EFFECTS OF FEEDING A RESIDUE OF THE SOYBEAN OIL INDUSTRY, ON BROILER PERFORMANCE

by

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INTRODUCTION

There are many clays and clay-like minerals in nature. Dependent upon the particular mineral compounds present in a material, its physical nature and crystal structure, they are classed as kaolins, bentonites, vermiculites, silicates, etc. Bentonite is a naturally occurring clay of volcanic origin with many industrial uses. It has extremely small particle size and unusual adsorptive properties. Several types of bentonite exist composed of a variety of minerals mainly montmorillonite and containing principally aluminum silicate with lesser amounts of oxides and silicates of iron, magnesium, calcium, sodium, with a variety of minor elements.

The two most common bentonites used in poultry feeds are sodium and calcium, sodium bentonite, often called Wyoming or Western, which expands in water and contains up to 3% sodium and carries it as its predominant exchangeable ion; and calcium bentonite, which has negligible swelling and contains 1 or 2% calcium and carries it as its principal exhcangeable ion. Sodium bentonite is being used to improve the pelleting characteristics of a variety of mixed feeds. It is claimed that a harder, more attractive pellet is produced when this material is added to the feed at levels of 2 to 2.5%. Such usage also normally increases pellet mill capacity, lowers power requirements and lengthens die life because of the lubricating nature given by plate slippage.

There has been increasing use of sodium bentonite in poultry rations as a caloric extender, as control of moisture content in droppings and as improver of growth, as it has been observed that equal or better performance can be obtained by replacing grain at 2.0 to 2.5% levels. The higher cost

of grain will encourage the use of bentonites in most poultry rations. Their value in controlling the moisture content of droppings, along with the formation of firm droppings, will help in poultry-house management and to reduce fecal contamination in processing.

Fats of animal and vegetal origin have become important energy sources for poultry, particularly in relation to the formulation of rations of high energy concentration. One of the striking added benefits of fats, and principally of vegetable oils is the increased rate of growth induced by their addition to broiler diets. In relation to this soybean oil is of particular interest because of the wide use of soybean products in poultry diets. That soybean oil is a good source of growth-stimulating properties has been well established (Carver and Johnson, 1954). It was thought that some of the favorable effects associated with bentonite and soybean oil could benefit the poultry industry.

The present work was conducted to gain information concerning the effects of different levels of dietary Soy-Ben[R], a by-product of the soybean oil industry composed of 67% bentonite, 29% soybean oil, and 4% water, on the growth of chicks. The criteria of performance was on the basis of:

(a) weight gain

(b) feed utilization

and in line with the above criteria, which of the five Soy-Ben levels will best support broiler growth rate and feed utilization.

[R] Registered trade name for a residue of the soybean oil industry, composed of 67% bentonite, 29% soybean oil, and 4% water. Available from Scotland Industries, Inc. 6621 El Monte, Prairie Village, KS 66208.

REVIEW OF LITERATURE

Bentonite has found wide usage in the manufacture of livestock and poultry feeds in addition to its many industrial applications. Sodium bentonite is used in poultry feed primarily as a pellet binder. It is generally concluded that a level of 1 to 2% in the ration not only acts as a pellet binder but improves the hardness of pellets as well (Kurnick and Reid, 1960; Quisenberry and Bradley, 1964; Scott et al., 1976).

The effect of sodium bentonite on fecal consistency would be anticipated because of its unique high water absorbing properties. It can absorb about 6 times its weight of water and expands 12 to 15 times its original dry volume (Patrick and Schaible, 1981). Quisenberry and Bradley (1964) demonstrated the efficacy of sodium bentonite in the reduction of the water content of the droppings from hens given a dietary source of this material. Sodium bentonite at both the 2.5 and 5.0% dietary levels significantly reduced the moisture content of the droppings, and they also suggested that the drying effect might improve litter condition and perhaps reduce the incidence of keel blisters. Leibetseder and Skalicky (1974) showed the effect of various pelleting additives on the water content of the droppings of chickens, and reported that the manure of control groups had a water content of 69%, the Ca-ligning sulphonate group 68-69%, and bentonite only 65% which was significantly different. Sodium bentonite has been used in commercial broiler and turkey production to reduce fecal contamination in processing. It has been added to finisher diets at rates of 2.0 to 2.5% for 5 to 10 days before slaughter. Sodium bentonite has been useful in preventing semen contamination when artificial insemination is employed with turkeys (Anderson, 1979).

The adsorptive properties of bentonite have been shown to interfere with vitamin A stability. Vecher (1948) reported that in chromatographic studies bentonite adsorbed vitamin A and carotene from certain solvents with the development of specific colors. This property was used by Vecher to separate quantitatively vitamin A from natural carries. Laughland and Phillips (1954a) showed that the inclusion of sodium bentonite in the diet severely limited the ability of vitamin A deficient rats to store the vitamin in the liver. This effect was observed both with vitamin A and with the provitamin β-carotene. Moreover, the liver weight per 100 g. body weight was found to be less in most of the groups receiving sodium bentonite than in control groups. The results may be interpreted in terms of a physical adsorption of vitamin A or β-carotene on sodium bentonite present in the small intestine. Also, Wilson (1953a, b, 1954) found that mice fed a diet containing 50% bentonite failed to grow normally and developed a deficiency of choline and possible other factors.

In studies with chicks conducted with practical-type diets, Laughland and Phillips (1956) were unable to demonstrate a detrimental effect on growth rate with levels as high as 6% sodium bentonite in the diet. Although sodium bentonite decreased the availability of vitamin A and carotene in all the diets which were used. Briggs and Spivey (1954) have demonstrated that under certain conditions a vitamin A deficiency could be produced in chicks by incorporating bentonite in the diet. The addition of up to 20% bentonite to a practical-type diet, or 5% bentonite 90 mesh or larger to a synthetic diet, did not cause vitamin A deficiency signs. Only the finely powdered product caused the development of avitaminosis A when fed in a synthetic-type diet. The use of a stabilized vitamin A source in the synthetic diet also prevented the development of any symptoms of vitamin A deficiency.

Though bentonites are traditionally thought of as pellet binders and have been used as such for about 30 years, feeding trials with poultry indicated other potential benefits more than 20 years ago (Kurnick and Reid, 1960). In a preliminary study, employing both medium and high energy diets, Gillis (quoted by Ewing, 1963) observed no adverse effects on growth or feed utilization with the feeding of up to 4% sodium bentonite to chicks to four weeks of age. In the same experiment, bentonite improved growth when fed in the medium energy diet. Addition of 2.5% bentonite to low energy diets produced a highly significant improvement in the growth rate of chicks, a slightly delayed feed passage time and an increased feed intake (Kurnick and Reid, 1960). Adding 2.5 or 5.0% bentonite in layer diets significantly reduced water content of the layer droppings. Body weight and egg size were increased and feed utilization of egg production was improved (Quisenberry and Bradley, 1964).

Somaiah (1969) showed that body weights of commercial egg-type pullets were significantly increased by clays and bentonites, water content of manure was significantly reduced. Higher egg production was obtained with 2.5% clay or 5% sodium bentonite. In a feeding trial, Van'K, (1976) working with chickens and with levels of 0.5, 1.0, 1.5, 2.0, or 2.5% bentonite in the diet, observed that for the higher levels 2.0 or 2.5% the differences in body weight gain and feed utilization were significant. He also reported that the clay had a bleaching effect on the meat.

Two samples of kaolin and one of calcium bentonite were added to a basal broiler diet. In the first experiment in batteries, the only significant effect on mean body weight was a reduction when 10% bentonite was added. With the experiment in floor pens final body weight was significantly

reduced by 5% of either type of kaolin and more by 5% calcium bentonite. In another experiment in batteries final body weight was increased by 1 or 2% of any supplement but was not affected by the 3% level of supplementation.

Ousterhout (1967) fed a number of kaolins to broilers at levels from 0.5 to 40% of the diets, and reported that caloric efficiency was generally improved up to at least 16% additions. Meanwhile, Sibbald and Slinger (1962) reported a metabolizable energy content of 242 calories per Kg. for kaolin.

Growth rate, feed consumption and age at sexual maturity were used as criteria of the dietary response of pullets when fed 25% bentonite or 25% wood flour as a diluent on the diet (Reid and Kurnick, 1961). It was found that feeding the 13% protein diet containing 25% bentonite reduced growth rate by only 0.09 Kg., while 25% wood flour reduced growth by 0.23 Kg. Feed intake amounted to 6.7 Kg. per bird during the 9-23 week period when bentonite was fed, while 7.4 Kg. per bird was consumed by the full fed high energy control group. Sexual maturity was delayed by 15 days by feeding 25% bentonite and 21 days by the 25% wood flour diet.

Blakely et al. (1955) reported satisfactory performance of turkey poults to six weeks of age with the feeding of up to 5% sodium bentonite in a practical diet. Almquist et al. (1967) found bentonite to improve nutrient retention in turkeys; there was increased utilization of nitrogen, fat, and carbohydrates while feed utilization improved about 1.5%.

Month old chickens were given a standard diet fed as meal or pelleted without binding agent or with 2% sodium bentonite or 2% Ca and Mg ligno-sulphonates. Daily intake of N was 2.6 g., and on the average the chickens given meal retained 20.5% of it. With pelleting retention was 55.0% without binding agent and 52.1% with ligno-sulphonates but bentonite restored it to 60.8% (Boza et al., 1972).

Since ducks are considered relatively inefficient in feed utilization, and have a rapid feed passage rate with very wet droppings, they are usually fed pelleted diets. As much as 5% sodium bentonite has been incorporated in some duck diets (Dean, 1976 quoted by Hollister and Kienholz, 1980). These workers used diets containing 16% protein and 3143 KcalME/Kg. These complete diets were modified by substituting the following amounts of sodium bentonite (0.0, 2.4, 4.8, or 9.1%). The diets were fed to ducklings from 0 to 7 weeks of age. At 7 weeks ducklings weights of the treatment groups were not significantly different from controls. Feed utilization was significantly decreased only in the group fed 9.1% sodium bentonite.

In vitro and in vivo studies with steers conducted with sodium bentonite (Erwin et al., 1957) reported that sodium bentonite bound pure carotene in vitro. Three percent of dietary sodium bentonite did not significantly influence either the rate of gain, feed utilization, digestibility of dry matter or crude fiber, or hepatic vitamin A and carotene retention in steers fed a diet containing 25% of dehydrated alfalfa.

Jordan (1953) reported improved gains and feed consumption when bentonite was fed to fattening lambs, whereas a subsequent report (Jordan, 1954) failed to substantiate previous findings. Sodium bentonite has been found to improve butter fat test in low-roughage fed to dairy cattle (Rindsing et al., 1969). There the cows were given a fat-depressing diet alone or with 5 or 10% bentonite. Either amount of bentonite significantly increased milk fat content with no significant difference between amounts of bentonite. However, milk production was significantly higher with 5% bentonite.

Martin et al. (1969) reported that bentonite up to 8% of the diet improved feedlot performance of lambs on high-roughage diets. Erwin et al.

(1957) showed that 3% of bentonite in steers diets had no effect on feedlot performance.

Collings et al. (1975) showed that bentonite added to a high-concentrate lamb ration improved weight gain over a 30-day period.

Rotermel et al. (1964) reported work with swine which imputed to bentonite improved caloric retention. Collings et al. (1980) replacing corn in corn-soybean meal starter, grower and finisher swine diets with 0, 2, and 3% levels of sodium bentonite showed that dietary bentonite increased rate and efficiency of gain in the starter period but not in the growing and finishing periods. Dry matter digestibility was depressed by dietary sodium bentonite. Acid detergent fiber digestibility was also depressed by dietary sodium bentonite. Energy and mineral element utilization were not significantly affected by dietary bentonite.

The soluble fraction of a residue from a water purification plant was absorbed on bentonite. From 3 months of age, bentonite was added to the rations of pigs at 4.52 mg.% in the first month, and gradually increasing the level to 10.85 mg.% in the fifth month. The bentonite contained about 0.04 mg. vitamin B_{12} per g., with availability of 70 to 75%. The pigs given bentonite gained 13% more than the controls during the whole 5 months, in absolute terms over 8 Kg., and feed utilization was improved (Tihonov and Pallon, 1962).

In a similar study Finzi (1964), working with a residue of the oil industry containing 69% bentonite, reported that when chickens were given the commercial feed or when the feed was supplemented with 1.5, 3.0, or 4.5% residue and fed up to 57 days, weights were 6.5, 7.0, and 6.0% greater in the experimental groups. At the termination of the study, at 72 days of

age, chicks weighed 2.5, 3.3 and 2.8% more, respectively. Quality of carcass and of meat of the controls and for birds given 4.5% residue were similar.

Early investigations on the feeding of diets containing added fat to chicks gave conflicting and inconclusive results concerning the amount and kinds of fat that could be used advantageously (Ewing, 1963). These results were due to the failure to maintain a proper balance of fats with other food elements, particularly protein. Henderson and Irwin (1940) found that chicks tolerated as much as 10% soybean oil in their diet, but higher levels caused growth depression and excessive shedding of feathers. On the other hand, Reiser and Pearson (1949) fed 20% of lard in a purified diet to chicks without harmful effects, whereas 20% cottonseed oil in the diet resulted in poor growth particularly in riboflavin-deficient diets. Yacowitz (1953) showed that 2.5 to 5% of cottonseed oil, soybean oil, or lard improved growth and feed utilization of growing chicks, whereas 15% of cottonseed oil caused a depression in growth and poor feathering.

Baldini and Rosenberg (1957) conducted some experiments designed to determine whether the beneficial effects of fat are due entirely to its energy content or to some other intrinsic value of fat. The diet contained enough fat to meet the chick's requirement for essential fatty acids and an adequate protein content. They found that the same number of calories supplied either as fat or carbohydrates gave identical gains in weight and feed utilization. They concluded that in a diet adequately supplied with essential fatty acids, the effect of fat is due entirely to its caloric value.

Carver and Johnson (1953) found that chicks fed a purified diet or a purified soybean protein diet containing respectively 0.05 and 0.04% fat

as determined by hexane extraction require factors present in unsaturated fat for maximum growth. Crude corn oil, soybean oil, wheat germ oil, and oleic acid concentrate and linoleic acid concentrate were found to contain these factors.

Biely and March (1954) showed that fat added to a diet containing only 19% protein depressed growth and feed utilization, but when added to diets with 24 or 28% protein the fat increased feed utilization without adverse effect on growth. These findings confirmed the importance of a proper balance between total calories and protein level in the diet.

Donaldson et al. (1957) showed that addition of as much as 30% stabilized yellow grease to a diet already containing 3.8% fat did not depress growth. Sunde (1956) concluded that the chick does not utilize saturated long-chain fatty acids. Carver et al. (1955) reported that neither hydrogenated tallow nor hydrogenated tallow fatty acids are efficiently utilized as fat supplements to broiler diets. Pepper et al. (1953) showed that wheat-soybean broiler diets were improved when supplemented with 2% soybean oil.

Supplemental fat in the diet of the growing chick has been shown to have deleterious effects in some cases and beneficial in others (Henderson and Irwin, 1940). Fraps (1943) found that growth rate of chicks was markedly depressed as the level of dietary cottonseed oil was raised from 10 to 30%. Kummerow et al. (1949) reported that 25% linseed oil depressed growth and increased the incidence of perosis in chicks.

The age at which chicks reach their full capacity to digest fats is related to the nature of the fat. Peters (quoted by Annison, 1974) stated that tallow was poorly utilized by chicks up to 4 weeks of age when included

at levels of 5, 10 and 25% in isocaloric semi-purified diets. Soybean oil examined in the same experiment was relatively well utilized in 2-week-old chicks. Lewis and Payne (1966) showed that addition of 5, 10 and 20% soybean oil to tallow increased the digestibility of the tallow from 75 to 87, 93 and 95%, respectively when fats were fed at a level of 8%. Similar studies have shown that unsaturated fatty acids are better digested than their saturated counterparts, and that addition of the former enhances the digestibility of the saturated acid (Young and Garret, 1963).

Two items of current interest when vegetable oils are used as energy sources as (1) the possible beneficial effect of essential fatty acids, particularly linoleic acid, (2) the interrelationships between the level of polyunsaturated fatty acids in the diet, and vitamin E requirement (Scott et al., 1976). In chicks the linoleic acid requirement has been shown to be 1.3 to 1.5% of the diets although the level and nature of dietary fat, the sex of the bird and the previous essential fatty acid status may all influence the essential fatty acid requirement (Annison, 1971). Balnave (1971) has shown that oils containing high levels of linoleic acid may improve total egg yield through an increase in individual egg size.

The vitamin E requirement of chicks may be influenced by the polyunsaturated fatty acid content of the diet and they are involved in the three well-defined vitamin E deficiency diseases in the chick, encephalomalacia, exudative diathesis and muscular dystrophy (Green and Bunyan, 1969). Fortunately, most vegetable oils contain enough vitamin E to completely protect birds from deficiency diseases, and other sources of polyunsaturated fatty acids are rarely used in practical diets (Jager, 1972; Alfin-Slater et al., 1969).

MATERIALS AND METHODS

Six diets were formulated in which corn and sorghum grain were replaced in Kansas State University (K.S.U.) 24 and 20% protein broiler-chick starter and finisher standard diets by 0.0, 2.5, 5.0, 7.5, 10.0, and 15% Soy-Ben on a weight basis. The special type of bentonite used was a sample of commercially available material and was kindly supplied by Dr. Chase Wilson, Scotland Industries, Inc., 6621 El Monte, Prairie Village, KS 66208.

The formulated diets were mechanically mixed at the Department of Grain Science and Industry feed mill, bagged, labeled, conveyed and kept at the Poultry Research Center. The diets were iso-nitrogenous and contained ground corn and sorghum grain as basal ingredients. Tables of the formulated diets are contained in the Appendix (Tables A-1 and A-2) for diets used in Experiment I and II (Tables A-3 and A-4) for Experiment III.

In this study, three experiments were conducted in which a total of 120 day-old, sexed, meat-strain, Hubbard broiler chicks from a commercial hatchery were used for each experiment. All chicks were vaccinated with intraocular New Castle disease vaccine on arrival at the Poultry Research Center. The chicks were randomized into lots, 10 chicks per lot. Three lots constituted the replicates for each diet treatment. They were kept in electrically heated batteries with wire mesh floors for the first four weeks. Later they were transferred to unheated batteries for the last four weeks where five birds were placed in each battery compartment. All experiments were conducted for an 8-week period, feed and water were supplied ad libitum. Live weights were recorded in grams every second week and

concurrent group feed consumption was determined by weighing back the amount of feed remaining for that period. Average gain, average feed intake and feed utilization were calculated. Experiment I was conducted from May to July, Experiment II from September to November of 1981, and Experiment III from December 1981 to February 1982.

The same experimental design and treatments were applied to the birds in Experiments I and II. The Control Diet was a standard Kansas State University (K.S.U.) broiler-chick starter and finisher diet containing 24 and 20% protein, respectively. That constituted treatment 1 for all the experiments. Replacements by Soy-Ben at the 0, 5, 10, and 15% levels to the Control Diet were made at the expense of the basal grains and these made up treatments 1, 2, 3, and 4 for Experiments I and II throughout the 8-week period.

The chicks of Experiment II had a lower starting average weight than that of Experiment I. They were delayed on their arrival at the Poultry Research Center by more than 48 hours, and showed severe dehydration. This inconsistency in body weight was taken into account when the statistical comparisons were made. It was also noticed in these experiments that the rather high levels of the experimental product exerted a considerable detrimental effect on the well being of the birds. A riboflavin deficiency was observed, but was overcome by the administration of riboflavin in the drinking water.

In view of the above observations the levels of Soy-Ben were reduced from 5 to 2.5% and from 15 to 7.5% in treatments 2 and 4, respectively. Therefore, the experimental diets fed during Experiment III contained 0.0, 2.5, 5.0, and 7.5% Soy-Ben levels, which were the corresponding 1, 2, 5, and

6 treatments. Records of live weight and feed consumption were kept for the first four weeks only, because the Soy-Ben was in short supply, and from there the chicks were given a standard Kansas State University (K.S.U.) 20% protein broiler-chick diet.

An analysis of variance according to a simple classification model was used and means were compared by the Least Significant Difference (LSD) test as described by Snedecor and Cochran (1980). Weight gain and feed utilization were the main factors analyzed and compared for the treatments.

RESULTS AND DISCUSSION

Data were analyzed for averages of weight gain and feed utilization for the 0-2, 2-4, 4-6, 6-8, 0-4, 0-6 and 0-8 weeks growing periods, respectively. Results will be presented and discussed under the heading of Experiment I, II and III. Data for average weight gain and feed utilization of Experiments I, II and III are in the Appendix (Tables A-5 to A-21).

Feeding Soy-Ben at 5, 10 and 15% resulted in the production of gross symptoms of riboflavin deficiency in just 1 to 2 weeks, in spite of the presence of riboflavin in the diets. The administration of additional riboflavin in the drinking water was effective in overcoming the detrimental effect of Soy-Ben on riboflavin availability.

Experiment I. The results and analysis of variance for average weight gains are given in Table 1, Figure 1. The Control Diet was significantly ($P < 0.05$) superior to the Soy-Ben treatments with regard to average weight gains during the early growing period 0-2 weeks, but treatments 2, 3 and 4 (5, 10 and 15% Soy-Ben), respectively, did not differ significantly ($P < 0.05$) from one another. The experimental treatments (2, 3 and 4) were significantly ($P < 0.05$) better than the Control Diet in terms of growth rate at 4-6 weeks (Table 1). Overall, the birds receiving the Soy-Ben diets and the Control Diet tended to gain weight at similar rate (Figure 1).

Chicks fed the Soy-Ben containing diets had significantly ($P < 0.05$) better feed utilization at 4-6 and 0-6 weeks of age (Table 2, Figure 2). Treatments 2, 3 and 4 did not differ significantly ($P < 0.05$) from one another with respect to feed utilization at both 4-6 and 0-6 weeks. Average

Table 1. Analysis of variance of average weight gains in Experiment I.

Sources of Variation	d.f.	Age in Weeks 0-2	2-4	4-6	6-8	0-4	0-6	0-8
		Mean Squares						
Treatments	3	1634.54*	1714.02	13022.15*	1642.25	2286.72	13957.60	19121.59
Error	8	252.72	782.11	1777.34	2408.78	1577.42	5238.27	10383.87
Diets		Means[1] - Weight Gain (g.)						
1 - 0.0% Soy-Ben		261.46b	522.76b	669.73b	589.16a	778.23a	1453.96b	2043.13a
2 - 5% Soy-Ben		225.46a	554.43a	812.60a	631.26a	779.90a	1592.50a	2223.76a
3 - 10% Soy-Ben		230.30a	577.79a	794.47a	575.84a	808.09a	1602.56a	2199.89a
4 - 15% Soy-Ben		205.00a	535.80a	794.00a	586.53a	740.80a	1534.80b	2121.33a

*Significant ($P < 0.05$)

[1]Means in the same column with different superscripts are significantly different ($P < 0.05$)

Table 2. Analysis of variance of average feed utilization in Experiment I.

Sources of Variation	d.f.	Age in Weeks 0-2	2-4	4-6	6-8	0-4	0-6	0-8
		Mean Squares						
Treatments	3	0.014	0.001	0.088*	0.023	0.012	0.017*	0.019
Error	8	0.017	0.003	0.020	0.028	0.011	0.002	0.010
Diets		Means[1] - Feed Utilization (Kg Feed per Kg Gain)						
1 - 0.0% Soy-Ben		1.663a	1.790a	2.233b	3.053a	1.753a	1.970b	2.303a
2 - 5.0% Soy-Ben		1.643a	1.750a	1.886a	3.016a	1.710a	1.806a	2.190a
3 - 10.0% Soy-Ben		1.516a	1.740a	1.870a	2.880a	1.600a	1.826a	2.090a
4 - 15% Soy-Ben		1.553a	1.760a	1.923a	3.210a	1.703a	1.820a	2.180a

*Significant ($P < 0.05$)

[1]Means in the same column with different superscripts are significantly different ($P < 0.05$)

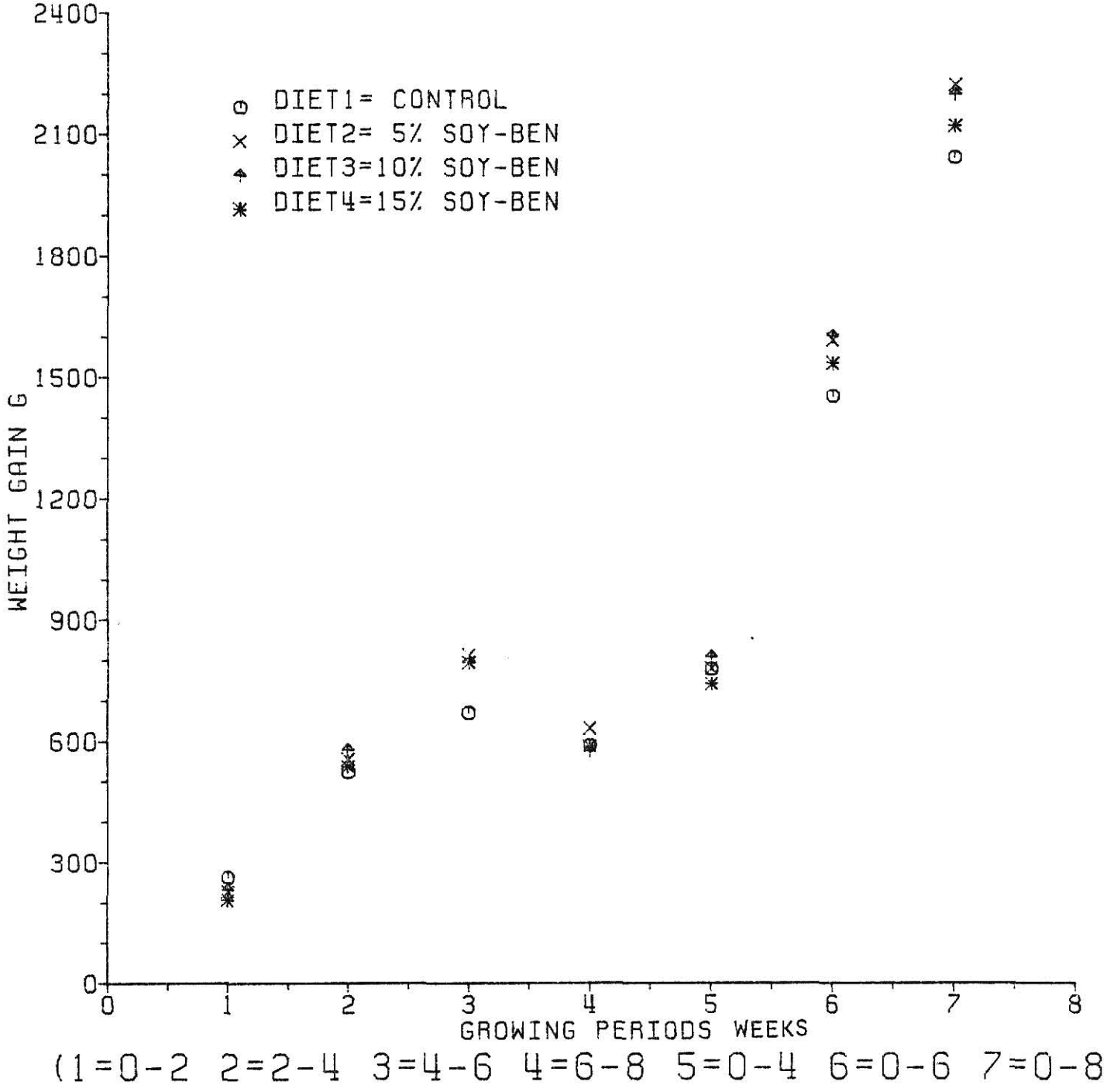

Figure 1. Effect of Diets on Weight Gain during Each Growing Period, Experiment I.

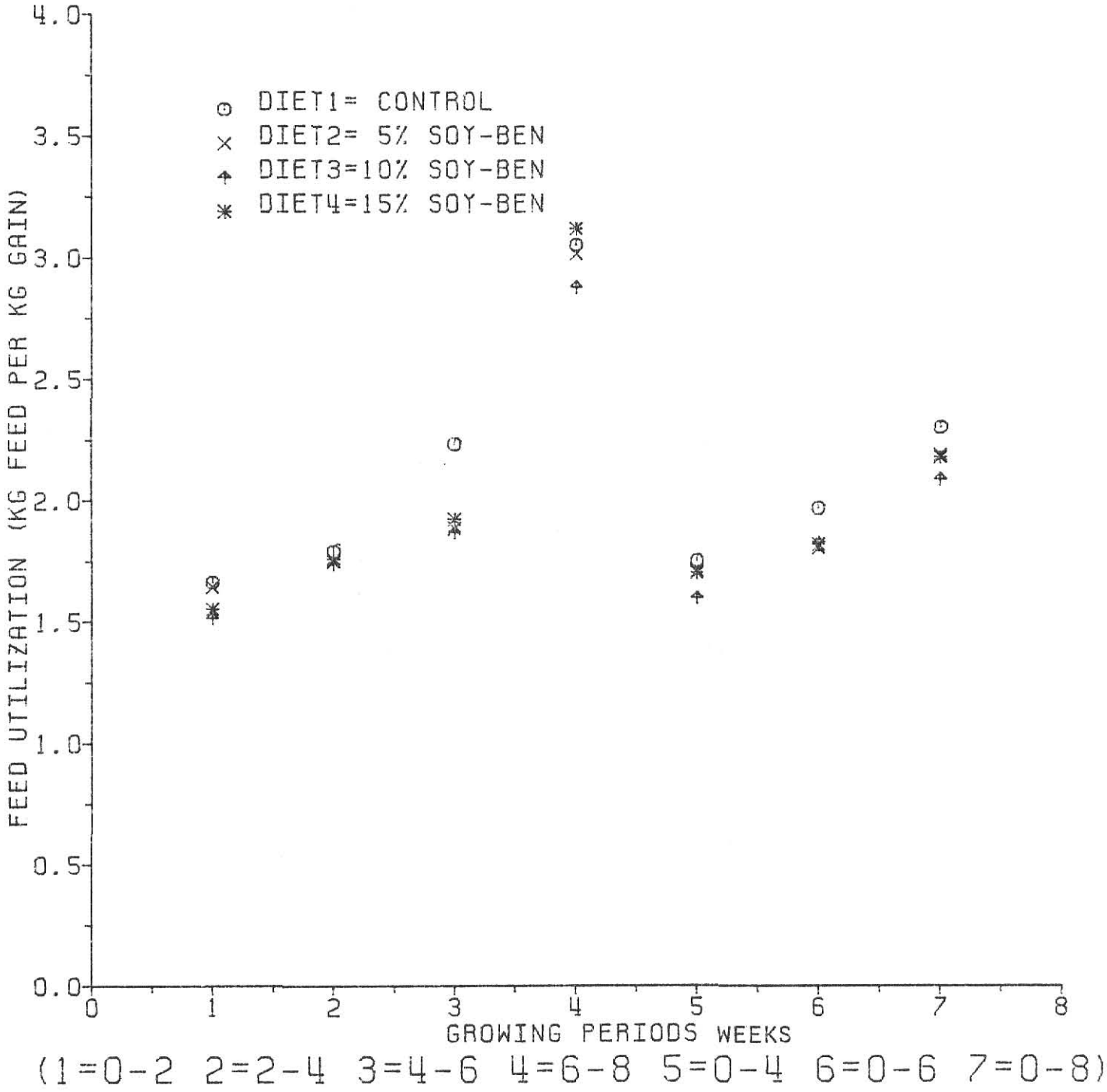

Figure 2. Effect of Diets on Feed Utilization during Each Growing Period, Experiment I.

weight gains from the 0, 5, 10 and 15% Soy-Ben treatments varied by only 139 g. per bird at 8 weeks of age. Chicks receiving the Control Diet were about 6% lighter in body weight at 8 weeks of age, although this was not a statistically significant difference ($P < 0.05$). Feed utilization was slightly improved as the level of Soy-Ben was increased in the diet. However, the 0, 5, 10 and 15% Soy-Ben treatments did not differ significantly ($P < 0.05$) from one another (Table 2, Figure 2).

Feed consumption interpreted from the feed utilization figures did not increase as Soy-Ben was increased in the diets, as rapidly as would be expected if the Soy-Ben product merely diluted the diet. It appeared that 5, 10, and 15% Soy-Ben levels contributed nutritionally or spared nutrients, since no depressing growth effect was observed. Thus, Soy-Ben fed as 5, 10, and 15% of the Control Diet was equivalent nutritionally to as much as 44, 21, and 15%, respectively, of an equal weight of the Control Diet for growing chicks to market weights.

Assuming that bentonites do not contain energy, and the fact that Soy-Ben was substituted at the expense of energy, this substitution produced an energy level in each experimental treatment that was not equal to that contained in the Control Diet. It was expected the Control Diet would stimulate better growth because of a higher energy level than the Soy-Ben containing formulas. Since this did not happen and the Soy-Ben dietary levels did not affect rate of growth and feed utilization, it was thought the soybean oil (29%) contained in Soy-Ben was partially responsible for counteracting the energy dilution effect coming from the Soy-Ben substitution. Another possible explanation is that reported by Kurnick and Reid (1960). They showed that when the diet contained 2.5 or 5% sodium bentonite

the passage rate of feed through the intestinal tract was delayed 4-7%. Therefore, this effect may be associated with changes in nutrient utilization observed in this study.

Experiment II. Analysis of variance of average weight gains and the experiment means weight gain throughout the experimental period are shown in Table 3, Figure 3, where differences in live weight are evident at 0-2, 2-4, 0-4, and 0-6 weeks. In all these growing periods there was no significant differences between diets 1 and 2 (0 and 5% Soy-Ben), respectively, but the effect of diet 3 (10% Soy-Ben) on rate of growth was significantly ($P < 0.05$) lower than that of diets 1 and 2.

With respect to feed utilization, diets 1 and 2 did not show significant differences during all the growing periods. However, they had significantly better feed utilization than diet 3 at 0-4 and 0-6 weeks (Table 4, Figure 4). It is evident from these results that the pattern of chicks performance receiving the Soy-Ben treatments was inconsistent compared to that of Experiment I. The significant differences observed in the corresponding growing periods were expected because of the reduced thriftiness of the birds of treatment 3. This suggests the chicks were unable to recover from the detrimental effect of initial dehydration on their health, and that Soy-Ben contributed to the reduced growth rate. They were delayed in transit. High mortality during the first weeks with the Soy-Ben treatments resulted in less than 50% survival at 4 weeks of age in treatment 3. All birds of treatment 4 had died.

It appeared that treatment 3 contributed to the statistical differences shown in some of the growing periods, because there were no significant differences between diets 1 and 2 throughout the 8-week

Table 3. Analysis of variance of average weight gains in Experiment II.

Source of Variation	d.f.	Age in Weeks 0-2	2-4	4-6	6-8	0-4	0-6	0-8
		Mean Squares						
Treatments	3	10571.777**	75576.082*	87952.654	67610.308	141849.505*	226477.675*	527073.737
Error	3	223.123	5613.141	9370.805	11939.760	7941.296	231.125	15493.28
Diets		Means[1] - Weight Gain (g.)						
1 - 0.0% Soy-Ben		242.210a	490.720a	660.740a	999.990a	732.930a	1393.670a	2406.670a
2 - 5.0% Soy-Ben		256.565a	482.835a	748.050a	876.935a	739.400a	1487.450a	2364.385a
3 - 10.0% Soy-Ben		140.305b	238.135b	241.700b	509.500b	378.440b	684.100b	1193.600b
4 - 15.0% Soy-Ben		99.180	58.970					

*Significant ($P < 0.05$)

**Significant ($P < 0.01$)

[1]Means in the same column with different superscripts are significantly different ($P < 0.05$)

Table 4. Analysis of variance of average feed utilization in Experiment II.

Sources of Variation	d.f.	Age in Weeks 0-2	2-4	4-6	6-8	0-4	0-6	0-8
		Mean Squares						
Treatments	3	0.042	0.118	2.536	1.999	0.420*	0.133*	0.083
Error	8	0.118	0.081	0.028	0.033	0.045	0.000	0.245
Diets		Means[1] - Feed Utilization (Kg Feed per Kg Gain)						
1 - 0.0% Soy-Ben		2.140a	1.580a	2.880a	1.350a	1.770a	2.100a	1.990a
2 - 5.0% Soy-Ben		2.000a	2.080a	2.560a	1.080a	2.040ab	2.250a	1.800a
3 - 10.0% Soy-Ben		1.925a	2.285a	5.250b	2.940a	2.045b	2.780b	2.300a
4 - 15.0% Soy-Ben								

*Significant ($P < 0.05$)

[1]Means in the same column with different superscripts are significantly different ($P < 0.05$)

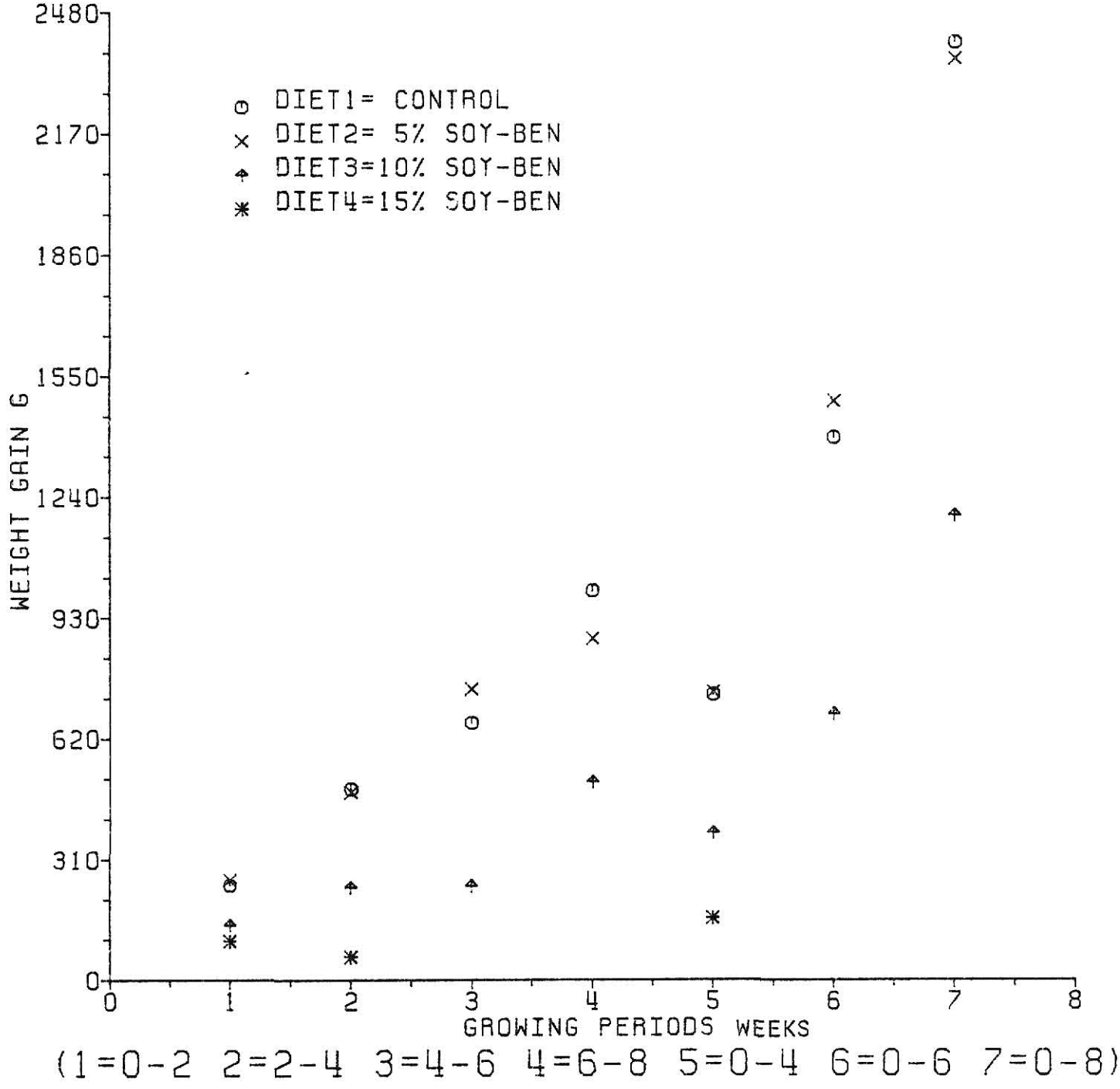

Figure 3. Effect of Diets on Weight Gain during Each Growing Period, Experiment II.

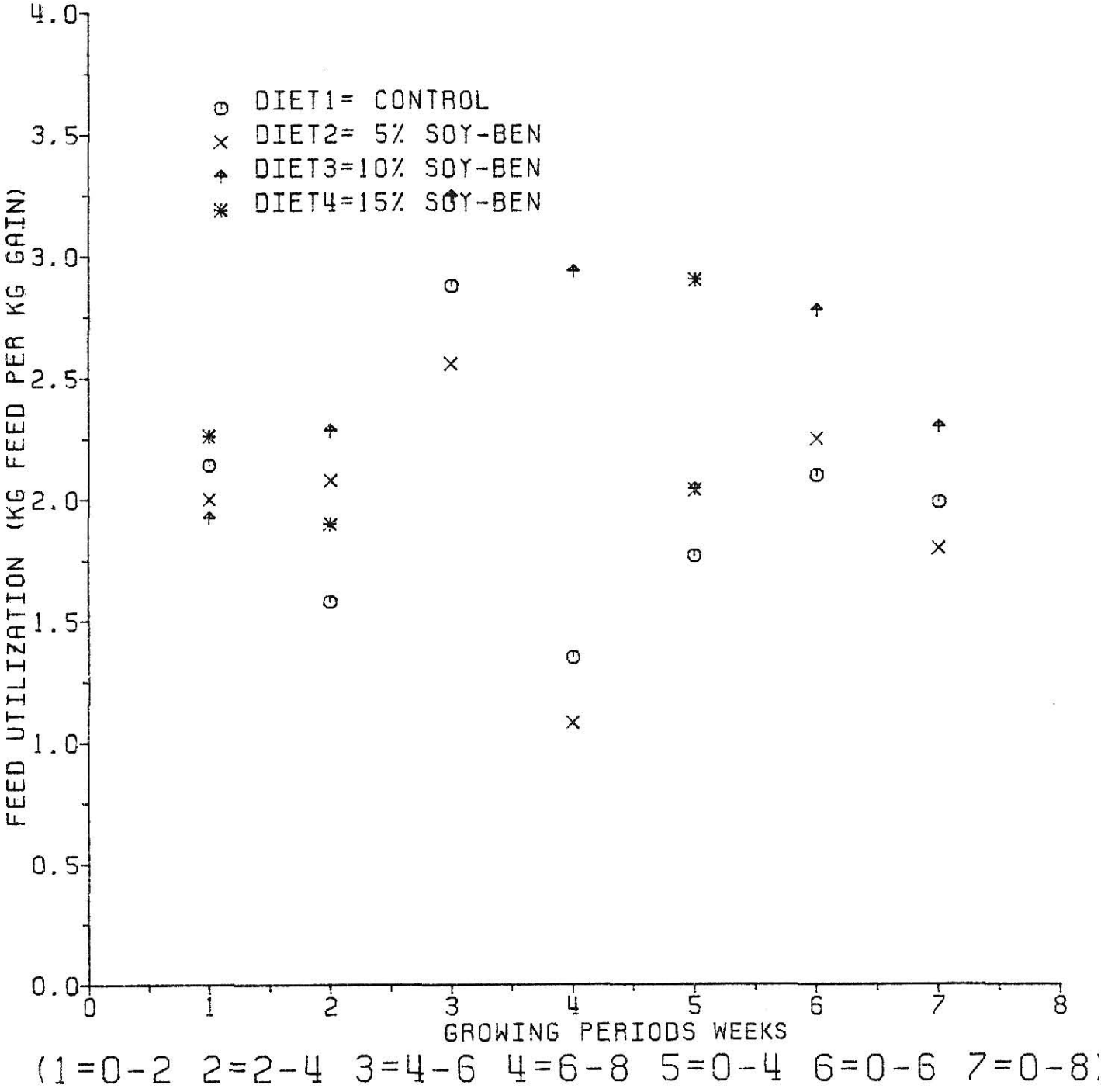

Figure 4. Effect of Diets on Feed Utilization during Each Growing Period, Experiment II.

experimental period. Therefore, to ensure overall protection level, only probabilities associated with diets 1 and 2 were compared. It was found that the numerical differences between diets 1 and 2 did not attain statistical differences (Table 3). The feeding of 0 or 5% Soy-Ben in the diet of broiler chicks to 8 weeks of age did not detrimentally affect either growth rate or feed utilization. Thus, diets 1 and 2 in Experiment I and II followed similar pattern in relation to birds performance. These data point to the possibility that similar results could be expected by using the Soy-Ben 0, 5, 10, and 15% dietary levels, unless something interferes with the health of the birds.

Experiment III. Statistical analysis of average weight gain data (Table 5) indicated a significant difference ($P < 0.05$) at 0-2 and 0-4 weeks of age. Average bird weights from 0.0 and 2.5% Soy-Ben treatments varied by only 16 g. and from 5.0 and 7.5% Soy-Ben by 26 g. at 2 weeks of age, respectively. This was not statistically different ($P < 0.05$). However, the Control Diet in this period produced birds which exhibited growth rates significantly better than those from diets 2 and 6 (Soy-Ben treatments), but there was a non-significant difference between the Control Diet and diet 5 (Soy-Ben treatment). At 0-4 weeks of age birds fed diets 1, 5 and 6 (0.0, 2.5, and 7.5% Soy-Ben) exhibited a statistically significant difference from birds given the 5% Soy-Ben treatment, but they were not significantly different from one another (Figure 5). A statistical analysis of feed utilization revealed a significant difference ($P < 0.05$) at 0-4 weeks of age (Table 6). However, treatments 6, 5, and 1 did not differ significantly ($P < 0.05$) among them, though they were significantly ($P < 0.05$) better utilized than diet 2 (5% Soy-Ben), (Table 6, Figure 6). All these

Table 5. Analysis of variance of average weight gains in Experiment III.

Sources of Variation	d.f.	Age in Weeks 0-2 (Week)	2-4 (Week)	0-4 (Week)
		Mean Squares		
Treatments	3	2026.00*	1978.78	19266.60*
Error	8	461.52	745.20	3976.39
Diets		Means[1] - Average Weight Gain (g.)		
1 - 0.0% Soy-Ben		285.68a	596.87ab	882.55a
2 - 5.0% Soy-Ben		241.52b	568.68b	743.51b
5 - 2.5% Soy-Ben		302.13a	630.78a	932.89a
6 - 7.5% Soy-Ben		267.40ab	591.00a	858.40a

*Significant ($P < 0.05$)

[1]Means in the same column with different superscripts are significantly different ($P < 0.05$)

Table 6. Analysis of variance of average feed utilization in Experiment III.

Sources of Variation	d.f.	Age in Weeks 0-2 (Week)	2-4 (Week)	0-4 (Week)
		Mean Squares		
Treatments	3	0.016	0.108	0.058*
Error	8	0.008	0.051	0.013

Diets	Means[1] - Average Feed Utilization (Kg Feed per Kg Gain)		
1 - 0.0% Soy-Ben	1.476a	1.823ab	1.696a
2 - 5.0% Soy-Ben	1.653b	2.170b	2.010b
5 - 2.5% Soy-Ben	1.523ab	1.906ab	1.736a
6 - 7.5% Soy-Ben	1.556ab	1.726a	1.816ab

*Significant ($P < 0.05$)

[1]Means in the same column with different superscripts are significantly different ($P < 0.05$)

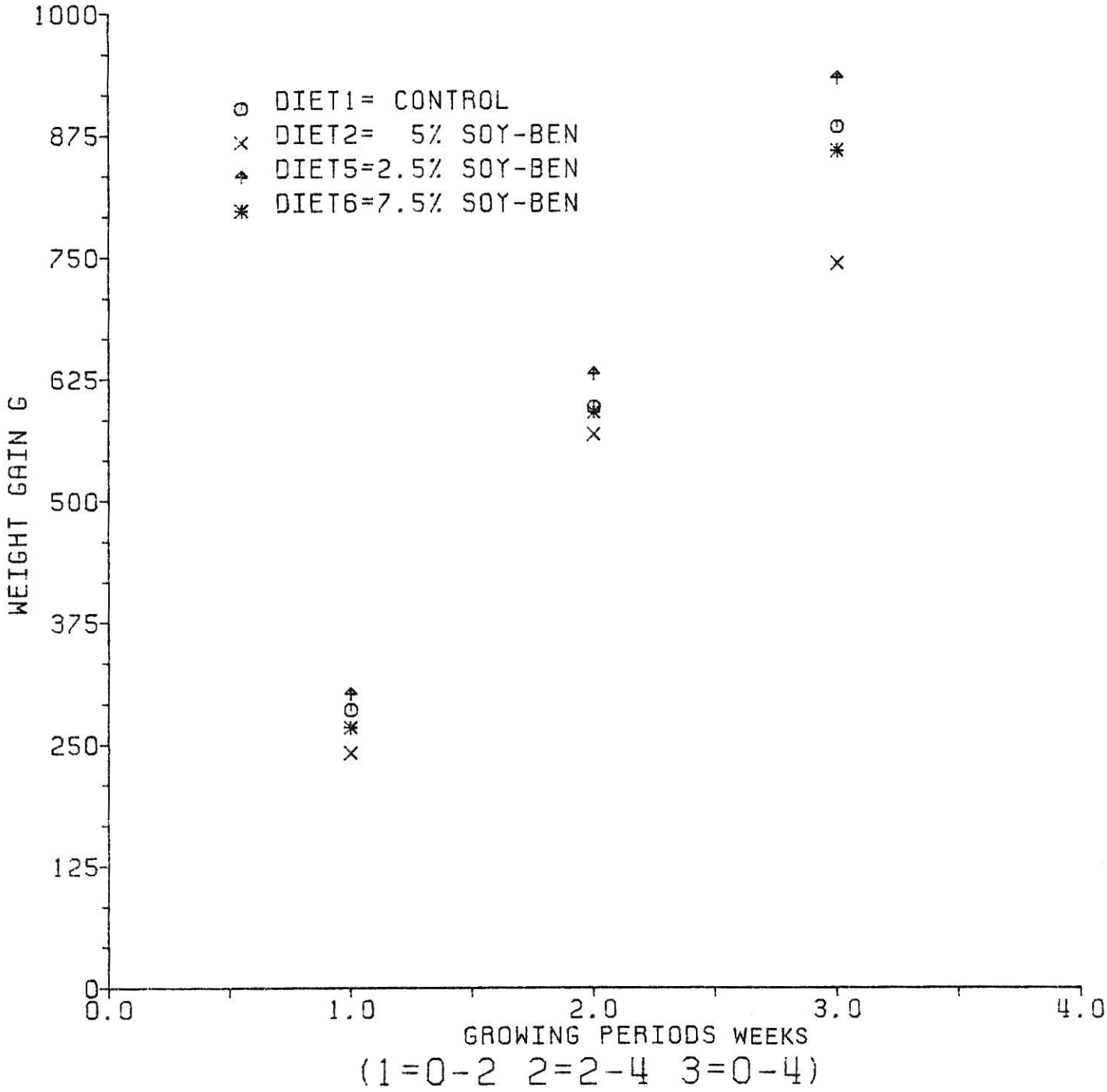

Figure 5. Effect of Diets on Weight Gain during Each Growing Period, Experiment III.

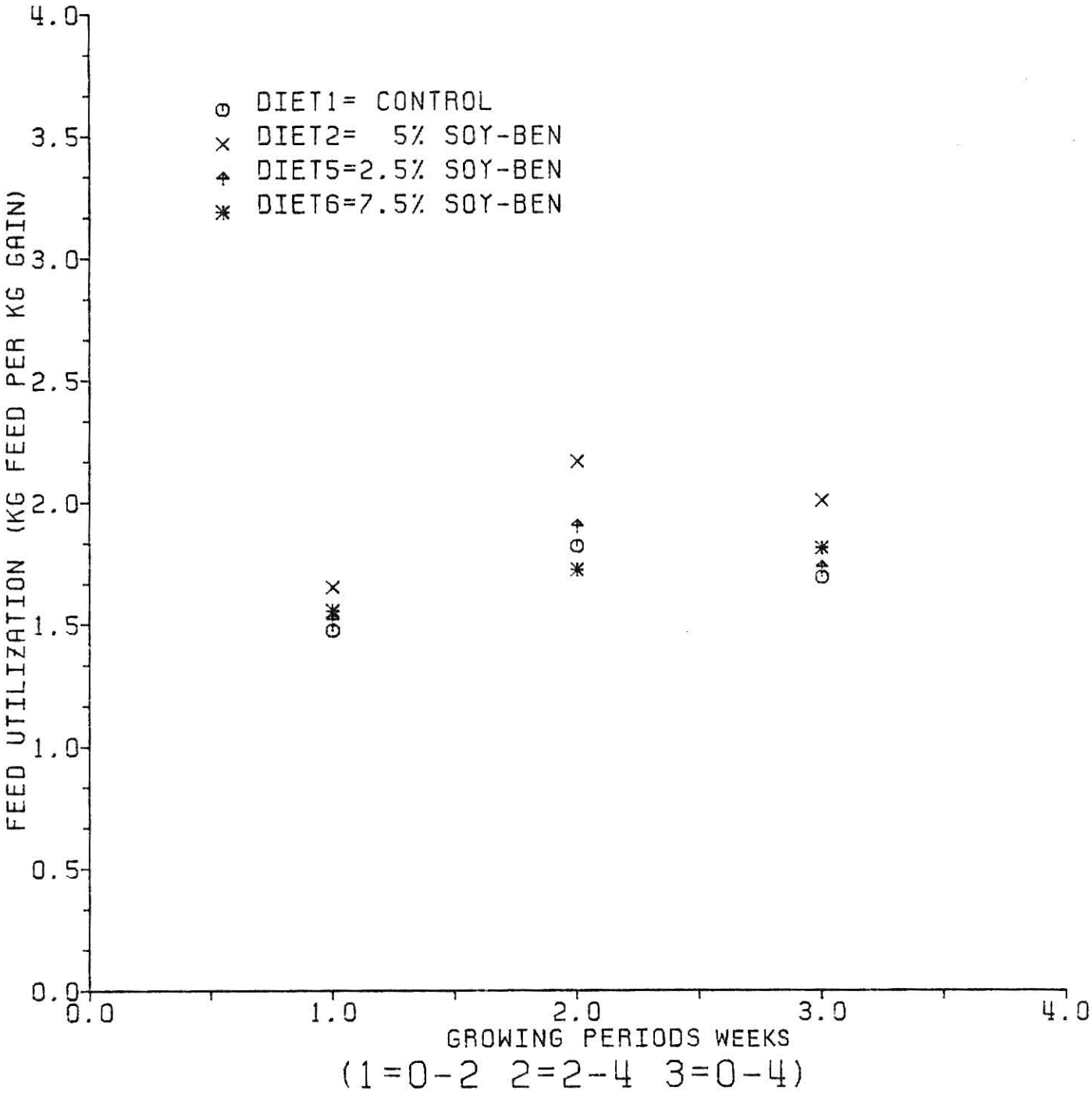

Figure 6. Effect of Diets on Feed Utilization during Each Growing Period, Experiment III.

statistical comparisons are based on data recorded during the 0-4 week period, because beyond that the Soy-Ben product was not available.

These data indicated that use of 2.5 to 7.5% Soy-Ben in the diet of broiler chicks to four weeks of age did not detrimentally affect either growth rate or feed utilization. These results point to the possibility that Soy-Ben spared nutrients because of the soybean oil content (29%) which suggests that utilization of the diets was according to their energy level. Because of the Soy-Ben substitution, the energy levels were lower in the experimental diets. It was thought that soybean oil may be responsible for the non-significant difference in growth rate and feed utilization observed in this experiment. Assuming that energy coming from the oil portion of Soy-Ben was real, this may explain its non depressing effect on performance of broilers fed the Soy-Ben treatments. Another explanation might be that reported by Kurnick and Reid (1960) in which they observed a decrease in rate of feed passage time, when bentonite was fed at 2.5 and 5.0% levels and if this effect is indeed real a better nutrient utilization would be expected.

SUMMARY AND CONCLUSIONS

This study was designed to gain information concerning the effects of different levels of Soy-Ben, a special bentonite by-product of the soybean oil industry (67% bentonite, 29% soybean oil and 4% water), on broiler diets, and to establish which of the different dietary levels would best support broiler growth.

Three experiments were conducted with six levels of Soy-Ben (0.0, 2.5, 5.0, 7.5, 10.0 and 15.0%) as dietary variables in broiler diets. Rather high dietary levels, 5 to 15%, were employed in the first two experiments as a dilution to the total diet. In Experiment III, Soy-Ben was tested at lower dietary levels 2.5 to 7.5% in view of the riboflavin deficiency observed in Experiment I. All diets were isonitrogenous. The chick starter and finisher broiler diets contained 24 and 20% protein, respectively. Each experiment was conducted for a period of eight weeks. A total of 360 broilers were used. Diets 1 and 2 were each fed to 90 birds, diets 3 and 4 were each fed to 60 birds and diets 5 and 6 were each fed to 30 birds. Weight of the birds as well as feed consumed was measured every two weeks. The performance data, growth rate and feed utilization, were analyzed statistically by one-way analysis of variance, with significant differences between treatment means determined using the Least Significant Differences (LSD) test.

The following conclusions could be drawn from the results obtained in this research:

1. In Experiment I, it was observed that Control Diet and Soy-Ben produced significant improvement in terms of growth rate at 0-2 and 4-6

weeks, respectively. However, in these periods there was no significant difference in average gain among the three Soy-Ben diets. Feed utilization was significantly better with all the experimental diets at both 4-6 and 0-6 weeks, but at 0-8 weeks chick weights and feed utilization of the treatment groups were not significantly different from controls.

2. In Experiment II, the incorporation of Soy-Ben in the diets had a limiting effect on body weight at 0-2, 2-4, 0-4 and 0-6 weeks of age. Feed utilization was also significantly reduced by feeding Soy-Ben, at 0-4 and 0-6 weeks. At 0-8 weeks the addition of 10% Soy-Ben did not significantly improve growth, but feed utilization of the treatment groups was not significantly different from controls. Soy-Ben limited body weight and feed utilization under the conditions of Experiment II.

3. In Experiment III, at 0-2 and 0-4 weeks growth rate tended to be improved by dietary addition of Soy-Ben. At 0-4 weeks feed utilization was significantly reduced by incorporating Soy-Ben to the diets. Therefore, feed utilization up to 4 weeks was essentially in direct proportion to the energy of the diets.

4. It appeared that the presence of Soy-Ben in the diet was necessary for the destruction or decreased availability of riboflavin, since in the absence of Soy-Ben no symptoms of riboflavin deficiency were seen. The minimum effective level of riboflavin in overcoming the Soy-Ben destructive action was not determined, however its administration in the drinking water was effective in correcting the vitamin deficiency symptoms.

5. The results of this study demonstrate that caution is necessary in the use of Soy-Ben in broiler diets with regard to the stability of riboflavin. Therefore, Soy-Ben can not be regarded as an inert ingredient when added to broiler diets.

6. The information from this study does not lead to any clear view about optimal or minimal levels of Soy-Ben in broiler diets. However, the 2.5% Soy-Ben level would be more preferable than the others because birds receiving it exhibited a slight but consistent improvement in terms of growth rate during the experimental period in which it was tested.

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APPENDIX

Table A-1 Composition of the broiler starter diets,[1] Experiments I and II

Ingredients	Concentration (lbs/100 lbs) Diets (with Percent Soy-Ben[2]) 0%S-B	5%S-B	10%S-B	15%S-B
Corn, yellow, ground	22.50	19.10	15.30	11.47
Sorghum grain, ground	22.00	19.50	17.00	14.50
Alfalfa, dehy., 17% Protein	2.50	2.50	2.50	2.50
Animal fat, yellow grease	5.00	5.00	5.00	5.00
Soybean meal, 44% Protein	44.50	45.40	46.70	48.00
Soy-Ben[2]	0.00	5.00	10.00	15.00
Premix A				
Ground limestone	1.00	1.00	1.00	1.00
Dicalcium phosphate	1.00	1.00	1.00	1.00
Salt	0.50	0.50	0.50	0.50
Total	100.00	100.00	100.00	100.00

Table A-1 (Continued)

Premix B[3] (g.)		
Vitamin A (10,000 I.U./g.)	-	20.0
Vitamin D_3 (15,000 I.C.U./g.)	-	8.0
Vitamin B_{12} (20 mg./lb.)	-	10.0
B-Complex vitamin mix[4]	-	45.0
Choline Chloride (50%)	-	40.0
Methionine	-	23.0
Trace mineral mix[5]	-	23.0
Sorghum, ground	-	285.0
Total		454 g. (1 lb.)

[1]All diets were isonitrogenous (24% Protein).

[2]Soy-Ben[R] residue of the soybean oil industry containing 67% bentonite, 29% soybean oil, and 4% water.

[3]Added in equal amounts to all diets.

[4]Supplies in mg./lb.: riboflavin 2,000; pantotheonic acid 2,680; niacin 6,000; choline chloride 20,000.

[5]Supplies by %: Mn 10; Fe 10; Cu 1; Zn 5; I_2 0.3; Co 0.1.

Table A-2 Composition of the broiler finisher diets,[1] Experiments I and II

	Concentration (lbs/100 lbs)			
	Diets (with Percent Soy-Ben[2])			
Ingredients	0%S-B	5%S-B	10%S-B	15%S-B
Corn, yellow, ground	27.00	24.50	21.00	17.00
Sorghum grain, ground	27.00	24.50	22.00	19.50
Alfalfa, dehy., 17% Protein	2.50	2.50	2.50	2.50
Animal fat, yellow grease	5.00	5.00	5.00	5.00
Soybean meal, 44% Protein	34.50	34.50	35.50	37.00
Fermentation residue	1.50	1.50	1.50	1.50
Soy-Ben[2]	--	5.00	10.00	15.00
Premix A				
Ground limestone	1.00	1.00	1.00	1.00
Dicalcium phosphate	1.00	1.00	1.00	1.00
Salt	0.50	0.50	0.50	0.50
Total	100.00	100.00	100.00	100.00

Table A-2 (Continued)

Premix B[3] (g.)		
Vitamin A (10,000 I.U./g.)	-	20.0
Vitamin D_3 (15,000 I.C.U./g.)	-	8.0
Vitamin B_{12} (20 mg./lb.)	-	10.0
B-Complex vitamin mix[4]	-	45.0
Choline Chloride (50%)	-	40.0
Methionine	-	23.0
Trace mineral mix[5]	-	23.0
Riboflavin	-	50.0
Amprol	-	23.0
Sorghum, ground	-	285.0
Total		527 g. (1. 16 lb.)

[1]All diets were isonitrogenous (20% Protein)

[2]Soy-Ben[R] residue of the soybean oil industry containing 67% bentonite, 29% soybean oil, and 4% water.

[3]Added in equal amounts to all diets.

[4]Supplies in mg./lb.: riboflavin 2,000; pantotheonic acid 2,680; niacin 6,000; choline chloride 20,000.

[5]Supplies by %: Mn 10; Fe 10; Cu 1; Zn 5; I_2 0.3; Co 0.1.

Table A-3 Composition of the broiler starter diets,[1] Experiment III

	Concentration (lbs/100 lbs)			
	Diets (with Percent Soy-Ben[2])			
Ingredients	0.0%S-B	2.5%S-B	5.0%S-B	7.5%S-B
Corn, yellow, ground	22.50	22.90	19.10	18.75
Sorghum, grain, ground	22.00	20.75	19.50	18.25
Alfalfa, dehy., 17% Protein	2.50	2.50	2.50	2.50
Animal fat, yellow grease	5.00	5.00	5.00	5.00
Soybean meal, 44% Protein	44.50	42.85	45.40	44.50
Soy-Ben[2]	--	2.50	5.00	7.50
Premix A				
Ground limestone	1.00	1.00	1.00	1.00
Dicalcium phosphate	1.00	1.00	1.00	1.00
Salt	0.50	0.50	0.50	0.50
Total	100.00	100.00	100.00	100.00

Table A-3 (Continued)

Premix B[3] (g.)		
Vitamin A (10,000 I.U./g.)	-	20.0
Vitamin D_3 (15,000 I.S.U./g.)	-	8.0
Vitamin B_{12} (20 mg./lb.)	-	10.0
B-Complex vitamin mix[4]	-	45.0
Choline Chloride (50%)	-	40.0
Methionine	-	23.0
Trace mineral mix[5]	-	23.0
Riboflavin	-	50.0
Sorghum, ground	-	285.0
Total		504 g. (1.11 lb.)

[1]All diets were isonitrogenous (24% Protein).

[2]Soy-Ben[R] residue of the soybean oil industry containing 67% bentonite, 29% soybean oil, and 4% water.

[3]Added in equal amounts to all diets.

[4]Supplies in mg./lb.: riboflavin 2,000; pantotheonic acid 2,680; niacin 6,000; choline chloride 20,000.

[5]Supplies by %: Mn 10; Fe 10; Cu 1; Zn 5; I_2 0.3; Co 0.1.

Table A-4 Composition of the broiler finisher diets,[1] Experiment III

	Concentration (lbs/100 lbs)			
	Diets (with Percent Soy-Ben[2])			
Ingredients	0.0%S-B	2.5%S-B	5.0%S-B	7.5%S-B
Corn, yellow, ground	27.00	29.25	24.50	25.15
Sorghum grain, ground	27.00	25.75	24.50	23.25
Alfalfa, dehy., 17% Protein	2.50	2.50	2.50	2.50
Animal fat, yellow grease	5.00	5.00	5.00	5.00
Soybean meal, 44% Protein	34.50	31.00	34.50	32.60
Fermentation residue	1.50	1.50	1.50	1.50
Soy-Ben[2]	--	2.50	5.00	7.50
Premix A				
Ground limestone	1.00	1.00	1.00	1.00
Dicalcium phosphate	1.00	1.00	1.00	1.00
Salt	0.50	0.50	0.50	0.50
Total	100.00	100.00	100.00	100.00

Table A-4 (Continued)

Premix B[3] (g.)		
Vitamin A (10,000 I.U./g.)	-	20.0
Vitamin D_3 (15,000 I.C.U./g.)	-	8.0
Vitamin B_{12} (20 mg./lb.)	-	10.0
B-Complex vitamin mix[4]	-	45.0
Choline Chloride (50%)	-	40.0
Methionine	-	23.0
Trace minerals mix[5]	-	23.0
Riboflavin	-	50.0
Sorghum, ground	-	285.0
Total		504 g. (1.11 lb.)

[1]All diets were isonitrogenous (24% Protein).

[2]Soy-Ben[R] residue of the soybean oil industry containing 67% bentonite, 29% soybean oil, and 4% water.

[3]Added in equal amounts to all diets.

[4]Supplies in mg./lb.: riboflavin 2,000; pantotheonic acid 2,680; niacin 6,000; choline chloride 20,000.

[5]Supplies by %: Mn 10; Fe 10; Cu 1; Zn 5; I_2 0.3; Co 0.1.

Table A-5 Average 0-2 week weight gains and feed utilization, Experiment I.

Diets[3]	Av. Wt. gain (g.)	Av. Feed Utilization[1]
1	261.46	1.663
2	225.46	1.643
3	230.30	1.516
4	205.00	1.553

Ranked diets for Av. Wt. gains[2] 1 3 2 4

Ranked diets for Av. Feed utilization 3 4 2 1

[1]Kg Feed per Kg gain

[2]Ranked diets based on Least Significant Difference (LSD) test. Any diets not underscored by the same line are significantly different.

[3]Diets: 1 - 0.0% Soy-Ben

2 - 5.0% Soy-Ben

3 - 10.0% Soy-Ben

4 - 15.0% Soy-Ben

Table A-6 Average 2-4 week gains and feed utilization, Experiment I.

Diets	Av. Wt. gain (g.)	Av. Feed Utilization
1	522.76	1.790
2	554.43	1.750
3	577.79	1.740
4	535.80	1.760

Ranked diets for Av. Wt. gains 3 2 4 1

Ranked diets for Av. Feed utilization 2 3 4 1

Table A-7 Average 4-6 week weight gains and feed utilization, Experiment I.

Diets	Av. Wt. gain (g.)	Av. Feed Utilization
1	669.73	2.233
2	812.60	1.886
3	794.47	1.870
4	794.00	1.923

Ranked diets for Av. Wt. gains 2 3 4 1

Ranked diets for Av. Feed utilization 3 2 4 1

Table A-8 Average 6-8 week weight gains and feed utilization, Experiment I.

Diets	Av. Wt. gain (g.)	Av. Feed Utilization
1	589.16	3.053
2	631.26	3.016
3	575.84	2.880
4	586.53	3.120

Ranked diets for Av. Wt. gains	2 1 4 3
Ranked diets for Av. Feed utilization	3 2 1 4

Table A-9 Average 0-4 week weight gains and feed utilization, Experiment I.

Diets	Av. Wt. gain (g.)	Av. Feed Utilization
1	778.23	1.753
2	779.90	1.710
3	808.09	1.600
4	740.80	1.703

Ranked diets for Av. Wt. gains	3 2 1 4
Ranked diets for Av. Feed utilization	3 4 2 1

Table A-10 Average 0-6 week weight gains and feed utilization, Experiment I.

Diets	Av. Wt. gains (g.)	Av. Feed Utilization
1	1453.96	1.970
2	1592.50	1.806
3	1602.56	1.826
4	1534.80	1.820

Ranked diets for Av. Wt. gains	3	2	4	1
Ranked diets for Av. feed utilization	2	4	3	1

Table A-11 Average 0-8 week weight gains and feed utilization, Experiment I.

Diets	Av. Wt. gains (g.)	Av. Feed Utilization
1	2043.12	2.303
2	2223.76	2.190
3	2199.89	2.090
4	2121.33	2.180

Ranked diets for Av. Wt. gains	2	3	4	1
Ranked diets for Av. Feed utilization	3	4	2	1

Table A-12 Average 0-2 week weight gains and feed utilization, Experiment II.

Diets	Av. Wt. gain (g.)	Av. Feed Utilization[1]
1	242.21	2.140
2	256.56	2.000
3	140.30	1.925
4	99.18	2.260

Ranked diets for average Wt. gains[2]	2	1	3	4
Ranked diets for Av. Feed utilization[2]	3	2	1	4

[1]Kg Feed per Kg gain

[2]Ranked diets are based on Least Significant Difference (LSD) test. Any diets not underscored by the same line are significantly different.

[3]Diets: 1 - 0.0% Soy-Ben

2 - 5.0% Soy-Ben

3 - 10.0% Soy-Ben

4 - 15.0% Soy-Ben

Table A-13 Average 2-4 week weight gains and feed utilization, Experiment II.

Diets	Av. Wt. gain (g.)	Av. Feed Utilization
1	490.72	1.580
2	482.83	2.080
3	238.13	2.285
4	58.97	1.900

Ranked diets for Av. Wt. gains 1 2 3 4

Ranked diets for Av. Feed utilization 1 4 2 3

Table A-14 Average 4-6 week weight gains and feed utilization, Experiment II.

Diets	Av. Wt. gain (g.)	Av. Feed Utilization
1	660.74	2.880
2	748.05	2.560
3	241.70	5.250
4		

Ranked diets for Av. Wt. gains 2 1 3

Ranked diets for Av. Feed utilization 2 1 3

Table A-15 Average 6-8 week weight gains and feed utilization, Experiment II.

Diets	Av. Wt. gain (g.)	Av. Feed Utilization
1	999.99	1.350
2	876.93	1.080
3	509.50	2.940

Ranked diets for Av. Wt. gains 1 2 3

Ranked diets for Av. Feed utilization 1 2 3

Table A-16 Average 0-4 week weight gains and feed utilization, Experiment II.

Diets	Av. Wt. gain (g.)	Av. Feed Utilization
1	732.93	1.770
2	739.40	2.040
3	378.44	2.045
4	158.15	2.905

Ranked diets for Av. Wt. gains 2 1 3 4

Ranked diets for Av. Feed utilization 1 2 3 4

Table A-17 Average 0-6 week weight gains and feed utilization, Experiment II.

Diets	Av. Wt. gain (g.)	Av. Feed Utilization
1	1393.67	2.100
2	1487.45	2.250
3	684.10	2.780

Ranked diets for Av. Wt. gains 2 1 3

Ranked diets for Av. Feed utilization 1 2 3

Table A-18 Average 0-8 week weight gains and feed utilization, Experiment II.

Diets	Av. Wt. gain (g.)	Av. Feed utilization
1	2406.67	1.990
2	2364.38	1.800
3	1193.60	2.300

Ranked diets for Av. Wt. gains 1 2 3

Ranked diets for Av. Feed utilization 2 1 3

Table A-19 Average 0-2 week weight gains and feed utilization, Experiment III.

Diets[3]	Av. Wt. gain (g.)	Av. Feed Utilization[1]
1	285.68	1.476
2	241.52	1.653
5	302.13	1.523
6	267.40	1.556

Ranked diets for Av. Wt. gains[2] 5 1 6 2

Ranked diets for Av. Feed utilization 1 5 6 2

[1]Kg Feed per Kg gain

[2]Ranked diets are based on Least Significant Difference (LSD) test. Any diets not underscored by the same line are significantly different.

[3]Diets: 1 - 0.0% Soy-Ben

2 - 5.0% Soy-Ben

5 - 2.5% Soy-Ben

6 7.5% Soy-Ben

Table A-20 Average 2-4 week weight gains and feed utilization, Experiment III.

Diets	Av. Wt. gain (g.)	Av. Feed Utilization
1	596.87	1.823
2	568.68	2.170
5	630.78	1.906
6	591.00	1.726

Ranked diets for Av. Wt. gains 5 1 6 2

Ranked diets for Av. Feed utilization 6 1 5 2

Table A-21 Average 0-4 week weight gains and feed utilization, Experiment III.

Diets	Av. Wt. gain (g.)	Av. Feed Utilization
1	882.55	1.696
2	743.51	2.010
5	932.89	1.736
6	858.40	1.816

Ranked diets for Av. Wt. gains 5 1 6 2

Ranked diets for Av. Feed utilization 1 5 6 2

EFFECTS OF FEEDING A RESIDUE ON THE SOYBEAN OIL INDUSTRY, ON BROILER PERFORMANCE

by

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B.Sc. (Agric.), National University of Honduras, C.A., 1978

AN ABSTRACT OF A MASTER'S THESIS

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Soy-Ben[R], a residue of the soybean oil industry, 67% bentonite, 29% soybean oil and 4% water, was tested in three experiments. It replaced grain in the Kansas State University (K.S.U.) starter and finisher broiler diets. Six diets, with 0, 2.5, 5, 7.5, 10 and 15% Soy-Ben as dietary levels were evaluated to determine which of the different levels would best support broiler performance. The starter and finisher diets were isonitrogenous, 24 and 20% protein, respectively. A total of 360 broilers were used, 10 chicks per lot, 3 lots as replicates per each treatment. Weight gain and feed utilization were the main criteria for evaluation throughout an 8-week period.

It was found that incorporation of Soy-Ben in the diets resulted in riboflavin deficiency. It would appear that the presence of bentonite in Soy-Ben was in some way associated with decreased availability of riboflavin possibly by absorbing it. All symptoms were corrected and prevented by using additional riboflavin in the feed.

In Experiment I, Soy-Ben depressed body weight at 4-6 weeks and produced better feed utilization at both 4-6 and 0-6 weeks. However, at 0-8 weeks chick weights and feed utilization of treatment groups were not significantly different from controls.

In Experiment II, Soy-Ben had a limiting effect on body weight at 0-2, 2-4, 0-4 and 0-6 weeks. Feed utilization was also significantly reduced at 0-4 and 0-6 weeks. Under Experiment II, specific conditions body weight and feed utilization were considerably affected.

R Registered trade name for a residue of the soybean oil industry, composed of 67% bentonite, 29% soybean oil and 4% water. Available from Scotland Industries, Inc., 6621 El Monte, Prairie Village, KS 66208.

In Experiment III, at 0-2 and 0-4 weeks growth rate tended to be improved by feeding 2.5, 5.0 and 7.5% Soy-Ben, but at 0-4 weeks feed utilization was significantly reduced. Of the three Soy-Ben diets, the 2.5% showed a trend toward improvement in terms of growth rate although not significantly different.