DIGESTIBILITY STUDIES WITH LAYING HENS

By

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Bachelor of Science

Oklahoma State University

1963

Submitted to the faculty of the Graduate College
of the Oklahoma State University
in partial fulfillment of the requirements
for the degree of
MASTER OF SCIENCE
July, 1966

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ACKNOWLEDGMENTS

The author wishes to express her sincere appreciation to Dr. Rollin H. Thayer, Professor of Poultry Science, for his advice, guidance, suggestions and encouragement in planning and conducting this research and in writing this thesis. An even greater appreciation is expressed for the knowledge and training that were gained through three years of close association with Dr. Thayer.

Appreciation is expressed to Dr. John W. West, Professor and Head of the Department of Poultry Science, for his helpful suggestions in the writing of this thesis.

Indebtedness is acknowledged to Dr. E. C. Nelson of the Department of Biochemistry for his help in supervising the chemical analyses and for the knowledge gained through association with him.

Special appreciation is extended to Dr. Robert D. Morrison of the Department of Mathematics and Statistics for his assistance and guidance in the statistical analyses, and to Robert Easterling of the Department of Mathematics and Statistics for writing the analysis of variance program for the computer.

Recognition is also extended to Jimmie D. Wolf and Mohebatulla Vahidi of the Department of Poultry Science for their assistance in the collection of these data.

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INTRODUCTION

Research efforts in poultry nutrition are being focused on the development of more precise methods by which to determine and express the nutrient intake requirements of laying hens. In pursuing these efforts, intensive studies have been made of dietary factors which are involved in the control of feed intake and, in turn, actual nutrient intake of laying hens. Research data indicate that the primary dietary factors include nutrient density, physical density, and the interrelationship between nutrient density and physical density. Data concerning these dietary factors have been utilized in the formulation of a nutrient intake concept in which nutrient requirements are based upon productive performance, and are related to actual feed intake. This concept has been used effectively in controlling nutrient intake in research studies with laying hens, and in practical feeding situations where it is desirable to control actual nutrient intake under diversified environmental conditions.

Physical density has been studied in terms of dietary volume, dietary weight, and dietary weight-dietary volume interrelationships. The physical density of experimental rations has been varied by changing weight per unit of volume and volume per unit of weight through the use of ground polyethylene fluff and washed blow sand. Sufficient research has been completed to demonstrate that these two ingredients can be used in this way to regulate feed intake and to provide graded nutrient intake levels. These adjustments in dietary weight and dietary volume provide a technique for studying the daily nutrient intake requirements of laying hens fed ad libitum. However, before this technique can be applied with maximum effectiveness in the establishment of precise nutrient intake standards, there is a need to determine the effect that this feed intake control procedure has upon the digestibility and metabolism of nutrients.

In view of the current situation, the study reported herein was undertaken. The primary objectives of the study were: (1) to determine the effect of ground polyethylene fluff and washed blow sand upon the digestibility of fat in the rations, and (2) to develop and refine analytical procedures for chromium and total fat in both feed and fecal material so that these procedures might be utilized in subsequent digestibility and metabolism studies with surgically altered laying hens.

REVIEW OF LITERATURE

The literature pertaining to the effects of the dilution of poultry rations is primarily concerned with experiments in which an inert material was used to replace a specific ingredient in the ration. With this procedure, the relative proportions of the individual nutrients within the ration are changed. Other experiments have been conducted in which an inert diluent was added at the expense of a portion of the entire ration, thus lowering the concentration of the nutrients in the ration without changing their relative proportions. These experiments have traditionally involved the use of such measures as growth rate, feed intake, and egg production for characterizing the effects of the inert diluents. However, no information is reported regarding the properties of the inert diluent *per se*.

There has been an ever increasing interest among research workers in the use of the inert diluents, polyethylene and sand. These two inert ingredients have been used as dietary volume and dietary weight control ingredients in both ruminant and nonruminant rations. The data reported from ruminant and nonruminant nutrition studies using polyethylene and sand have been primarily concerned with the influence of nutrient density, bulk, dietary volume, and dietary weight on feed intake as well as the resulting performance in terms of body weight change and egg production. Little is known of the effect, if any, that polyethylene and sand may have on nutrient digestibility. The literature cited in this review will involve only those references which summarize data on the use of polyethylene and sand in poultry rations.

In studying the influence of dietary energy on growth response in chicks, Mraz et al. (1956) added sand to a basal diet to obtain a series of diets with a relatively constant dietary density and graded levels of energy. Mraz et al. (1957) conducted an experiment to study the response of growing male chicks to varying densities and levels of dietary energy and density. In this study a basal diet was diluted with sand to vary the dietary density and to obtain graded levels of energy in the experimental rations. The energy-protein ratio was held constant; therefore all nutrients, including energy, retained the same quantitative relation to each other in all rations.

Gleaves et al. (1963a) designed an experiment in which dietary volume was used to regulate the nutrient intake of laying hens under ad libitum feeding conditions. Polyethylene fluff was used to adjust the dietary volume of the experimental rations. Results from this experiment showed that the intake of nutrients by laying hens can be regulated within workable limits with dietary volume control. It was also indicated that more than four weeks were required for hens to reach maximum feed consumption when fed high-volume diets.

Gleaves (1965) reported data from a study on the effects of dietary weight and dietary volume upon feed consumption and the reproductive performance of laying hens. Polyethylene fluff was used as a volume control ingredient. In addition, washed blow sand was used to control dietary weight. Data from this experiment showed that dietary weight and dietary volume had a significant linear effect upon feed weight consumption. As dietary volume was increased, there was a corresponding significant linear decrease in feed weight consumption. The main effect of dietary volume upon the reproductive performance of laying hens was upon body weight change. As dietary volume was increased there was a resultant decrease in body weight gain.

Wolf (1965) conducted an experiment to determine the effects of different nutrient intakes during the growing period upon subsequent reproductive performance of pullet replacements. Through the use of polyethylene fluff and washed blow sand, it was possible to regulate the nutrient intake of growing pullets. The response factors measured in this experiment were sexual maturity, feed consumption, egg production, egg weight, and body weight gain.

Harms and Waldroup (1965) suggested that sand is an excellent diluent in experimental feeds since bulkiness from increased fiber content would not be involved. These workers reported that levels of sand as high as 36 percent can be tolerated by laying hens provided the feed is balanced as far as other nutrients are concerned. Diluting the diet with 6.7 or 13.4 percent of sand did not affect the rate of lay. However, the addition of sand to the feed resulted in an increase in the amount of feed consumed per day. These results in feed consumption agree with those obtained by Gleaves (1965).

Since fat digestibility was used to measure relative nutrient digestibility in the experimental rations used in this experiment, some of the factors affecting fat digestibility will be reviewed. One of the factors which has been shown to modify the digestibility of certain fats is the age of the bird (Duckworth et al., 1950; Renner and Hill, 1958). In a study with chicks, Fedde et al. (1960) reported that digestibility of beef tallow increased from 53 percent at one week of age to 80 percent at 12 weeks of age. Carver et al. (1955) conducted studies to determine the utilization of fats added to broiler rations and reported the digestibility of tallow to be above 80 percent, but with hydrogenated tallow the digestibility was reduced to as low as 11 percent.

In experiments with chicks, March and Biely (1957) compared the digestibility of tallow to that of corn oil and found corn oil to be approximately 90 percent digestible and tallow to be near 73 percent digestible. When the animal fat was hydrogenated, digestibility was reduced to between 23 and 44 percent.

Cheng et al. (1949) found that dietary calcium in rat diets had a marked influence on the digestibility of fat. Digestibility of beef tallow was decreased by high dietary calcium and increased by reducing the calcium intake. Fedde et al. (1960) fed graded levels of calcium to chicks which received diets that contained 20 percent of beef tallow and observed a progressive decrease in fat digestibility as the calcium content of the diet was increased.

Cheng et al. (1949) performed digestibility studies with rats and suggested that there was a relationship between the melting point of fats and their digestibility. However, their results showed very little difference in the digestibility of lard when the melting point of the samples fed ranged from 30 to 48 degrees C. When the melting point was increased above 48 degrees C., the digestibility of the fat declined rapidly.

In fat digestibility studies with chicks, Fedde _et al_. (1960) reported that the digestibility of beef tallow was not dependent upon growth rate or feed intake. Williams _et al_. (1959) fed graded levels of fat to chicks and noted that high levels of dietary fat resulted in higher digestibility than did low levels of dietary fat. However, when corrections were made for the low digestibility of the fat present in the basal ration, the added fat was utilized equally well at all supplemental levels.

Biely and March (1957) showed that the extent to which tallow was utilized by the chick depended upon the level fed and the protein content of the diet. When 10 to 12 percent of tallow was fed to chicks, it was utilized best in diets which contained protein levels above 26 percent. Richardson _et al_. (1958) conducted feeding trials with chicks to study the effect of finely ground rice hulls, ground oats, extracted rice bran, and wheat bran fed at levels calculated to supply 2 percent and 4 percent of crude fiber with and without 6 percent and 12 percent of vegetable fat, respectively. The addition of fat to the rations improved performance in all instances, but the magnitude of improvement was influenced by the source of fiber. The finely ground rice hulls gave the poorest performance. These workers concluded that the rice hulls were an energy diluent with resulting effects on feed conversion.

Since inert materials have been used successfully to modify the nutritive value of experimental rations, it has become increasingly evident that further studies are needed to elucidate the effects of inert materials _per se_ and specifically their effect on nutrient digestibility. In view of this apparent lack of published information pertaining to inert materials, the experiment reported herein was undertaken in an effort to determine the effect of polyethylene fluff and washed blow sand on nutrient digestibility in laying hens.

EXPERIMENTAL PROCEDURES AND METHODS

GENERAL PROCEDURE. The experiment was conducted in a cage layer laboratory located on the Oklahoma State University Poultry Farm. The cage laboratory contains 576 individual wire cages which are arranged in 24 blocks with 24 cages per block. Each cage, 10 inches wide and 18 inches from front to back, is equipped with an automatic waterer, a feeder and a feed storage container. This particular setup makes it possible to keep records on individual pullets, thus permitting each pullet to be used as an experimental unit.

Environmental conditions are partially controlled within the cage laboratory at all times. Temperature and ventilation are regulated with the use of a furnace, air washer, air ducts, and fans engineered specifically for the laboratory. Temperature in the laboratory varies from a low of 60 degrees Fahrenheit during the winter months to a high of approximately 90 degrees Fahrenheit during the summer months. Artificial light is provided by incandescent lamps which are controlled by automatic time clocks. During the experiment, the pullets were given 14 hours of continuous light and 10 consecutive hours of darkness each day.

The experiment was initiated on October 29, 1964 and terminated on February 22, 1965. The pullets were approximately 16 weeks of age when the experiment began and were 32 weeks of age when the experiment was terminated. The experimental term, 114 days in length, included 3 phases and 9 experimental periods (see Table I). The Preconditioning Phase (Period 1) included the first 23 days of the study. The Conditioning Phase (the next 21 days) included Periods 2, 3 and 4 with 7 days in each period. The Treatment Phase was comprised of Periods 5, 6, 7, 8, and 9, and included the last 72 days of the experiment. Periods 5 and 6 consisted of 7 days each, and Periods 7 and 8 consisted of 14 days each; Period 9 was 28 days in length.

TREATMENT DESIGN. Four dietary terms are referred to throughout this thesis and as used herein will have the following connotations: (1) dietary weight is an estimated figure for daily feed consumption, in grams, which has been selected as being within the realm of possible feed consumption at a specific time during the growing or egg production period; (2) dietary volume is the number of milliliters of space occupied by the dietary weight selected; (3) dietary protein is the number of grams of protein in the dietary weight selected; (4) dietary energy is the number of Calories of metabolizable energy in the dietary weight selected.

The reason the experimental design involved Preconditioning, Conditioning and Treatment Phases is explained in the following discussion. Research experience has shown that polyethylene and blow sand should be added to experimental rations in progressively increasing amounts until the desired dietary levels are reached. Therefore, the Preconditioning Phase and Conditioning Phase were set up to facilitate the adjustment of the pullets to the experimental rations containing polyethylene and blow sand. During the Preconditioning Phase, all pullets were fed the same experimental ration (Experimental Basal I) without added polyethylene or blow sand. In the Conditioning Phase, the amounts of polyethylene and blow sand which were added to the experimental rations were progressively increased until the desired dietary levels had been reached. The precise way in which these two inert ingredients were progressively increased will be explained later. Throughout the Treatment Phase, the experimental rations contained the desired dietary levels of polyethylene and blow sand.

A completely randomized experimental design was used in which each of 25 treatments was replicated 4 times (4 pullets per treatment). Statistical analyses of data were done on 9 of these treatments which were arranged in a 3 x 3 factorial design using the zero, intermediate and high levels of polyethylene and sand. The statistical analyses for digestion coefficients and total fat digested data were arranged in a randomized block design. Since a uniformity trial had revealed that there were no statistically significant differences in the performance of laying hens due to location of cages within the cage laboratory, it was possible to conduct a completely randomized experiment. The treatments (experimental rations) consisted of 5 equally spaced levels of polyethylene fluff (0, 18, 36, 54 and 72 grams) and 5 equally spaced levels of washed blow sand (0, 18, 36, 54 and 72 grams) which were added singly and in all combinations to an equivalent dietary weight of Experimental Basal II. This 5 x 5 factorial arrangement of treatments is presented in Table II. These desired dietary levels of polyethylene and blow sand were selected from among the intermediate dietary levels used by Gleaves (1965) to adjust dietary weight and dietary volume in experimental rations for laying hens. Since the desired dietary levels of polyethylene and blow sand were selected from the intermediate dietary levels used in the 9 x 9 factorial experiment conducted by Gleaves (1965), the extreme levels which control nutrient intake were not included. Although the dietary weight and dietary volume of Experimental Basal II remained constant in all experimental rations, the total dietary weight and total dietary volume of the experimental rations were varied (see Table I). This series of 25 experimental rations was fed during each experimental period in the Treatment Phase (Periods 5 through 9).

During the Conditioning Phase, Periods 2, 3 and 4, the experimental rations contained gradations of 1/4, 1/2 and 3/4, respectively, of the desired dietary levels each of polyethylene and blow sand. For example, the 5 equally spaced levels each of polyethylene and blow sand (0, 4.5, 9.0, 13.5 and 18.0 grams) in Period 2 were increased to the levels (0, 9, 18, 27 and 36 grams) in Period 3, followed by another increase to the levels (0, 13.5, 27.0, 40.5 and 54.0 grams) in Period 4. Thus, each series of 25 experimental rations was changed for each experimental period in the Conditioning Phase; however, the dietary weight of Experimental Basal II remained constant for all experimental rations (see Table I).

EXPERIMENTAL RATIONS. The two basal rations (Table III) used in this experiment included Experimental Basal I (growing pullet ration) and Experimental Basal II (laying hen ration). The experimental basals were formulated on a daily nutrient intake basis using the procedure outlined by Gleaves *et al*. (1963b). The values used for dietary protein and dietary energy in formulating the experimental basals were selected from actual intake figures observed by Wolf (1965). Dietary volume of the experimental basals and experimental rations were calculated using the values in milliliters of dry volume occupied by each ingredient as listed by Tarpey et al. (1965). As an index for determining fat digestibility, chromic oxide was incorporated into the experimental basals at a 0.3 percent level.

The amount in grams of each ration ingredient listed represents the estimated amount of that ingredient which would be consumed per pullet per day. Thus, the total weight in grams of these ingredients constitutes dietary weight and the total volume in milliliters occupied by this dietary weight represents the dietary volume of the basals. The composition of the vitamin-mineral concentrate (VMC-60) used in the basals is presented in Table IV.

A series of 25 experimental rations was fed during each of the 9 experimental periods. The compositions of all experimental rations used in this experiment are summarized in Table I. In Period 1, all experimental rations were composed of Experimental Basal I without added polyethylene or blow sand. Each series of 25 experimental rations for Periods 2 through 9 contained five equally spaced levels of polyethylene and five equally spaced levels of blow sand which were added singly and in all combinations to 108.6 grams of Experimental Basal II. The five levels each of polyethylene and blow sand for Periods 2, 3 and 4 were added in proportions of 1/4, 1/2 and 3/4, respectively, of the desired dietary levels of these two ingredients. The same series of rations was fed in Periods 5 through 9 and contained the desired dietary levels of polyethylene and blow sand. Although the dietary weight and dietary volume of Experimental Basal II in the experimental rations remained the same for Periods 2 through 9, the total dietary weight and total dietary volume of each experimental ration varied as listed in Table I.

SAMPLE COLLECTION. On the last day of each experimental period, the fecal samples were collected in polyethylene-lined metal pans suspended beneath each individual cage. A 24-hour collection period was used to assure a representative sample of excrement. In theory, a small excreta sample would be sufficient to provide data for calculations. However, the physiological processes of the chicken do not result in the production of excrement of uniform composition hour-to-hour. This is primarily because of diurnal rhythm in the elimination of cecal droppings which contain only traces of urinary excreta (Herrick and Edgar, 1947). It has been demonstrated experimentally that collecting excrement in unit periods of 24 hours is satisfactory to circumvent the diurnal rhythm of excretion in cecal droppings (Dansky and Hill, 1952).

SAMPLE PREPARATION FOR STORAGE. Immediately after each collection period, any scurf, feathers or other foreign material in the collection pans was removed with a vacuum cleaner. The excreta were transferred with a rubber spatula from the collection pans to a Waring Blendor. Water was added to the wet fecal sample in the blendor and homogenized for two to three minutes. The fecal samples were poured into individual air-tight plastic sample containers, labeled, frozen, and stored until they could be analyzed for total fat and chromium. Varied amounts of water, depending on the cohesiveness of individual samples, were added to achieve a viscosity which homogenized readily but did not permit rapid settling of suspended particles after blending. In addition, feed samples were collected from individual treatments during each experimental period, put into sample containers and stored in a refrigerated room at 35 degrees Fahrenheit until chemical analyses could be made.

SAMPLE PREPARATION FOR ANALYSES. To prepare wet fecal samples for chromic oxide determination by the nitric-perchloric acid oxidation method, the samples were thawed and blended in a Waring Blendor. While still blending, a sample was taken with a large mouth pipette and placed into a glass thimble for weighing. However, difficulties were encountered during the digestion and oxidation steps of this method. For this reason another analytical method was employed for which the sample preparation is described in the following paragraph.

The fecal samples were thawed by setting the sample containers in a pan of warm water. The sample was then blended in a Waring Blendor and transferred to a porcelain evaporating dish for drying. Both feed and fecal samples were dried in a forced-air drying oven at a temperature of approximately 90 degrees Fahrenheit. After drying to a constant weight, the individual samples were ground into a fine powder with a mortar and pestle, mixed thoroughly, and weighed in preparation for chromium and fat analyses.

ANALYSIS FOR CHROMIUM.

Colorimetric measurement. The analytical method used as a starting point for the determination of chromic oxide was essentially that described by Kimura and Miller (1957). However, difficulties were encountered with that part of the analytical procedure in which a nitric-perchloric acid oxidation with molybdate catalyst is used. Temperature was found to be very critical and there was the need for constant attention especially when the samples contained polyethylene and sand.

Although the controls on the hot plates were set at the minimal temperature, superheating of the samples still occurred and as a result there was violent bumping of the flasks. It was observed that in the samples containing polyethylene, the polyethylene particles were not digested by the nitric acid, but melted together and formed a layer in the flask. When perchloric acid was added to the sample solution and heated, the polyethylene ignited inside the flask, thus increasing the danger of explosion. Therefore, another analytical procedure was used to determine the chromic oxide content in the feed and fecal samples.

Atomic absorption flame measurement. Solutions of chromic oxide were prepared from feed and fecal samples and were used for chromium determinations by the atomic absorption procedure described by Williams et al. (1962). All feed and fecal sample solutions of chromic oxide were read on the atomic absorption spectrophotometer the same day. This was done so as to reduce errors in chromium determinations caused by fluctuations in line voltage and variations in flame conditions due to unstable air and acetylene pressures.

Atomic absorption spectroscopy was introduced by Walsh (1955). Russell et al. (1957) suggested the possibility of using this principle in the development of a rapid, accurate method for determination of chromium with the possibility of greater speed and simplicity than the titration procedure or colorimetric measurement. An examination of this possibility and a comparison with an established chemical method were made by Williams et al. (1962). Their results showed a close agreement between the two methods and indicated that the atomic absorption method is a readily reliable technique for the determination of chromium in feed and fecal material.

ANALYSIS FOR FAT. Total fat content in feed and fecal samples was determined by extracting the fat on a Goldfisch fat extraction apparatus with petroleum ether. Analyses were made in sets of nine samples at a time. A set consisted of one replicate from each treatment for a specific experimental period. The purpose of this procedure was to reduce analyses error and variations in measurements due to changes in line voltage and other variables which can change with time.

THE DETERMINATION OF NUTRIENT DIGESTIBILITY. Various methods have been proposed for the determination of digestibility coefficients. The most widely accepted is the method whereby an indigestible reference material is incorporated in the ration, where it serves as an index of digestibility. By obtaining the ratio of the concentration of the reference material to that of a given nutrient in the feed and the same ratio in the feces, the digestibility coefficient of the nutrient can be calculated. Chromic oxide is the most widely used reference substance in digestibility studies since it can be recovered quantitatively in the feces (Kane et al., 1950; Dansky and Hill, 1952; and Schurch et al., 1950).

The use of a reference substance, such as chromic oxide, makes it possible to feed laying hens ad libitum and leads to a simplified experimental procedure by avoiding the necessity of a quantitative record of either feed intake or fecal output. Therefore, digestibility can be computed from selected portions of the feces which are free of feathers, feed and other foreign material. This experimental procedure not only reduces the amount of time, labor and expense involved in digestibility studies, but also gives more consistent and accurate results (Hill *et al*., 1960).

Determination of true digestibility with poultry is complicated by the fact that urinary and fecal excrements are voided together. Therefore most digestibility studies with poultry are limited to the techniques which determine the total availability of a given nutrient; that is, the coefficient of digestibility. Thus, in this study to determine the effect of polyethylene fluff and washed blow sand on digestibility of nutrients in rations, total available fat was selected as a measurement for digestibility of nutrients in general. In determining total fat digestibility, the chromic oxide indicator method was used and the fat digested was considered to be the fat consumed minus the fat excreted. There was no correction made for urinary fat. The digestibility coefficients for total available fat were calculated by means of the following formula:

$$\text{Digestibility} = 100 - \left(100 \; \frac{\%\ \text{chromium in feed}}{\%\ \text{chromium in feces}} \times \frac{\%\ \text{fat in feces}}{\%\ \text{fat in feed}} \right)$$

DATA COLLECTION AND STATISTICAL ANALYSES. At the end of each experimental period, individual feed consumption and body weight data were collected and recorded for all pullets. Throughout the experiment, daily egg production records were kept for each pullet and mortality was recorded as observed.

Limitations imposed by insufficient funds, time and available laboratory facilities made it impractical to perform chemical analyses on all samples collected in this experiment. Thus, for purposes of analyses, an approach was made to select a limited number of samples that would be representative of the experimental conditions employed. The samples from each replicate of 9 treatments applied in 5 different experimental periods were selected for chemical and statistical analyses. This analyses design included Treatments 1, 3, 5, 11, 13, 15, 21, 23 and 25 for Periods 1, 3, 5, 7 and 9. By selecting these specific experimental periods, the analyses included samples from each phase of the experiment (see Tables I and II).

The 9 treatments included 3 equally spaced levels of polyethylene and 3 equally spaced levels of blow sand and all combinations of the respective levels of these two inert ingredients. The three levels each of polyethylene and blow sand were selected by taking the lower and upper extremes of the five levels applied in each experimental period and including the intermediate level equally spaced between the two extremes. The treatments, related as levels, were analyzed in a 3 x 3 factorial arrangement. In consultation with a statistician, it was reasoned that this factorial arrangement would give a representative sample characteristic of the experimental treatments and would be adequate to evaluate the effect of polyethylene and blow sand upon fat digestibility in the experimental rations.

Since chemical analyses were limited to Treatments 1, 3, 5, 11, 13, 15, 21, 23 and 25 for Periods 1, 3, 5, 7 and 9, the data reported herein will be confined to these specified treatments and experimental periods. From the feed consumption, body weight and egg production data collected, the following values were computed for each of the five experimental periods: daily feed intake in grams, body weight gain or loss in grams, and number of eggs per pullet. The data obtained from chemical analyses were used to compute the following values for individual pullets in each experimental period: total fat in feed, total fat in feces, chromium in feed, and chromium in feces. From these ratios of the total fat and chromium in feces, the digestibility coefficients of fat were computed. In addition to making these various computations, the IBM 7040 electronic computer was also used to summarize the data for each pullet by treatments and by experimental periods and to perform the statistical analyses.

Analyses of variance were calculated for each experimental period, using the method outlined by Snedecor (1956). The following responses were involved in these analyses: observed feed weight consumption, observed feed volume consumption, observed total fat consumption, observed total fat digested, digestion coefficients for fat, body weight change, and number of eggs. The data obtained for the various responses are presented in tables as means and as analyses of variance by experimental periods.

RESULTS AND DISCUSSION

The results of this experiment will be presented and discussed with respect to the data from individual periods under separate headings designated by each of the following responses: digestion coefficients for fat, feed weight consumption, feed volume consumption, total fat digested, body weight change, and egg production (Table V through Table LXVI). From a consideration of the analyses of variance computed from the data of this experiment, it is evident that the main effects of sand and polyethylene are significant for specific responses. In addition, there is some evidence that a sand x polyethylene interaction is present during certain periods. From a statistical standpoint, the main effects of sand and polyethylene should not be discussed independently of each other when an interaction exists. Despite this fact, the relative size of the mean squares for the main effects of sand and polyethylene as compared to the interaction mean squares justifies further study of their actions. Inasmuch as this significant interaction is present, the author recognizes that it limits the confidence that can be placed on the main effects of sand and polyethylene, but still feels that certain inferences can be made. Therefore, the sand and polyethylene main effects will be discussed individually even though a significant interaction does exist for the specific responses.

Since the analyses included the Conditioning Phase, it will be discussed in conjunction with the Treatment Phase. However, nutritional measurements are primarily concerned with treatment effects observed during the Treatment Phase. Therefore, major inferences will be drawn primarily from the data pertaining to the Treatment Phase.

DIGESTION COEFFICIENTS FOR FAT. The analyses of variance for the digestion coefficients in Periods 3, 5, 7 and 9 are presented in Tables V, VI, VII and VIII, respectively. The means for main effects of sand and polyethylene for Periods 3, 5, 7 and 9 are given in Tables IX, X, XI and XII, respectively.

The linear main effect of polyethylene on the digestion coefficients for fat was significant ($P < .01$) in all periods with the exception of Periods 7 and 9. These results suggest that by Period 7 the pullets had adjusted to the desired dietary levels of polyethylene. A trend toward this apparent adjustment was becoming evident in Period 5. This trend is indicated by a decrease in the F value from 303.28 in Period 3 to 163.73 in Period 5 (Tables V and VI, respectively). As indicated in the tables of means for main effects (Tables IX, X, XI and XII), polyethylene had its greatest effect in decreasing digestion coefficients during the Conditioning Phase (Period 3). When the digestion coefficients at polyethylene level 1 are compared to the digestion coefficients at polyethylene levels 2 and 3, it can be seen that the digestion coefficients at level 1 rapidly decreased with time, whereas the digestion coefficients at level 2 decreased less rapidly and the digestion coefficients at level 3 increased slightly with time. Thus by Period 9, the digestion coefficients were essentially the same at all three levels of polyethylene. Since there was a substantial decrease in the digestion coefficients with time at polyethylene level 1 (zero level), the apparent adjustment to polyethylene may have been more pronounced than the data indicate.

The linear main effect of sand on the digestion coefficients for fat was significant ($P < .01$) in all periods. In addition, there was a significant quadratic effect of sand in Periods 3 ($P < .01$) and 9 ($P < .05$). The main effect means in Tables IX, X, XI and XII show that the digestion coefficients are relatively the same at dietary sand levels 1 and 2, but are markedly decreased at dietary sand level 3. For example, the mean digestion coefficients in Period 9 (Table XII) were 75.88 at level 1, 76.38 at level 2, and 65.97 at level 3. These results suggest that sand may be added to experimental rations at dietary levels not to exceed dietary level 2 without appreciable detrimental effects on digestion coefficients. Apparently, the pullets are able to make adjustments to polyethylene, but not to sand because the quadratic effect was persistent throughout the experiment.

There was a significant sand x polyethylene interaction in Periods 3 ($P < .01$), 5 ($P < .05$) and 9 ($P < .01$). The means for these interactions are presented in Tables XIII, XIV and XV. The disappearance of the sand x polyethylene interaction in Period 7 gives further evidence that the pullets did make adjustments to polyethylene and in so doing eliminated the interaction effect. Graphic illustrations which show the average digestion coefficients for fat in Periods 3, 5, 7 and 9 are presented in Figures 1, 2, 3, and 4, respectively.

<u>FEED WEIGHT CONSUMPTION</u>. The analyses of variance for the feed weight consumption data in Periods 3, 5, 7 and 9 are given in Tables XVI, XVII, XVIII and XIX, respectively. The means for main effects of sand and

polyethylene for Periods 3, 5, 7 and 9 are presented in Tables XX, XXI, XXII and XXIII, respectively.

Polyethylene had no significant effect on feed weight consumption during the entire experiment. The main effect means in Tables XX, XXI, XXII and XXIII show that feed weight consumption was essentially the same at all dietary polyethylene levels within a given period with the exception of level 3 in Period 9. However, there were indications from these means that feed weight consumption at a given dietary polyethylene level increased with time. For example, at polyethylene level 3 feed weight consumption was 103.25 grams in Period 3, 107.92 grams in Period 5, 121.58 grams in Period 7, and 141.83 grams in Period 9. This trend toward increased feed weight consumption might have continued if the experiment had been conducted for a longer period of time.

These results indicate that the pullets can make adjustments to increased dietary volume and that they will compensate for the reduced concentration of nutrients by increasing feed weight consumption. Also, these results give further evidence that polyethylene can be used as a volume control ingredient in experimental rations, since the dietary volume can be increased without appreciably increasing the dietary weight.

Sand increased feed weight consumption in Periods 5 ($P < .01$), 7 ($P < .01$) and 9 ($P < .05$), but had no significant effect in Period 3. Feed weight consumption increased as the dietary level of sand increased. As previously discussed, there was an increase in feed weight consumption with time as brought about by polyethylene. A similar trend was brought about by sand. These increases in feed weight consumption are indicated in Tables XX, XXI, XXII and XXIII. No explanation for this increased feed weight consumption with time as brought about by sand is apparent from available data; thus further studies are needed.

On the basis of evidence presented in the literature review, the effect of sand to increase feed weight consumption was to be expected since the addition of sand did increase the dietary weight of the experimental rations. These results substantiate the fact that pullets can tolerate the dietary levels of sand that were used in this experiment because it is evident that feed weight consumption was not depressed. Also, these results support previous work indicating that sand can be used as a dietary weight control ingredient in experimental rations without appreciably increasing dietary volume.

<u>FEED VOLUME CONSUMPTION</u>. The analyses of variance for feed volume consumption in Periods 3, 5, 7 and 9 are given in Tables XXIV, XXV, XXVI and XXVII, respectively. The means for main effects of sand and polyethylene for Periods 3, 5, 7 and 9 are presented in Tables XXVIII, XXIX, XXX and XXXI, respectively.

When feed weight consumption was put on a volume basis, the linear main effect of polyethylene was significant ($P < .01$) in all periods. As the dietary levels of polyethylene were increased, there was a tremendous increase in feed volume consumption as indicated in Tables XXVIII, XXIX, XXX and XXXI. Also, it can be seen from the means that volume consumption progressively increased with time with the exception of polyethylene levels 1 and 2 in Period 9. This was the same trend that was observed with feed weight consumption. Polyethylene had a significant effect on feed volume consumption within a given period but had little effect on feed weight consumption as previously discussed. This was to be expected because polyethylene is a low density, high volume material. These results present further evidence that pullets can make adjustments to increased dietary volume and that they will compensate for reduced nutrient density due to added polyethylene.

Although the addition of sand significantly increased feed volume consumption only during Period 7 ($P < .05$), there was a definite trend toward increased feed volume consumption when sand was added, especially sand level 3. The data offer no ready explanation for this trend.

TOTAL FAT CONSUMPTION. The analyses of variance for total fat consumption in Periods 3, 5, 7 and 9 are given in Tables XXXII, XXXIII, XXXIV and XXXV, respectively. The means for main effects of sand and polyethylene for Periods 3, 5, 7 and 9 are presented in Tables XXXVI, XXXVII, XXXVIII and XXXIX, respectively.

Total fat consumption decreased linearly with increasing levels of polyethylene during all periods. However, this decrease was significant only during Periods 3 and 5. There was a decrease in the level of significance from $P < .01$ in Period 3 to $P < .05$ in Period 5 and to no significance in Period 7. This is evidence that an adjustment was being made by the pullets so that volume intake increased and feed weight consumption was permitted to approach an intake which would provide a fat intake near equivalent to that consumed by the pullets fed polyethylene level 1 (zero level). Thus, an adjustment period is essential when introducing polyethylene into experimental rations.

Sand decreased fat consumption during Periods 3 ($P < .01$) and 9 ($P < .05$). These data show that the adjustment to the addition of sand was somewhat more rapid than to the addition of polyethylene because in Period 5 the pullets were apparently adjusted to sand, but not yet fully adjusted to polyethylene. Apparently, all pullets were fully adjusted in Period 7 where no detrimental effects of sand and polyethylene on total fat consumption were observed.

There was a significant sand x polyethylene interaction ($P < .05$) in Period 3 (Tables XXXII and XL). This interaction effect was due to the combined effects of both sand and polyethylene in reducing total fat consumption. As the pullets adjusted to sand and polyethylene, this interaction effect disappeared in subsequent periods.

TOTAL FAT DIGESTED. The analyses of variance for total fat digested in Periods 3, 5, 7 and 9 are presented in Tables XLI, XLII, XLIII and XLIV, respectively. The means for main effects of sand and polyethylene for Periods 3, 5, 7 and 9 are given in Tables XLV, XLVI, XLVII and XLVIII, respectively.

Total fat digested was significantly decreased by polyethylene in Periods 3 and 5 ($P < .01$) and in Period 7 ($P < .05$). This is essentially the same pattern that was observed with total fat consumption. This means that once an adjustment to polyethylene had been made by the pullets in the Conditioning Phase, the total amount of fat digested was essentially equivalent in all treatments.

Sand significantly decreased total fat digested ($P < .01$) in all periods with the exception of Period 5. The decrease in total fat digested was due primarily to the effect of sand level 3. This effect of sand was evident in relation to the digestion coefficients as previously discussed. Thus, care should be taken in adding sand as a dietary weight control ingredient so that its effect on digestion coefficients and, in turn, on total nutrients digested does not bring about erroneous conclusions on nutrient intake requirements.

There was a significant sand x polyethylene interaction in Periods 3 ($P < .01$) and 9 ($P < .05$). The means for interaction effect of sand x polyethylene in Periods 3 (Table XLIX) and 9 (Table L) show that the effect of polyethylene on total fat digested was greater at sand level 3 than at sand level 2. This interaction was influenced by the detrimental effect of sand on total fat digested. Apparently, this effect of sand was never overcome by the pullets under the conditions of this experiment.

BODY WEIGHT CHANGE. The analyses of variance for total body weight change in Periods 3, 5, 7 and 9 are presented in Tables LI, LII, LIII and LIV, respectively. The means for main effects of sand and polyethylene in Periods 3, 5, 7 and 9 are given in Tables LV, LVI, LVII and LVIII, respectively.

There were no significant differences in total body weight change during the entire experiment. Although the initial introduction of sand and polyethylene into the experimental rations induced no significant differences in total body weight change among treatments, there was a trend toward decreased body weight gains with time. This was also true for the treatment without sand and polyethylene. There is no explanation for this development. Body weight gains were depressed in Periods 5 and 7. In fact, the pullets on all treatments lost weight in Period 7. A possible explanation for this body weight loss is that the pullets were nearing peak egg production during this time. However, substantial gains were made by the pullets on all treatments during Period 9.

EGG PRODUCTION. The analyses of variance for egg production in Periods 3, 5, 7 and 9 are given in Tables LIX, LX, LXI and LXII, respectively. The means for main effects of sand and polyethylene upon the number of eggs per pullet for Periods 3, 5, 7 and 9 are presented in Tables LXIII, LXIV, LXV and LXVI, respectively.

Neither sand nor polyethylene had any significant effect on the number of eggs produced during any period. As indicated in Table LXIII, there were differences in egg numbers among treatments during Period 3; however, these differences were due to the fact that all pullets had not started to lay.

SUMMARY

An experiment with a 5 x 5 factorial arrangement of treatments was conducted to study the effects of blow sand and polyethylene upon nutrient digestibility in pullets. The experiment included 3 phases and 9 periods which were as follows: Preconditioning Phase (Period 1); Conditioning Phase (Periods 2, 3 and 4); and Treatment Phase (Periods 5, 6, 7, 8 and 9). The treatments (experimental rations) consisted of 5 equally spaced levels each of polyethylene and blow sand and all combinations of the respective levels of these two ingredients. During the Preconditioning Phase, all pullets were fed the same experimental ration without added blow sand or polyethylene. During the Conditioning Phase and Treatment Phase, each of the 25 experimental rations was fed to four individually fed pullets. During the Conditioning Phase, Periods 2, 3 and 4, the experimental rations contained gradations of 1/4, 1/2, and 3/4, respectively, of the desired dietary levels of both polyethylene and sand as fed in the Treatment Phase. Chromic oxide was included in the experimental rations as an index for determining nutrient digestibility. At the end of each experimental period, feed and fecal samples were collected and stored for analyses purposes. Fat digestibility in the feed and fecal samples was used to measure relative nutrient digestibility in the experimental rations. From the original 5 x 5 factorial design, a 3 x 3 factorial arrangement of treatments consisting of the

zero, intermediate and extreme levels each of polyethylene and sand was selected for study. These 9 treatments were analyzed for Periods 1, 3, 5, 7 and 9.

1. Digestion Coefficients. As the dietary level of polyethylene was increased, there was a significant linear decrease in digestion coefficients during the Conditioning Phase. However, the pullets were able to adjust to the desired dietary levels of polyethylene by Period 7 (Treatment Phase) and during Period 9 the digestion coefficients were essentially equivalent at all three dietary levels of polyethylene used in this experiment.

   As the dietary level of sand was increased, both linear and quadratic effects were exerted upon digestion coefficients. There was a marked reduction in digestion coefficients at sand level 3 whereas digestion coefficients were relatively the same at sand levels 1 and 2. Apparently, the pullets were not able to adjust to the high level of sand. Data from this experiment indicate that sand has no appreciable effect on digestion coefficients when added at dietary levels not exceeding dietary level 2.

2. Feed Weight Consumption. The dietary levels of polyethylene used in this study had no significant effect on feed weight consumption. However, there was a trend toward increased feed weight consumption with time, which might have continued had the experimental term been extended.

   Sand had a significant linear effect upon feed weight consumption. As the dietary level of sand was increased there was a concurrent increase in feed weight consumption. It can be concluded that pullets can tolerate the dietary levels of sand fed in this experiment, since feed weight consumption was not depressed.

3. Feed Volume Consumption. As the dietary levels of polyethylene were increased there was a significant increase in feed volume consumption. This presents further evidence that pullets can adjust to increased dietary volume. Sand significantly increased feed volume consumption only during Period 7; however, there was a trend toward increased feed volume consumption at the high level of sand. No explanation is offered for this trend.

4. Total Fat Consumption. As the dietary levels of polyethylene were increased, there was a linear decrease in total fat consumption. However, this was statistically significant only during Periods 3 and 5. Sand had its greatest effect in decreasing total fat consumption during Period 3. Data from this study indicate that the adjustment period is longer for polyethylene than for sand. Apparently, the pullets fed polyethylene were able to compensate for the increased dietary volume by increasing feed weight consumption, because total fat consumption was about the same for all treatments during Periods 7 and 9.

5. Total Fat Digested. The effect of polyethylene on total fat digested was essentially the same as that on total fat consumption. This implies that once the pullets had made an adjustment to polyethylene in the Conditioning Phase, the total amount of fat digested was essentially equivalent in all treatments. Sand significantly decreased total fat digested in all periods with the exception of Period 5. This decrease in total fat digested was due primarily to

the effect of sand level 3.

6. Body Weight Change. There were no significant differences in body weight change during the entire experiment.

7. Egg Production. Neither sand nor polyethylene had any significant effect on the number of eggs produced per pullet.

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APPENDIX

TABLE I

EXPERIMENTAL DESIGN AND RATION COMPOSITION

Treatment No.	Basal No.	Preconditioning Phase, Period 1: Dietary Wt. (gm)	Preconditioning Phase, Period 1: Dietary Vol. (ml)	Basal No.	Conditioning Phase, Period 2: Dietary Wt. (gm)	Conditioning Phase, Period 2: Dietary Vol. (ml)	Conditioning Phase, Period 3: Dietary Wt. (gm)	Conditioning Phase, Period 3: Dietary Vol. (ml)	Conditioning Phase, Period 4: Dietary Wt. (gm)	Conditioning Phase, Period 4: Dietary Vol. (ml)	Treatment Phase, Periods 5, 6, 7, 8, 9: Dietary Wt. (gm)	Treatment Phase, Periods 5, 6, 7, 8, 9: Dietary Vol. (ml)
				Basal II	108.6	157.6	108.6	157.6	108.6	157.6	108.6	157.6
1	Basal I	103.5	168.6	Polyethylene	--	--	--	--	--	--	--	--
				Sand	--	--	--	--	--	--	--	--
				Total	108.6	157.6	108.6	157.6	108.6	157.6	108.6	157.6
				Basal II	108.6	157.6	108.6	157.6	108.6	157.6	108.6	157.6
2	Basal I	103.5	168.6	Polyethylene	4.5	20.3	9.0	40.6	13.5	60.9	18.0	81.2
				Sand	--	--	--	--	--	--	--	--
				Total	113.1	177.9	117.6	198.2	122.1	218.5	126.6	238.8
				Basal II	108.6	157.6	108.6	157.6	108.6	157.6	108.6	157.6
3	Basal I	103.5	168.6	Polyethylene	9.0	40.6	18.0	81.2	27.0	121.8	36.0	162.3
				Sand	--	--	--	--	--	--	--	--
				Total	117.6	198.2	126.6	238.8	135.6	279.4	144.6	319.9
				Basal II	108.6	157.6	108.6	157.6	108.6	157.6	108.6	157.6
4	Basal I	103.5	168.6	Polyethylene	13.5	60.9	27.0	121.8	40.5	182.7	54.0	243.5
				Sand	--	--	--	--	--	--	--	--
				Total	122.1	218.5	135.6	279.4	149.1	340.3	162.6	401.1
				Basal II	108.6	157.6	108.6	157.6	108.6	157.6	108.6	157.6
5	Basal I	103.5	168.6	Polyethylene	18.0	81.2	36.0	162.3	54.0	243.5	72.0	324.7
				Sand	--	--	--	--	--	--	--	--
				Total	126.6	238.8	144.6	319.9	162.6	401.1	180.6	482.3
				Basal II	108.6	157.6	108.6	157.6	108.6	157.6	108.6	157.6
6	Basal I	103.5	168.6	Polyethylene	--	--	--	--	--	--	--	--
				Sand	4.5	3.4	9.0	6.9	13.5	10.3	18.0	13.7
				Total	113.1	161.0	117.6	164.5	122.1	167.9	126.6	171.3
				Basal II	108.6	157.6	108.6	157.6	108.6	157.6	108.6	157.6
7	Basal I	103.5	168.6	Polyethylene	4.5	20.3	9.0	40.6	13.5	60.9	18.0	81.2
				Sand	4.5	3.4	9.0	6.9	13.5	10.3	18.0	13.7
				Total	117.6	181.3	126.6	205.1	135.6	228.8	144.6	252.5
				Basal II	108.6	157.6	108.6	157.6	108.6	157.6	108.6	157.6
8	Basal I	103.5	168.6	Polyethylene	9.0	40.6	18.0	81.2	27.0	121.8	36.0	162.3
				Sand	4.5	3.4	9.0	6.9	13.5	10.3	18.0	13.7
				Total	122.1	201.6	135.6	245.7	149.1	289.7	162.6	333.6

TABLE I (continued)

Treatment No.	Basal No.	Preconditioning Phase Period 1 Dietary Wt. (gm)	Dietary Vol. (ml)	Basal No.	Conditioning Phase Period 2 Dietary Wt. (gm)	Dietary Vol. (ml)	Period 3 Dietary Wt. (gm)	Dietary Vol. (ml)	Period 4 Dietary Wt. (gm)	Dietary Vol. (ml)	Treatment Phase Periods 5, 6, 7, 8, 9 Dietary Wt. (gm)	Dietary Vol. (ml)
				Basal II	108.6	157.6	108.6	157.6	108.6	157.6	108.6	157.6
9	Basal I	103.5	168.6	Polyethylene	13.5	60.9	27.0	121.8	40.5	182.7	54.0	243.5
				Sand	4.5	3.4	9.0	6.9	13.5	10.3	18.0	13.7
				Total	126.6	221.9	144.6	286.3	162.6	350.6	180.6	414.8
				Basal II	108.6	157.6	108.6	157.6	108.6	157.6	108.6	157.6
10	Basal I	103.5	168.6	Polyethylene	18.0	81.2	36.0	162.3	54.0	243.5	72.0	324.7
				Sand	4.5	3.4	9.0	6.9	13.5	10.3	18.0	13.7
				Total	131.1	242.2	153.6	326.8	176.1	411.4	198.6	496.0
				Basal II	108.6	157.6	108.6	157.6	108.6	157.6	108.6	157.6
11	Basal I	103.5	168.6	Polyethylene	--	--	--	--	--	--	--	--
				Sand	9.0	6.9	18.0	13.7	27.0	20.6	36.0	27.5
				Total	117.6	164.5	126.6	171.3	135.6	178.2	144.6	185.1
				Basal II	108.6	157.6	108.6	157.6	108.6	157.6	108.6	157.6
12	Basal I	103.5	168.6	Polyethylene	4.5	20.3	9.0	40.6	13.5	60.9	18.0	81.2
				Sand	9.0	6.9	18.0	13.7	27.0	20.6	36.0	27.5
				Total	122.1	184.8	135.6	211.9	149.1	239.1	162.6	266.3
				Basal II	108.6	157.6	108.6	157.6	108.6	157.6	108.6	157.6
13	Basal I	103.5	168.6	Polyethylene	9.0	40.6	18.0	81.2	27.0	121.8	36.0	162.3
				Sand	9.0	6.9	18.0	13.7	27.0	20.6	36.0	27.5
				Total	126.6	205.1	144.6	252.5	162.6	300.0	180.6	347.4
				Basal II	108.6	157.6	108.6	157.6	108.6	157.6	108.6	157.6
14	Basal I	103.5	168.6	Polyethylene	13.5	60.9	27.0	121.8	40.5	182.7	54.0	243.5
				Sand	9.0	6.9	18.0	13.7	27.0	20.6	36.0	27.5
				Total	131.1	225.4	153.6	293.1	176.1	360.9	198.6	428.6
				Basal II	108.6	157.6	108.6	157.6	108.6	157.6	108.6	157.6
15	Basal I	103.5	168.6	Polyethylene	18.0	81.2	36.0	162.4	54.0	243.5	72.0	324.7
				Sand	9.0	6.9	18.0	13.7	27.0	20.6	36.0	27.5
				Total	135.6	245.7	162.6	333.7	189.6	421.7	216.6	509.8
				Basal II	108.6	157.6	108.6	157.6	108.6	157.6	108.6	157.6
16	Basal I	103.5	168.6	Polyethylene	--	--	--	--	--	--	--	--
				Sand	13.5	10.3	27.0	20.6	40.5	30.9	54.0	41.2
				Total	122.1	167.9	135.6	178.2	149.1	188.5	162.6	198.8
				Basal II	108.6	157.6	108.6	157.6	108.6	157.6	108.6	157.6
17	Basal I	103.5	168.6	Polyethylene	4.5	20.3	9.0	40.6	13.5	60.9	18.0	81.2
				Sand	13.5	10.3	27.0	20.6	40.5	30.9	54.0	41.2
				Total	126.6	188.2	144.6	218.8	162.6	249.4	180.6	280.0

TABLE I (continued)

Treatment No.	Basal No.	Preconditioning Phase Period 1 Dietary Wt. (gm)	Preconditioning Phase Period 1 Dietary Vol. (ml)	Basal No.	Conditioning Phase Period 2 Dietary Wt. (gm)	Conditioning Phase Period 2 Dietary Vol. (ml)	Conditioning Phase Period 3 Dietary Wt. (gm)	Conditioning Phase Period 3 Dietary Vol. (ml)	Conditioning Phase Period 4 Dietary Wt. (gm)	Conditioning Phase Period 4 Dietary Vol. (ml)	Treatment Phase Periods 5, 6, 7, 8, 9 Dietary Wt. (gm)	Treatment Phase Periods 5, 6, 7, 8, 9 Dietary Vol. (ml)
				Basal II	108.6	157.6	108.6	157.6	108.6	157.6	108.6	157.6
18	Basal I	103.5	168.6	Polyethylene	9.0	40.6	18.0	81.2	27.0	121.8	36.0	162.3
				Sand	13.5	10.3	27.0	20.6	40.5	30.9	54.0	41.2
				Total	131.1	208.5	153.6	259.4	176.1	310.3	198.6	361.1
				Basal II	108.6	157.6	108.6	157.6	108.6	157.6	108.6	157.6
19	Basal I	103.5	168.6	Polyethylene	13.5	60.9	27.0	121.8	40.5	182.7	54.0	243.5
				Sand	13.5	10.3	27.0	20.6	40.5	30.9	54.0	41.2
				Total	135.6	228.8	162.6	300.0	189.6	371.2	216.6	442.3
				Basal II	108.6	157.6	108.6	157.6	108.6	157.6	108.6	157.6
20	Basal I	103.5	168.6	Polyethylene	18.0	81.2	36.0	162.3	54.0	243.5	72.0	324.7
				Sand	13.5	10.3	27.0	20.6	40.5	30.9	54.0	41.2
				Total	140.1	249.1	171.6	340.5	203.1	432.0	234.6	523.5
				Basal II	108.6	157.6	108.6	157.6	108.6	157.6	108.6	157.6
21	Basal I	103.5	168.6	Polyethylene	--	--	--	--	--	--	--	--
				Sand	18.0	13.7	36.0	27.5	54.0	41.2	72.0	54.9
				Total	126.6	171.3	144.6	185.1	162.6	198.8	180.6	212.5
				Basal II	108.6	157.6	108.6	157.6	108.6	157.6	108.6	157.6
22	Basal I	103.5	168.6	Polyethylene	4.5	20.3	9.0	40.6	13.5	60.9	18.0	81.2
				Sand	18.0	13.7	36.0	27.5	54.0	41.2	72.0	54.9
				Total	131.1	191.6	153.6	225.7	176.1	259.7	198.6	293.7
				Basal II	108.6	157.6	108.6	157.6	108.6	157.6	108.6	157.6
23	Basal I	103.5	168.6	Polyethylene	9.0	40.6	18.0	81.2	27.0	121.8	36.0	162.3
				Sand	18.0	13.7	36.0	27.5	54.0	41.2	72.0	54.9
				Total	135.6	211.9	162.6	266.3	189.6	320.6	216.6	374.8
				Basal II	108.6	157.6	108.6	157.6	108.6	157.6	108.6	157.6
24	Basal I	103.5	168.6	Polyethylene	13.5	60.9	27.0	121.8	40.5	182.7	54.0	243.5
				Sand	18.0	13.7	36.0	27.5	54.0	41.2	72.0	54.9
				Total	140.1	232.2	171.6	306.9	203.1	381.5	234.6	456.0
				Basal II	108.6	157.6	108.6	157.6	108.6	157.6	108.6	157.6
25	Basal I	103.5	168.6	Polyethylene	18.0	81.2	36.0	162.3	54.0	243.5	72.0	324.7
				Sand	18.0	13.7	36.0	27.5	54.0	41.2	72.0	54.9
				Total	144.6	252.5	180.6	347.4	216.6	442.3	252.6	537.2

TABLE II

FACTORIAL ARRANGEMENT OF TREATMENTS

Sand in grams added to dietary weight of Experimental Basal II	Polyethylene in grams added to dietary weight of Experimental Basal II: 0	18	36	54	72
0	Treatment 1	Treatment 2	Treatment 3	Treatment 4	Treatment 5
18	Treatment 6	Treatment 7	Treatment 8	Treatment 9	Treatment 10
36	Treatment 11	Treatment 12	Treatment 13	Treatment 14	Treatment 15
54	Treatment 16	Treatment 17	Treatment 18	Treatment 19	Treatment 20
72	Treatment 21	Treatment 22	Treatment 23	Treatment 24	Treatment 25

TABLE III

COMPOSITION OF EXPERIMENTAL BASALS

Ingredients	Experimental Basal I (grams)	Experimental Basal II (grams)
Fat (feed grade tallow)	2.22	2.42
Corn, ground yellow	23.10	31.19
Milo, ground yellow	25.35	45.48
Oat mill feed	23.80	2.47
Alfalfa meal (17% protein)	1.15	1.04
Fish meal (Herring, 70% protein)	4.33	3.82
Soybean oil meal (50% protein)	8.68	7.75
Blood meal (84% protein)	2.32	2.06
Gelatin (95% protein)	1.15	1.04
Dried whey	1.15	1.04
Dried condensed fermented corn extractives	1.42	1.28
dl-Methionine	0.11	0.12
Calcium carbonate	2.74	2.90
Dicalcium phosphate	4.63	4.58
Salt	0.52	0.54
VMC-60	0.52	0.54
Chromic oxide	0.31	0.33
Total	103.50	108.60

TABLE IV

COMPOSITION OF VMC-60

Vitamins and minerals	Units	Units contained in 10 lbs. of concentrate	Adds per lb. of finished ration, when added at the 0.5 percent level
Vitamin A	U.S.P.	16,000,000	8,000
Vitamin D_3	I.C.U.	2,400,000	1,200
Vitamin E	I.U.	12,000	6
Vitamin K	mg.	6,000	3
Vitamin B_{12}	mg.	16	0.008
Riboflavin	mg.	8,000	4
Niacin	mg.	64,000	32
Pantothenic acid	mg.	16,000	8
Choline chloride	mg.	1,000,000	500
Manganese	mg.	55,400	27.7
Iodine	mg.	1,720	0.86
Cobalt	mg.	1,180	0.59
Iron	mg.	43,600	21.8
Copper	mg.	3,300	1.65
Zinc	mg.	45,400	22.7

TABLE V

ANALYSIS OF VARIANCE OF DIGESTION COEFFICIENTS FOR FAT IN PERIOD 3

Source of variation	df	SS	MS	F
Total	35	6354.71160		
Replicates	3	128.09180	42.67306	3.36*
Treatments	(8)			
Sand (S)	(2)			
S_{linear}	1	1007.65960	1007.65960	79.29**
$S_{quadratic}$	1	591.51558	591.51558	46.55**
Polyethylene (P)	(2)			
P_{linear}	1	3854.02028	3854.02028	303.28**
$P_{quadratic}$	1	0.00046	0.00046	
Interactions	(4)			
S x P	4	468.50616	117.12654	9.22**
Error	24	304.99054	12.70793	

* Significant at the five percent level of probability

** Significant at the one percent level of probability

TABLE VI

ANALYSIS OF VARIANCE OF DIGESTION COEFFICIENTS FOR FAT IN PERIOD 5

Source of variation	df	SS	MS	F
Total	35	3214.46376		
Replicates	3	531.48179	177.16059	14.79**
Treatments	(8)			
Sand (S)	(2)			
S_{linear}	1	251.46518	251.46518	20.96**
$S_{quadratic}$	1	30.51213	30.51213	2.54
Polyethylene (P)	(2)			
P_{linear}	1	1963.92278	1963.92278	163.73**
$P_{quadratic}$	1	1.23736	1.23736	
Interactions	(4)			
S x P	4	147.97250	36.99313	3.08*
Error	24	287.87201	11.99466	

*Significant at the five percent level of probability

**Significant at the one percent level of probability

TABLE VII

ANALYSIS OF VARIANCE OF DIGESTION COEFFICIENTS FOR FAT IN PERIOD 7

Source of variation	df	SS	MS	F
Total	35	4575.69992		
Replicates	3	296.59951	98.86650	2.06
Treatments	(8)			
Sand (S)	(2)			
S_{linear}	1	2578.94668	2578.94668	53.68**
$S_{quadratic}$	1	165.74520	165.74520	3.45
Polyethylene (P)	(2)			
P_{linear}	1	7.22106	7.22106	
$P_{quadratic}$	1	160.22378	160.22378	3.34
Interactions	(4)			
S x P	4	214.02338	53.50584	1.11
Error	24	1152.94039	48.03918	

*Significant at the five percent level of probability

**Significant at the one percent level of probability

TABLE VIII

ANALYSIS OF VARIANCE OF DIGESTION COEFFICIENTS FOR FAT IN PERIOD 9

Source of variation	df	SS	MS	F
Total	35	3059.69128		
Replicates	3	124.05334	41.35111	1.29
Treatments	(8)			
Sand (S)	(2)			
S_{linear}	1	588.84114	588.84114	18.36**
$S_{quadratic}$	1	238.36058	238.36058	7.43*
Polyethylene (P)	(2)			
P_{linear}	1	112.53232	112.53232	3.51
$P_{quadratic}$	1	81.06851	81.06851	2.53
Interactions	(4)			
S x P	4	1144.91778	286.22945	8.92**
Error	24	769.91758	32.07989	

*Significant at the five percent level of probability

**Significant at the one percent level of probability

TABLE IX

MEANS FOR MAIN EFFECTS OF SAND AND POLYETHYLENE UPON DIGESTION COEFFICIENTS FOR FAT IN PERIOD 3

	Level		
Factor	1	2	3
Sand	79.04	81.16	66.08
Polyethylene	88.10	75.42	62.75

TABLE X

MEANS FOR MAIN EFFECTS OF SAND AND POLYETHYLENE UPON DIGESTION COEFFICIENTS FOR FAT IN PERIOD 5

	Level		
Factor	1	2	3
Sand	76.29	71.10	69.81
Polyethylene	81.32	72.66	63.22

TABLE XI

MEANS FOR MAIN EFFECTS OF SAND AND POLYETHYLENE UPON DIGESTION COEFFICIENTS FOR FAT IN PERIOD 7

	Level		
Factor	1	2	3
Sand	72.80	66.99	52.07
Polyethylene	64.89	60.97	65.99

TABLE XII

MEANS FOR MAIN EFFECTS OF SAND AND POLYETHYLENE UPON DIGESTION COEFFICIENTS FOR FAT IN PERIOD 9

	Level		
Factor	1	2	3
Sand	75.88	76.38	65.97
Polyethylene	73.85	74.86	69.52

TABLE XIII

MEANS FOR INTERACTION EFFECT OF SAND X POLYETHYLENE UPON DIGESTION COEFFICIENTS FOR FAT IN PERIOD 3

Sand Level	Polyethylene Level 1	2	3
1	92.91	80.12	64.09
2	87.35	82.95	73.18
3	84.04	63.20	51.00

TABLE XIV

MEANS FOR INTERACTION EFFECT OF SAND X POLYETHYLENE UPON DIGESTION COEFFICIENTS FOR FAT IN PERIOD 5

Sand Level	Polyethylene Level 1	2	3
1	83.28	77.09	68.50
2	81.84	73.21	58.25
3	78.83	67.69	62.92

TABLE XV

MEANS FOR INTERACTION EFFECT OF SAND X POLYETHYLENE UPON DIGESTION COEFFICIENTS FOR FAT IN PERIOD 9

Sand Level	Polyethylene Level 1	2	3
1	83.84	75.62	68.17
2	79.33	72.22	77.59
3	58.37	76.75	62.79

TABLE XVI

ANALYSIS OF VARIANCE FOR FEED WEIGHT CONSUMPTION DATA IN PERIOD 3

Source of variation	df	SS	MS	F
Total	35	16866.55377		
Treatments	(8)			
Sand (S)	(2)			
S_{linear}	1	570.37502	570.37502	1.06
$S_{quadratic}$	1	767.01372	767.01372	1.43
Polyethylene (P)	(2)			
P_{linear}	1	198.37500	198.37500	
$P_{quadratic}$	1	110.01386	110.01386	
Interactions	(4)			
S x P	4	729.77770	182.44443	
Error	27	14490.99847	536.70364	

TABLE XVII

ANALYSIS OF VARIANCE FOR FEED WEIGHT CONSUMPTION DATA IN PERIOD 5

Source of variation	df	SS	MS	F
Total	35	45716.99763		
Treatments	(8)			
Sand (S)	(2)			
S_{linear}	1	10333.50008	10333.50008	9.19**
$S_{quadratic}$	1	241.99992	241.99992	
Polyethylene (P)	(2)			
P_{linear}	1	24.00000	24.00000	
$P_{quadratic}$	1	40.49999	40.49999	
Interactions	(4)			
S x P	4	4705.00012	1176.25003	1.05
Error	27	30371.99752	1124.88879	

**Significant at the one percent level of probability

TABLE XVIII

ANALYSIS OF VARIANCE FOR FEED WEIGHT CONSUMPTION DATA IN PERIOD 7

Source of variation	df	SS	MS	F
Total	35	72599.99518		
Treatments	(8)			
Sand (S)	(2)			
S_{linear}	1	23625.37408	23625.37408	15.26**
$S_{quadratic}$	1	1596.12456	1596.12456	1.03
Polyethylene (P)	(2)			
P_{linear}	1	400.16668	400.16668	
$P_{quadratic}$	1	71.99998	71.99998	
Interactions	(4)			
S x P	4	5110.33420	1277.58355	
Error	27	41795.99568	1547.99984	

**Significant at the one percent level of probability

TABLE XIX

ANALYSIS OF VARIANCE FOR FEED WEIGHT CONSUMPTION DATA IN PERIOD 9

Source of variation	df	SS	MS	F
Total	35	45978.30116		
Treatments	(8)			
Sand (S)	(2)			
S_{linear}	1	6600.16656	6600.16656	5.52*
$S_{quadratic}$	1	1042.72195	1042.72195	
Polyethylene (P)	(2)			
P_{linear}	1	3313.49988	3313.49988	2.77
$P_{quadratic}$	1	854.22195	854.22195	
Interactions	(4)			
S x P	4	1870.94458	467.73615	
Error	27	32296.74624	1196.17578	

*Significant at the five percent level of probability

TABLE XX

MEANS FOR MAIN EFFECTS OF SAND AND POLYETHYLENE UPON GRAMS OF FEED WEIGHT CONSUMPTION IN PERIOD 3

	Level		
Factor	1	2	3
Sand	100.00	95.08	109.75
Polyethylene	97.50	104.08	103.25

TABLE XXI

MEANS FOR MAIN EFFECTS OF SAND AND POLYETHYLENE UPON GRAMS OF FEED WEIGHT CONSUMPTION IN PERIOD 5

	Level		
Factor	1	2	3
Sand	89.25	104.50	130.75
Polyethylene	109.92	106.67	107.92

TABLE XXII

MEANS FOR MAIN EFFECTS OF SAND AND POLYETHYLENE UPON GRAMS OF FEED WEIGHT CONSUMPTION IN PERIOD 7

	Level		
Factor	1	2	3
Sand	98.00	115.25	160.75
Polyethylene	129.75	122.67	121.58

TABLE XXIII

MEANS FOR MAIN EFFECTS OF SAND AND POLYETHYLENE UPON GRAMS OF FEED WEIGHT CONSUMPTION IN PERIOD 9

	Level		
Factor	1	2	3
Sand	106.25	134.25	139.42
Polyethylene	118.33	119.75	141.83

TABLE XXIV

ANALYSIS OF VARIANCE FOR FEED VOLUME CONSUMPTION IN PERIOD 3

Source of variation	df	SS	MS	F
Total	35	89510.26400		
Treatments	(8)			
Sand (S)	(2)			
S_{linear}	1	497.38018	497.38018	
$S_{quadratic}$	1	2609.51468	2609.51468	1.58
Polyethylene (P)	(2)			
P_{linear}	1	38188.86182	38188.86182	23.11**
$P_{quadratic}$	1	1019.90594	1019.90594	
Interactions	(4)			
S x P	4	2571.06738	642.76685	
Error	27	44623.53400	1652.72348	

**Significant at the one percent level of probability

TABLE XXV

ANALYSIS OF VARIANCE FOR FEED VOLUME CONSUMPTION IN PERIOD 5

Source of variation	df	SS	MS	F
Total	35	148239.38282		
Treatments	(8)			
Sand (S)	(2)			
S_{linear}	1	2586.04355	2586.04355	1.11
$S_{quadratic}$	1	90.51530	90.51530	
Polyethylene (P)	(2)			
P_{linear}	1	73206.25586	73206.25586	31.48**
$P_{quadratic}$	1	202.91540	202.91540	
Interactions	(4)			
S x P	4	9369.82520	2342.45630	1.01
Error	27	62783.82751	2325.32694	

**Significant at the one percent level of probability

TABLE XXVI

ANALYSIS OF VARIANCE FOR FEED VOLUME CONSUMPTION IN PERIOD 7

Source of variation	df	SS	MS	F
Total	35	200596.19260		
Treatments	(8)			
Sand (S)	(2)			
S_{linear}	1	16346.80273	16346.80273	4.83*
$S_{quadratic}$	1	2895.60428	2895.60428	
Polyethylene (P)	(2)			
P_{linear}	1	79461.64805	79461.74805	23.51**
$P_{quadratic}$	1	353.21016	353.21016	
Interactions	(4)			
S x P	4	10295.25586	2573.81396	
Error	27	91243.57152	3379.39153	

*Significant at the five percent level of probability

**Significant at the one percent level of probability

TABLE XXVII

ANALYSIS OF VARIANCE FOR FEED VOLUME CONSUMPTION IN PERIOD 9

Source of variation	df	SS	MS	F
Total	35	284317.06719		
Treatments	(8)			
Sand (S)	(2)			
S_{linear}	1	826.90692	826.90692	
$S_{quadratic}$	1	3721.01898	3721.01898	1.16
Polyethylene (P)	(2)			
P_{linear}	1	182136.05273	182136.05273	56.61**
$P_{quadratic}$	1	2389.04974	2389.04974	
Interactions	(4)			
S x P	4	8381.02344	2095.25586	
Error	27	86863.01538	3217.14871	

**Significant at the one percent level of probability

TABLE XXVIII

MEANS FOR MAIN EFFECTS OF SAND AND POLYETHYLENE UPON MILLILITERS OF FEED CONSUMPTION IN PERIOD 3

	Level		
Factor	1	2	3
Sand	186.43	163.82	177.32
Polyethylene	132.20	183.38	211.98

TABLE XXIX

MEANS FOR MAIN EFFECTS OF SAND AND POLYETHYLENE UPON MILLILITERS OF FEED CONSUMPTION IN PERIOD 5

	Level		
Factor	1	2	3
Sand	193.12	200.14	213.88
Polyethylene	145.47	205.74	255.93

TABLE XXX

MEANS FOR MAIN EFFECTS OF SAND AND POLYETHYLENE UPON MILLILITERS OF FEED CONSUMPTION IN PERIOD 7

	Level		
Factor	1	2	3
Sand	211.45	218.52	263.64
Polyethylene	171.45	235.63	286.53

TABLE XXXI

MEANS FOR MAIN EFFECTS OF SAND AND POLYETHYLENE UPON MILLILITERS OF FEED CONSUMPTION IN PERIOD 9

	Level		
Factor	1	2	3
Sand	228.80	256.23	240.54
Polyethylene	160.50	230.34	334.73

TABLE XXXII

ANALYSIS OF VARIANCE FOR TOTAL FAT CONSUMPTION IN PERIOD 3

Source of variation	df	SS	MS	F
Total	35	91.36055		
Treatments	(8)			
Sand (S)	(2)			
S_{linear}	1	23.09018	23.09018	27.83**
$S_{quadratic}$	1	3.74955	3.74955	4.52*
Polyethylene (P)	(2)			
P_{linear}	1	31.97223	31.97223	38.54**
$P_{quadratic}$	1	0.30761	0.30761	
Interactions	(4)			
S x P	4	9.84272	2.46068	2.97*
Error	27	22.39826	0.82956	

*Significant at the five percent level of probability

**Significant at the one percent level of probability

TABLE XXXIII

ANALYSIS OF VARIANCE FOR TOTAL FAT CONSUMPTION IN PERIOD 5

Source of variation	df	SS	MS	F
Total	35	33.22646		
Treatments	(8)			
Sand (S)	(2)			
S_{linear}	1	2.09680	2.09680	2.62
$S_{quadratic}$	1	1.79715	1.79715	2.25
Polyethylene (P)	(2)			
P_{linear}	1	5.52711	5.52711	6.91*
$P_{quadratic}$	1	0.12681	0.12681	
Interactions	(4)			
S x P	4	2.10305	0.52576	
Error	27	21.57554	0.79909	

*Significant at the five percent level of probability

TABLE XXXIV

ANALYSIS OF VARIANCE FOR TOTAL FAT CONSUMPTION IN PERIOD 7

Source of variation	df	SS	MS	F
Total	35	37.32200		
Treatments	(8)			
Sand (S)	(2)			
S_{linear}	1	1.75012	1.75012	1.75
$S_{quadratic}$	1	0.25497	0.25497	
Polyethylene (P)	(2)			
P_{linear}	1	2.58485	2.58485	2.59
$P_{quadratic}$	1	2.61487	2.61487	2.62
Interactions	(4)			
S x P	4	3.14793	0.78698	
Error	27	26.96926	0.99886	

TABLE XXXV

ANALYSIS OF VARIANCE FOR TOTAL FAT CONSUMPTION
IN PERIOD 9

Source of variation	df	SS	MS	F
Total	35	49.62835		
Treatments	(8)			
Sand (S)	(2)			
S_{linear}	1	5.80351	5.80351	5.25*
$S_{quadratic}$	1	5.19925	5.19925	4.70*
Polyethylene (P)	(2)			
P_{linear}	1	0.41169	0.41169	
$P_{quadratic}$	1	3.07875	3.07875	2.78
Interactions	(4)			
S x P	4	5.32635	1.33159	1.20
Error	27	29.86280	1.10602	

*Significant at the five percent level of probability

TABLE XXXVI

MEANS FOR MAIN EFFECTS OF SAND AND POLYETHYLENE UPON GRAMS OF TOTAL FAT CONSUMPTION IN PERIOD 3

	Level		
Factor	1	2	3
Sand	5.22	3.56	3.26
Polyethylene	5.24	3.88	2.93

TABLE XXXVII

MEANS FOR MAIN EFFECTS OF SAND AND POLYETHYLENE UPON GRAMS OF TOTAL FAT CONSUMPTION IN PERIOD 5

	Level		
Factor	1	2	3
Sand	3.80	3.03	3.21
Polyethylene	3.87	3.26	2.91

TABLE XXXVIII

MEANS FOR MAIN EFFECTS OF SAND AND POLYETHYLENE UPON GRAMS OF TOTAL FAT CONSUMPTION IN PERIOD 7

	Level		
Factor	1	2	3
Sand	4.07	3.62	3.53
Polyethylene	4.26	3.36	3.60

TABLE XXXIX

MEANS FOR MAIN EFFECTS OF SAND AND POLYETHYLENE UPON GRAMS OF TOTAL FAT CONSUMPTION IN PERIOD 9

	Level		
Factor	1	2	3
Sand	4.65	4.97	3.67
Polyethylene	4.77	4.02	4.50

TABLE XL

MEANS FOR INTERACTION EFFECT OF SAND X POLYETHYLENE UPON GRAMS OF TOTAL FAT CONSUMPTION IN PERIOD 3

	Polyethylene Level		
Sand Level	1	2	3
1	7.39	4.96	3.33
2	4.12	3.51	3.04
3	4.19	3.18	2.41

TABLE XLI

ANALYSIS OF VARIANCE FOR TOTAL FAT DIGESTED
IN PERIOD 3

Source of variation	df	SS	MS	F
Total	35	103.45518		
Replicates	3	3.62277	1.20759	2.36
Treatments	(8)			
Sand (S)	(2)			
S_{linear}	1	26.22586	26.22586	51.36**
$S_{quadratic}$	1	1.14031	1.14031	2.21
Polyethylene (P)	(2)			
P_{linear}	1	47.10485	47.10485	92.26**
$P_{quadratic}$	1	0.68883	0.68883	1.35
Interactions	(4)			
S x P	4	12.41824	3.10456	6.08**
Error	24	12.25432	0.51059	

**Significant at the one percent level of probability

TABLE LXII

ANALYSIS OF VARIANCE FOR TOTAL FAT DIGESTED IN PERIOD 5

Source of variation	df	SS	MS	F
Total	35	30.98036		
Replicates	3	2.01315	0.67105	1.20
Treatments	(8)			
Sand (S)	(2)			
S_{linear}	1	2.33293	2.33293	4.19
$S_{quadratic}$	1	1.36315	1.36315	2.45
Polyethylene (P)	(2)			
P_{linear}	1	10.25980	10.25980	18.41**
$P_{quadratic}$	1	0.10843	0.10843	
Interactions	(4)			
S x P	4	1.53068	0.38267	
Error	24	13.37222	0.55717	

**Significant at the one percent level of probability

TABLE XLIII

ANALYSIS OF VARIANCE FOR TOTAL FAT DIGESTED
IN PERIOD 7

Source of variation	df	SS	MS	F
Total	35	21.60062		
Replicates	3	0.93957	0.31319	
Treatments	(8)			
Sand (S)	(2)			
S_{linear}	1	7.87034	7.87034	21.32**
$S_{quadratic}$	1	0.00046	0.00046	
Polyethylene (P)	(2)			
P_{linear}	1	0.88430	0.88430	2.40
$P_{quadratic}$	1	1.86956	1.86956	5.07*
Interactions	(4)			
S x P	4	1.17762	0.29440	
Error	24	8.85877	0.36911	

*Significant at the five percent level of probability

**Significant at the one percent level of probability

TABLE XLIV

ANALYSIS OF VARIANCE FOR TOTAL FAT DIGESTED
IN PERIOD 9

Source of variation	df	SS	MS	F
Total	35	37.47948		
Replicates	3	2.74170	0.91390	1.82
Treatments	(8)			
Sand (S)	(2)			
S_{linear}	1	7.34063	7.34063	14.63**
$S_{quadratic}$	1	5.26945	5.26945	10.50**
Polyethylene (P)	(2)			
P_{linear}	1	1.65271	1.65271	3.29
$P_{quadratic}$	1	1.43198	1.43198	2.85
Interactions	(4)			
S x P	4	6.99746	1.74936	3.48*
Error	24	12.04555	0.50189	

*Significant at the five percent level of probability

**Significant at the one percent level of probability

TABLE XLV

MEANS FOR MAIN EFFECTS OF SAND AND POLYETHYLENE UPON GRAMS OF TOTAL FAT DIGESTED IN PERIOD 3

	Level		
Factor	1	2	3
Sand	4.33	2.91	2.24
Polyethylene	4.66	2.97	1.86

TABLE XLVI

MEANS FOR MAIN EFFECTS OF SAND AND POLYETHYLENE UPON GRAMS OF TOTAL FAT DIGESTED IN PERIOD 5

	Level		
Factor	1	2	3
Sand	2.92	2.19	2.29
Polyethylene	3.16	2.39	1.85

TABLE XLVII

MEANS FOR MAIN EFFECTS OF SAND AND POLYETHYLENE UPON GRAMS OF TOTAL FAT DIGESTED IN PERIOD 7

	Level		
Factor	1	2	3
Sand	2.97	2.41	1.83
Polyethylene	2.76	2.08	2.37

TABLE XLVIII

MEANS FOR MAIN EFFECTS OF SAND AND POLYETHYLENE UPON GRAMS OF TOTAL FAT DIGESTED IN PERIOD 9

	Level		
Factor	1	2	3
Sand	3.55	3.81	2.44
Polyethylene	3.67	2.99	3.15

TABLE XLIX

MEANS FOR INTERACTION EFFECT OF SAND X POLYETHYLENE UPON GRAMS OF TOTAL FAT DIGESTED IN PERIOD 3

	Polyethylene Level		
Sand Level	1	2	3
1	6.86	4.01	2.13
2	3.60	2.92	2.22
3	3.52	1.98	1.23

TABLE L

MEANS FOR INTERACTION EFFECT OF SAND X POLYETHYLENE UPON GRAMS OF TOTAL FAT DIGESTED IN PERIOD 9

	Polyethylene Level		
Sand Level	1	2	3
1	4.51	3.05	3.09
2	4.50	3.21	3,72
3	2.00	2.70	2.63

TABLE LI

ANALYSIS OF VARIANCE FOR BODY WEIGHT LOSS OR GAIN IN PERIOD 3

Source of variation	df	SS	MS	F
Total	35	77630.54976		
Treatments	(8)			
Sand (S)	(2)			
S_{linear}	1	1066.66668	1066.66668	
$S_{quadratic}$	1	2688.88828	2688.88828	1.08
Polyethylene (P)	(2)			
P_{linear}	1	599.99999	599.99999	
$P_{quadratic}$	1	555.55541	555.55541	
Interactions	(4)			
S x P	4	5644.44400	1411.11100	
Error	27	67074.99540	2484.25908	

TABLE LII

ANALYSIS OF VARIANCE FOR BODY WEIGHT LOSS OR GAIN IN PERIOD 5

Source of variation	df	SS	MS	F
Total	35	124899.98742		
Treatments	(8)			
Sand (S)	(2)			
S_{linear}	1	1666.66668	1666.66668	
$S_{quadratic}$	1	199.99998	199.99998	
Polyethylene (P)	(2)			
P_{linear}	1	6337.49992	6337.49992	1.65
$P_{quadratic}$	1	3612.49884	3612.49884	
Interactions	(4)			
S x P	4	9183.33224	2295.83306	
Error	27	103899.98976	3848.14777	

TABLE LIII

ANALYSIS OF VARIANCE FOR BODY WEIGHT LOSS OR GAIN IN PERIOD 7

Source of variation	df	SS	MS	F
Total	35	143897.20444		
Treatments	(8)			
Sand (S)	(2)			
S_{linear}	1	5704.16592	5704.16592	1.36
$S_{quadratic}$	1	8234.71944	8234.71944	1.96
Polyethylene (P)	(2)			
P_{linear}	1	416.66662	416.66662	
$P_{quadratic}$	1	2222.22174	2222.22174	
Interactions	(4)			
S x P	4	14144.44528	3536.11132	
Error	27	113174.98544	4191.66612	

TABLE LIV

ANALYSIS OF VARIANCE FOR BODY WEIGHT LOSS OR GAIN IN PERIOD 9

Source of variation	df	SS	MS	F
Total	35	197897.19305		
Treatments	(8)			
Sand (S)	(2)			
S_{linear}	1	13537.50032	13537.50032	2.17
$S_{quadratic}$	1	2568.05496	2568.05496	
Polyethylene (P)	(2)			
P_{linear}	1	266.66667	266.66667	
$P_{quadratic}$	1	555.55542	555.55542	
Interactions	(4)			
S x P	4	12244.44304	3061.11076	
Error	27	168724.97264	6249.07306	

TABLE LV

MEANS FOR MAIN EFFECTS OF SAND AND POLYETHYLENE UPON BODY WEIGHT CHANGE IN GRAMS IN PERIOD 3

	Level		
Factor	1	2	3
Sand	114.17	89.17	100.83
Polyethylene	109.17	95.83	99.17

TABLE LVI

MEANS FOR MAIN EFFECTS OF SAND AND POLYETHYLENE UPON BODY WEIGHT CHANGE IN GRAMS IN PERIOD 5

	Level		
Factor	1	2	3
Sand	18.33	31.67	35.00
Polyethylene	51.67	14.17	19.17

TABLE LVII

MEANS FOR MAIN EFFECTS OF SAND AND POLYETHYLENE UPON BODY WEIGHT CHANGE IN GRAMS IN PERIOD 7

	Level		
Factor	1	2	3
Sand	-25.00	-41.67	5.83
Polyethylene	-21.67	-9.17	-30.00

TABLE LVIII

MEANS FOR MAIN EFFECTS OF SAND AND POLYETHYLENE UPON BODY WEIGHT CHANGE IN GRAMS IN PERIOD 9

	Level		
Factor	1	2	3
Sand	40.00	81.67	87.50
Polyethylene	75.83	64.17	69.17

TABLE LIX

ANALYSIS OF VARIANCE FOR EGG PRODUCTION IN PERIOD 3

Source of variation	df	SS	MS	F
Total	35	48.55555		
Treatments	(8)			
Sand (S)	(2)			
S_{linear}	1	0.66667	0.66667	
$S_{quadratic}$	1	1.38889	1.38889	1.09
Polyethylene (P)	(2)			
P_{linear}	1	0.16667	0.16667	
$P_{quadratic}$	1	6.72222	6.72222	5.26*
Interactions	(4)			
S x P	4	5.11111	1.27778	
Error	27	34.49999	1.27777	

*Significant at the five percent level of probability

TABLE LX

ANALYSIS OF VARIANCE FOR EGG PRODUCTION IN PERIOD 5

Source of variation	df	SS	MS	F
Total	35	199.55553		
Treatments	(8)			
Sand (S)	(2)			
S_{linear}	1	1.50000	1.50000	
$S_{quadratic}$	1	0.05556	0.05556	
Polyethylene (P)	(2)			
P_{linear}	1	6.00000	6.00000	1.06
$P_{quadratic}$	1	20.05555	20.05555	3.42
Interactions	(4)			
S x P	4	13.44444	3.36111	
Error	27	158.49998	5.87036	

TABLE LXI

ANALYSIS OF VARIANCE FOR EGG PRODUCTION IN PERIOD 7

Source of variation	df	SS	MS	F
Total	35	330.74997		
Treatments	(8)			
Sand (S)	(2)			
S_{linear}	1	1.04167	1.04167	
$S_{quadratic}$	1	0.12500	0.12500	
Polyethylene (P)	(2)			
P_{linear}	1	22.04167	22.04167	2.08
$P_{quadratic}$	1	0.12500	0.12500	
Interactions	(4)			
S x P	4	20.66667	5.16667	
Error	27	286.74996	10.62036	

TABLE LXII

ANALYSIS OF VARIANCE FOR EGG PRODUCTION
IN PERIOD 9

Source of variation	df	SS	MS	F
Total	35	1177.63865		
Treatments	(8)			
Sand (S)	(2)			
S_{linear}	1	0.04167	0.04167	
$S_{quadratic}$	1	8.68055	8.68055	
Polyethylene (P)	(2)			
P_{linear}	1	8.16667	8.16667	
$P_{quadratic}$	1	133.38886	133.38886	3.60
Interactions	(4)			
S x P	4	28.11111	7.02778	
Error	27	999.24979	37.00925	

TABLE LXIII

MEANS FOR MAIN EFFECTS OF SAND AND POLYETHYLENE UPON NUMBER OF EGGS PER PULLET IN PERIOD 3

	Level		
Factor	1	2	3
Sand	0.08	0.67	0.42
Polyethylene	0.00	1.00	0.17

TABLE LXIV

MEANS FOR MAIN EFFECTS OF SAND AND POLYETHYLENE UPON NUMBER OF EGGS PER PULLET IN PERIOD 5

	Level		
Factor	1	2	3
Sand	3.33	3.17	2.83
Polyethylene	2.08	4.17	3.08

TABLE LXV

MEANS FOR MAIN EFFECTS OF SAND AND POLYETHYLENE UPON NUMBER OF EGGS PER PULLET IN PERIOD 7

	Level		
Factor	1	2	3
Sand	11.25	11.17	10.83
Polyethylene	12.08	11.00	10.17

TABLE LXVI

MEANS FOR MAIN EFFECTS OF SAND AND POLYETHYLENE UPON NUMBER OF EGGS PER PULLET IN PERIOD 9

	Level		
Factor	1	2	3
Sand	21.92	23.00	22.00
Polyethylene	24.25	19.58	23.08

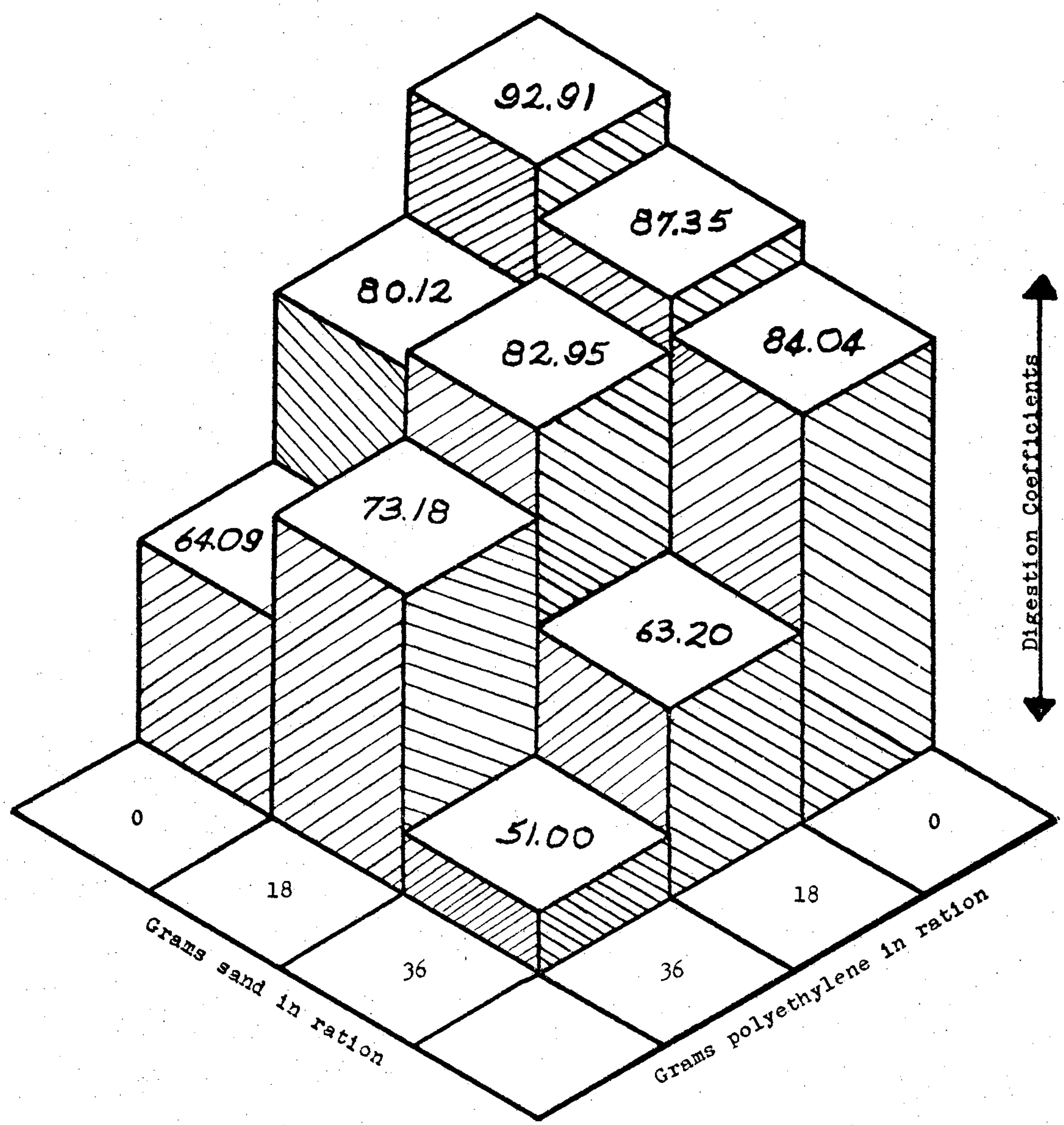

Figure 1. Digestion Coefficients for Fat in Period 3

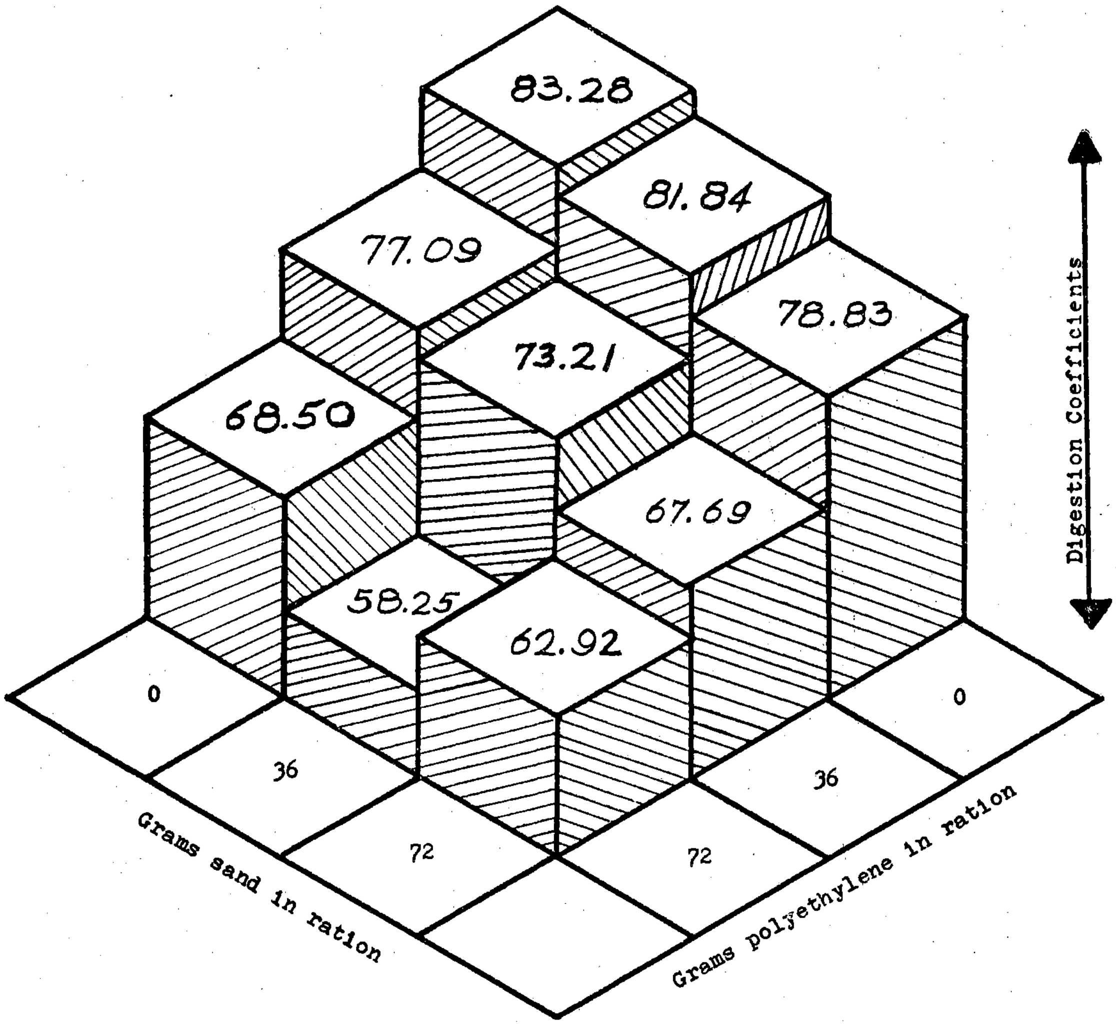

Figure 2. Digestion Coefficients for Fat in Period 5

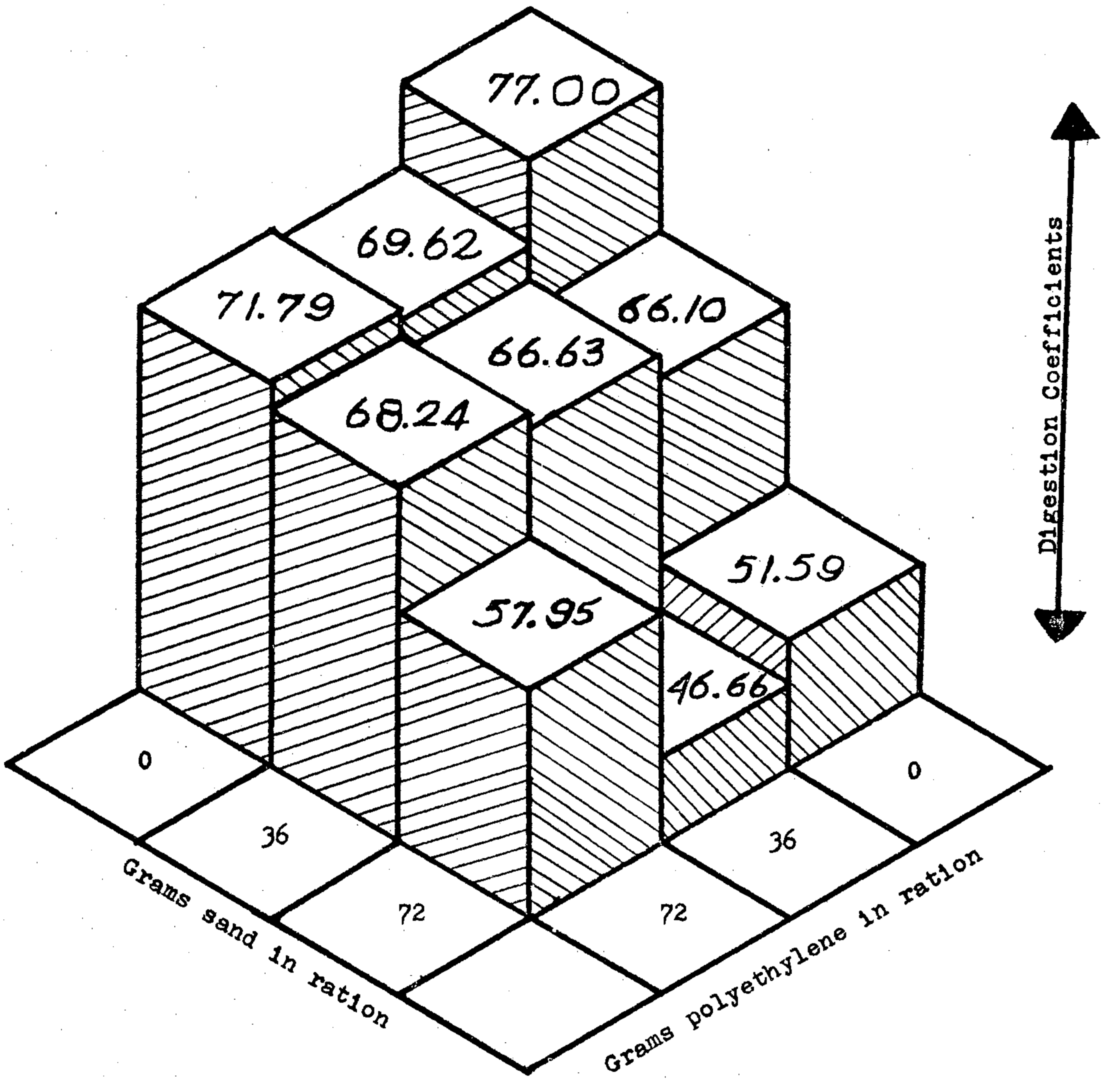

Figure 3. Digestion Coefficients for Fat in Period 7

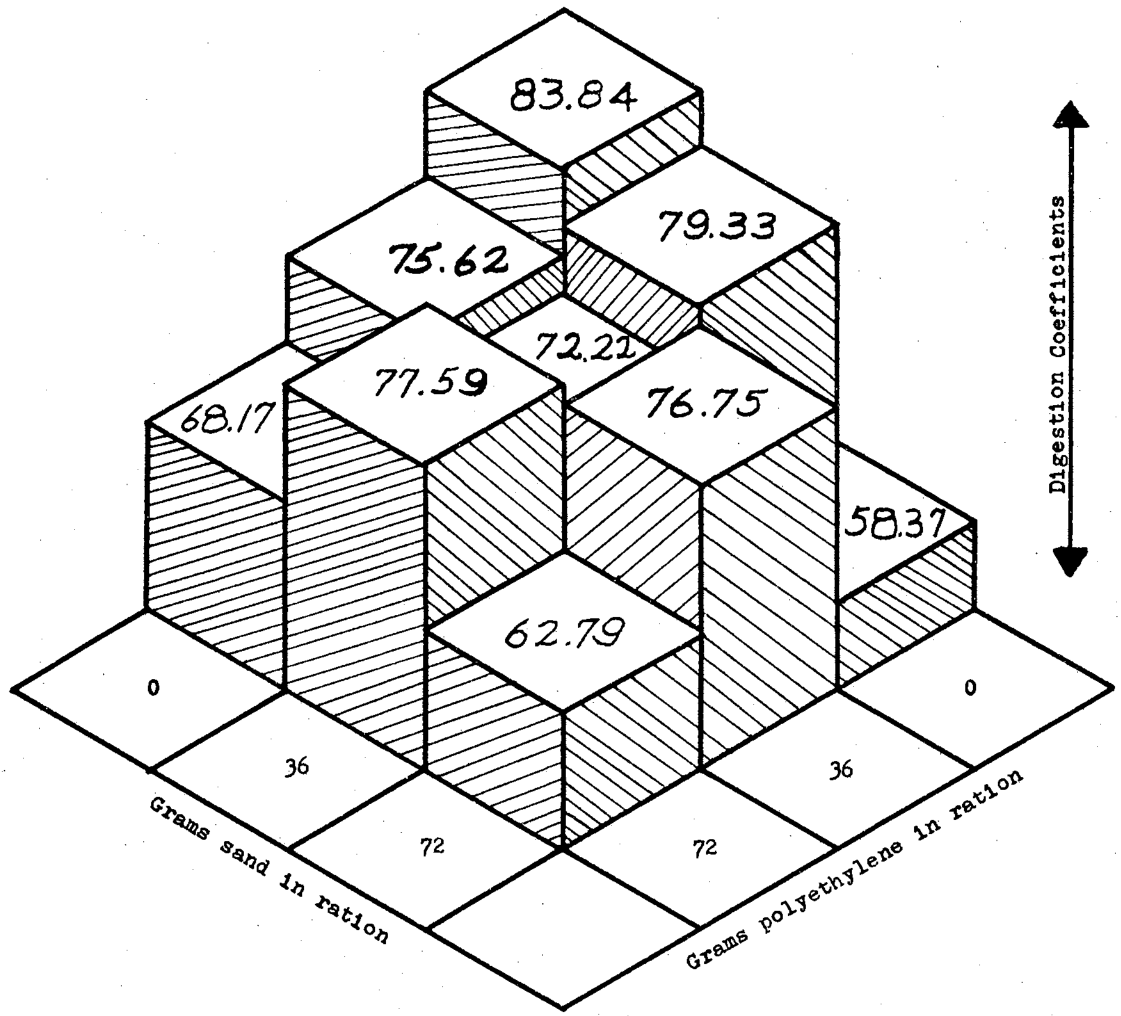

Figure 4. Digestion Coefficients for Fat in Period 9

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