystine accounted for less than 11% (Holt and Sosulski, 1979). In addition to this, they reported that the sulphur-containing amino acid, methionine, was the first limiting amino acid followed by threonine and valine. Makashewa (1983) reported that methionine and tryptophan were the limiting amino acids.

2. Carbohydrates:

Bailey and Doulter (1971) observed 42 and 34% starch in the smooth pea and wrinkled pea, respectively. This is consistent with the findings of Cerning-Beroard and Filiatre (1976) who reported that the smooth seed type have a higher starch content (48%) than the wrinkled type (33%). Makashewa (1983) reported that the starch content in pea seeds was in the range of 20-50% and is in the amylopectin form in the smooth seed variety. In the wrinkled variety a great preponderance of amylose was noted with an average of 69.2% (65.5-72.9%) which agrees with the findings of Vogt (1984).

Peas contain 8-10.2% of ethanol soluble sugars (Cerning-Beroard and Filiatre, 1976). The same investigators reported sucrose contents to be 30 and 38% in wrinkled and smooth pea, respectively, which were in contrast with the findings of Hebblethwaithe et al. (1985) who reported sucrose was scarcely present.

Values of other carbohydrates present were hemicellulose (6%) and cellulose(6-8%) for the smooth seeded variety and 5 and 5.5%, respectively, for the wrinkled pea variety. Further, lignin contents of 1 to 2 and 0.5% for the smooth and wrinkled varieties, respectively, were noted by Cerning-Beroard and Filiatre (1976).

3. Fats:

The fat content of peas is low (Hebblethwaithe et al., 1985). Triglycerides represent about 90% of the total lipids and a majority of the fatty acids (84%) are unsaturated. Linoleic acid represents 50% of the total fatty acids.

4. Vitamins:

The amounts of vitamins and minerals present in peas have received limited study. Makashewa (1983) summarized that peas contain 4 mg/kg provitamin A, 3 to 5 mg/kg thiamine, 1 to 1.5 mg/kg riboflavin 300 to 500 mg/kg ascorbic acid and 1 to 2 mg/kg pantothenic acid.

5. Minerals:

The ash content of peas contains 79% phosphorus and calcium, and the remaining elements (sulphur, silicon, sodium, magnesium, iron) comprise 21%. The seeds also contain small quantities of manganese, copper, molybdenum, boron, iodine, cobalt and zinc (Makashewa, 1983; Allen, 1983).

6. Antinutritional factors:

Peas like other pulse seeds contain some antinutritional factors such as trypsin-inhibitors and lectins (phytohemagglutins) which can lower the feeding value (Davidson, 1980; Hebblethwaithe et al., 1985). Wrinkled seeds have less trypsin inhibiting activity (TIA) than the smooth seeds. Naturally occurring trypsin and chymotrypsin inhibitors are polypeptides with molecular weights between 8,000 and 12,000 or about 20,000 (Liener and Kakade, 1980; Weder, 1981). However, the level of trypsin inhibitor in the peas is one-tenth that level found in soybeans and can be easily destroyed by wet heating (Kienholz et al., 1962; Liener and Kakade, 1980).

The presence of tannins in the colored flower pea variety account for lowering the feeding value (Lindgren, 1975; Vogt, 1984).

(E). NUTRITIONAL EVALUATION OF PEAS IN POULTRY

Peas (P.sativum) are potential protein sources (Cerning-Beroard and Filiatre, 1976) for both humans and animals, and their importance as a good source of nutritious food has been recognized since Neolithic times

(Hebblethwaithe _et al._, 1985). They reported that peas are most widely used for human consumption and in recent years interest in its use as an animal feed has increased even in developed countries.

(1). Broilers:

Peas have been researched for use in broiler feeds by various investigators. Moran _et al._ (1968) reported that use of pea meal at 65% with complete replacement of soybean meal resulted in a large reduction in feed conversion, weight gain and a significant decrease in chick growth. At 35%, a lowered growth and feed utilization were encountered by the same investigators. Goather and McGinnis (1972) reported that growth was markedly depressed in chicks fed a basal diet containing dry field peas. The feeding value of field beans, field peas and lupins were examined by Koreleski and Rys (1974). Weight gain from birds fed field peas were less than the birds fed soybean meal. However, the difference was not statistically significant. Hanczakowski _et al._ (1979) noted no decline in growth or feed conversion with 32% of Spring pea (var. finale) in the diets of broilers.

Depression in growth rate of chicks fed raw peas compared to those fed soybean was attributed to the legume seeds having zinc binding substances not readily digested (Kienholz _et al._, 1962). The presence of these substances was verified. Supplementing the diets containing raw peas with zinc significantly improved performance in chicks. However, supplementation with zinc was found to be only 1/3 as effective as autoclaving or heat treatment in overcoming growth depressing properties of peas.

The presence of unidentified growth inhibitors were also suggested (Huyghebeart _et al_., 1978; Vogt, 1984). Heat treatment was found to improve the nutritive value of peas for poultry.

Moran _et al_. (1968) reported that steam pelleting of peas subtantially improved the performance of birds fed 35 and 65% peas. Feed conversion was 2-3% more efficient in processed (heat treated) peas fed at 5, 10 and 20% in broiler diets (Huyghebaert _et al_., 1978). They reasoned this slight increase in the nutritive value of peas could be from either the increase in the digestibilities of amino acids or energy or may be due to the inactivation of antinutritive factors. Further, no significant difference on weight gain, mortality and flavor of the meat was observed between broilers fed pea meal either processed or raw and corn-soy. An increase in the digestibilty of amino acids in pea seeds, after autoclaving at 121 C for 45 min, was observed by Zima and Zima (1980).

Deficiency of one or more amino acids has been reported. The principal growth-limiting amino acid in raw pea protein was methionine (Woods _et al_., 1943). Petersen et al. (1944) confirmed this finding when the Alaska field pea was fed to chickens. The addition of methionine (0.25%) to a 12% pea protein diet permitted growth rate equivalent to either 0.5 or 0.75% additions. The growth rate was comparable to the 12% soybean protein control diet. Goatcher and McGinnis (1972) observed significant improvement in the protein efficiency ratio by supplementing methionine to diets containing peas. Petkov and Sedlakova (1973) replaced soybean meal with field peas at 25, 36 or 45% in broiler feeds which were either raw or autoclaved, without or with added methionine. The addition of methionine improved the weight gain and the protein efficiency ratio. They concluded that field peas could wholly replace soybean meal if methionine is supplemented. Reddy et al., (1979) experimented with 44 lines of green, yellow and Australian winter peas (P.sativum L. var. arvense). Chicks were fed with and without methionine, and they observed that supplementation of 0.2% d,l-methionine significantly improved growth and protein efficiency ratio in all pea lines tested. No significant differences were observed from the control soybean meal and pea supplemented diets.

(2). Layers:

Nguen Ngi (1964) observed that a 30% ground pea diet supported 8% lower egg production than did the same diet supplemented with 0.1% methionine and 12-15% lower than diets having peas processed by steaming or fermenting with or without added methionine. Moran et al. (1968) fed raw peas to layers at 15 and 30%. Production and egg weights were not affected. The only differences observed by the above research workers were with feed utilization and feed consumption. Hens fed the corn-soy diets were significantly more efficient in producing eggs. Further improvements in feed utilization were observed with both levels of peas when it was pelleted.

Egg production was not adversely affected when hens were fed three cultivars of peas at 15 and 30% in cereal based diets (Lindgren, 1975). Similarly, Anderson (1979) fed peas at 30% to laying hens and found no significant difference in egg production. However, an increased deformation and decrease in shell thickness were observed. Davidson (1980) fed oat based diets containing 1/3 ground field peas to laying hens. Egg production was only half that of the control diet containing fish meal; however, heating and flaking increased egg production to about 3/4 of the control output. Further, methionine supplementation in addition to heat treatment of the peas allowed full egg production. The pea meal contains anti-nutritive agents and heat treatment which appears to reduce their activity, in part, from the destruction of phytohemagglutins, was reported by the same investigator. Ritcher (1981) fed 2100 hybrid Single Comb White Leghorn laying hens diets without peas (P.sativum L. var. Nadia) or with 10, 20 or 30% from 22 to 73 weeks of age with added methionine at 6.1 to 6.7g/kg. Feeding peas had no effect on feed intake, laying performance, egg weight, shell strength, body weights, mortality and hemoglobin content. He concluded that peas could be included at 30% in diets for laying hens without adversely affecting performance. Peas contain anti-nutritive factors in addition to being deficient in methionine Davidson et al. 1981). Laying hens fed diets containing 40% peas had live weight loss and reduced rate of lay (to about 85% of normal) in 20 weeks. The effect of lowered egg production was, however, overcome by supplementation of methionine to the diets.

(3). Turkeys:

Limited work has been done on turkeys fed peas. Savage et al. (1986) incorporated peas (P.sativum L. var. Miranda) in diets of market turkeys at levels from 25% in the starter to 55% in the finisher and concluded that feeding yellow peas was not detrimental to growth rate, feed utilization or meat quality. The diets were supplemented with methionine and fat.

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CHAPTER III

BROILER CHICKENS RAISED IN BATTERIES AND ON LITTER FLOORS FED YELLOW PEA (PISUM SATIVUM L. VAR. MIRANDA) DIETS WITHOUT AND WITH SUPPLEMENTATION AND AUTOCLAVED YELLOW PEAS

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ABSTRACT

Five experiments were conducted with commercial broilers to evaluate the effects of feeding 0%, 25%, 50% and 65% yellow pea (Pisum sativum L. var. Miranda) diets, and the supplementation with d,l-methionine, choline, l-tryptophan, l-threonine and l-lysine to the 50% yellow pea (YP) diet. The percentage of peas in the diets replaced the percentage of crude protein derived from soybean meal. The broilers in Experiments 1, 4 and 5 were reared on wood shaving litter floors, and the broilers in Experiments 2 and 3 were reared on wire floors in battery brooder and growing cages to 4 or 7 weeks of age (WOA).

In Experiment 1, the mean male, female and combined sex body weights at 7 WOA were significantly heavier (P<.05) for broilers fed 0% and 25% YP diets than for those fed the 50% and 65% YP diets. Feed conversion was higher (P<.05) for broilers fed the 65% YP diets than the 0%, 25% and 50% YP diets.

In Experiments 2 and 3, feeding diets containing 25% and 50% YP did not significantly (P>.05) depress either growth rate or improve feed utilization when compared to the 0% YP diet. Supplementation of choline (.12%) or d,l-methionine (.4%) or the combination of the two to 50% YP diets did not (P>.05) improve performance. Choline supplementation did not reduce the incidence of leg deformities. No differences (P>.05) were observed in

mean male, female and combined sex body weights and mean feed conversion when broilers were fed 50% autoclaved and untreated YP diets.

In Experiment 4, the mean 7 week body weights of males fed 50% YP without l-tryptophan (.045%) were lower ($P<.05$) than those of males fed the 0%, 25% and 50% YP supplemented with tryptophan. Feed conversion was higher ($P<.05$) for the broilers fed 50% YP diet than for those fed 0% (C-S) diet. No differences ($P>.05$) in mean combined sexes and female body weights and feed conversion were observed among the broilers fed diets containing 25% YP and 50% YP supplemented with tryptophan.

In Experiment 5, no differences ($P>.05$) in mean body weights and feed conversion were observed among the broilers fed 0% and 25% YP diets. However, broilers fed the unsupplemented 50% YP diet had lower mean ($P<.05$) body weights than those on the 0% and 25% YP diets. Broilers fed 50% YP diets supplemented with either l-threonine (.03%) alone or a combination of l-tryptophan (.01%) and l-threonine had comparable mean ($P>.05$) body weights to those on the 0% and 25% YP diets. Lysine supplementation (.1%) produced lower mean body weights than the supplementation of the combination of l-lysine with either l-tryptophan or l-threonine or all three amino acids. No difference ($P>.05$%) in feed conversion was observed among the dietary treatments.

Feeding of 25% YP diet did not affect broiler performance. However, feeding of 50% unsupplemented and untreated YP diet depressed growth rate and increased feed conversion. Supplementation of the 50% YP diet with either l-tryptophan or l-threonine or the combination of the two improved performance.

INTRODUCTION

Pacific Northwest (PNW) poultry producers must import corn and soybean from the Midwest, which substantially increases the costs of these feed ingredients. Reducing the costs of imports and subsequently feeds have been a major concern to PNW poultry producers. Therefore, it has always been a priority to develop as well as utilize new indigenous alternative feed sources that can totally or partially replace corn and/or soybeans as an energy and/or protein source.

An alternative crop, yellow peas (Pisum sativum L. var. Miranda), has been introduced in the PNW as a possible plant protein source in poultry diets (Savage et al., 1986). They reported that yellow peas, Miranda variety, fed to market turkeys did not cause any detrimental effects to growth rate, feed utilization or meat quality.

However, incorporation of peas (genus: Pisum) at higher levels (65%) in chickens as a replacement of soybeans resulted in large reduction in feed conversion and weight gain (Moran et al., 1968). The depression in growth rate of chicks fed raw peas was attributed to unidentified growth inhibitors (Huyghebeart et al., 1978; Vogt, 1984). Heat treatment was found to improve the nutritive value of peas for poultry (Kienholz et al., 1962; Moran et al., 1968).

A deficiency of one or more amino acids has been reported. The principal growth-limiting amino acid in raw pea protein was methionine (Woods et al., 1943). The addition of methionine improved weight gain and the protein efficiency ratio in broilers (Goatcher and McGinnis, 1972; Petkov and Sedlakowa, 1973; Reddy et al., 1979). Holt and Sosulski (1979) reported that threonine and valine were the limiting amino acids followed by methionine. However, valine was ruled out as a limiting amino acid in pea meal by Cook and Robertson (1941). Moran et al. (1968) fed peas supplemented with methionine, cystine and tryptophan. A marked improvement was observed in chick growth and feed conversion in the group supplemented with essential amino acids over the unsupplemented group.

Studies evaluating the feeding of miranda variety of yellow peas to broilers have not been reported. Therefore, experiments were conducted with broilers either on litter or in battery cages to study the effects on growth and feed efficiency by feeding diets containing 25%, 50% and 65% yellow pea (YP) and 50% YP diets supplemented with either d,l-methionine, choline, tryptophan, threonine, lysine or their combinations. The feeding of autoclaved YP diet was also investigated.

MATERIALS AND METHODS

Experiment 1:

Five hundred and twenty day-old straight run commercial broiler chicks were randomly placed in 16 pens (1.2 m x 3 m/pen). The pens were housed in a naturally ventilated and uninsulated house (49 m x 13 m). Each pen had approximately 32 or 33 chicks. Each chick was provided with $0.1m^2$ floor space. The floor was covered with wood shavings litter (approximately 10 cms deep). In each pen an automatic Plasson waterer and an adjustable hanging tube feeder (diameter 40 cms) were used with an infra red heat lamp which served as a heat source for at least the first 4 weeks of age (WOA). A hand waterer (3.5 L) was used for the first 5 days and removed. Continuous light (5.38 lux) was provided throughout the experiment. Litter was stirred regularly once a week. The caked material was removed and replaced with fresh, clean and dry wood shavings.

The four dietary treatments were corn-soy(C-S), corn + 25% yellow peas (YP), corn + 50% YP and corn + 65% YP. The percent yellow peas replaced the percent of crude protein derived from soybean meal in the C-S diet. The dietary treatments were replicated four times (4 pens). The diets were formulated to be isocaloric and isonitrogenous. The starter rations were fed from day-old to 3 WOA and the finisher diets were fed from 3 to 7 WOA. The starter and finisher diets are presented in Table 1 and Table 2. Feed and water were provided ad libitum throughout the experiment (day-old to 7 WOA).

Males and females were weighed separately at 4 and 7 weeks of age. Feed was also weighed back for each pen at 4 and 7 weeks of age. During the course of the experiment, mortality was noted daily.

The data for both 4 and 7 weeks were statistically analyzed by one-way analysis of variance (Steel and Torrie, 1980), and significant means were separated by using Fisher's protracted least significant difference (FPLSD) test (Petersen, 1985).

Experiment 2:

Three hundred and sixty commercial broiler hatching eggs were purchased from a commercial hatchery, and were incubated in a Jamesway Model 252 incubator in the Department of Poultry Science. The standard temperature and relative humidity were followed as outlined by the operation manual of the manufacturer. Eggs were turned automatically every two hours during incubation. The eggs were candled and transfered to the hatching baskets at 19 days of incubation.

This experiment was carried out in electrically heated battery cages[1] with sub-floor heaters and raised wire floors for the first 4 WOA. During the first week of life, the battery temperature was set at 37.8 C (100 F) and decreased (5 F) weekly thereafter until the temperature was 21.1 C (70 F). Feed was provided on an egg flat, and a plastic hand waterer (3.8 L) was used in each cage for the first five days to facilitate the chicks getting access to feed and water quickly. Both egg flats and hand waterer were removed after five days. After this period, regular feeders and waterers attached to the sides of cages were used with 24 hrs of continuous incandescent light. THe chicks received mash feed and water ad libitum. There were 7 dietary treatments in this experiment. Each dietary treatment was replicated 4 times with each replicate containing 9 straight run chicks. The composition of C-S, 25% and 50% YP diets in this experiment was similar to the starter diets of Experiment 1. The 50% YP diet was supplemented with either .12% choline-50 (1.18g/kg premix) or .4% d,l-methionine or .12% choline-50 (1.18g/kg premix) and .4% d,l-methionine. A 50% autoclaved YP diet was also included. Ground raw YP were autoclaved[2] at 121 C at 15 psi for 20 min. Mortality was recorded as in Experiment 1. This experiment was terminated when the chicks were 4 WOA. Body weights were taken at 4 WOA by sexes and feed weighed back. Feed consumption and feed

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[1] Wes Bilt Manufacturing Co. Inc., Hayward, California

[2] Central Scientific Co. Autoclaving Chamber, Chicago

conversion were determined. Leg deformities in males and females were recorded separately and scored from 1 to 4 (1= normal, 2= slight bowing of one or both hock joints, 3= medium bowing of one or both hock joints, 4= severe bowing and stretching of one or both hock joints) in increasing order of severity.

The body weights and feed conversion data were statistically analyzed as in Experiment 1.

<u>Experiment 3:</u>

This experiment was similar to Experiment 2 except the experiment was extended to 7 WOA. A total of 336 broiler chicks were randomly assigned equally (12 straight-run chicks) per replicate and housed in similar conditions as in Experiment 2 except that the broilers were reared in growing batteries[3] from 4 to 7 WOA. Managerial practices and dietary treatments were used as in Experiment 2. Male and female body weights along with feed conversion were determined at 4 and 7 weeks. The data were statistically analyzed as described in Experiment 1. The leg deformities were recorded at 4 and 7 weeks and scored as in Experiment 2 during the weighing period of 4 and 7 WOA.

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[3] Beacon Steel Products Co. Inc., Westminister, Maryland

Experiment 4:

Six hundred and forty straight run commercial chicks were randomly placed equally in 16 wood shaving Litter pens. Each pen (1.2 m x 3 m) housed 40 chicks with a floor space of .09 m^2/chick. This experiment was conducted in the same facility as Experiment 1. Similar brooding, rearing and other managerial practices were adopted as outlined in Experiment 1. There were 4 dietary treatments. Each dietary treatment was replicated 4 times. The compositions of C-S, 25% YP and 50% YP in this experiment were similar to the starter and finisher diets of Experiment 1 (Tables 1 and 2). The 50% YP diet was supplemented with .045% l-tryptophan (45 g/kg premix). Total tryptophan in the supplemented starter diet was .29% and in the finisher diet was .27%. Performance data were analyzed for 4 and 7 weeks as mentioned in Experiment 1.

Experiment 5:

One thousand and six hundred commercial broiler chicks were housed in the same facility as Experiment 1 with similar managerial and brooding practices. There were 10 isocaloric and isonitrogenous dietary treatments each for a starter and finisher diets. The C-S, 25% YP, 50% YP were similar to that of Experiment 1 (Tables 1 and 2). The 50% YP was additionally supplemented with either .01% l-tryptophan (Trp) (20.3 g/kg premix) or .03%

l-threonine (Thr) (60.6g/kg premix) or .1% l-lysine (Lys) (234.4g/kg premix) or .01% Trp + .03% Thr premixes or .01% Trp + .1% Lys premixes or .03% Thr + .1% Lys premixes or a combination of the Trp, Thr + Lys premixes. The total levels of Trp, Thr and Lys in the supplemented starter diets were .25%, .79% and 1.38%, respectively. The total levels of Trp, Thr and Lys in the supplemented finisher rations were .23%, .74% and 1.26%, respectively. Each dietary treatment was replicated 4 times with 40 straight run commercial broiler chicks per replicate (.09 m^2/chick). Performance data were analyzed as outlined in Experiment 1.

Table 1. Composition of broiler starter diets

Ingredients	Yellow pea content of crude protein			
	0	25	50	65
	---------	%	---------	
Corn, yellow	58.35	36.69	14.94	1.70
Soybean meal (47.5%CP)	32.15	24.00	15.85	11.00
Yellow peas (21.3%CP)	0.00	27.20	54.50	71.00
Meat & bone ml(49.5%CP)	5.00	5.00	5.00	5.00
Animal fat	2.00	4.50	7.00	8.50
Dehy.alfalfa ml(17.5%CP)	1.00	1.00	1.00	1.00
Defluorinated phosphate	0.42	0.42	0.42	0.42
Limestone flour	0.35	0.35	0.35	0.35
Salt (iodized)	0.25	0.25	0.25	0.25
Vitamin premix[1]	0.20	0.20	0.20	0.20
Trace mineral mixture[2]	0.05	0.05	0.05	0.05
d,l-methionine (98%)	0.13	0.24	0.34	0.43
Amprol plus[3]	0.05	0.05	0.05	0.05
Baciferm-50[4]	0.05	0.05	0.05	0.05
<u>Calculated analysis</u>				
Crude protein, %	23.1	23.1	23.1	23.1
Metabolizable energy, kcal/kg	3029	3029	3029	3029
Calcium, %	0.97	0.95	0.94	0.93
Available phosphorus, %	0.50	0.50	0.48	0.48
Methionine, %	0.49	0.53	0.55	0.59
Meth. and cyst, %	0.88	0.89	0.89	0.91
Tryptophan, %	0.27	0.25	0.24	0.23
Threonine, %	0.94	0.85	0.76	0.71
Lysine, %	1.27	1.27	1.28	1.29
Choline, %	0.15	0.12	0.08	0.06

[1]Provided per kg of diet: Vitamin A, 3300 IU; vitamin D3, 1100 IU; riboflavin, 3.3 mg; d-pantothenic acid, 5.5 mg; niacin, 22 mg; choline, 190.9 mg; vitamin B12, 5.5 mcg; vitamin E, 1.1 IU; vitamin K, 55 mg; folic acid, 22 mg; ethoxyquin, 0.06 g.

[2]Provided per kg of diet: Ca, 97.5 mg; Mn, 60 mg; Fe, 20 mg; Cu, 2.0 mg; Zn, 27.5 mg; Co, 2 mg.

[3]Amprol plus was gratuitously provided by Merck & Co. Inc., Rahway, NJ.

[4]Baciferm was gratuitously provided by International Mineral & Chemical Corp., Terre Haute, Indiana.

Table 2. Composition of broiler finisher diets

Ingredients	Yellow pea content of crude protein			
	0	25	50	65
	%			
Corn, yellow	63.52	42.17	22.34	10.38
Soybean meal (47.5%CP)	27.40	20.20	13.00	8.70
Yellow peas (21.3%CP)	0.00	25.40	50.00	65.00
Meat & bone ml (49.5%CP)	5.00	5.00	5.00	5.00
Animal fat	2.00	5.00	5.00	8.50
Dehy.alfalfa ml(17.5%CP)	1.00	1.00	1.00	1.00
Defluorinated phosphate	0.25	0.28	0.30	0.30
Limestone flour	0.13	0.15	0.17	0.17
Salt (iodized)	0.25	0.25	0.25	0.25
Vitamin premix[1]	0.20	0.20	0.20	0.20
Trace mineral mixture[2]	0.05	0.05	0.05	0.05
d,l-methionine (98%)	0.10	0.20	0.29	0.35
Amprol plus[3]	0.05	0.05	0.05	0.05
Baciferm-50[4]	0.05	0.05	0.05	0.05
<u>Calculated analysis</u>				
Crude protein, %	21.4	21.4	21.4	21.4
Metabolizable energy, kcal/kg	3028	3028	3028	3028
Calcium, %	0.82	0.82	0.82	0.82
Available phosphorus, %	0.44	0.45	0.45	0.45
Methionine, %	0.44	0.47	0.49	0.51
Meth. and cyst, %	0.80	0.81	0.80	0.81
Tryptophan, %	0.25	0.24	0.22	0.21
Threonine, %	0.87	0.79	0.71	0.67
Lysine, %	1.13	1.15	1.16	1.17
Choline, %	0.14	0.11	0.08	0.06

[1]Provided per kg of diet: Vitamin A, 3300 IU; vitamin D3, 1100 IU; riboflavin, 3.3 mg; d-pantothenic acid, 5.5 mg; niacin, 22 mg; choline, 190.9 mg; vitamin B12, 5.5 mcg; vitamin E, 1.1 IU; vitamin K, 55 mg; folic acid, 22 mg; ethoxyquin, 0.06 g.

[2]Provided per kg of diet: Ca, 97.5 mg; Mn, 60 mg; Fe, 20 mg; Cu, 2.0 mg; Zn, 27.5 mg; Co, 2 mg.

[3]Amprol plus was gratuitously provided by Merck & Co. Inc., Rahway, NJ.

[4]Baciferm was gratuitously provided by International Mineral & Chemical Corp., Terre Haute, Indiana.

RESULTS AND DISCUSSIONS

In Experiment 1, no significant differences (P>.05) among the dietary treatments were observed in the mean male, female, combined-sex body weights and feed conversion at 4 WOA (Table 3).

At 7 weeks, the mean male, female and combined-sex body weights were significantly lower (P<.05) for the broilers fed the 50% YP and 65% YP diets than for those fed the 0 and 25% YP diets (Table 3). Feed conversion was higher (P<.05) in broilers fed 65% YP diet than in broilers fed 0%, 25% and 50% YP diets.

The reductions in body weight with broilers fed peas at higher levels (50 and 65%) are in agreement with Moran et al. (1968). A significant decrease in chick growth and increase in feed conversion were found when pea meal was fed at 65%. Slower chick growth was also observed by feeding peas at 35%. Kienholz et al. (1962) fed diets containing 93% raw peas (Alaska) as the main protein source. Growth depression was observed in broilers fed peas when compared with the broilers fed corn-soy diets. The effects of replacing soybean oil meal with field peas fed at lower levels of 5, 10 or 20% were studied by Huyghebeart et al. (1978). Weight gain, mortality and flavor of meat were not significantly affected by the pea meal. In the present experiment, yellow peas fed at 25% did not significantly depress body weights. Replacing 5 to

35% soybean meal with pea meal in chicken diets in a 7-week feeding trial had no adverse effects on growth or feed efficiency (Vogt et al., 1979). Mortality in broilers fed corn-soy was 2.59% ± 2.58; 25% YP was 2.40% ± .80; 50% YP was 8.00% ± 4.93; and 65% YP was 5.24% ± 3.40.

Although no measurements were taken, gross observations suggested there may be a correlation between leg problems and the pea level in the diet in Experiment 1. Depressed growth rate may be attributed to deficiency of methionine in the 50% YP diet (Experiment 1). Therefore, broilers were reared to 4 (Experiment 2) and 7 (Experiment 3) weeks of age in battery cages and supplemented with choline and d,l-methionine. Mean body weights and feed conversion for the various dietary treatments from day-old to 4 WOA for Experiment 2 are presented in Table 4, and mean body weights and feed conversion for those fed similar dietary treatments from day-old to 7 WOA are presented in Table 5. Yellow pea diets fed at 25 and 50% without supplementation and 50% YP diets supplemented with additional choline and d,l-methionine did not significantly improve (P>.05) growth rate and feed conversion in both the experiments when compared with C-S fed chicks. Autoclaving raw yellow peas and incorporating these at 50% of the crude protein from soybean meal also did not produce significant differences in performance cpmpared to the C-S fed chicks.

The supplementation with d,l-methionine was carried out in the present study because the deficiency of one or more amino acids in peas is well documented. Petersen et al. (1944) reported that field peas were deficient in methionine and not cystine and a .25% methionine supplementation produced growth rate in chicks which were comparable to the 12% protein control diet. Methionine is deficient in pea meal and supplementation of the same improves chick growth (Bolin et al., 1946; Goatcher and McGinnis, 1972). A nonsignificant improvement in the mean body weights of broilers was observed when 50% YP diets were supplemented with d,l-methionine as compared with the unsupplemented 50% YP diet. In the studies conducted by Petkov and Sedlakova (1973), broilers fed raw peas at 45% with .3% added methionine had better weight gain and feed efficiency compared with broilers fed 36% raw peas without methionine, and they concluded that raw peas could wholly replace soybean meal if methionine is supplemented in the diets. Supplementation of .2% d,l-methionine to 44 breeding types of green, yellow and Austrian winter peas gave a significant increase in both chick growth and protein efficiency ratios when compared with unsupplemented diets (Reddy et al., 1979).

Because of the long-known beneficial effects from autoclaving soybeans, an attempt was made to improve the nutritive value by autoclaving the yellow peas. These autoclaved yellow peas were fed at 50% of the crude protein from soybean meal protein. Only marginal improvement was observed in mean body weight and feed conversion when compared with unsupplemented raw yellow peas fed at 50% (Tables 4 and 5). Kienholz et al. (1962) reported that chick growth equivalent to soybean meal was obtained when autoclaved peas were included in the diets and fed at the rate of 93%. The destruction of growth inhibitors or toxic factors present in the peas was speculative. However, Moran et al. (1968) observed no substantial changes in chick growth upon autoclaving peas at 121 C for 15 min. Overall digestibility of the pea meal was improved.

A total of four birds died in Experiment 2 and 12 birds died in Experiment 3 during the course of the feeding trial. No abnormalities were detected in necropsy findings.

Since deficiency of choline causes perosis (North, 1984), the supplementation of choline to 50% YP diet in Experiment 2 and 3 was investigated. Data for leg deformity and leg score are presented in Table 6. No statistical analysis could be performed. However, the data for the total number of leg deformities indicate that broilers fed 50% YP diet supplemented with choline had a higher incidence of leg deformity than with the other dietary treatments. Therefore, supplementation of choline was not effective in reducing the incidence of leg deformity.

In Experiment 4, mean body weights and feed conversion of broilers fed 25 and 50% YP diets and 50% YP diet supplemented with l-tryptophan for 4 and 7 WOA are presented in Table 7. Mean female and combined sex body weights and feed conversion for both the 50% pea diets without and with tryptophan supplementation were significantly lower ($P<.05$) than for the broilers fed the 25% YP diet at 4 WOA. Male broilers fed the 50% YP diet supplemented with tryptophan premix (45g/kg) had significantly ($P<.05$) better growth rate than male broilers fed no tryptophan supplementation. No significant differences ($P>.05$) were observed between the C-S and 25% YP diets for mean body weights for males, females and combined sexes and feed conversion.

At 7 WOA, mean male body weight was significantly ($P<.05$) smaller in the unsupplemented 50% YP diet than for males fed the diets with 0% and 25% YP and 50% YP diet with tryptophan. The supplementation of l-tryptophan to the 50% YP diet improved male growth rate. Feed was utilized less efficiently ($P<.05$) with the feeding of the unsupplemented 50% YP diet than the C-S diet. No significant differences ($P>.05$) were observed in mean female and combined sex body weights for broilers fed 0%, 25%, 50% YP diets and 50% YP diet supplemented with tryptophan. Moran et al. (1968) fed raw peas supplemented with methionine, cystine and tryptophan. A marked improvement was observed in chick growth and feed conversion in the group supplemented with the essential amino acids than the unsupplemented group. Mortality in corn-soy fed broilers were 1.96% $\pm$ 1.26; 25% YP, 3.98% $\pm$ 1.75; 50% YP, 6.00% $\pm$ 1.33; and in tryptophan supplemented group, 6.09% $\pm$ 2.12.

In Experiment 5, the data for mean body weights and feed conversion from day-old to 4 weeks and day-old to 7 WOA are presented in Table 7. Mean body weights for broilers fed 0% and 25% YP diets were significantly higher than for the unsupplemented 50% YP fed broilers. Broilers fed the tryptophan or threonine supplemented diets or a combination of the two in 50% YP diets had body weights similar ($P>.05$) to broilers fed 25% YP diets. Broilers fed 50% YP supplemented with lysine had significantly lower ($P<.05$) body weights than those on C-S and 25% YP diets. No significant differences ($P>.05$) were observed in mean body weights between broilers fed 50% YP diets unsupplemented and supplemented with lysine. Feed conversion at 4 WOA was not significant ($P>.05$) among the dietary treatments.

At 7 WOA, mean body weights were not significantly different ($P>.05$) among broilers fed 0%, 25% and 50% YP diets supplemented with either threonine or threonine and tryptophan combination (Table 7). Significant growth depression was observed when lysine was supplemented alone in the 50% YP diet than in other dietary treatments. However, significant improvement ($P<.05$) in mean body weights was observed when lysine was supplemented with either tryptophan or threonine or the combination of all three amino acids in the 50% YP diets. Feed conversion of broilers was not significantly different ($P>.05$) among all the dietary treatments. Holt and Sosulski (1979) reported that threonine and valine are the limiting amino acids in peas followed by methionine. Valine was ruled out as a limiting amino acid in pea meal by Cook and Robertson (1941). In the present study, the supplementation of threonine alone or in combination with tryptophan to the 50% YP diet improved mean body weights of broilers more than did the unsupplemented 50% YP diet. The improvement of chick body weight was documented earlier (Moran et al., 1968) with tryptophan supplemetation in pea meal diets. Lysine supplementation proved to have no beneficial effects in improving body weights in the present study. Pea meal has a relatively high lysine content of 1.46% (Moran et al., 1968), and thus additional supplementation of lysine to yellow pea may not be required.

Table 3. Mean body weights and feed conversion of broilers reared on litter floor to 4 and 7 weeks of age and fed 0%, 25%, 50% and 65% yellow pea (YP) diets (Exp.1)

YP (% of CP)	4 weeks of age				7 weeks of age			
	Mean body weights[1]			Feed conv.[1]	Mean body weights[1]			Feed conv.[1]
	Males(M)	Females(F)	M+F		Males(M)	Females(F)	M+F	
	g				g			
0	788a	720a	752a	1.68a	1760a	1503bc	1629a	2.11a
25	765a	720a	734a	1.70a	1733a	1539c	1638a	2.14a
50	711a	653a	675a	1.68a	1580b	1413ab	1485b	2.18a
65	752a	660a	702a	1.69a	1521b	1364a	1440b	2.40b

[1]Mean values in each column with different letters are significantly different (P<.05).

Table 4. Mean body weights and feed conversion of broilers reared in battery cages to 4 weeks of age and fed yellow pea (YP) diets without and with supplementation of choline, d,l-methionine and a combination of the two and autoclaved YP (Exp.2)

YP (% of CP)	Mean body weights[1]	Feed conv.[1]
	(g)	
0	795	1.63
25	866	1.60
50	876	1.69
50 YP + choline-50 (1.18g/kg)	843	1.65
50 YP + .4% d,l-methionine	808	1.60
50 YP + choline-50 + d,l-methionine	889	1.62
Autoclaved YP-50	825	1.68

[1]Mean values in each column are not significantly different (P>.05).

Table 5. Mean body weights and feed conversion of broilers reared in battery cages to 4 and 7 weeks of age and fed yellow pea (YP) diets without and with supplementation of choline, d,l-methionine and a combination of the two and autoclaved YP (Exp. 3)

YP (% of CP)	4 weeks of age		7 weeks of age	
	Mean body weights[1]	Feed conv.[1]	Mean body weights[1]	Feed conv.[1]
	(g)		(g)	
0	811	1.75	1690	2.05
25	866	1.64	1911	2.01
50	784	1.70	1782	2.04
50 YP + choline-50 (1.18 g/kg)	865	1.63	1814	2.02
50 YP +.4% d,l-methionine	841	1.52	1803	1.94
50 YP + choline-50 + d,l-methionine	853	1.65	1828	2.05
Autoclaved YP-50	856	1.73	1821	2.04

[1]Mean body weights in each column are not significantly different (P>.05).

Table 6. Incidence of leg deformity and leg score in broilers reared in batteries to 4 weeks of age (WOA) (Exp. 2) and 7 WOA (Exp. 3) and fed yellow pea (YP) diets without and with supplementation of choline, d,l-methionine and a combination of the two and autoclaved YP

YP (% of CP)	Exp. 2 Leg deformity Male(M)	Female(F)	M + F	Mean leg score[1] M	F	Exp. 3 Leg deformity Male(M)	Female(F)	M+F	Mean leg score[1] M	F
	No.					No.				
0	4	2	6	1.8	1.5	7	2	9	1.7	1.0
25	2	3	5	4.0	1.7	4	7	11	1.5	2.4
50	8	3	11	2.3	2.3	8	9	17	2.5	2.1
50 YP + choline-50 (1.18 g/kg)	9	4	13	1.2	1.3	10	6	16	2.1	1.5
50 YP +.4% d,l-methionine	5	1	6	1.0	2.0	2	3	5	2.0	1.3
50 YP + choline-50 + d,l-methionine	8	5	13	1.0	2.0	7	2	9	1.9	1.5
Autoclaved YP-50	8	3	11	2.6	1.7	8	4	12	1.9	1.8

[1]leg score: 1=slight bowing of one or both hock joints
2=medium bowing of one or both hock joints
3=severe bowing of one or both hock joints
4=extreme bowing and stretching of one or both hock joints.

Table 7. Mean body weights and feed conversion of broilers reared on litter floor to 4 and 7 weeks of age and fed 0%, 25% and 50% yellow pea (YP) diets and 50% YP diet supplemented with tryptophan (Trp) (Exp. 4)

YP (% of CP)	4 weeks of age				7 weeks of age			
	Mean body weights[1]			Feed conv.[1]	Mean body weights[1]			Feed conv.[1]
	Males(M)	Females(F)	M+F		Males(M)	Females(F)	M+F	
	g				g			
0	986a	855ab	918a	1.70c	2142a	1769a	1953a	2.16b
25	972ab	878a	918a	1.73bc	2111a	1809a	1904a	2.21ab
50	882c	824b	855b	1.78a	2003b	1733a	1863a	2.25a
50 YP + Trp premix (45g/kg)	950b	828b	878b	1.77ab	2106a	1733a	1944a	2.20ab

[1]Mean values in each column with different letters are significantly different (P<.05).

Table 8. Mean body weights and feed conversion of broilers reared on litter floor to 4 and 7 weeks of age and fed 0%, 25% and 50% yellow pea (YP) diets and 50% YP diet supplemented with tryptophan (Trp), threonine (Thr), lysine (Lys) and the combination of the three (Exp.5)

YP (% of CP)	4 weeks of age		7 weeks of age	
	Mean body weights[1] (g)	Feed conv.[1]	Mean body weights[1] (g)	Feed conv.[1]
0	943a	1.73a	2114ab	2.15a
25	930ab	1.71a	2164a	2.13a
50	889de	1.75a	2105b	2.15a
50 YP + l-Trp (20.3 g/kg)	903bcde	1.73a	2082bc	2.14a
50 YP + l-Thr (60.6 g/kg)	907bcd	1.77a	2123ab	2.13a
50 YP + l-Lys (234.4 g/kg)	898cde	1.75a	2037c	2.14a
50 YP + l-Trp + l-Thr	921abc	1.74a	2123ab	2.14a
50 YP + l-Trp + l-Lys	857f	1.81a	2100b	2.10a
50 YP + l-Thr + l-Lys	875cf	1.72a	2096b	2.10a
50 YP + l-Trp + l-Thr +l-Lys	894cde	1.74a	2105b	2.10a

[1]Mean values in each column with different letters are significantly different ($P<.05$).

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CHAPTER IV

CONCLUSIONS

The feeding of a 25% YP diet did not affect broiler performance when fed from day-old to 7 WOA. However, feeding a 50% YP diet depressed growth. Supplementation of either threonine or tryptophan alone or the combination of threonine and tryptophan to the 50% YP diet improved body weight more than did the 50% unsupplemented YP diet. Inclusion of methionine and lysine to the 50% YP diet did not improve performance when compared with unsupplemented 50% YP diet. Choline supplementation did not reduce the incidence of leg deformities in broilers. Autoclaving of yellow peas is not required.

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APPENDIX

APPENDIX

The following data provide more information regarding the experiments. Enclosed are mean male, female, and combined body weights along with feed conversion of Experiment 2, Experiment 3 and Experiment 5.

Table A1. Mean body weights and feed conversion of broilers reared in battery cages to 4 weeks of age fed yellow pea (YP) diets without and with supplementation of choline, d,l-methionine and a combination of two and autoclaved YP (Exp.2)

YP (% of CP)	Mean body weights[1]			Feed conv.[1]
	Males(M)	Females(F)	M+F	
	g			
0	820	674	675	1.63
25	1034	787	866	1.60
50	913	823	876	1.69
50 YP + choline-50 (1.18g/kg)	876	807	843	1.65
50 YP +.4% d,l-methionine	811	804	808	1.60
50 YP + choline-50 + d,l-methionine	933	838	889	1.62
Autoclaved YP-50	870	776	825	1.68

[1]Mean values in each column are not significantly different (P>.05).

Table A2. Mean body weights and feed conversion of broilers reared in battery cages to 4 and 7 weeks of age and fed yellow pea (YP) diets without and with supplementation of choline, d,l-methionine and a combination of the two and autoclaved YP (Exp.3)

YP (% of CP)	4 weeks of age				7 weeks of age			
	Mean body weights[1]			Feed conv.[1]	Mean body weights[1]			Feed conv.[1]
	Males(M)	Females(F)	M+F		Males(M)	Females(F)	M+F	
	g				g			
0	855	773	811	1.75	1735	1633	1690	2.05
25	901	819	866	1.64	2001	1764	1911	2.01
50	784	778	784	1.70	2009	1669	1782	2.04
50 YP + choline-50 (1.18 g/kg)	889	840	865	1.63	1932	1707	1814	2.02
50 YP +.4% d,l-methionine	891	807	841	1.52	1987	1685	1803	1.94
50 YP + choline-50 + d,l-methionine	853	853	853	1.65	1903	1740	1828	2.05
Autoclaved YP-50	906	818	856	1.73	2003	1590	1821	2.04

[1]Mean values in each column are not significantly different (P>.05).

Table A3. Mean body weights and feed conversion of broilers reared on litter floor to 4 and 7 weeks of age and fed 0%, 25% and 50% yellow pea (YP) diets and 50% YP diet supplemented with tryptophan (Trp), threonine (Thr), lysine (Lys) and the combination of the three (Exp.5)

YP (% of CP)	4 weeks of age				7 weeks of age			
	Mean body weights[1]			Feed conv.[1]	Mean body weights[1]			Feed conv.[1]
	Males(M)	Females(F)	M + F		Males(M)	Females(F)	M + F	
	------------- g -------------				------------- g -------------			
0	1007a	894a	943a	1.73a	2372a	1891c	2114ab	2.15a
25	998ab	894a	930ab	1.71a	2372a	1982a	2164a	2.13a
50	943cd	844bcd	889de	1.75a	2291b	1928bc	2105b	2.15a
50 YP + l-Trp (20.3g/kg)	943cd	871ab	903bcde	1.73a	2318ab	1901bc	2082bc	2.14a
50 YP + l-Thr (60.6g/kg)	980abc	848bcd	907bcd	1.77a	2313ab	1891c	2123ab	2.13a
50 YP + l-Lys (234.4g/kg)	957bcd	844bcd	898cde	1.75a	2191c	1891c	2037c	2.14a
50 YP + l-Trp + l-Thr	975abc	875ab	921abc	1.74a	2263bc	1946ab	2123ab	2.14a
50 YP + l-Trp + l-Lys	885e	816d	857f	1.81a	2304ab	1910bc	2100b	2.10a
50 YP + l-Thr + l-Lys	939cd	835cd	875cf	1.72a	2286b	1910bc	2096b	2.10a
50 YP + l-Trp + l-Thr + l-Lys	925de	866abc	894cde	1.74a	2277b	1928bc	2105b	2.10a

[1]Mean values in each column with different letters are significantly different (P<.05).