EFFECTS OF ADDED DIETARY FAT AND PROTEIN ON THE GROWTH AND CARCASS CHARACTERISTICS OF TURKEYS

by

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Introduction

For several years, the turkey has been marketed primarily as a fresh or frozen whole-bird product. In recent years, the turkey industry has moved extensively into the further processing and the marketing of cut-up and specialty turkey products. While fat deposition, in part, is beneficial for attaining a high quality whole turkey, the same amount of fat deposition may be a detrimental factor in the further processing of turkeys. Excessive fat deposited under the breast skin or in the cavity results in increased labor costs, as extra labor is required to remove the fat. Additionally, excess fat has a low return value to the processor and is unappealing to the consumer. Therefore, it is economically important that turkeys destined for further processing be raised and marketed with minimal excess fat deposition.

The effects of added dietary fat and protein level on carcass quality and fat deposition is of great economic importance and remains to be determined more accurately. Fat is commonly added to diets of older turkeys to increase body weight gain and feed efficiency (gain:feed). Increasing the protein content of poultry diets has been shown to decrease fat deposition within the carcass as determined by carcass composition. However, data are lacking on how added dietary fat and protein levels quantitatively affect the carcass quality and fat deposition of the further processed turkey. The research presented in Part I of this dissertation was designed to determine the quantitative effects of added dietary fat from three sources and of varying protein on the performance of growing turkeys. The more specific objectives were:

1. to estimate the values of three sources of feed-grade fat varying in chemical composition as measured by their effect on body weight gain, feed consumption and feed efficiency of growing male turkeys from 8 to 22 weeks of age,
2. to quantitate the effects of added dietary fat and protein on the body weight gain, feed consumption and feed efficiency of growing male turkeys from 8 to 22 weeks of age, and
3. to quantitate the effects of added dietary fat and protein on the carcass quality of further processed turkeys as measured by fat deposition, carcass yield and breast meat yield.

The Nicholas Large White turkey is the strain of turkey commonly raised in North America. Other strains of large-type turkeys have also been introduced into the United States such as the British United Turkey from Europe and the Hybrid turkey from Canada. These three strains supply most of the turkeys raised today.

Jaindl Turkeys in Orefield, Pennsylvania has developed a unique strain of large-type turkey which has been genetically selected for an increased breast meat yield. A similar selection program has been used to produce a medium-type strain of turkey. Jaindl turkeys are raised on corn-soybean meal diets with no added fat to market ages between 24 to 28 weeks of age. To this date, no research has been conducted to compare the growth performance and carcass quality of Jaindl turkeys with other strains. Recently, interest in comparing the Nicholas strain with the Jaindl strain of large-type turkey and the feasibility of marketing the Jaindl medium-type turkey as a turkey broiler has been generated. The research presented in Part IIA and IIB of this dissertation was designed to determine the quantitative effects of added dietary fat and protein on the growth performance, yield of carcass parts and fat deposition of the Nicholas Large, Jaindl Large and Jaindl Medium turkey to various ages. The more specific objectives were:

1. to compare the growth performance of the Nicholas strain with that of the Jaindl Large White and Medium White to three and four market ages for the male and female, respectively,
2. to quantitate the effects of added dietary fat and protein on the body weight gain, feed consumption and feed efficiency for each sex within each strain to the various market ages,
3. to compare the effects of age, sex, strain, added fat and protein on the carcass quality of the turkey as measured by the yield of carcass parts, the fat deposition within the abdomen and under the skin and the composition of breast meat, and
4. to evaluate the criteria used to determine the optimum market age for each strain.

Review of Literature

Lipid metabolism in poultry

Growth of any species requires that lipid deposition occur either in membranes of cells or in adipose depots. Leveille *et al.* (1975) demonstrated the liver to be the major site of lipid biosynthesis in the chick. Unlike in mammals, adipose tissue was found to be relatively unimportant as a site of fatty acid synthesis, however, adipose tissue did have the capacity to esterify free fatty acids to glycerol. In their study, chick liver slices were over four times more active than rat liver slices in synthesizing fatty acids and cholesterol. The liver has also been shown to be the primary site of lipid biosynthesis in the turkey (Borron and Britton, 1977).

Fatty acids synthesized in the liver are transported as triglycerides in very low density lipoproteins (VLDL) to adipose tissue for storage (Leclercq *et al.*, 1974). Once the VLDL released by the liver reach the target tissue, lipoprotein lipase hydrolyzes the VLDL for free fatty acid uptake by the cell (Borron *et al.*, 1979).

Hepatic lipogenesis is under the control of several hormones. Capuzzi *et al.* (1971) demonstrated that insulin stimulated lipogenesis in chicken hepatocytes. The lipogenic effect of insulin on chick liver has been demonstrated by other workers (Vives *et al.*, 1981; Touchburn *et al.*, 1981). Harvey *et al.* (1977) showed that the effect of insulin on lipogenesis was decreased *in vitro* by avian and mammalian growth hormone. In addition to growth hormone, glucagon has been shown to have an antilipogenic effect in avians as in mammals (Capuzzi *et al.*, 1975).

Dietary factors can also influence hepatic lipogenesis. Increasing the level of dietary fat or protein at the expense of carbohydrate has been shown to significantly impair hepatic lipogenesis in the chick (Leveille *et al.*, 1975). Replacement of dietary carbohydrate with protein as opposed to fat resulted in a more rapid depression of lipogenesis, suggesting that dietary protein and fat have specific independent effects on lipogenesis.

The accretion of fat from *de novo* synthesis is an exothermic process. Approximately 10% of the metabolizable energy (ME) of glucose is lost as heat during fatty acid synthesis (Moran, 1985). Supplying fatty acids by the addition of fat to the diet avoids *de novo* synthesis of fatty acids and the associated heat loss. Like mammals, poultry digest dietary triglycerides to 2-monoglycerides and free fatty acids for absorption. Renner and Hill (1958) reported evidence to support this process, known as the partition theory of fat absorption, as mixtures of free fatty acids fed to chicks had lower metabolizable energy values than those of the neutral fats from which they were derived. Upon hydrolysis and absorption *via* micelle formation, the enterocytes reform the 2-monoglycerides and fatty acids into VLDL (Moran, 1985). The absorption and formation of VLDL may be aided by fatty acid binding protein, whose presence was verified in the mucosa of the mesenteric intestine of the chicken by Katongole and March (1979).

Unlike the chylomicron formed by mammals, the VLDL formed by the avian are absorbed directly into the portal vein and, therefore, must pass through the liver before reaching the vena cava for transport to peripheral tissues. Passage through the liver allows for hepatocyte modification of incompatible fatty acids. The avian liver is able to readily convert stearic to oleic acid and to elongate free medium and short chain fatty acids to C-16 and C-18 fatty acids before incorporation into VLDL (Moran, 1985). Like the *de novo* synthesis of fatty acids, modification of dietary fatty acids also results in heat loss, thus the composition of dietary fat affects its utilization by the avian.

Factors affecting the value of fats

Presumably, a dietary fat which provides fatty acids similar to those in the fat of the fowl requires minimal modification by the liver resulting in a higher net energy value for that fat. Fuller and Rendon (1979) reported evidence to support this assumption. Broiler chicks fed a diet containing 11.6% poultry fat had the lowest heat production per kilogram gain as compared with those fed diets containing corn oil, coconut oil or tallow. The chicks that were fed coconut oil had the greatest heat production while those fed tallow or corn oil were intermediate in the amount of heat lost.

Fats from various sources have different ME values. Renner and Hill (1958) included different fats at the 20% level in diets fed to growing chicks 4 to 8 weeks of age. Metabolizable energy values of 9.3, 8.8, 8.7 and 7.2 kcal per g were determined for soybean oil, lard, corn oil and tallow, respectively. The respective absorbabilities [(ether extract in feed - ether extract in excreta)/ether extract in feed x 100] of the fat sources were 98.8, 93.4, 92.9 and 76.2%, demonstrating that the determined ME value of fat was directly related to its absorbability. Other researchers have confirmed the difference in the absorbability and ME of tallow when compared with vegetable oils (Young, 1961; Young and Artman, 1961; Sibbald *et al.*, 1962; Whitehead and Fisher, 1975).

The fatty acid composition of a fat has also been shown to influence its absorption. Sunde (1956) and Renner and Hill (1958) showed that the chick was unable to absorb the saturated fatty acids stearate and palmitate when they were fed singly. Renner and Hill (1961) demonstrated that the absorbability of palmitic and stearic acids increased to 84 and 78%, respectively, when present in a mixture with 76% unsaturated fatty acids. Maximum utilization of these fatty acids occurred when they were fed in the form of triglycerides. Young (1961) confirmed these results, as palmitic and stearic acid absorbability increased when fed in mixtures containing high amounts of unsaturated fatty acids. However, the amount of saturated and unsaturated fatty acids in a fat source cannot be used as a guideline to predict fully its value. For example, lard which contains 35% saturated fatty acids is as well utilized as corn oil which contains 11% saturated fatty acids. The position of the fatty acids on the glycerol moiety has been shown to effect the digestibility of a fat. Renner and Hill (1961) and Mattson and Streck (1974) demonstrated that the absorption of a saturated fatty acid was increased if it is located in position 2 of the triglyceride molecule for the chick and rat, respectively.

In general, blends of animal fats and vegetable oils are absorbed and metabolized more efficiently compared with an animal fat being fed individually. Sibbald *et al.* (1962) reported mixtures of tallow and soapstocks and tallow and dried soybean meal gums to be more available as energy sources than when tallow was fed singly. Cerniglia *et al.* (1980) found that the determined ME values for 80:20, 60:40, 40:60, and 20:80 blends of soybean oil:tallow exceeded calculated ME values. In each of the above-mentioned studies, the ME values of the fat mixtures were not an additive function of the ME values of the individual fats.

In addition to supplying energy to the diet, fats are also a source of the essential fatty acid linoleic acid. Ross and Adamson (1961) and Machlin and Gordon (1961) demonstrated a growth response when fat or fat products were added to semi-purified diets for broiler chicks. The growth response was not totally attributable to the energy value of the fat *per se*, but due to the fatty acid linoleic acid, confirming the essentiallity of linoleic acid for the chicken. Ketola *et al.* (1973) reported the minimum requirement of linoleic acid for the young turkey to be 1% of the diet or 3.2% of the calories. Halloran and Sibbald (1979) presented data that showed that the apparent and true metabolizable energy values of certain fats and their linoleic content were proportional. However, they cautioned that this relationship applied only to certain types of fats and that extrapolation to fats made up of other structures or compositions may result in inaccurate comparisons. Other factors such as moisture, impurity and unsaponifiable contents can affect the energy value of a fat (Scott *et al.*, 1982)

In summary, fats from various sources are utilized differently by poultry, with fats from animal sources being utilized less efficiently than fat from vegetable sources. The ratio of saturated to unsaturated fatty acids and of free fatty acids to total fatty acids, the position of the fatty acids on the glycerol moiety, and the linoleic acid, moisture, impurity and unsaponifiable contents affect the value of a fat.

Effects of fat on growth

Biely and March (1954) reported an increased rate of growth and an increase in feed efficiency when 8% tallow was added to the diets of turkeys from 0 to 10 weeks of age. Several others have shown that supplemental fat improves the weight gain of turkeys through-out the starting and growing periods (Touchburn and Naber, 1966; Jensen *et al.*, 1970; Owen *et al.*, 1981; Sell and Owings, 1981; Potter and McCarthy, 1985)

Addition of fat to the diet widens the calorie:protein (C:P) ratio if the protein level of the diet is held constant. Experiments conducted with turkeys indicate that the turkey can tolerate wide C:P ratios. Donaldson *et al.* (1958) found that poults were able to tolerate diets with 10.5 and 18% added fat better than diets with 3% added fat as measured by growth rate. Touchburn and Naber (1966) demonstrated that the performance of growing turkeys was not adversely affected by wide C:P ratios. Jensen *et al.* (1970) fed diets containing 8 and 12% added fat and observed no significant protein x ME interactions on the performance of turkeys. Sell and Owings (1981), Owings and Sell (1982) and Sell *et al.* (1985) have reported the performance of male or female turkeys to be improved when fat was added to the diet, regardless of whether nutrient density of the diet was increased commensurate with the changes in ME levels. Sell *et al.* (1985) have suggested that the use of optimum C:P ratios may place unnecessary and costly restraints on formulation of turkey diets in linear programming and that the benefits of altering dietary energy or protein should be evaluated independently. Potter and McCarthy (1985) demonstrated the protein requirement of turkeys from 8 to 20 weeks of age to be unaffected when fat was added up to 10% of the diet.

Added dietary fat has the greatest effect on feed utilization by turkeys. Several experiments have been conducted which have consistently shown increased feed utilization due to added dietary fat. Touchburn and Naber (1966) found that the addition of 10.4% fat to the diet from 8 to 12 weeks of age increased the feed efficiency (gain:feed) of turkeys 10.1%, and that the magnitude of this improvement increased with age. Jensen *et al.* (1970) reported that for each 1% added fat, 8 to 24-week feed efficiency increased 1.7%. Jensen and Falen (1973) later reported a 1.4% increase in feed efficiency for each 1% fat added to pelleted diets for turkeys from 8 to 24 weeks of age. Potter *et al.* (1974) demonstrated that the feed efficiency of turkeys was improved .25 to 1.64% per 1% added fat between 8 and 10 weeks of age and 2.74 to 3.05% between 10 and 20 weeks of age. Potter and McCarthy (1985) reported that feed efficiency increased 1.7 to 2.8% per 1% added fat in the diets for Large White turkeys between 8 and 20 weeks of age.

Research has shown the feed efficiency of turkeys older than eight weeks of age increased approximately 2% per 1% fat added to the diets. The magnitude of the response reported is dependent primarily on the magnitude of the increase in dietary ME per increment of added fat and the definition and method involved in calculating feed utilization. For example, Sell and Owings (1981) reported an increase in feed utilization of .8 to 1.9% for each 1% fat added to the diets of growing turkeys while Potter and McCarthy (1985) observed a 1.7 to 2.8% increase in feed utilization for each 1% added fat. The percent increase in feed utilization per 1% added fat was calculated by regressing feed utilization on the level of added fat, and dividing the slope of the determined line by the intercept value. Sell and Owings (1981) used feed conversion values (feed:gain) while Potter and McCarthy (1985) used feed efficiency values (gain:feed) in their respective calculations. Feed conversion values are decreased when fat is added to the diet while feed efficiency values are increased, therefore, the intercept of a regression line determined from feed conversions is a maximum value while that of a regression line determined from feed efficiencies is a minimum value. Thus, division of the slope by the intercept calculated from feed conversions results in a smaller value. When recalculated using feed efficiencies, the response per 1% added fat in Sell and Owings (1981) study ranged from 1.0 to 2.3%, similar to those values observed by Potter and McCarthy (1985).

Effect of age

Researchers studying the effect of fat on feed utilization by turkeys have reported two consistent findings: 1) the value of added fat increases with age of the turkey, with the most benefit occurring after eight weeks of age, and 2) the increase in feed utilization is usually greater than can be attributed to the contribution of ME by fat to the diet.

The influence of age on fat absorption by poultry has been well documented. Renner and Hill (1958) demonstrated tallow to be more efficiently absorbed by chicks eight weeks of age as compared with chicks two weeks of age. Whitehead and Fisher (1975) reported that the absorption of tallow by Large White turkeys increased from 54 to 74% between two and eight weeks of age. Sell *et al.* (1986), using an animal-vegetable fat blend, reported fat retentions for turkeys of 74.6, 83.9, 89.8, and 93.5% at 2, 4, 6 and 8 weeks of age, respectively. Their data suggested that the increase in fat retention and absorption may be due, in part, to an increase in the absorption of stearate and palmitate. Additionally, the activity of fatty acid binding protein was found to increase 4-fold from two to six weeks weeks of age and may aid in explaining the increase in fat utilization with age by the young turkey. Increased fat utilization with age is also reflected in the feed efficiencies of older turkeys. Potter (1976) reported that supplemental fat improved the feed efficiency of male and female turkeys 1.25% per 1% added fat prior to 8 weeks of age; yet when fed from 8 weeks onward, feed efficiency was increased 1.52 to 2.96% per 1% added fat. Sell and Owings (1984) found the feed conversion of male turkeys improved 1.6% per 1% added fat from 0 to 6 weeks of age and 3.6% per 1% added fat from 12 to 20 weeks of age.

Moran (1985) has attributed the increase in dietary fat utilization seen in the older turkey to fat depot development as the bird reaches sexual maturity. Under steroid influcence, free fatty acids are directly deposited into the depots. Touchburn and Naber (1966) attributed the "extra-caloric" effect of fat in older turkeys observed in their study to dietary triglycerides being directly assimilated into depot fat of the turkey, bypassing the energy loss required to synthesize fatty acids from carbohydrate.

Extra-caloric effect

Touchburn and Naber (1966) coined the term extra-caloric effect to describe the improvement in performance of turkeys observed when fat was added to the diet. They noted that the magnitude of the improvement in feed efficiency exceeded that which was expected based on the contribution of ME by fat to the diet. Jensen *et al.* (1970) noted an extra-caloric effect when fat was added to the diets of turkeys from 8 to 24 weeks of age. Potter *et al.* (1974) reported greater-than-expected feed efficiencies when fat was added to the diets of turkeys from 8 weeks of age onward. In addition to the turkey, the extra-caloric effect has been reported in the laying hen (Horani and Sell, 1977; Mateos and Sell, 1981a,b) and broiler (Brue and Latshaw, 1985).

Researchers have offered a variety of reasons to explain the extra-caloric effect of fat. Jensen *et al.* (1970) stated that the fat used in their study had approximately 32% more calories than its assumed ME value based upon calculations using the ME values of the experimental diets and their associated feed conversions. The difference in calories was attributed to the lowering of the heat increment, as dietary fat addition avoided the need for fatty acid synthesis from carbohydrate . However, the addition of 32% more calories to the assumed ME value of the fat resulted in a ME value that was 9% greater than its gross energy. Obviously, a feedstuff cannot have a ME value greater than its gross energy.

Touchburn and Naber (1966) suggested that the ME value of the fat used in formulating their experimental diets was determined with young birds and that the ME value for the same fat may increase if determined with older birds. Mateos and Sell (1981a) found the extra-metabolic effect observed with laying hens to vary with the procedure used to determine the ME values. The method of Hill and Anderson (1958) is the standard procedure used to determine the ME value for a fat. The test fat is substituted for glucose up to the 20% level of the diet and the ME of the diets determined. The ME value of the fat is then determined by extrapolation to the 100% level of substitution. This extrapolation results in a large standard deviation (approximately a five-fold increase) about the ME value of the fat *versus* that about the diets (Potter, 1986). De Groote (1974) suggested that the energy value of fats is underestimated using ME values based on the different utilization of calories from fat than that from carbohydrate and that net energy should be used in energy evaluations. Halloran and Sibbald (1979) found the true metabolizable energy value of 11 fat sources to be higher than their respective apparent metabolizable energy value corrected for nitrogen. Thus, the discrepancy observed between the previously reported or determined ME value of a fat and the greater-than-expected increase in feed utilization observed by researchers may be, in part, due to the underestimation of the previously determined ME values of fats and the variation associated with their determinations.

Mateos and Sell (1981a, 1982) hypothesized that the extra-metabolic effect of fat seen for laying hens was due to a decrease in food passage rate through the gut. The authors suggested that the increase in transit time may increase the digestibility of other nutrients, however no data were presented to support this assumption.

Owen *et al.* (1981) did not observe an extra-caloric effect from fat added to the diets of male turkeys as the calories needed per gram of gain were similar over all levels of added fat. They suggested that the increase in feed utilization from added fat others had observed may be due to the way dietary substitutions were made. Jensen *et al.* (1970) and Potter *et al.* (1974) replaced corn with dehulled soybean meal and fat in order to hold protein levels constant. The replacement of corn with dehulled soybean meal protein may have provided a better balance of amino acids resulting in increased growth. However, Touchburn and Naber (1966) have shown that when corn gluten meal was used instead of dehulled soybean meal to hold protein constant, added dietary fat still resulted in greater than expected feed utilization by turkeys.

Potter *et al.* (1974) and Potter and McCarthy (1985) concluded that the greater-than-expected feed efficiencies observed in their studies were due to over-consumptions of feed. In both studies, the turkeys failed to adjust (sufficiently lower) feed intake to equalize ME intake when fat was added to the diet, and thus the extra feed consumed was used to increase body weight gain. The added fat "acted like" it contained more ME than expected rather than containing more ME *per se* as suggested by Jensen *et al.* (1970). Brue and Latshaw (1985) have reported similar results for broilers. Broilers fed diets containing added fat failed to adjust ME intake to that of those fed diets containing no added fat. The increased ME intake resulted in a greater body weight gain and lower feed conversion.

Effects of varying fat and protein on carcass composition

Increasing nutrient density or widening of the C:P ratio of diets for broilers results in decreased growth and increased fat deposition. Bartov *et al.* (1974) reported increased abdominal fat deposition in broilers when the protein level was decreased in the finisher diet. Increasing the nutrient density of the diets in broilers has been shown to increase abdominal fat (Waldroup *et al.*, 1976). Deaton *et al.* (1981) fed isocaloric and isonitrogenous diets containing three levels of animal fat, and found that fat addition to the diet significantly increased abdominal fat deposition. Summers and Leeson (1979) reported that the abdominal fat pad of broilers significantly increased as the C:P ratio was widened *via* lowering the protein content of the diet.

Few studies have been conducted to determine the effects of varying fat and protein in the diet on carcass composition and components of turkeys. Salmon and O'Neil (1971) found that 2% added dietary fat levels increased the yield of skin and fat deposited in muscle tissues while decreasing the yield of breast meat, thigh meat and drumsticks. Essary *et al.* (1971) reported that abdominal fat and the ratio of skin to meat of male and female turkeys increased with age and with the addition of 8% fat to the diet.

Leeson and Summers (1980) have reported the carcass composition and yields of commercial cuts for Large White turkeys biweekly from hatch to 24 weeks of age, creating the first such data base for turkeys. Moran (1984) suggested that the National Research Council (NRC) (1984) ME requirements for turkeys were too high and promote fat deposition due to excess energy intake. Feeding a diet based on the NRC (1984) ME requirements and a low energy diet to British United Turkey males resulted in equal meat yields when the birds were processed at 20 weeks of age. Feeding the diet based upon the NRC (1984) ME requirements resulted in higher skin yields, which may be indicative of increased fat deposition within the carcass. Sell *et al.* (1985) and Summers *et al.* (1985) reported that dietary fat or protein did not affect carcass yields of Nicholas Large White turkeys, yet addition of fat to the diet did increase fat deposition. To this author's knowledge, only a few studies have been designed for turkeys to examine the effects of added dietary fat and protein on the yield of carcass parts and fat deposition.

PART I. Effects of Fat Source, Fat Level and Protein Level on Growth and Carcass Quality of Turkeys

The research presented in Part I of this dissertation was designed to determine the quantitative effects of added dietary fat from three sources and protein on the performance of growing turkeys. The more specific objectives were:

1. to estimate the values of three sources of feed-grade fat varying in chemical composition as measured by their effect on body weight gain, feed consumption and feed efficiency of growing male turkeys from 8 to 22 weeks of age,
2. to quantitate the effects of added dietary fat and protein on the body weight gain, feed consumption and feed efficiency of growing male turkeys from 8 to 22 weeks of age, and
3. to quantitate the effects of added dietary fat and protein on the carcass quality of further processed turkeys as measured by fat deposition, carcass yield and breast meat yield.

Materials and Methods

Birds

On December 27, 1984, 917 Nicholas Large White male turkeys which were 52 days of age (designated as 8 weeks) were randomized into 36 pens such that each pen contained 25 or 26 birds, a density of 2.49 or 2.59 birds per m^2, respectively. Each pen was 2.74 x 3.66 m and was equipped with a 1.22-m trough feeder and .76-m automatic waterer with wood shavings for litter. Management procedures included daily washing of waterers, stirring of the litter twice a week in each pen and the recording of ambient temperature in the morning and evening.

Diets

Table 1 contains the design for Experiment 1. The dietary variables included four levels of added fat (0, 5, 10 or 15%) from three sources (Fat 1, Fat 2 or Fat 3) and three levels of crude protein (18, 21 or 24%). Fat 1, Fat 2 and Fat 3 were supplied by Stern, Valley Proteins and Gro-Pro, respectively. Diets were prepared in all combinations forming a 4 x 3 x 3 factorial, a total of 36 diets.

The composition of the 18% protein basal diet used for the first four weeks of the experiment is presented in Table 2. Five basal mixtures of identical formulation, each totaling 1,117 kg and representing all constant ingredients or 66.6% of each diet, were prepared. Six and eleven basal mixtures, each totaling 1,148 kg, were prepared in the same manner for the 12 to 16 and 16 to 22-week periods, respectively. Individual diets for each four-week period were prepared by blending the appropriate amounts of ground yellow corn, dehulled soybean meal, fat from one of the three sources and equal quantities of each basal mixture. Each diet was assigned randomly to a pen, and provided *ad libitum* in mash form to the turkeys from 8 to 22 weeks of age.

At 12 and 16 weeks of age, the dietary protein levels were decreased 2% by adding 5.44% ground yellow corn in place of 5.04% dehulled soybean meal, .30% mono- and dicalcium phosphate and .10% ground limestone. To increase the protein content within a period by 3%, 7.56% dehulled soybean meal was added in the place of an equal amount of ground yellow corn.

Thus, from 8 to 12, 12 to 16 and 16 to 22 weeks of age, the low protein diets contained 18, 16 and 14% protein, the standard protein diets 21, 19 and 17% protein and the high protein diets 24, 22 and 20% protein, respectively. When an increment of 5% fat was added to the diet, 1.1% dehulled soybean meal was also added in the place of 6.1% ground yellow corn in order to hold protein constant (Table 3).

Data Collection

All turkeys were group weighed at eight weeks of age and individually weighed to the nearest .05 kg at 10, 12, 14, 16, 18, 20 and 22 weeks of age. Mortality was recorded daily, and feed consumption and feed efficiency were determined biweekly on a pen basis. Body weight gains, feed consumptions and feed efficiencies were determined on both a cumulative and period basis for each pen of turkeys.

Processing data

To obtain processing data, turkeys were pooled according to one of 12 treatment groups each consisting of 0, 5, 10 or 15% added fat and low, standard or high protein diets. Each of the 12 treatment groups contained from 63 to 71 turkeys. The day after the final weighing, the turkeys were loaded and transported approximately 140 miles to Marval Foods in Dayton, Virginia for processing the same day.

At 1600 hr the treatment groups were placed on the shackles at intervals of approximately 2 min. A count of the number of turkeys in each group was taken at the stunner and at the transfer point to the evisceration line to assure accuracy. As the turkeys proceeded through the evisceration line, the gizzards with associated fat in each group were removed, counted, weighed then set aside for removal of the gizzard fat. The leaf (abdominal) fat was then removed from the carcass and weighed for each treatment group. The necks and neck skins from each treatment group were removed, counted and weighed. Before any condemned parts were removed, carcasses of each treatment were group weighed. Condemned parts were then removed and weighed, and the carcasses by groups were chilled overnight in ice water. After all birds had been processed, the fat from around the gizzards was removed, and this fat and the gizzards (with contents) weighed according to treatment group.

At 0800 hr the following day, the turkeys of each treatment group were placed on the further processing line. The breast with skin of each turkey was removed and individually weighed. The skin was then removed from each breast and weighed by treatment group. Average breast meat weight was obtained by subtracting the skin weight from the average weight of the individual breast with skin for each treatment group.

Statistical Analysis

All body weight, body weight gain, feed consumption and feed efficiency (gain:feed) data for each period were subjected to analysis of variance. The independent variables in the model were fat source, level of added fat and level of protein. The three-way interaction of fat source x fat level x protein level was used for a measure of error mean square, and differences between treatment means were determined by the Least Significant Difference method. Regression lines were determined for the effect of fat and protein level on the growth parameters measured using the following regression model:

$$Y = b_0 + b_1 X_1 + b_2 X_2$$

where b_0 is the intercept associated with the low protein diets, b_1 is the slope of added fat common to all protein levels, X_1 the percentage of added dietary fat, b_2 is the increase in Y per 1% increase in protein, and X_2 being coded 1 for the standard and high protein diets and 0 for the low protein diets. The Y variable equals body weight gain, feed consumption or feed efficiency. The model used for determining the regression lines for fat sources was as follows:

$$Y = b_0 + b_1 X_1 + b_2 X_2 + b_3 X_3$$

where b_0 is the average Y value resulting from feeding no added fat, b_1 through b_3 are the slopes and X_1 through X_3 are the percentages of added fat from Fat 1, Fat 2 and Fat 3, respectively.

All processing data were subjected to analyses of variance. The independent variables in the model were level of added fat and protein level. Differences between treatment means were determined by the Least Significant Difference method.

Results

The average body weight gains, feed consumptions and feed efficiencies of male turkeys 8 to 22 weeks of age by fat level, fat source and protein level are presented in Table 4. Plots of 8 to 22-week body weight gains, feed consumptions and feed efficiencies on level of added fat by protein levels are presented in Figure 1, 2 and 3, respectively. Similar plots by source of fat are presented in Figures 4, 5 and 6, respectively. Analyses of variance of data are presented in Table 5. No significant two-way interaction occurred between fat level, fat source and protein level, therefore, only the main effects will be presented and discussed.

Effect of level of added fat

From feeding diets containing 0, 5, 10 and 15% added fat, body weight gains of male turkeys 8 to 22 weeks of age were 10.91, 11.27, 11.73 and 11.57 kg, respectively (Table 4). Thus, 5, 10 and 15% added fat significantly increased body weight gain 3.3, 7.5 and 6.0%, respectively. Because of a lack of a continued increase in body weight gain from diets with 15% over 10% added fat, a significant quadratic effect due to added fat was observed (Table 5; Figure 1). Based upon the 0, 5 and 10% levels of added fat, the calculated increase in body weight gain was .082 kg or .83% and .72% per 1% added fat to the low and both the standard and high protein diets, respectively (Figure 1).

Feed consumptions of the turkeys fed diets containing 0, 5, 10 and 15% added fat during the 14-week experiment were 36.99, 34.96, 32.66 and 29.83 kg, respectively (Table 4). Feed consumption was linearly decreased .476 kg or 1.3% for each 1% fat added to the diet (Figure 2). The feed consumptions and percent decreases in feed consumption for each age period and level of added fat are presented in Table 6. Cumulative feed consumptions were decreased 5.5, 11.7 and 19.4% from the addition of 5, 10 and 15% added fat, respectively.

Addition of 0, 5, 10 or 15% fat to the diet resulted in feed efficiencies of .2946, .3222, .3591 and .3877, respectively. These values represent a linear increase of .0063 units per 1% added fat to the diet (Figure 3). When this increase is expressed as a percentage of the respective intercepts, feed efficiency was increased 2.3 and 2.1% per 1% added fat to the low and both the standard and high protein diets, respectively.

The increases in body weight gain and improvement in feed utilization from added fat occurred at all age periods (Table 7). The effects of added fat on the intake of feed, metabolizable energy and protein required per kg gain are also presented in Table 7. Both the energy and protein required per unit gain decreased with age. Within the age period of 16 to 22 weeks, added fat significantly improved energy utilization. Within all age periods, each 5% increment of added fat significantly improved protein utilization. The effect of added fat on feed efficiency increased with age as shown in Table 8. The improvement in feed efficiency per 1% added fat increased from a minimum value of 1.29% at 8 to 10 weeks of age to a maximum value of 2.73% from 18 to 20 weeks of age.

Effect of source of fat

Those turkeys fed diets containing added fat from each of the three sources had significantly greater body weight gains when compared with turkeys fed diets with no added fat (Table 4). The addition of Fat 2 failed to increase body weight gain as much as that from Fat 1 or Fat 3, however, this difference was not significant. The addition of fat at the 15% level from each source produced a quadratic effect. For each 1% added fat up to 10%, body weight gains were linearly increased .088, .061 and .099 kg or .8, .6 and .9% for Fat 1, Fat 2 and Fat 3, respectively (Figure 4).

Feed consumption was significantly decreased when fat was added to the diet from each of the three sources (Table 4). The addition of Fat 2 decreased feed consumption significantly more than the addition of Fat 1 and Fat 3. Feed consumptions were decreased .438. .559 and .412 kg or 1.2, 1.5 and 1.1% for each 1% added fat from Fat 1, Fat 2 and Fat 3, respectively (Figure 5).

Feed efficiency significantly improved when each of the three sources of fat was added to the diet (Table 4). Addition of fat from Fat 2 resulted in a significantly better feed efficiency when compared with the other two fats. For each 1% added fat, feed efficiency was increased .00606, .00686 and .00593 units or 2.06, 2.34 and 2.02% for Fat 1, Fat 2 and Fat 3, respectively (Figure 6). The effects on feed consumption and feed efficiency were linear from increasing levels of added fat up to 15%.

Effects of level of protein

Decreasing the crude protein level of the diets from 21 to 18, 19 to 16 and 17 to 14% during the respective 8 to 12, 12 to 16 and 16 to 22-week periods significantly decreased 8 to 22-week body weight gain 13.2% or from 11.92 to 10.35 kg. Feeding low protein diets significantly decreased feed consumption 5.7% and feed efficiency 8.1% from feeding standard protein diets. An increase in the protein level of the diet to 24, 22 and 20% during the respective periods failed to increase body weight gain, feed consumption and feed efficiency.

Processing data

The 22-week average live body weights, fresh carcass weights (without neck, giblets and leaf fat) and fresh carcass yields of male turkeys fed diets varying in levels of added fat and protein are presented in Table 9. Plots of live body weight and fresh carcass weight by protein levels on level of added fat are presented in Figures 7 and 8, respectively. In comparison to the standard and high protein diets, feeding low protein diets significantly depressed body weights 10.4%. No further increase in body weight occurred when high protein diets were fed. Addition of 5, 10 or 15% fat to the diet significantly increased body weights 2.5, 5.4 and 4.6%, respectively.

Fresh carcass weight when plotted on level of added fat (Figure 8) provides a reflection of the average live body weight. Addition of 10 and 15% fat to the diet increased fresh carcass weight 5.3 and 4.4% in comparison to 0% added fat. Feeding low protein diets depressed fresh carcass weight 12.4% and fresh carcass yield 2.4% as compared to both the standard and high protein diets (Table 9).

The effects of diet on breast meat (w/o bone and skin) yields are presented in Table 10 and Figure 9. Addition of fat to the diet failed to significantly affect kilogram breast meat yield. Breast meat yield, when expressed as a percentage of fresh carcass weight, was significantly lower for those turkeys fed diets containing 15% added fat as compared with those fed diets containing 0, 5 and 10% added fat. While added fat failed to significantly affect the weight of breast meat yield *per se*, when expressed per unit of feed consumed, breast meat yield was greatly increased from added fat (Figure 10). Considering only the standard protein and high protein diets, breast meat yield increased linearly from .088 to .112 kg per kilogram feed consumed when 0 and 15% fat was added, respectively. These values represent an increase of 27% in breast meat per unit of feed consumed or a 1.8% increase per 1% added fat.

Breast meat yields from feeding the low, standard and high protein diets were 2.73, 3.37 and 3.41 kg, respectively. Feeding the low protein diets depressed kilogram breast meat yield 19.5% in contrast to feeding the standard protein and high protein diets. Thus, from feeding low protein diets, live body weight was depressed 10.4% and kilogram breast yield was depressed 19.5%. From feeding the standard protein diets, the average breast meat yields were 23.31 and 31.15% of the live and fresh carcass weights, respectively. Feeding low protein diets significantly depressed each of these values 2.17% when expressed as percent of the live and carcass weight, respectively. Feeding high protein diets increased the amount of breast meat per unit of fresh carcass weight .66% over that obtained from feeding the standard protein diets. From feeding low, standard and high protein diets, .0850, .0991 and .1003 kg of breast meat was deposited per kg feed consumed, respectively. Thus, the breast yield per kg feed consumed from feeding low protein diets was only 85% of that from feeding standard protein or high protein diets (Table 10).

The effects of the dietary variables on the quantity of fat deposited in the abdomen (leaf fat) and around the gizzard are presented in Table 11 and illustrated in Figure 11. Increasing the protein level of the diet significantly reduced the quantity of leaf and gizzard fat deposited. From feeding low, standard and high protein diets, the amounts of leaf and gizzard fat deposited were .181, .127 and .101 kg, respectively. As the level of added dietary fat increased up to 10%, the quantity of leaf and gizzard fat deposited significantly increased. From feeding diets containing 0, 5, 10 and 15% added fat, the quantities of leaf and gizzard deposited were .084, .121, .166 and .175 kg, respectively. For each 1% added fat up to 10%, leaf and gizzard fat increased 10.2, 8.0 and 12.2% for the low, standard and high protein diets, respectively. The effects of each 5% increment of added dietary fat, up to the 10% level, on the deposition of leaf and gizzard fat was counteracted by increasing the protein content of the diet 3% (Figure 11).

Those turkeys fed low protein diets had a greater gizzard weight (16.4%) and a lower neck weight (4.8%) than that of those fed standard protein and high protein diets (Table 12). Dietary fat had no affect on gizzard weight or neck weight. The average breast skin yield of turkeys fed standard protein diets was significantly greater (14.2%) than that of those fed the low protein and high protein diets. Added dietary fat significantly increased both breast and neck skin yields an average of 15 and 31%, respectively.

Discussion

Addition of fat to the diets of growing male turkeys stimulated body weight gain, with maximum body weight gain occurring when 10% fat was added to the diet. The stimulation of body weight gain of growing turkeys from added fat is well documented (Touchburn and Naber, 1966; Jensen *et al.*, 1970; Sell and Owings, 1981; Potter and McCarthy, 1985). Inclusion of fat at the 15% level is not recommended due to handling problems and a lack of a continued increase in body weight gain over 10% added fat in this study.

Based on the NRC (1984) ingredient composition values, the standard protein diets without added fat fed from 8 to 12, 12 to 16 and 16 to 22 weeks of age contained 2,950, 3,009 and 3,069 kcal ME/kg, respectively. Using a value of 8,200 kcal ME/kg for fat, the addition of 1.00% fat and .22% dehulled soybean meal to the diet in place of 1.22% ground yellow corn increased the ME of the diet by 47 kcal/kg or about 1.6% (Table 1; Appendix A). Thus, if the energy intake of the turkey is assumed to remain constant a 1.6% increase in feed efficiency or a 1.4% decrease in feed consumption [((1-(1/1.16)) x 100)/10] would be expected per 1% added fat to the diet. The feed efficiency of those turkeys fed diets containing added fat increased 2.1 to 2.3% per 1% added fat. The decreases in feed consumption from each level of added fat are shown on a biweekly and cumulative basis in Table 6. A decrease in feed consumption of about 7.4, 13.8 and 19.4% was expected from 5, 10 and 15% added fat, respectively, based on the metabolizable energy contents of the diet. Consistently, those turkeys fed diets containing 5, 10 or 15% added fat consumed more feed than expected. Touchburn and Naber (1966) and Jensen *et al.* (1970) attributed the better-than-expected feed efficiencies observed in their experiments to the fat containing more calories than the ME value assigned it. The feed efficiency response in this study (2.1 to 2.3%) was greater than that expected based on the contribution of ME from fat added to the diet (1.60%), and is attributed, in part, to a stimulation of feed consumption. The over-consumption of feed resulted in an increase in body weight gain and a better-than-expected feed efficiency. The expected decrease per 1% added fat in feed consumption of 1.4% or expected increase in feed efficiency of

1.6% was based on the assumption of a constant ME intake by the turkey. The results of this study show that this assumption is invalid for the growing turkey. Addition of fat to the diet stimulated feed intake which resulted in a greater energy intake. As a result, both body weight gain and feed efficiency improved.

The magnitude of the response from added fat on feed efficiency increased with age of the turkey and agrees with the findings of others (Touchburn and Naber, 1966; Jensen *et al.*, 1970; Potter *et al.*, 1974; Sell and Owings, 1981; Potter and McCarthy, 1985). The ME consumed per unit gain significantly decreased for each 5% added fat from 16 to 22 weeks of age, indicative of a greater benefit from fat at older ages (Table 7). Additionally, the percent increase in feed efficiency per 1% added fat increased with age, with the greatest increase occurring from 16 to 20 weeks of age. As the turkey approaches sexual maturity, the increase in gonadotropin levels stimulate lipogenesis and depot development (Moran, 1985). Deposition of dietary fatty acids directly into fat depots avoids *de novo* synthesis of fatty acids from carbohydrate and the associated heat loss, and a maximal benefit from added dietary fat occurs. Moran (1982) reported that the benefit from 5% added fat was the greatest between 18 and 20 weeks of age and that this benefit decreased between 20 and 22 weeks of age for Nicholas Large White males. The author attributed the greater benefit of fat at older ages to increased steroid levels as the males reached sexual maturity (18 to 20 weeks of age), hence, promoting the deposition of dietary triglycerides directly into fat depots. As the depots reach capacity (20 to 22 weeks of age), the benefit from added fat as measured by feed utilization diminished. The increase in feed efficiency per 1% added fat up to 20 weeks of age (Table 8) and breast skin yield from added fat in this study may be, in part, due to dietary triglycerides being directly deposited into fat depots under the influence of testosterone as the males approached sexual maturity.

The addition of fat to the diet from each of the three sources stimulated body weight gain and reduced feed consumption, thus improving the feed efficiency of growing male turkeys between 8 and 22 weeks of age. The relative value of Fat 2 to Fat 1 and Fat 3 can be estimated based upon the feed efficiency data. For each 1% added fat from Fat 1, Fat 2 and Fat 3, feed efficiency was increased 2.06, 2.34 and 2.02%, respectively. Therefore, the increase in feed efficiency per 1%

added fat from Fat 2 was 12% greater than that of both Fat 1 and Fat 3. However, the increase in feed efficiency from added fat cannot be totally attributed to the contribution of ME by fat to the diet. In order to hold protein constant, corn was removed and dehulled soybean meal was added upon fat addition to the diet. Thus, based upon the feed efficiencies reported in this study, Fat 2 inmroved feed efficiency 6% more than Fat 1 and Fat 3 in improving feed efficiency.

Table 13 contains the analysis of samples from each of the fat sources, and aids in explaining the superior value estimated for Fat 2. The levels of moisture, impurities and unsaponifiables were much smaller for Fat 2 as compared to those obtained for Fat 1 and Fat 3. Moisture, impurities and unsaponifiables (MIU) contain little or no energy and contribute to decreasing the energy value of a fat. Those turkeys fed diets containing Fat 2 consumed 4.4% less feed than those fed diets containing Fat 1 or Fat 3, indicative of a greater energy value for Fat 2. In addition, Fat 2 had a greater total fatty acid content with 3.2 times less free fatty acids than Fat 1 or Fat 3. Renner and Hill (1958) have demonstrated that free fatty acids are utilized less efficiently than fatty acids which are esterified with glycerol. In addition, the gross energy of free fatty acids and glycerol is less than that of a triglyceride. Moisture, impurities, unsaponifiable, free fatty acid and total fatty acid contents of a fat do affect the feed efficiency response of the growing turkey and thus its value as an energy source.

Dietary protein levels of 21, 19 and 17% from 8 to 12, 12 to 16 and 16 to 22 weeks of age, respectively, supported maximum body weight gains, feed consumptions and feed efficiencies. Lowering the protein content 3% below these levels resulted in decreased body weight gains, feed consumptions and feed efficiencies. By calculation, the low protein diets contained only 68, 74 and 75% of the NRC (1984) recommended levels of lysine for turkeys 8 to 12, 12 to 16 and 16 to 22 weeks of age, respectively. Comparable values of 85, 96 and 101 and 102, 118 and 129% were calculated for the standard and high protein diets, respectively. Lysine, although calculated to be marginally deficient in the standard protein diets, did not appear to be limiting in either the standard or high protein diets. Additional studies are needed to determine if lysine is the sole limiting factor in low protein diets for growing turkeys such as those fed in this study. If lysine is the limiting factor, the feeding of low protein diets may be feasible if supplemented with a commercial lysine product.

Analysis of variance of the data in this study indicated the lack of a significant fat x protein interaction. Inspection of Figures 1 through 3 clearly show that within a protein level, added fat did not affect the protein requirement. Potter and McCarthy (1985) have also reported that supplemental fat did not affect the protein requirement of male or female turkeys between 16 and 20 weeks of age. Additionally, the protein consumed per kg gain decreased from each 5% increment of fat added to the diet. Sell *et al.* (1985) has reported similar results for male turkeys, showing that protein consumption per unit gain decreased when diets containing 4 or 8% added fat were fed from 9 to 20 weeks of age. The results from this study have verified that protein does not become a limiting factor when fat is added to diets for growing turkeys.

The addition of fat to the diet of growing turkeys is beneficial in increasing growth and feed utilization. However, information is limited on how added dietary fat and protein affect carcass yield, breast yield and fat deposition within the abdomen and breast meat, all measurements being of importance to the further processor. In this study, 10% fat added to diets adequate in protein (standard and high protein diets) resulted in the maximum live weight, fresh carcass weight and fresh carcass yield at 22 weeks of age. Feeding low protein diets resulted in a significantly lower live weight (10.4%) and fresh carcass weight (12.5%), yet the percent yield was not affected. The results of this study agree with those of Summers *et al.*, (1985) who found that the feeding of low protein diets to male and female turkeys decreased carcass yield. Sell *et al.*, (1985) have reported carcass yield of male turkeys at 20 weeks of age to be unaffected by added dietary fat or the feeding of low, medium or high protein diets. However, the lysine contents of their medium and high protein diets were below those recommended by the NRC (1984) and below those of the standard and high protein diets fed in this study. The possibility of lysine being a limiting factor may account for the discrepancy in results between the two studies.

The move toward the further processing of turkeys has made the yield of breast meat of primary importance, as it is the item of greatest economic value. Added dietary fat failed to affect the amount of breast meat yield *per se* in this study, however, the amount of breast meat produced per kg feed consumed was significantly increased 1.8% per 1% added fat to the diet. This finding represents a further increase in profitability for the producer-processor, as breast meat can be produced at a lower feed cost if fat can be economically added to the diet.

A reduction in body weight of 10.4% was associated with an 19.5% reduction in the amount of breast meat produced when low protein diets were fed in this study. If a depression in body weight occurs during the growout period due to a deficient or marginal protein level or intake, a two-fold decrease in breast meat yield may result. Hasiak (1983) reported the breast yield of turkeys raised in the summer to be 3.77% lower than the breast yield of those grown during the winter. The experimental diets met the NRC (1984) stated requirements for crude protein, however, the feed consumption of those turkeys raised in the summer was 15.4% lower than that of those raised in the winter. A lower protein (and energy) intake due to lower feed consumption is common for turkeys raised in the summer and may result in a protein deficiency. The results from this study have demonstrated that breast meat yield can be dramatically decreased if dietary protein levels are deficient. It, therefore, becomes critical for the poultry nutritionist to formulate diets with adequate protein levels to maximize not only growth but breast meat yield.

Addition of 5, 10 and 15% fat significantly increased breast skin yield, and this finding is in agreement with other reports (Salmon and O'Neil, 1971; Essary *et al.*, 1971; Sell *et al.*, 1985). An increase in breast skin yield was indicative of increased fat deposition under the skin due to added dietary fat (Moran, 1985). The fat deposited under the breast skin results in increased labor costs, as it must be removed before the skin can be used as a covering for breast meat products, Fat addition to the diet also increased the amount of fat deposited around the gizzard and the abdomen. Maximum gizzard and leaf fat deposition occurred at the 10% level of added fat across all levels of protein. The lowering of the protein content of the diet significantly increased the amount of fat deposition in the carcass. Lowering dietary protein has been shown to increase abdominal fat in broilers (Bartov *et al.*, 1974; Summers and Leeson, 1979) and turkeys (Essary *et al.*, 1971; Summers *et al.*, 1985). Inspection of Figure 11 shows that the increase in fat deposition from each 5% added fat was counteracted with a 3% increase in dietary protein. Thus, while added fat increased fat deposition, this increase may be alleviated by an increase in dietary protein. While increasing protein level is not required for maximum performance of the growing turkey, it does aid in counteracting the increase of fat deposition when fat is added to the diet.

Summary and Conclusions

An experiment was conducted to quantitate the effects of fat from three sources and of protein on the performance and carcass quality of male turkeys between 8 and 22 weeks of age. The addition of each 1% fat increased body weight gain .72%, decreased feed consumption 1.3% and increased feed efficiency 2.1% in diets adequate in protein (standard and high protein diets). The growing male turkey failed to adjust caloric intake when fat was added to the diet, resulting in an over-consumption of feed and a better-than-expected feed efficiency. In addition, the metabolizable energy consumption per kg gain significantly decreased when fat was added to the diet after 16 weeks of age. Based upon observed feed efficiencies from feeding each of the sources, Fat 2 improved feed efficiency approximately 6% more than Fat 1 and Fat 3. The difference was attributed to Fat 2 having 3.7% less MIU, 33% less free fatty acids and 3.35% more total fatty acids than both Fat 1 and Fat 3. Addition of fat significantly improved 22-week body weights and fresh carcass weights of male turkeys. While fat addition to the standard and high protein diets failed to affect kilogram breast meat yield *per se*, the amount of breast meat produced per kg feed consumed was increased 1.8% per 1% added fat to the diet. Addition of each 1% fat (up to 10%) to the low, standard and high protein diets increased the amount of fat deposition around the gizzard and in the abdomen 10.2, 8.0 and 12.0%, respectively, compared with 0% added dietary fat.

The feeding of low as compared to standard protein diets decreased body weight gain 13.2%, feed consumption 5.7% and feed efficiencies 8.1%. The low protein diets were calculated to be deficient in lysine. Protein did not become a limiting factor when fat was added to the diet, illustrating the growing turkey's tolerance to wide calorie:protein ratios. The feeding of the low protein diets reduced live weight 10.4% and decreased breast meat yield 19.5%. Increasing the protein content of the diet 3% alleviated the increase in fat deposition which occurred from each 5% increment of added fat up to 10%.

Based on the results of this experiment, the addition of 10% added fat to diets adequate in protein stimulated body weight gain and produced better-than-expected feed efficiencies without adversely affecting fresh carcass yield or kilogram breast meat yield. In addition, added fat resulted in an increase in the amount of breast meat produced per kg feed consumed, which can contribute to lowered production costs when fat can be economically added to the diet. A disadvantage of fat addition to the diet is an increased amount of fat deposition under the skin, around the gizzard and in the abdominal area. However, when the protein content of the diet was increased by 3%, the effect of a 5% addition of fat to the diet on fat depostion was counteracted. While the level of dietary protein does not need to be increased when fat is added to the diet to increase growth of turkeys, increasing the protein content of the diet is effective in controlling the amount of fat deposition.

Table 1. Design of Experiment 1

Source of fat	Protein[1]	Level of fat, % 0	5	10	15
		Diet number			
Fat 1	Low	1	10	19	28
	Standard	2	11	20	29
	High	3	12	21	30
Fat 2	Low	4	13	22	31
	Standard	5	14	23	32
	High	6	15	24	33
Fat 3	Low	7	16	25	34
	Standard	8	17	26	35
	High	9	18	27	36

[1]Diets fed from 8 to 12, 12 to 16 and 16 to 22 weeks of age contained 18, 16 and 14% protein for the low level, 21, 19 and 17% protein for the standard level and 24, 22 and 20% protein for the high level, respectively.

Table 2. Composition of 18% protein basal diet

Ingredient	g/kg
Ground yellow	738.34
Dehulled soybean meal	191.80
Meat and bone meal	40
Mono and dicalcium phosphate	18
Ground limestone	4
Iodized salt	4
Trace mineral mix[1]	.5
Vitamins and feed additives[2]	1.36
DL-Methionine	2.0
Total	1,000.00
Calculated analyses (%)[3]:	
Protein	18.0
Ether extract	3.3
Calcium	1.03
Phosphorus, total	.87
Phosphorus, available	.67
Sodium	.21
Methionine	.51
Cystine	.26
Lysine	.89
Metabolizable energy (kcal/kg)	3,020

[1]Supplied the following amounts of trace mineral in mg/kg complete diet: 150 manganese, 120 zinc, 40 iron, 6 copper and 1.5 iodine from manganese oxide, ferrous sulfate (monohydrate), copper oxide, and calcium iodate, respectively.

[2]Supplied the following amounts of vitamins and feed additives in mg/kg complete diet unless otherwise stated: 4,414 IU vitamin A, 2,207 ICU vitamin D_3., 1.1 IU vitamin E, 1.76 menadione sodium bisulfite complex, 4.41 riboflavin, 8.82 calcium pantothenate (D), 33.1 g niacin, 227 choline chloride, 5.5 μg vitamin B_{12}, .28 folic acid, 124 ethoxyquin, .2 selenium from sodium selenite and 22 bacitracin from zinc bacitracin.

[3]Calculated from values given by NRC (1984).

Table 3. Protocol for dietary changes

Fat addition:	
	+5.0% stabilized fat
	+1.1% dehulled soybean meal
	-6.1% ground yellow corn
Protein within period (3% addition):	
	+7.56% dehulled soybean meal
	-7.56% ground yellow corn
Protein between periods (2% decrease):	
	+5.44% ground yellow corn
	-5.04% dehulled soybean meal
	- .30% mono and dicalcium phosphate
	- .10% ground limestone

Table 4. Effects of varying level of added fat, source of fat and level of protein in diets of male turkeys 8 to 22 weeks of age[1]

Dietary variable	Body weight gain (kg)	Feed consumption (kg)	Feed efficiency (gain/feed)
		Level of added fat	
0% fat	10.91	36.99	.2946
5% fat	11.27 (3.3)[2]	34.96 (-5.5)	.3222 (9.4)
10% fat	11.73 (7.5)	32.66 (-11.7)	.3591 (21.9)
15% fat	11.57 (6.0)	29.83 (-19.4)	.3877 (31.6)
DRS[3]	.29 (2.6)	.75 (2.2)	.0065 (1.9)
		Source of fat	
None	10.91	36.99	.2946
Fat 1[4]	11.57 (6.0)	32.80 (-11.3)	.3541 (20.2)
Fat 2	11.39 (4.4)	31.59 (-14.6)	.3620 (22.9)
Fat 3	11.63 (6.6)	33.06 (-10.6)	.3527 (19.6)
DRS	.29 (2.6)	.75 (2.2)	.0065 (1.9)
		Level of protein	
Low protein[5]	10.35 (-13.2)	32.30 (-5.7)	.3229 (-8.1)
Standard protein	11.92	34.24	.3513
High protein	11.85 (-.6)	34.29 (.2)	.3485 (-.8)
DRS	.25 (2.2)	.65 (1.9)	.0056 (1.6)

[1]Each value represents the average of 9 or 12 pens of turkeys with 25 or 26 birds per pen.

[2]Values in parentheses indicate percent increase of respective value over lowest level of added fat or standard level of protein.

[3]DRS = difference required for significance at .05 level.

[4]Fatl 1 = Stern, Fat 2 = Valley Proteins and Fat 3 = Gro-Pro.

[5]Diets fed from 8 to 12, 12 to 16, and 16 to 22 weeks of age contained 18, 16, and 14% protein for the low protein diets, 21, 19, and 17% protein for the standard protein diets, and 24, 22, and 20% protein for the high protein diets, respectively.

Table 5. Analyses of variance of 8 to 22-week body weight gains, feed consumptions and feed efficiencies of male turkeys

Source	Degrees of freedom	Mean squares		
		Body weight gain	Feed consumption	Feed efficiency ($x10^{-6}$)
Source of fat (S)	2	.1188	4.0506*	149.56
Level of fat (F)	3	1.1891***	85.3132***	15,054.47***
Linear	1	2.7109***	254.5096***	45,020.48***
Quadratic	1	.6246**	1.3991	2.30
Cubic	1	.2318	.0304	140.63
Level of protein (P)	2	9.3931***	15.4767***	2,947.00***
Linear	1	13.4087***	23.7486***	3,939.84***
Quadratic	1	5.3776***	7.2048***	1,954.16***
S x F	6	.0188	.8216	70.06
S x P	4	.2014	.7163	96.08
F x P	6	.0744	.5425	99.50
Error				
S x F x P	12	.0792	.5276	40.07
Total	35			

*P≤.05.
**P≤.01.
***P≤.001.

Table 6. Decrease in feed consumption from 5, 10 or 15% added fat in each two-week period and on a cumulative basis

Age (weeks)	Added fat, % 0	5	10	15	5-0	10-0	15-0
	kg				(%)		
				Feed consumption			
8-10	3.226	3.076	2.918	2.730	-4.6	- 9.5	-15.4
10-12	4.272	4.069	3.801	3.543	-4.8	-11.0	-17.1
12-14	5.010	4.747	4.356	3.983	-5.2	-13.1	-20.5
14-16	5.451	5.071	4.750	4.333	-7.0	-12.9	-20.5
16-18	6.446	6.176	5.815	5.378	-4.2	- 9.8	-16.6
18-20	6.667	6.265	5.894	5.327	-6.0	-11.6	-20.1
20-22	5.923	5.555	5.125	4.540	-6.2	-13.5	-23.3
8-22	36.994	34.959	32.658	29.834	-5.5	-11.7	-19.4

[1]A decrease of about 7.4, 13.8 and 19.4% in feed consumption was expected from the addition of 5, 10 and 15% fat, respectively, assuming metabolizable energy consumption remained constant.

Table 7. Effects of added fat on efficiency of feed, metabolizable energy and protein utilization of male turkeys

Level of added fat (%)	Body weight gain (kg)	Consumption per kg gain		
		Feed (kg)	Metabolizable energy (kcal)	Protein (kg)
		8 to 12 weeks of age		
0	3.015	2.50[a]	7,367[a]	.522[a]
5	3.117	2.30[b]	7,356[a]	.481[b]
10	3.153	2.14[c]	7,362[a]	.447[c]
15	3.115	2.03[d]	7,452[a]	.422[d]
		12 to 16 weeks of age		
0	3.060	3.42[a]	10,287[ab]	.650[a]
5	3.074	3.19[b]	10,385[a]	.607[b]
10	3.212	2.84[c]	9,918[ab]	.540[c]
15	3.172	2.62[d]	9,793[b]	.498[d]
		16 to 22 weeks of age		
0	4.834	3.95[a]	12,116[a]	.668[a]
5	5.083	3.55[b]	11,755[b]	.601[b]
10	5.370	3.14[c]	11,157[c]	.532[c]
15	5.286	2.89[d]	10,970[c]	.489[d]

[1]Each value represents an average of three pens of male turkeys. Values within an age and column with different superscripts are significantly different ($P \leq .05$).

Table 8. Percent increase in feed efficiency of male turkeys 8 to 22 weeks of age per 1% added fat

Age (weeks)	Regression equation[1]	Increase in feed efficiency per 1% added fat
		(%)
8-10	$Y = .3784 + .0267\ X_1 + .0049\ X_2$	1.29[2]
10-12	$Y = .3540 + .0134\ X_1 + .0074\ X_2$	2.09
12-14	$Y = .2988 + .0009\ X_1 + .0066\ X_2$	2.21
14-16	$Y = .2705 + .0036\ X_1 + .0057\ X_2$	2.11
16-18	$Y = .2486 + .0066\ X_1 + .0067\ X_2$	2.70
18-20	$Y = .2560 + .0087\ X_1 + .0070\ X_2$	2.73
20-22	$Y = .1998 + .0100\ X_1 + .0049\ X_2$	2.45
8-22	$Y = .2755 + .0090\ X_1 + .0063\ X_2$	2.28

[1]Y = feed efficiency (gain:feed), X_1 = level of protein in percent and X_2 = level of added fat in percent.

[2]Calculated by dividing slope (regression coefficient) of level of added fat (X_2) by Y intercept x 100.

Table 9. Mean live body weight, fresh carcass weight (minus neck, giblets and leaf fat) and percent fresh carcass yield of male turkeys fed diets varying in levels of added fat and protein from 8 to 22 weeks of age

Protein[1] level	Level of added fat, % 0	5	10	15	Average[2]
		22-week body weight, kg			
Low	12.630[3]	12.890	13.067	13.086	12.918[a]
Standard	13.975	14.507	14.783	14.501	14.441[b]
High	13.867	14.102	14.821	14.728	14.380[b]
Average[2]	13.491[a]	13.833[ab]	14.224[bc]	14.105[bc]	
		Fresh carcass weight, kg			
Low	9.252	9.457	9.417	9.560	9.422[a]
Standard	10.471	10.862	11.093	10.800	10.806[b]
High	10.331	10.466	11.123	11.016	10.734[b]
Average	10.018[a]	10.262[ab]	10.544[b]	10.459[b]	
		Fresh carcass yield, %			
Low	73.26	73.37	72.07	73.06	72.94[a]
Standard	74.93	74.88	75.04	74.48	74.83[b]
High	74.50	74.22	75.05	74.80	74.64[b]
Average	74.23[a]	74.15[a]	74.05[a]	74.11[a]	

[1]Diets fed from 8 to 12, 12 to 16, and 16 to 22 weeks of age contained 18, 16, and 14% protein for the low protien diets; 21, 19, and 17% protein for the standard protein diets; and 24, 22, and 20% protein for the high protein diets, respectively.

[2]Averages within a row or column with different superscripts are significantly different ($P \leq .05$).

[3]Each value represents the average value of 63 to 71 turkeys.

Table 10. Mean breast weight, breast as a percentage of live and fresh carcass weight and kilograms breast yield per kilogram feed consumed of male turkeys fed diets varying in levels of added fat and protein from 8 to 22 weeks of age

Protein[1] level	Level of added fat, % 0	5	10	15	Average[2]
	Breast meat, kg[3]				
Low	2.73[4]	2.76	2.74	2.69	2.73[a]
Standard	3.28	3.45	3.43	3.31	3.37[b]
High	3.35	3.31	3.54	3.45	3.41[b]
Average[2]	3.12[a]	3.17[a]	3.24[a]	3.15[a]	
	Breast meat as percent live weight				
Low	21.64[2]	21.38	20.98	20.55	21.14[a]
Standard	23.47	23.76	23.21	22.80	23.31[b]
High	24.17	23.49	23.87	23.43	23.74[b]
Average	23.10[a]	22.88[a]	22.69[ab]	22.26[b]	
	Breast meat weight as percent fresh carcass weight				
Low	29.54	29.14	29.11	28.13	28.98[a]
Standard	31.32	31.73	30.93	30.61	31.15[b]
High	32.44	31.66	31.81	31.32	31.81[c]
Average	31.11[a]	30.84[a]	30.62[a]	30.02[b]	
	Kilograms breast per kilogram feed consumed				
Low	.0775	.0819	.0873	.0932	.0850[a]
Standard	.0866	.0960	.1044	.1093	.0991[b]
High	.0885	.0939	.1050	.1137	.1003[b]
Average	.0842[a]	.0906[b]	.0989[c]	.1054[d]	

[1]Diets fed from 8 to 12, 12 to 16, and 16 to 22 weeks of age contained 18, 16, and 14% protein for the low protein diets; 21, 19, and 17% protein for the standard protein diets; and 24, 22, and 20% protein for the high protein diets, respectively.

[2]Averages within a row or column with different superscripts are significantly different ($P \leq .05$).

[3]Without skin and bone.

[4]Each value represents the average value of 63 to 71 turkeys.

Table 11. Mean leaf fat, gizzard fat, and total leaf and gizzard fat weights of male turkeys fed diets varying in levels of fat and protein from 8 to 22 weeks of age

Protein[1] level	Level of added fat, % 0	5	10	15	Average[2]
		Leaf fat, kg			
Low	.050[3]	.076	.105	.106	.084[a]
Standard	.037	.051	.071	.062	.055[b]
High	.025	.037	.044	.057	.041[b]
Average[2]	.037[a]	.055[a]	.074[b]	.075[b]	
		Gizzard fat, kg			
Low	.060	.089	.115	.127	.097[a]
Standard	.046	.062	.078	.180	.071[b]
High	.033	.052	.084	.074	.061[b]
Average	.046[a]	.066[b]	.092[c]	.101[c]	
		Leaf and gizzard fat, kg			
Low	.110	.160	.220	.233	.181[a]
Standard	.083	.113	.149	.162	.127[b]
High	.058	.089	.128	.131	.101[c]
Average	.084[a]	.121[b]	.166[c]	.175[c]	

[1]Diets fed from 8 to 12, 12 to 16, and 16 to 22 weeks of age contained 18, 16, and 14% protein for the low protein diets; 21, 19, and 17% protein for the standard protein diets; and 24, 22, and 20% protein for the high protein diets, respectively.

[2]Averages within a row or column with different superscripts are significantly different ($P \leq .05$).

[3]Each value represents the average value of 63 to 71 turkeys.

Table 12. Mean gizzard, neck, breast skin and neck skin weights of male turkeys fed diets varying in levels of fat and protein from 8 to 22 weeks of age

Protein[1] level	Level of added fat, % 0	5	10	15	Average[2]
		Gizzard weight, kg			
Low	.156[3]	.153	.148	.141	.149[a]
Standard	.128	.122	.135	.139	.131[b]
High	.119	.121	.126	.132	.125[b]
Average[2]	.134[a]	.132[a]	.136[a]	.137[a]	
		Neck weight, kg			
Low	.330	.356	.355	.361	.350[a]
Standard	.376	.381	.369	.357	.371[b]
High	.371	.357	.367	.360	.364[ab]
Average	.359[a]	.365[a]	.364[a]	.359[a]	
		Breast skin, kg			
Low	.241	.274	.283	.261	.265[a]
Standard	.278	.313	.328	.316	.309[b]
High	.243	.260	.294	.307	.276[a]
Average	.254[a]	.282[b]	.302[b]	.295[b]	
		Neck skin, kg			
Low	.276	.369	.367	.380	.348[a]
Standard	.283	.351	.387	.345	.342[ab]
High	.255	.296	.353	.348	.313[b]
Average	.271[a]	.339[b]	.369[b]	.358[b]	

[1]Diets fed from 8 to 12, 12 to 16, and 16 to 22 weeks of age contained 18, 16, and 14% protein for the low protein diets; 21, 19, and 17% protein for the standard protein diets; and 24, 22, and 20% protein for the high protein diets, respectively.

[2]Averages within a row or column with different superscripts are significantly different ($P \leq .05$).

[3]Each value represents the average value of 63 to 71 turkeys.

Table 13. Analyses of fat samples

Measurement	Source[1]		
	Fat 1	Fat 2	Fat 3
Moisture, %	1.14	.30	1.73
Impurities,%	.51	.16	.36
Unsaponifiables, %	3.27	.89	3.00
Free fatty acids, %	48.7	15.0	48.1
Total fatty acids, %	89.1	92.8	89.8
Iodine number	90.5	85.0	97.3
Active oxygen method	7.36	2.66	6.90
Peroxide value	.12	.47	.43
Number of samples	10	10	4

[1]Fat 1 = Stern, Fat 2 = Valley Proteins and Fat 3 = Gro-Pro.

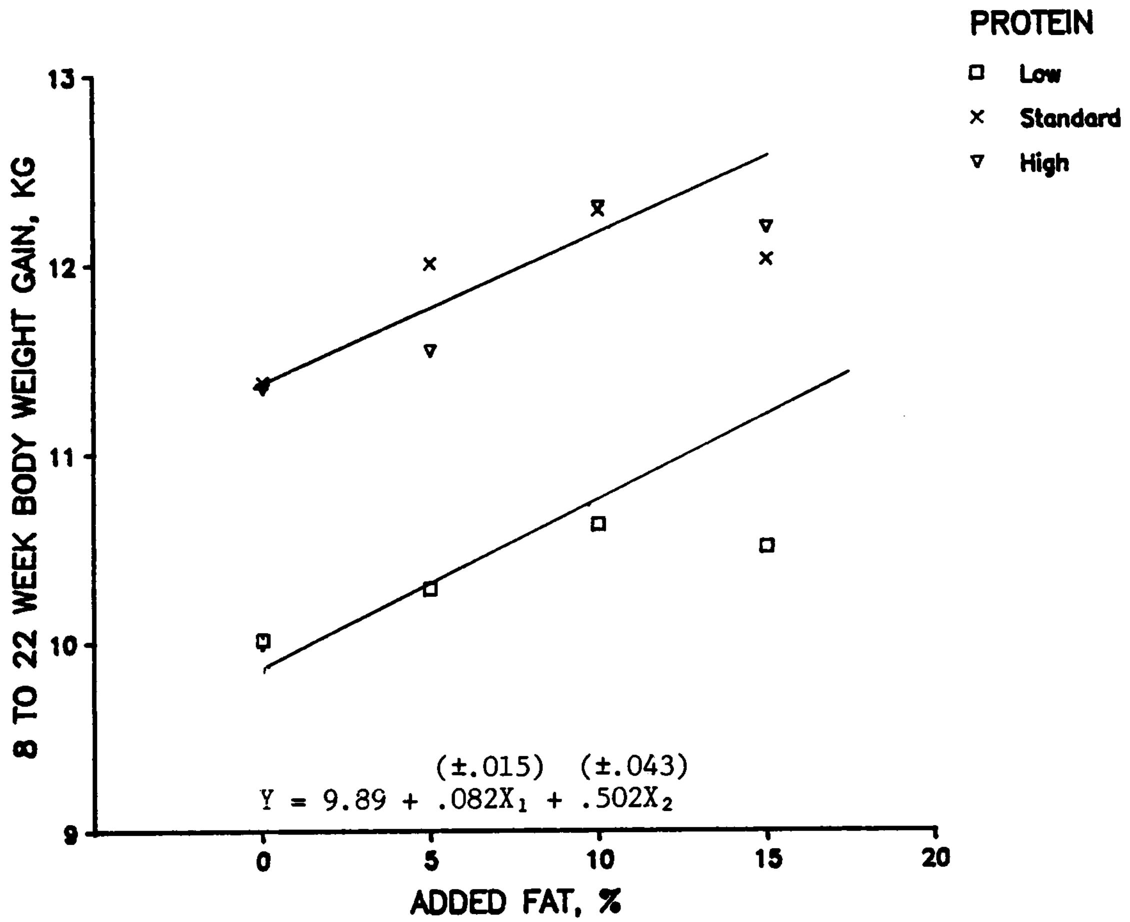

Figure 1. Effects of fat and protein on body weight gain of Large White male turkeys between 8 and 22 weeks of age. A single regression line was determined for the standard and high protein diets. Y = body weight gain, X_1 = level of added fat and X_2 = protein coded 1 for the standard and high protein diets and 0 for the low protein diets.

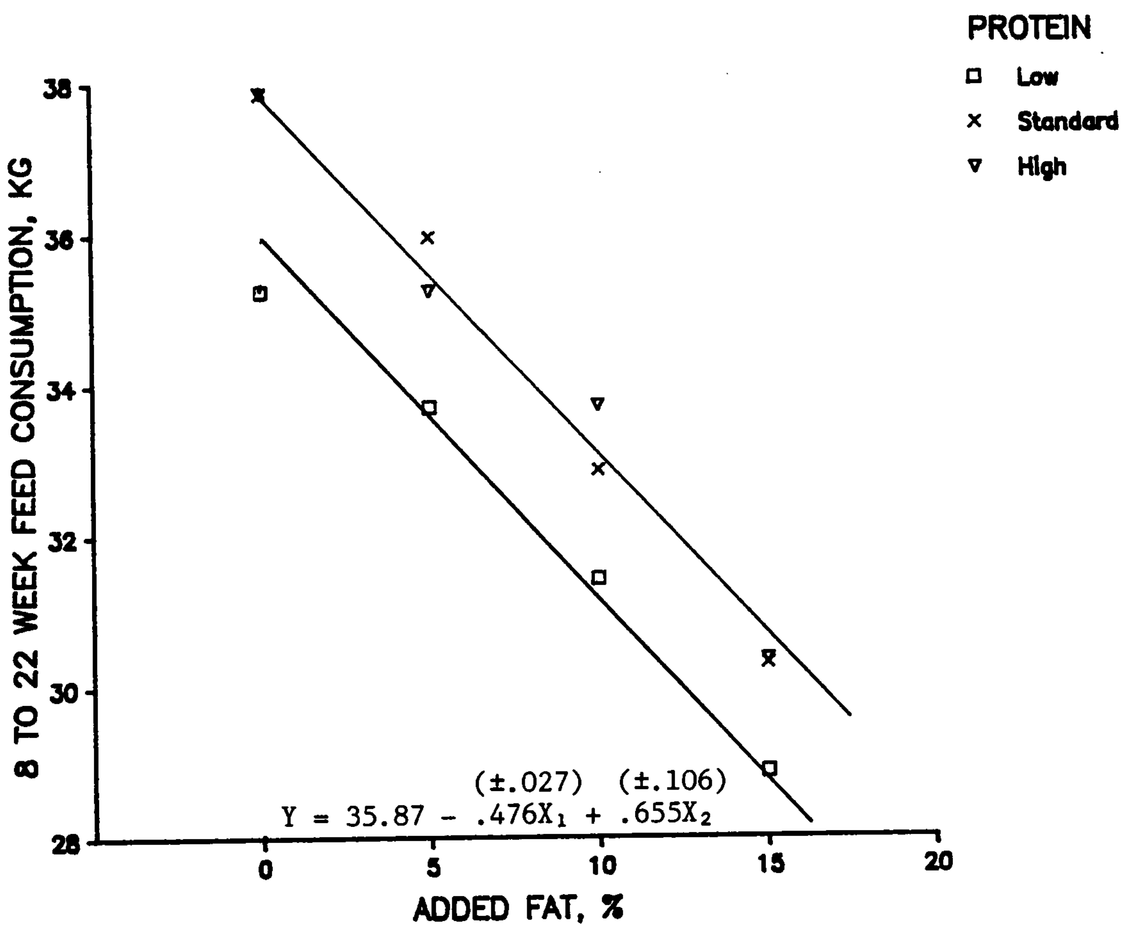

Figure 2. Effects of fat and protein on feed consumption of Large White male turkeys between 8 and 22 weeks of age. A single regression line was determined for the standard and high protein diets. Y = feed consumption, X_1 = level of added fat and X_2 = protein coded 1 for the standard and high protein diets and 0 for the low protein diets.

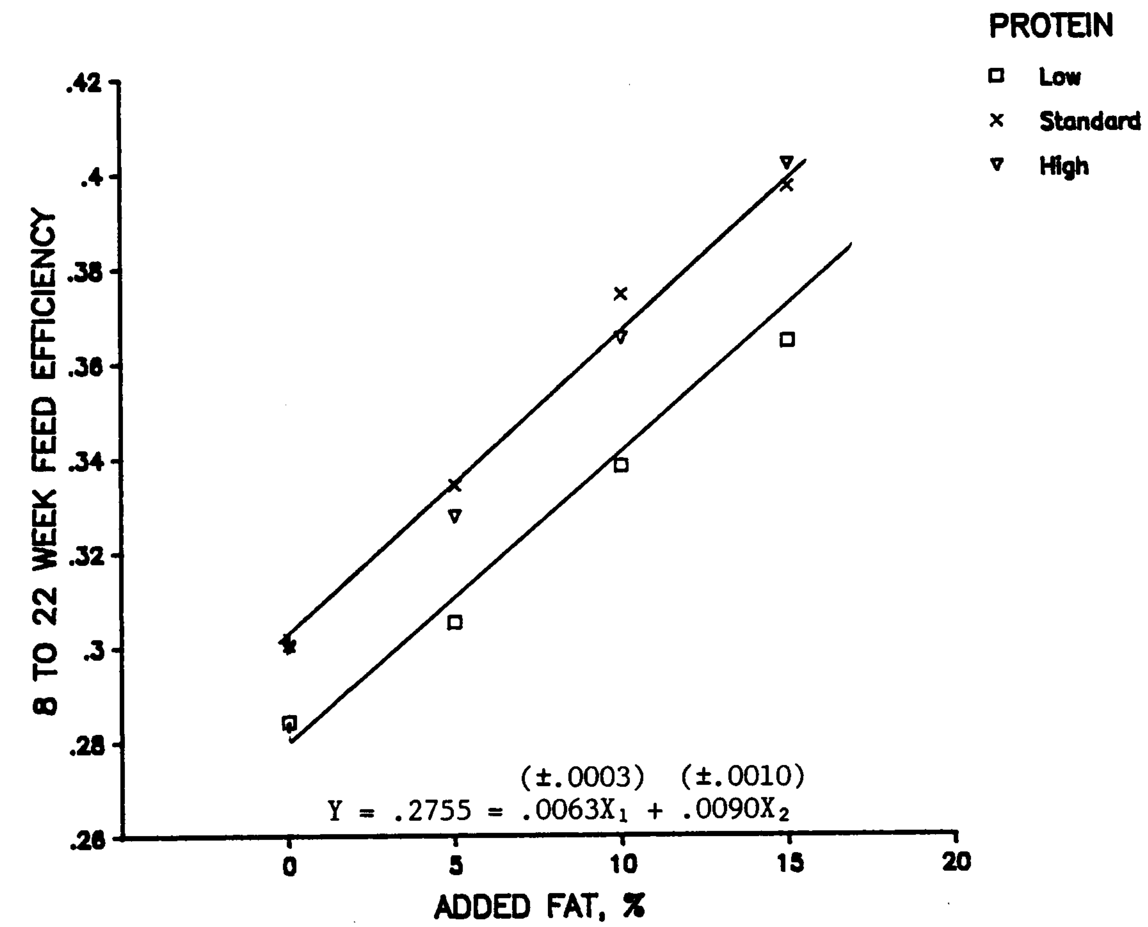

Figure 3. Effects of fat and protein on feed efficiency of Large White male turkeys between 8 and 22 weeks of age. A single regression line was determined for the standard and high protein diets. Y = feed efficiency, X_1 = level of added fat and X_2 = protein coded 1 for the standard and high protein diets and 0 for the low protein diets.

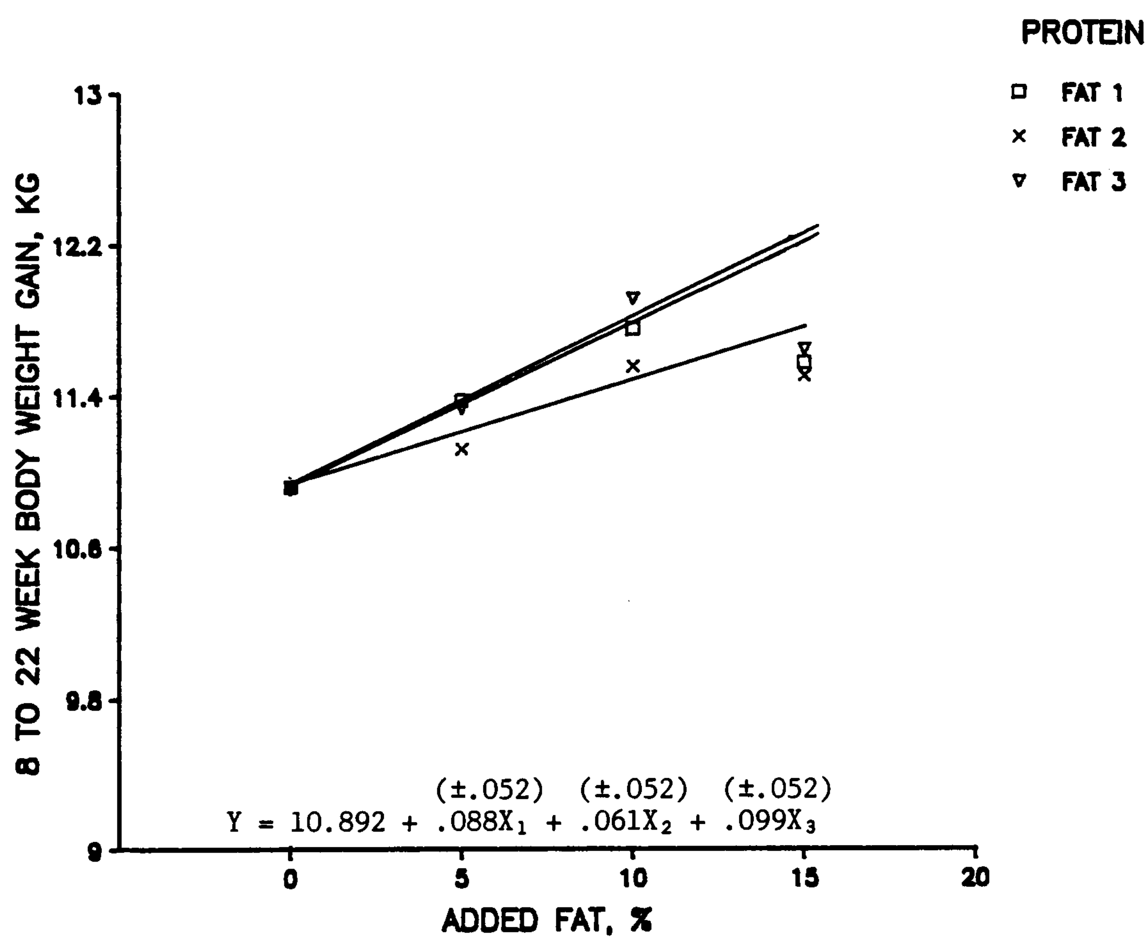

Figure 4. Effects of four levels of added fat from three sources on body weight gain of Large White male turkeys between 8 and 22 weeks of age. Y = body weight gain and X_1, X_2 and X_3 = the level of added fat from Fat 1, Fat 2 and Fat 3, respectively.

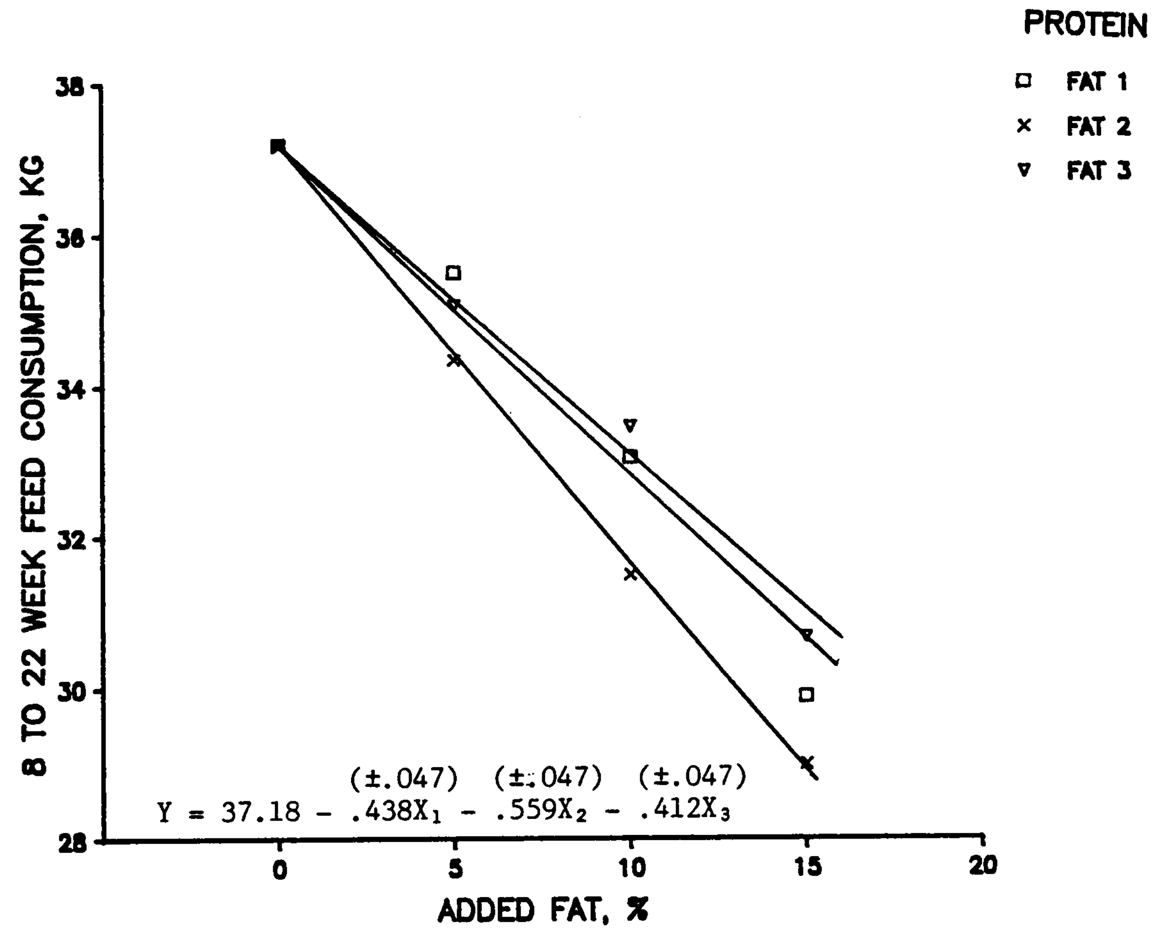

Figure 5. Effects of four levels of added fat from three sources on feed consumption of Large White male turkeys between 8 and 22 weeks of age Y = feed consumption and X_1, X_2 and X_3 = the level of added fat from Fat 1, Fat 2 and Fat 3, respectively.

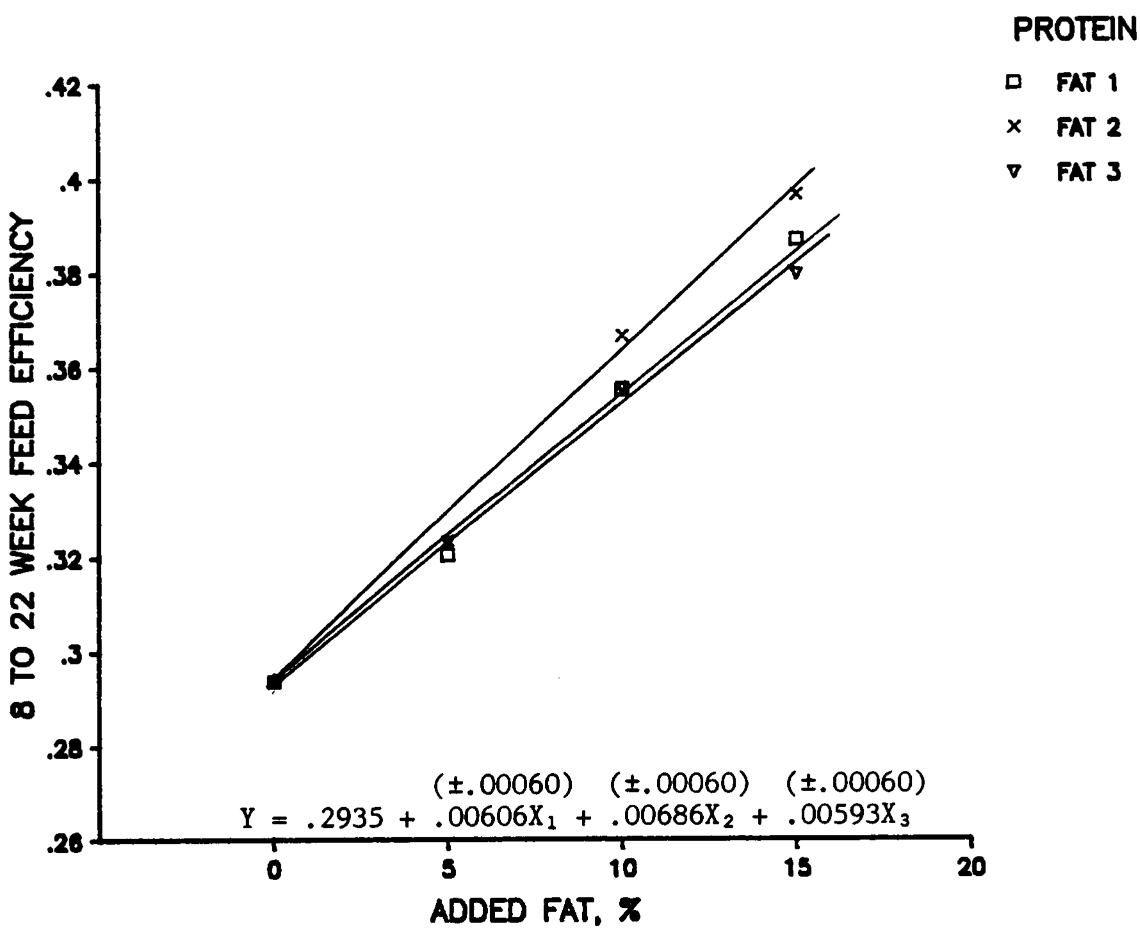

Figure 6. Effects of four levels of added fat from three sources on feed efficiency of Large White male turkeys between 8 and 22 weeks of age. Y = feed efficiency and X_1, X_2 and X_3 = the level of added fat from Fat 1, Fat 2 and Fat 3, respectively.

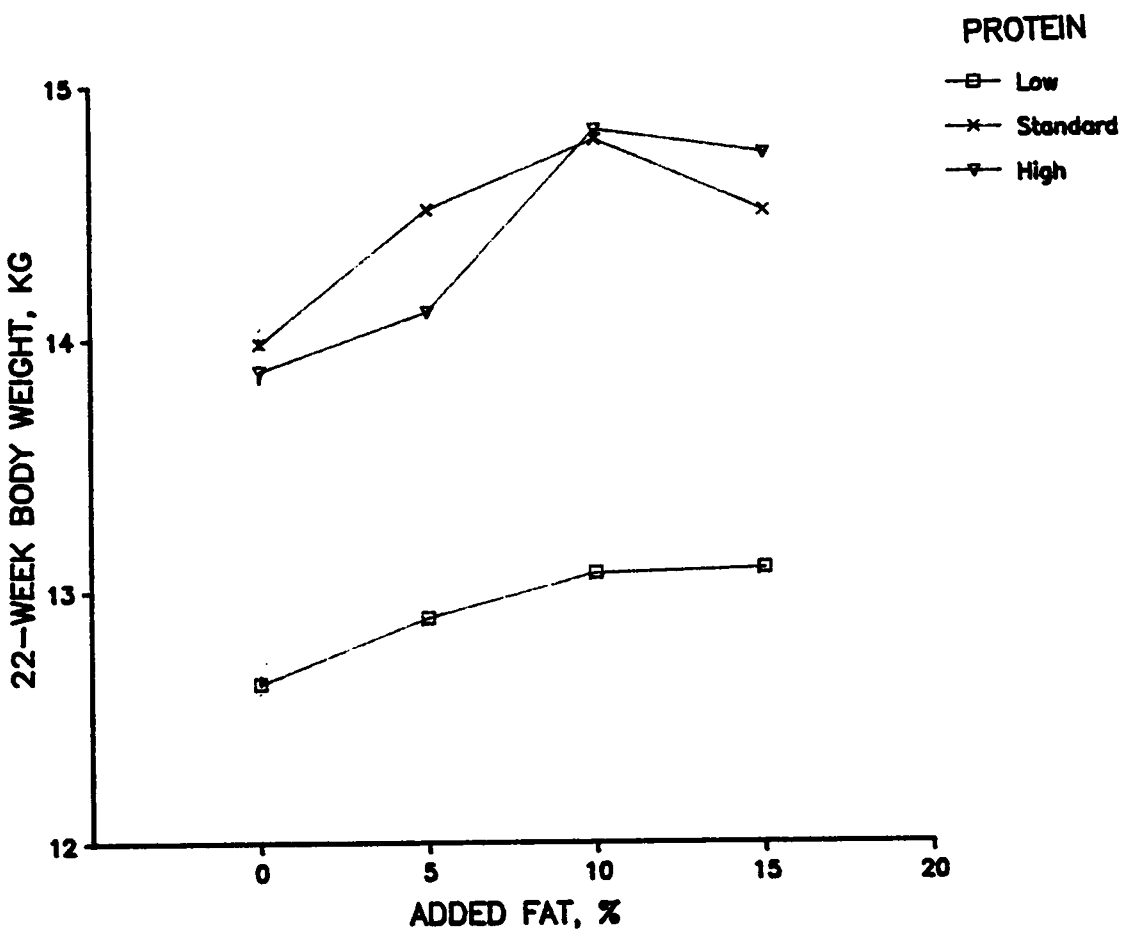

Figure 7. Effects of fat and protein on body weight of Large White male turkeys processed at 22 weeks of age.

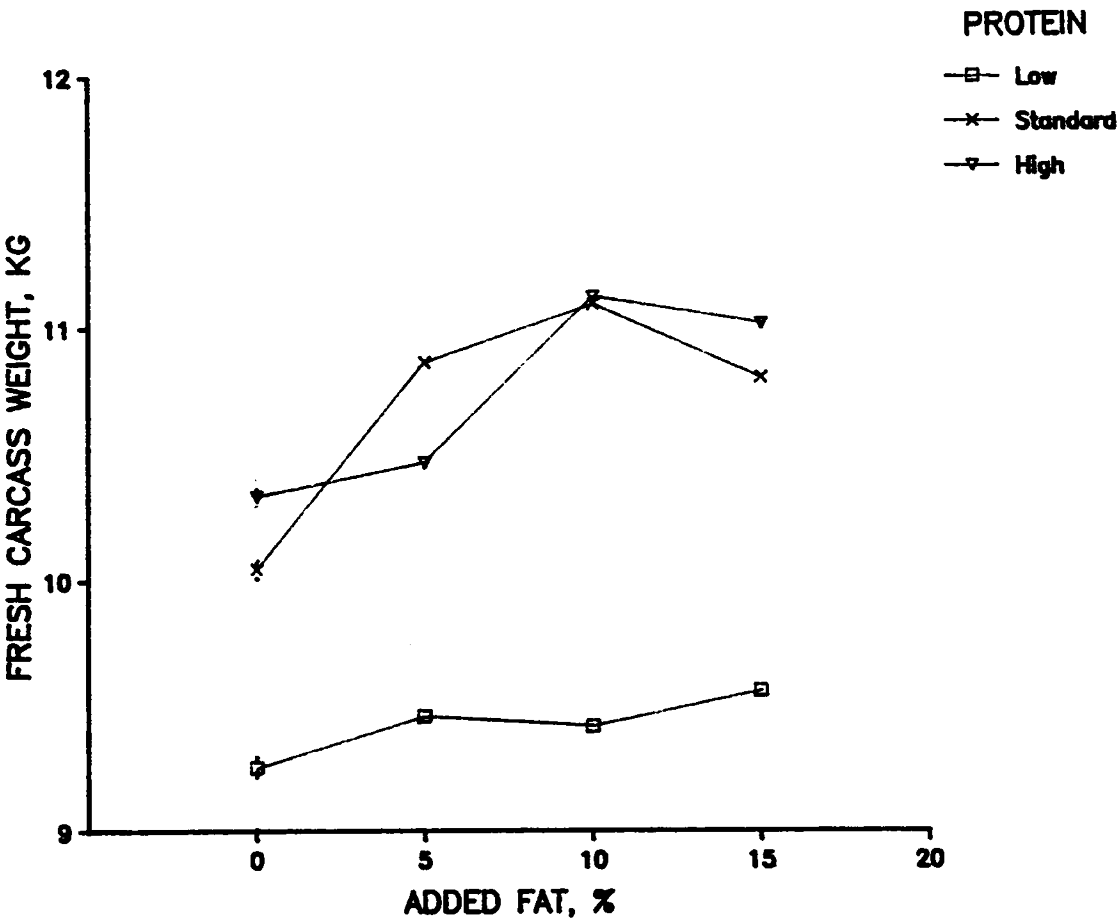

Figure 8. Effects of fat and protein on fresh carcass weight of Large White male turkeys processed at 22 weeks of age.

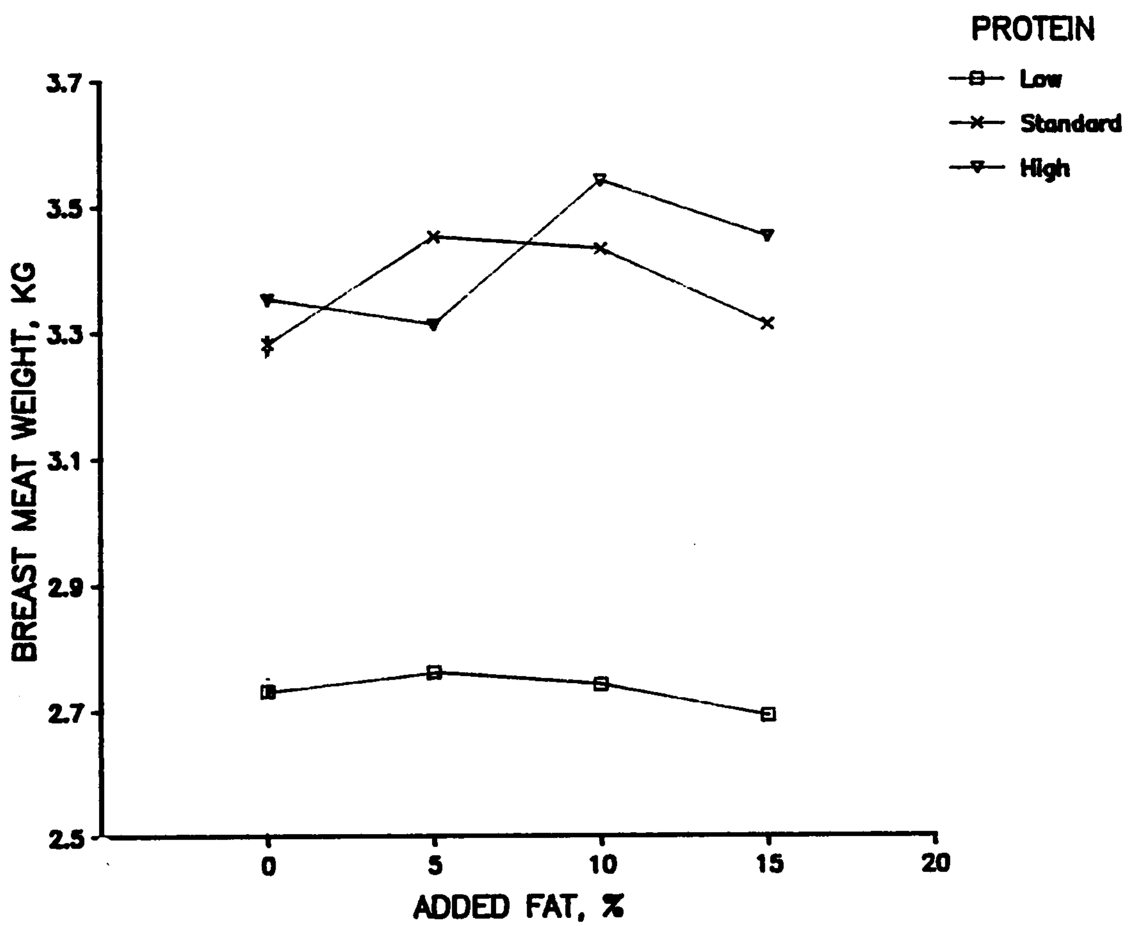

Figure 9. Effects of fat and protein on breast meat (w/o skin and bone) weight of Large White male turkeys processed at 22 weeks of age.

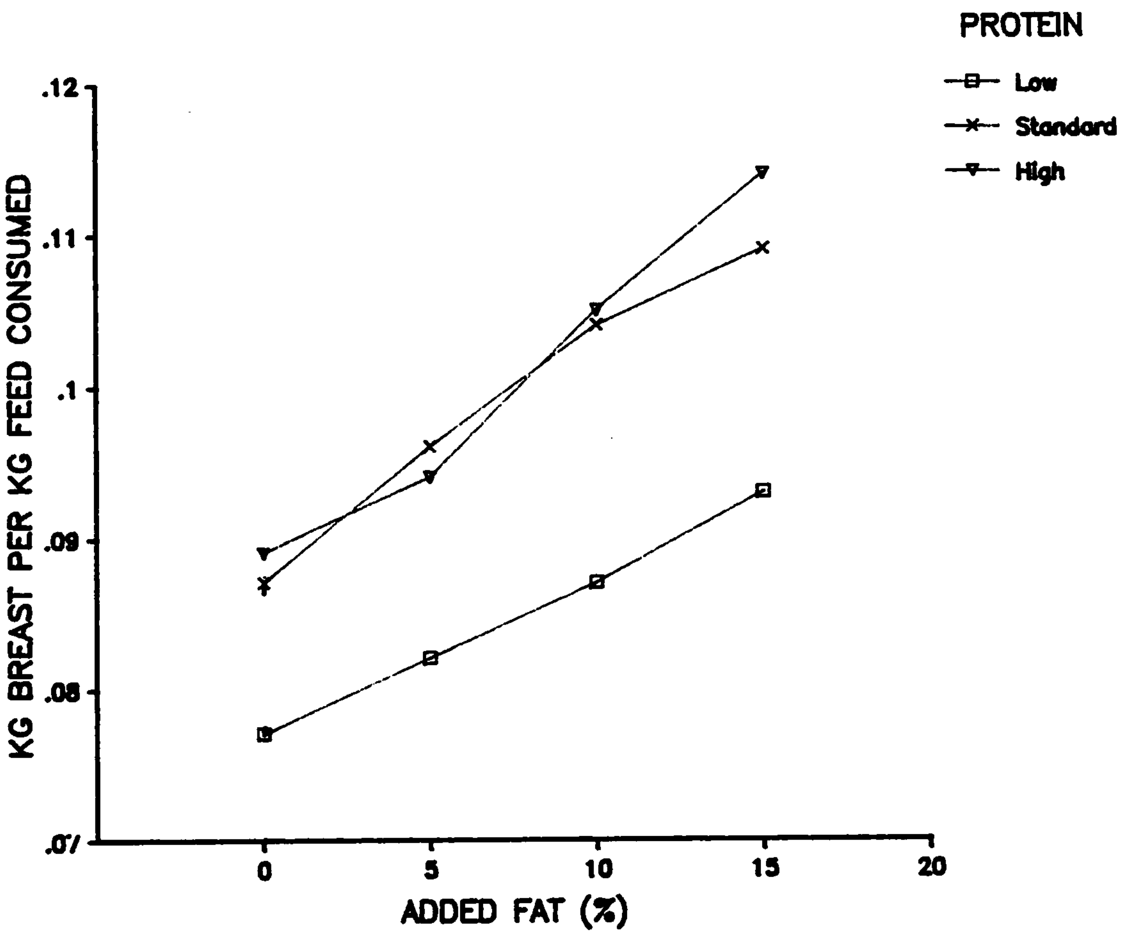

Figure 10. Plot of kg of breast yield per kg feed consumed of Large White male turkeys processed at 22 weeks of age on level of added fat by protein level.

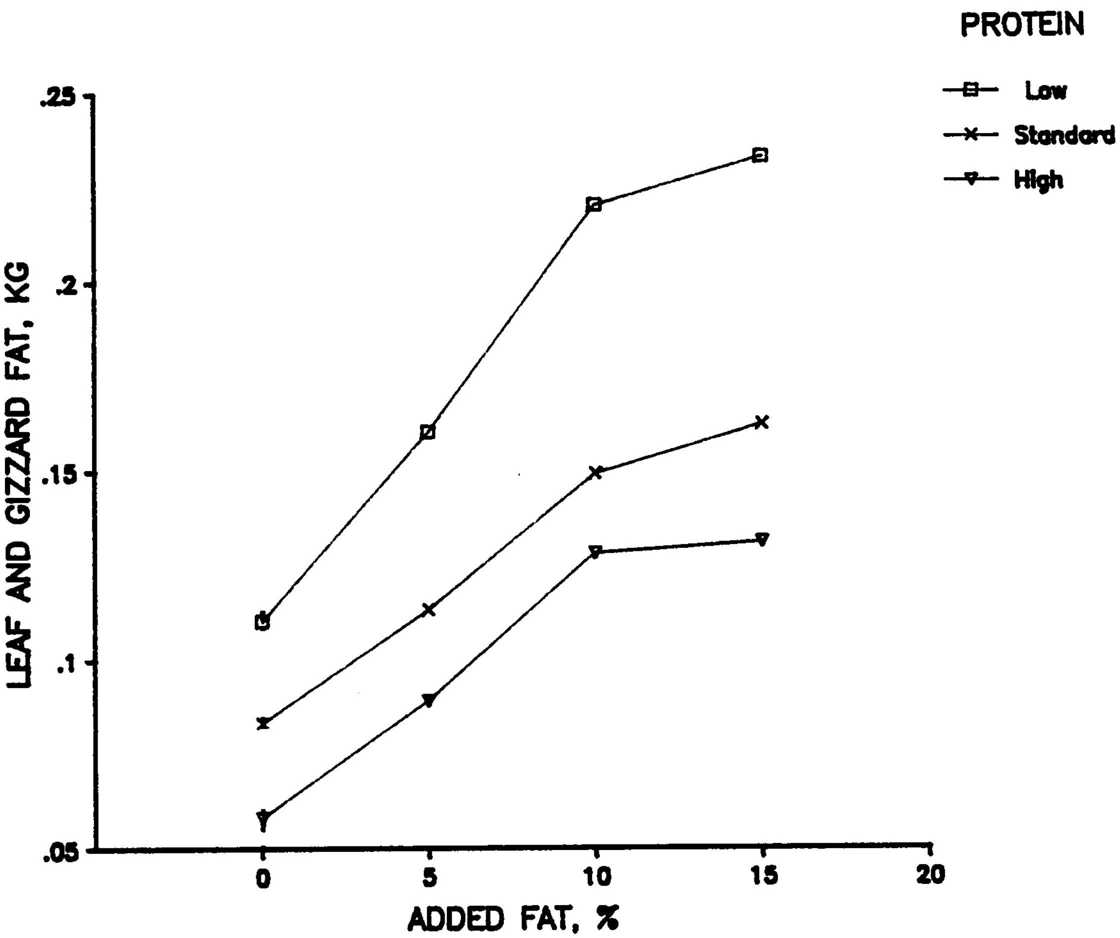

Figure 11. Effects of fat and protein on the amount of leaf and gizzard fat of Large White male turkeys processed at 22 weeks of age.

PART II. Effects of Dietary Fat, Protein, Age, Sex and Strain on the Growth and Carcass Characteristics of the Turkey

The research presented in Part IIA and IIB of this dissertation was designed to determine the quantitative effects of added dietary fat and protein on the growth performance, yield of carcass parts and fat deposition of the Nicholas Large, Jaindl Large and Jaindl Medium turkey to various ages. The more specific objectives were:

1. to compare the growth performance of the Nicholas strain with that of the Jaindl Large White and Medium White to three and four market ages for the male and female, respectively,
2. to quantitate the effects of added dietary fat and protein on the body weight gain, feed consumption and feed efficiency for each sex within each strain to the various market ages,
3. to compare the effects of age, sex, strain, added fat and protein on the carcass quality of the turkey as measured by the yield of carcass parts, the fat deposition within the abdomen and under the skin and the composition of breast meat, and
4. to evaluate the criteria used to determine the optimum market age for each strain.

PART IIA. Effects on Growth

Materials and Methods

Birds

Males and females of three strains of turkeys, Nicholas Large (N), Jaindl Large (JL) and Jaindl Medium (JM), were utilized in this study. On September 16, 1985, when the turkeys were eight weeks of age, birds within a sex and strain were randomized into six pens such that each contained 48 females or 27 males for a total of 36 pens and 1,350 birds. Each pen was 2.74 x 3.66 m and was equipped with a 1.22-m trough feeder and .76-m automatic waterer with wood shavings for litter. Management procedures included daily washing of waterers, twice a week stirring of the litter in each pen and the recording of ambient temperature in the morning and evening.

Diets

The design for Experiment 2 is presented in Table 14. The dietary variables included three levels of added fat (0, 5 or 10%) and two levels of crude protein (21 or 24%). Diets were prepared in all combinations forming a 3 x 2 factorial among dietary treatments for a total of six diets.

The composition of the basal diets for each four-week age period are presented in Table 15. All feed mixing took place under the author's supervision at Perdue Farms' research feed mill in Berlin, Maryland. The basal mixes and diets for the first two four-week periods were mixed on September 4, 1985, and the remaining basals and diets mixed on October 23, 1985. Three and four basal mixtures of identical formulation each totaling 2,184 kg and representing all constant ingredients or 80.24% of each diet were prepared for the 8 to 12 and 12 to 16-week of age periods, respectively, on the first mix date. On the second mix date, four, three and two mixtures each totaling 2,268 kg were prepared in the same manner for the 16 to 20, 20 to 24 and 24 to 28-week of age period, respectively. The individual diets without added fat for each four-week age period were prepared by blending the appropriate amounts of ground yellow corn, dehulled soybean meal and equal quantities of each basal mixture. The diets were then pelleted at an average temperature of 80°C. To assure accuracy, fat was added to the diets as required at the VPI&SU feed mill. The pelleted diet was placed in a horizontal mixer, and the 5 or 10% fat added and allowed to mix approximately five minutes to ensure pellet integrity. Each of the six diets was randomly assigned to one pen of males and one pen of females of each strain. Diets were provided in pelleted form *ad libitum* under continuous light from 8 to 20 weeks of age. Artificial light was removed at 20 weeks of age to prevent the females from coming into egg production. Natural daylight, approximately 9 hr, served as the light source from 20 to 28 weeks of age.

The protein level of the diet was decreased by 2% increments at 12, 16 and 20 weeks of age by substituting 5.34% ground yellow corn in place of 5.00% dehulled soybean meal, .30% defluorinated phosphate and .04% DL-methionine. At 24 weeks of age, the protein level was decreased 1% by substituting 2.67% ground yellow corn for 2.50% dehulled soybean meal, .15% defluorinated phosphate .02% DL-methionine. The procedures for increasing the protein level 3% within a period and the addition of 5% fat are the same as outlined in Experiment 1. The diets fed from 8 to 12, 12 to 16, 16 to 20, 20 to 24 and 24 to 28 weeks of age contained 21, 19, 17, 15 and 14% protein for the standard protein diets and 24, 22, 20, 18 and 17% protein for the high protein diets, respectively.

Marketing schedule

The marketing schedule for Experiment 2 is presented in Table 16. On November 11, 1985, when the turkeys were 16 weeks of age, one-quarter of the hens within a pen were marketed. One-third and one-half of the remaining females and males were marketed at 20 and 24 weeks of age, respectively. The final market date for the remaining birds was at 28 weeks 2 days of age (designated as 28 weeks) when the study was terminated.

Data collection and analysis

The turkeys were individually weighed to the nearest .05 kg at 8 weeks of age and biweekly thereafter with the final weighing at 28 weeks of age. Mortality was recorded daily and feed consumption was determined biweekly on a pen basis. Body weight gains, feed consumptions and feed efficiencies (gain:feed) were determined on both a cumulative and period basis for each pen of turkeys. All data were subjected to analysis of variance, and differences among treatments were determined by the Least Significant Difference method.

Results

Analysis of variance of the data showed only the main effects of strain, added fat and protein to be significant. For brevity, only the dietary effects on cumulative body weight gain, feed consumption and feed efficiency to each market age for females and males will be presented and discussed. Tables 17 through 20 contain the effects of strain, added fat and protein on the cumulative performance of females turkeys to 16, 20, 24 and 28 weeks of age, respectively. The above effects on the cumulative performance of male turkeys to 20, 24 and 28 weeks of age are presented in Tables 21 through 23, respectively. Tables 1-7 of Appendix B contain the effects of added fat and protein within strains at these same age periods for each sex. Plots of body weights on age and of body weight gains, feed consumptions and feed efficiencies on age at the end of two-week periods by strain for females and males on age are presented in Figures 12 through 15 and 16 through 19, respectively. Plots of body weight on feed consumed are presented in Figures 20 and 21 for females and males, respectively.

Effects of strain

Both sexes of the N strain had superior body weights at all ages throughout the experiment (Figures 12 and 16, respectively). At the market ages of 16, 20, 24 and 28 weeks, the N female weighed 7.53, 8.99, 9.66 and 10.35 kg, respectively. The JL female weighed 79.5, 83.3 and 85.2 and 88.1% as much as the N female at the respective ages. At the same respective ages, the JM female weighed 62.7, 64.0, 64.9 and 68.0% as much as the N female. The N male marketed at 20, 24 and 28 weeks of age weighed 14.77, 16.36 and 18.32 kg with the JL male weighing 78.3, 79.9 and 82.4% as much, respectively. The JM male weighed 60.9, 62.2 and 63.6% as much as the N male at the respective ages.

The biweekly body weight gains of the N strain after 8 weeks age were superior to those of the JL strain until the female reached 14 weeks of age and the male reached 20 weeks of age (Figures 13 and 17, respectively). By 16, 20, 24 and 28 weeks of age, the JL female had gained 83.4, 88.0, 89.9 and 93.5% and the JM female 63.3, 65.1, 66.2 and 70.2% as much as the N female, respectively. At each market age for males, the N male had gained 26.7, 23.7 and 17.9% more weight than the JL male and 64.4, 54.4 and 56.2% more weight than the JM male.

The severe decrease in body weight gain between 20 and 22 weeks of age along with the associated decrease in feed consumption and feed efficiency was due to the removal of artificial light and the initiation of natural daylight as the only light source (Figures 13-15 and 17-19). During the 20-week experiment, cumulative feed consumptions were 32.79, 26.91 and 21.32 kg for the N, JL and JM female, respectively (Table·20). The feed consumptions of the male turkeys followed a similar pattern with the N, JL and JM male consuming 64, 57 and 54% more than the female, respectively.

The JL female had a superior feed efficiency compared wit the N female to any given age from 12 to 28 weeks (Figure 15). The cumulative feed efficiencies of the JL female to 16, 20, 24 and 28 weeks of age were .4002, .3472, .2980 and .2666, respectively. Comparable values of .3565, .3069, .2638 and .2334 for the N female and .3800, .3266, .2784 and .2526 for the JM female were obtained. To any given age from 12 to 18 weeks, the JL and JM male had superior feed efficiencies to those of the N male (Figure 19). Cumulative feed efficiencies of the JL male at 20, 24 and 28 weeks of age were .3938, .3287 and .3208, respectively. These values were 4.0, 4.5 and 7.8% greater than the respective values for the N male. Cumulative feed efficiencies of the JM male were .3832, .3224 and .2951 at 20, 24 and 28 weeks of age, respectively. While the feed efficiency of the JL strain was superior to the N strain to each market age, the N strain had the superior feed efficiency to weights greater than 6 kg. Plots of body weight on cumulative feed consumed for both sexes illustrates this point (Figures 20 and 21).

Effects of dietary variables within females

Addition of 10% fat to the diet increased the body weight gain of female turkeys 3.6% to 16 weeks of age only (Table 17). Within strains, N females fed diets containing 10% added fat had gained 9.8% more weight by 16 weeks of age compared with those fed the 0% added fat diets. Addition of fat to the diets of the JL and JM female failed to significantly improve cumulative body weight gain (Tables 1-4; Appendix B). This apparent interaction of fat by strain approached significance ($P = .06$).

Addition of fat to the diet at both the 5 and 10% levels reduced feed consumption to each age. Cumulative feed consumptions to 16, 20, 24 and 28 weeks of age were decreased 5.7, 6.5, 7.3 and 7.9%, respectively, when 5% fat was added to the diet. The addition of 10% fat to the diet decreased feed consumptions 9.6, 11.0, 12.1 and 11.9% for the respective age periods. The feed consumptions of the JL and JM female were significantly decreased from 5 or 10% added fat at all ages. The feed consumption of the N female also decreased, but not significantly due to a greater variation between pens treated alike (Table 1-4; Appendix B).

The feed efficiency of female turkeys was significantly increased from each 5% increment of added fat at all age periods. For each 1% added fat, the feed efficiency of female turkeys to 16, 20, 24 and 28 weeks of age increased 1.5, 1.6, 1.5 and 1.7%, respectively. Within strains, each 5% increment of fat added to the diet increased the feed efficiency of the JL female to all ages, and feed efficiency of the N female to all ages except 28 weeks of age (Table 1-4; Appendix B).

The feeding of high protein diets improved the body weight gain of all female turkeys to 16, 24 and 28 weeks of age 3.1, 5.2 and 5.4%, respectively. The increases in body weight gain to 24 and 28 weeks of age resulted in increases in feed efficiency of 3.4 and 3.9%, respectively (Tables 17-20). The increase in body weight gain of all females to 16 weeks of age was associated with an 8.2% increase in gain for the JM female, while the increase to 24 weeks of age was associated with a 5.4% increase in gain for the JL female (Tables 1 and 3; Appendix B).

Effect of dietary variables within males

The cumulative feed consumptions of male turkeys to 20, 24 and 28 weeks of age were decreased 13.1, 13.4 and 12.5% from the addition of 10% fat to the diet, respectively (Tables 21-23). Within strains, the addition of 5 and 10% fat decreased the feed consumption of the JM male, while only 10% added fat reduced the feed consumptions of the N and JL male. Feed consumptions to 20, 24 and 28 weeks of age of the N male were decreased 10.9, 12.1 and 11.1%, respectively, when 10% fat was added to the diet. Comparable values of 12.2, 12.9 and 11.3% were observed for the JL male. Feed consumptions of the JM male to 20, 24 and 28 weeks of age were decreased 8.6, 7.0 and 6.2%, respectively, by the addition of 5% fat to the diet. Comparable values of 17.6, 16.1

and 16.2% were observed for the JM male from the addition of 10% fat to the diet (Tables 5-7; Appendix B).

The feed efficiency of male turkeys to all ages was linearly improved 1.6, 1.8 and 2.1% for each 1% added fat to the diet. To each market age, the feed efficiencies of the N and JM male were increased from 5 and 10% added fat, while that of the JL male increased only when 10% fat was added to the diet (Tables 5-7; Appendix B).

Discussion

The growth data for the JL and JM turkey presented in this dissertation are the first published information for these two strains of turkeys. Leeson and Summers (1980) have reported data on the body weight gain, carcass composition and carcass yield for the N male and female turkey up to 24 weeks of age, however this study is the first to report the growth performance of the N turkey up to 28 weeks of age.

The influence of strain had the most significant effect on the growth and feed efficiencyy of both males and females. The N male is commonly marketed at 20 and the N female at 16 weeks of age. At these respective market ages, the N male in this study weighed 28% more than the JL male while the N female weighed 26% more than the JL female. Average market weights for the N male and female were 14.77 and 7.53 kg, respectively. The JL male and female did not reach comparable weights until 27 and 20 weeks of age, respectively, or took 1.35 and 1.25 times longer to reach comparable market weights.

The growth rate of the N strain was superior to the growth rates reported in the recent literature for large-type turkeys (Leeson and Summers, 1980; Moran, 1982; Sell and Owings, 1984; Moran *et al.*, 1984; Sell *et al.*, 1985; Summers *et al.*, 1985; Sell *et al.*, 1986). Moran *et al.*, (1984) has compared the growth rates of Nicholas, British United Turkeys and Hybrid large-type male turkeys and found the British United Turkey male to be superior. The JL male used in this study weighed 90 and 82% as much as the Nicholas and Hybrid males used in the Moran *et al.* (1984) study at 20 and 24 weeks of age, respectively.

Simplistically speaking, growth is a function of feed intake and the rate at which feed is converted to body weight gain. The N strain consumed significantly more feed than the JL strain, and thus growth rate followed a similar pattern. McCarthy and Siegel (1983) noted that the increased growth rate of selected strains of chickens is mainly associated with an increased appetite or an accelerated rate of voluntary intake of food. This concept has been demonstrated in this study for the turkey. The N strain has been selected primarily for growth rate, while the JL strain has been selected primarily for breast meat yield. The greater growth rate of the N strain is clearly due to a greater voluntary food intake.

The superior feed utilization by the JL strain as compared to the N strain was not enough to offset the affect that feed consumption had on growth rate. McCarthy and Siegel (1983) noted that only a minor part of the genetic variation which is utilized in selecting for body weight gain in chickens is associated with differences in feed efficiency. While the JL strain had a superior feed efficiency to each market age, the amount of feed consumed by the JL strain to reach the heavier weights was greater than that consumed by the N strain. Chambers *et al.* (1983) has stated that a comparison of feed efficiencies between slow- and fast-maturing broiler lines should be made at a given weight rather than at a given age. Because feed efficiency decreases as the bird matures, "true" differences in feed efficiencies are not seen when comparisons are made at a given age. The data from this study have demonstrated that the N strain of large-type turkey has a superior growth performance based on the ability to reach heavier market weights at a younger age and on less feed.

The JM strain is a medium-type turkey that can be marketed as a turkey broiler at a range in weight of approximately 5 to 6 kg. The JM female had reached this weight range by the first processing date at 16 weeks of age. The males had reached 5 kg by 14 weeks of age and by 20 weeks of age weighed 9.01 kg. The market age of 16 weeks allowed for the JM females to be marketed as a turkey broiler while marketing of the JM male at 20 weeks of age results in a heavier turkey which can be used for further processing.

The effects of age and strain on growth performance after 20 weeks of age were somewhat confounded with environmental lighting. Turkeys are generally raised under continuous light to the market ages of 16 and 20 weeks of age for females and males, respectively. However, continuous lighting to 20 weeks of age resulted in the females from all strains to exhibit mating behavior in preparation for egg laying. The decision to initiate the use of natural daylight as the only source of light after 20 weeks of age resulted in a dramatic decrease in feed consumption and thus a smaller body weight gain. A specific lighting program which prevents the initiation of egg production (sexual maturity) is required if the female turkey is raised to older ages.

The addition of fat to the diet failed to consistently improve body weight gain to each market age. The body weight gain to 16 and 20 weeks of age for only the female turkeys that were fed diets containing 10% added fat was increased. The addition of each 1% fat to the diet increased the ME content of the diet by 1.6%. Therefore, the expected decrease in feed consumption was 7.4 and 13.8% and the expected improvement in feed efficiency was 8 and 16% for 5 and 10% added fat, respectively. Those turkeys fed diets containing 5 or 10% added fat decreased feed consumption approximately 6 and 12%, respectively. Hence, the greater-than-expected feed consumptions of those turkeys fed diets containing added fat resulted in an increased body weight gain and superior feed efficiey.

Because of the detrimental effects observed from the feeding of the low protein diets in Experiment 1, only the standard protein and high protein series of diets were fed in this study in order to validate comparisons between strains. The feeding of the standard protein diets allowed for maximum growth performance for each strain of turkey. The female turkey benefited from the feeding of high protein diets, as body weight gain was increased to 16, 24 and 28 weeks of age.

The lack of a consistent effect on body weight gain from fat addition to the diet appeared to be contradictory to the results reported in Experiment 1 and in the literature which show that fat supplementation stimulated body weight gain (Touchburn and Naber, 1966; Jensen *et al.*, 1970; Owen *et al.*, 1981; Sell and Owings, 1981; Owings and Sell, 1982). However, based on the design of this experiment, the number of replicates available for testing differences between dietary treatments was limited. In determining the effects of added dietary fat within a sex, 6 *vs.* 6 pens were compared. Analyses within a given sex and strain resulted in a comparison of 2 *vs.* 2 pens. In Experiment 1, the effects from added fat were determined by comparing 9 *vs.* 9 pens of the same sex and strain. In addition to a lower number of pens available for comparisons, the number of birds per pen was reduced at each market date, which resulted in an increased variation within a pen. The increased variation due to the above mentioned factors may, in part, explain the lack of consistent effect of fat on body weight gain, feed consumption and feed efficiency as noted in other studies. To more accurately assess the effect of added fat on the performance of growing JL or JM turkeys, a greater number of replicates per dietary treatment is recommended in order to increase the precision of the experiment.

Table 14. Design of Experiment 2

Strain	Protein[1]	Sex	Level of fat, % 0	5	10
			Diet number		
Nicholas Large White	Standard	M	1	3	5
		F			
	High	M	2	4	6
		F			
Jaindl Large White	Standard	M	1	3	5
		F			
	High	M	2	4	6
		F			
Jaindl Medium White	Standard	M	1	3	5
		F			
	High	M	2	4	6
		F			

[1]Diets fed from 8 to 12, 12 to 16, 16 to 20, 20 to 24 and 24 to 28 weeks of age contained 21, 19, 17, 15, and 14% protein for standard diets and 24, 22, 20, 18 and 17% protein for high diets, respectively.

Table 15. Composition of standard protein basal diets

Ingredients	Age, weeks 8-12	12-16	16-20	20-24	24-28
	-----(g/kg)-----				
Ground yellow corn	671.7	725.1	778.5	831.9	858.6
Dehulled soybean meal	247.0	197.0	147.0	97.0	72.0
Menhaden fish meal	10.0	10.0	10.0	10.0	10.0
Poultry-meat blend	40.0	40.0	40.0	40.0	40.0
Defluorinated phosphate	25.0	22.0	19.0	16.0	14.5
Iodized salt	3.5	3.5	3.5	3.5	3.5
Trace mineral mix[1]	0.5	0.5	0.5	0.5	0.5
Vitamin and feed additives[2]	.2	.2	.2	.2	.2
DL-Methionine	2.0	1.6	1.2	0.8	0.6
Flavomycin 10	.1	.1	.1	.1	.1
	1,000.0	1,000.0	1,000.0	1,000.0	1,000.0
Calculated nutrient content					
Metabolizable energy, kcal/kg	2,984	3,041	3,098	3,155	3,183
Crude protein, %	21.02	19.02	17.03	15.03	14.02
Ether extract, %	3.29	3.44	3.59	3.74	3.82
Calcium, %	1.18	1.07	.97	.86	.81
Phosphorus, total, %	.94	.87	.80	.73	.69
Phosphorus, available, %	.70	.64	.59	.53	.50
Sodium, %	.32	.30	.29	.27	.25
Potassium, %	.95	.86	.78	.69	.65
Lysine, %	1.09	.94	.80	.65	.58
Methionine, %	.56	.49	.43	.36	.32
Methionine & cystine, %	.90	.80	.71	.61	.56

[1]Supplied the following amounts of minerals in mg/kg complete diet: 80 manganese, 72.5 zinc, 37.5 iron, 10 copper, 7.5 iodine, .1 selenium and 17.5 calcium from manganese oxide and sulfate, zinc oxide, ferrous carbonate, copper sulfate, calcium iodate,sodium selenite and calcium carbonate, respectively.

[2]Supplied the following amounts of vitamins and feed additives in mg/kg complete diet unless otherwise stated: 6,614 IU vitamin A, 2,204 ICU vitamin D_3, 11 IU vitamin E, 11 μg vitamin B_{12}, 6.6 riboflavin, 44 niacin, 8.3 pantothenic acid (D), 1.7 menadione, 1.1 folic acid 1.9 pyridoxine, 1.4 thiamin, .05 biotin and .1 selenium.

Table 16. Processing schedule for Experiment 2

Date	Age, weeks	Number marketed[1] Males	Females
November 11, 1985	16	None	1/4
December 9, 1985	20	1/3	1/3
January 8, 1986	24	1/2	1/2
February 5, 1986	28, 2 days	Remainder	Remainder

[1]Portion of remaining turkeys marketed.

Table 17. Effects of strain, protein and fat on performance of female turkeys eight to sixteen weeks of age

	Body weight (kg)	Body weight gain (kg)	Feed consumption (kg)	Feed efficiency
Strain[1]				
N	7.53	4.82	13.54	.3565
JL	5.99	4.02	10.07	.4002
JM	4.72	3.05	8.05	.3800
Difference				
N over JL	1.54***	.80***	3.47***	-.0437***
N over JM	2.81***	1.77***	5.49***	-.0235**
JL over JM	1.27***	.97***	2.02***	.0202**
Protein				
High	6.13	4.02	10.68	.3810
Standard	6.04	3.90	10.43	.3767
Difference	.09	.12*	.25	.0043
Fat (%)				
0	6.00	3.90	11.12	.3532
5	6.08	3.94	10.49	.3782
10	6.16	4.04	10.05	.4051
Difference				
5 over 0	.08	.04	- .63*	.0250**
10 over 0	.16	.14*	-1.07**	.0519***
10 over 5	.08	.10	- .44	.0269**
Difference required for significance				
6 *vs*. 6 pens	.21	.13	.53	.0109
9 *vs*. 9 pens	.17	.11	.43	.0089

[1]N=Nicholas Large White, JL=Jaindl Large White and JM=Jaindl Medium White.

*P≤.05, **P≤.01, ***P≤.001.

Table 18. Effects of strain, protein and fat on performance of female turkeys eight to twenty weeks of age

	Body weight (kg)	Body weight gain (kg)	Feed consumption (kg)	Feed efficiency
Strain[1]				
N	8.99	6.27	20.49	.3069
JL	7.49	5.52	15.95	.3472
JM	5.75	4.08	12.53	.3266
Difference				
N over JL	1.50***	.75***	4.54***	-.0403***
N over JM	3.24***	2.19***	7.96***	-.0197**
JL over JM	1.74***	1.44***	3.42***	.0206**
Protein				
High	7.46	5.35	16.46	.3287
Standard	7.36	5.22	16.19	.3251
Difference	.10	.13	.27	.0036
Fat (%)				
0	7.31	5.20	17.34	.3016
5	7.43	5.30	16.21	.3283
10	7.49	5.37	15.42	.3508
Difference				
5 over 0	.12	.10	-1.13*	.0267**
10 over 0	.18	.17	-1.92**	.0492***
10 over 5	.06	.07	- .79	.0225**
Difference required for significance				
6 *vs*. 6 pens	.29	.22	.86	.0099
9 *vs*. 9 pens	.24	.18	.70	.0081

[1]N=Nicholas Large White, JL=Jaindl Large White and JM=Jaindl Medium White.

*P≤.05, **P≤.01, ***P≤.001.

Table 19. Effects of strain, protein and fat on performance of female turkeys eight to twenty-four weeks of age

	Body weight (kg)	Body weight gain (kg)	Feed consumption (kg)	Feed efficiency
Strain[1]				
N	9.66	6.95	26.38	.2638
JL	8.23	6.25	21.06	.2980
JM	6.27	4.60	16.57	.2784
Difference				
N over JL	1.43***	.70**	5.32***	-.0342***
N over JM	3.39***	2.35***	9.81***	-.0146***
JL over JM	1.96***	1.65***	4.49***	.0196***
Protein				
High	8.18	6.08	21.53	.2847
Standard	7.92	5.78	21.14	.2753
Difference	.26	.30*	.39	.0094**
Fat (%)				
0	8.05	5.95	22.81	.2619
5	8.01	5.87	21.14	.2782
10	8.09	5.97	20.06	.3000
Difference				
5 over 0	-.04	-.08	-1.67*	.0163***
10 over 0	.04	.02	-2.75**	.0381***
10 over 5	.08	.10	-1.08	.0218***
Difference required for significance				
6 *vs*. 6 pens	.35	.28	1.23	.0051
9 *vs*. 9 pens	.29	.23	1.01	.0042

[1]N=Nicholas Large White, JL=Jaindl Large White and JM=Jaindl Medium White.

*P≤.05, **P≤.01, ***P≤.001.

Table 20. Effects of strain, protein and fat on performance of female turkeys eight to twenty-eight weeks of age

	Body weight (kg)	Body weight gain (kg)	Feed consumption (kg)	Feed efficiency
Strain[1]				
N	10.35	7.64	32.79	.2334
JL	9.12	7.14	26.91	.2666
JM	7.04	5.36	21.32	.2526
Difference				
N over JL	1.23***	.50*	5.88***	-.0332***
N over JM	3.31***	2.28***	11.47***	-.0192**
JL over JM	2.08***	1.78***	5.59***	.0140*
Protein				
High	9.00	6.89	27.23	.2556
Standard	8.68	6.54	26.79	.2461
Difference	.32*	.35*	.44	.0095*
Fat (%)				
0	8.80	6.70	28.92	.2328
5	8.71	6.57	26.63	.2476
10	8.99	6.87	25.47	.2722
Difference				
5 over 0	-.09	-.13	-2.29**	.0148*
10 over 0	.19	.17	-3.45***	.0394***
10 over 5	.28	.30	-1.16*	.0246**
Difference required for significance				
6 *vs*. 6 pens	.33	.37	1.00	.0109
9 *vs*. 9 pens	.27	.30	.82	.0089

[1]N=Nicholas Large White, JL=Jaindl Large White and JM=Jaindl Medium White.

*P≤.05, **P≤.01, ***P≤.001.

Table 21. Effects of strain, protein and fat on performance of male turkeys eight to twenty weeks of age

	Body weight (kg)	Body weight gain (kg)	Feed consumption (kg)	Feed efficiency
Strain[1]				
N	14.77	11.49	30.45	.3785
JL	11.56	9.07	23.09	.3938
JM	9.00	6.99	18.32	.3832
Difference				
N over JL	3.21***	2.42***	7.36***	-.0153*
N over JM	5.77***	4.50***	12.13***	-.0047
JL over JM	2.56***	2.08***	4.77***	.0106
Protein				
High	11.94	9.33	24.30	.3866
Standard	11.62	9.03	23.61	.3838
Difference	.32	.30	.69	.0028
Fat (%)				
0	11.66	9.06	25.44	.3571
5	11.92	9.30	24.31	.3828
10	11.75	9.18	22.11	.4157
Difference				
5 over 0	.26	.24	-1.13	.0257**
10 over 0	.09	.12	-3.33**	.0586***
10 over 5	-.17	-.12	-2.20**	.0329**
Difference required for significance				
6 *vs*. 6 pens	.52	.52	1.18	.0131
9 *vs*. 9 pens	.42	.42	.97	.0107

[1]N=Nicholas Large White, JL=Jaindl Large White and JM=Jaindl Medium White.

*P≤.05, **P≤.01, ***P≤.001.

Table 22. Effects of strain, protein and fat on performance of male turkeys eight to twenty-four weeks of age

	Body weight (kg)	Body weight gain (kg)	Feed consumption (kg)	Feed efficiency
Strain[1]				
N	16.36	13.08	41.73	.3146
JL	13.07	10.57	32.28	.3287
JM	10.17	8.15	25.41	.3224
Difference				
N over JL	3.29***	2.51***	9.45***	-.0141*
N over JM	6.19***	4.43***	16.32***	-.0078
JL over JM	2.90***	2.42***	6.87***	.0063
Protein				
High	13.47	10.86	33.75	.3243
Standard	12.93	10.34	32.53	.3195
Difference	.54*	.52	1.22	.0048
Fat (%)				
0	13.08	10.48	35.36	.2975
5	13.22	10.60	33.44	.3174
10	13.30	10.72	30.62	.3509
Difference				
5 over 0	.14	.12	-1.92	.0199**
10 over 0	.22	.24	-4.74***	.0534***
10 over 5	.08	.12	-2.82*	.0335**
Difference required for significance				
6 *vs*. 6 pens	.64	.65	2.02	.0131
9 *vs*. 9 pens	.52	.54	1.66	.0107

[1]N=Nicholas Large White, JL=Jaindl Large White and JM=Jaindl Medium White.

*P≤.05, **P≤.01, ***P≤.001.

Table 23. Effects of strain, protein and fat on performance of male turkeys eight to twenty-eight weeks of age

	Body weight (kg)	Body weight gain (kg)	Feed consumption (kg)	Feed efficiency
Strain[1]				
N	18.32	15.04	53.73	.2810
JL	15.10	12.76	42.27	.3028
JM	11.65	9.63	32.88	.2951
Difference				
N over JL	3.22***	2.28***	11.46***	-.0218*
N over JM	6.67***	5.41***	20.85***	-.0141
JL over JM	3.45***	3.13***	9.39***	.0077
Protein				
High	15.24	12.74	43.85	.2935
Standard	14.81	12.22	42.08	.2924
Difference	.43	.52	1.77	.0011
Fat (%)				
0	14.74	12.14	45.63	.2666
5	14.96	12.49	43.33	.2890
10	15.38	12.80	39.92	.3233
Difference				
5 over 0	.22	.35	-2.30	.0224*
10 over 0	.64	.66	-5.71**	.0567**
10 over 5	.42	.31	-3.41*	.0343**
Difference required for significance				
6 *vs*. 6 pens	.87	.69	2.73	.0199
9 *vs*. 9 pens	.71	.56	2.23	.0162

[1]N=Nicholas Large White, JL=Jaindl Large White and JM=Jaindl Medium White.

*P≤.05, **P≤.01, ***P≤.001.

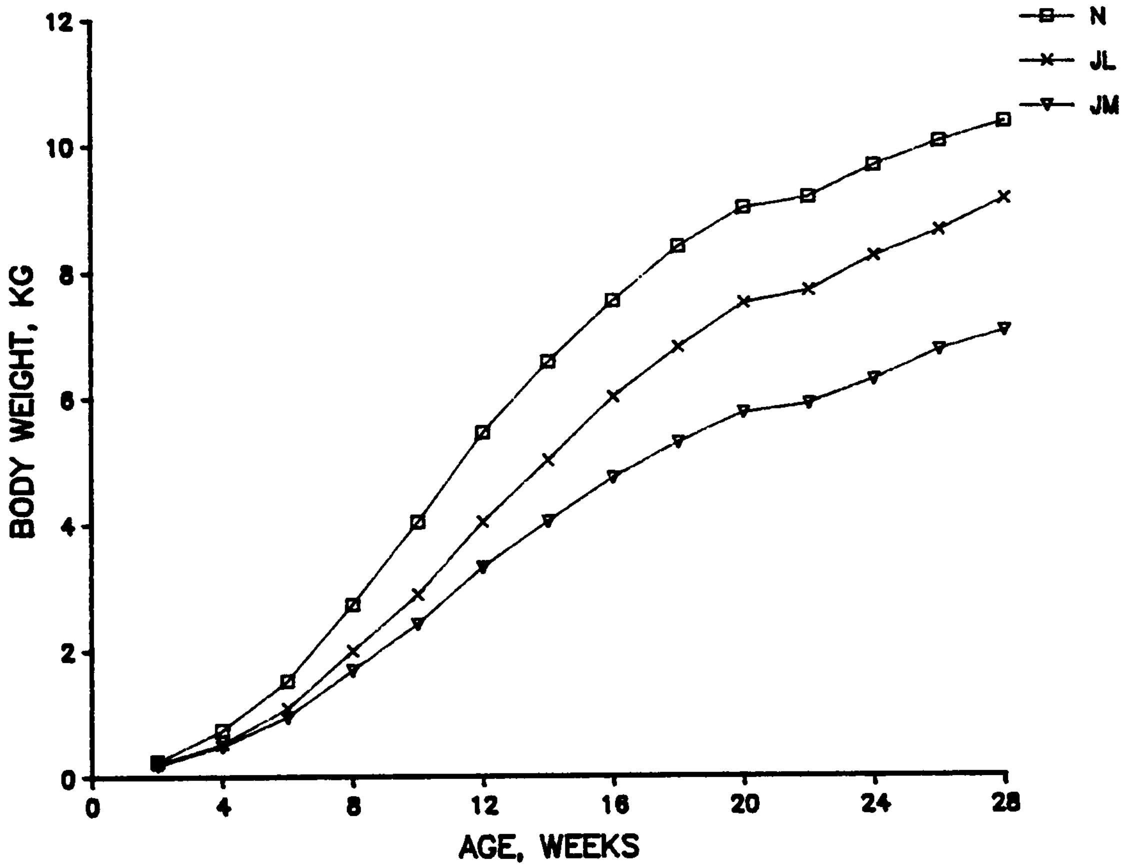

Figure 12. Average biweekly body weights of three strains of female turkeys from 8 to 28 weeks of age.

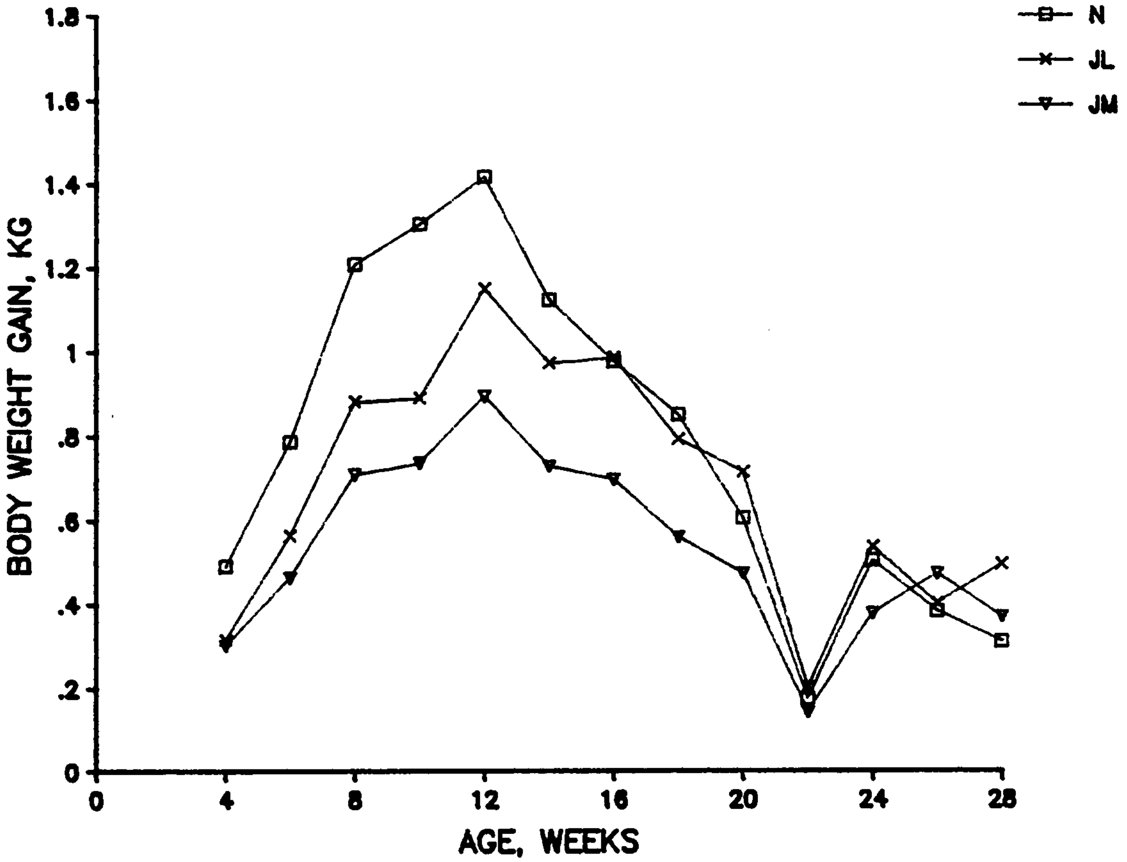

Figure 13. Average biweekly body weight gains of three strains of female turkeys from 8 to 28 weeks of age.

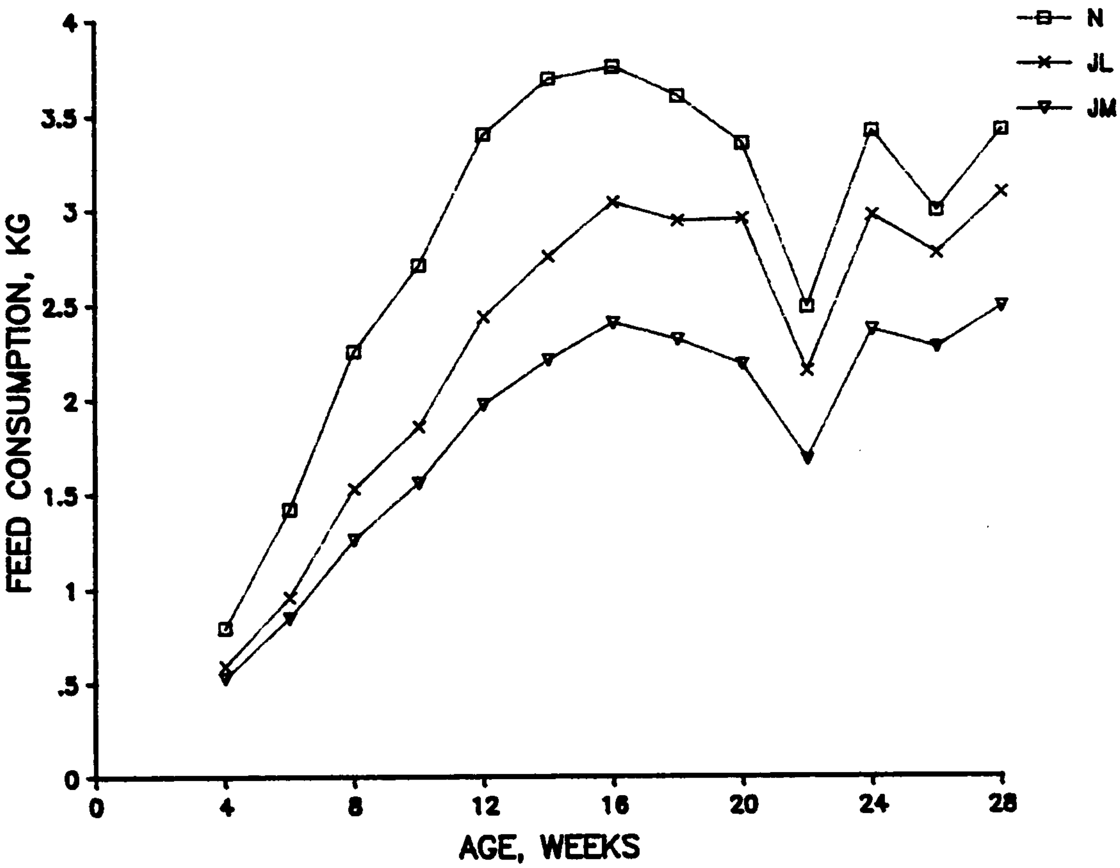

Figure 14. Average biweekly feed consumptions of three strains of female turkeys from 8 to 28 weeks of age.

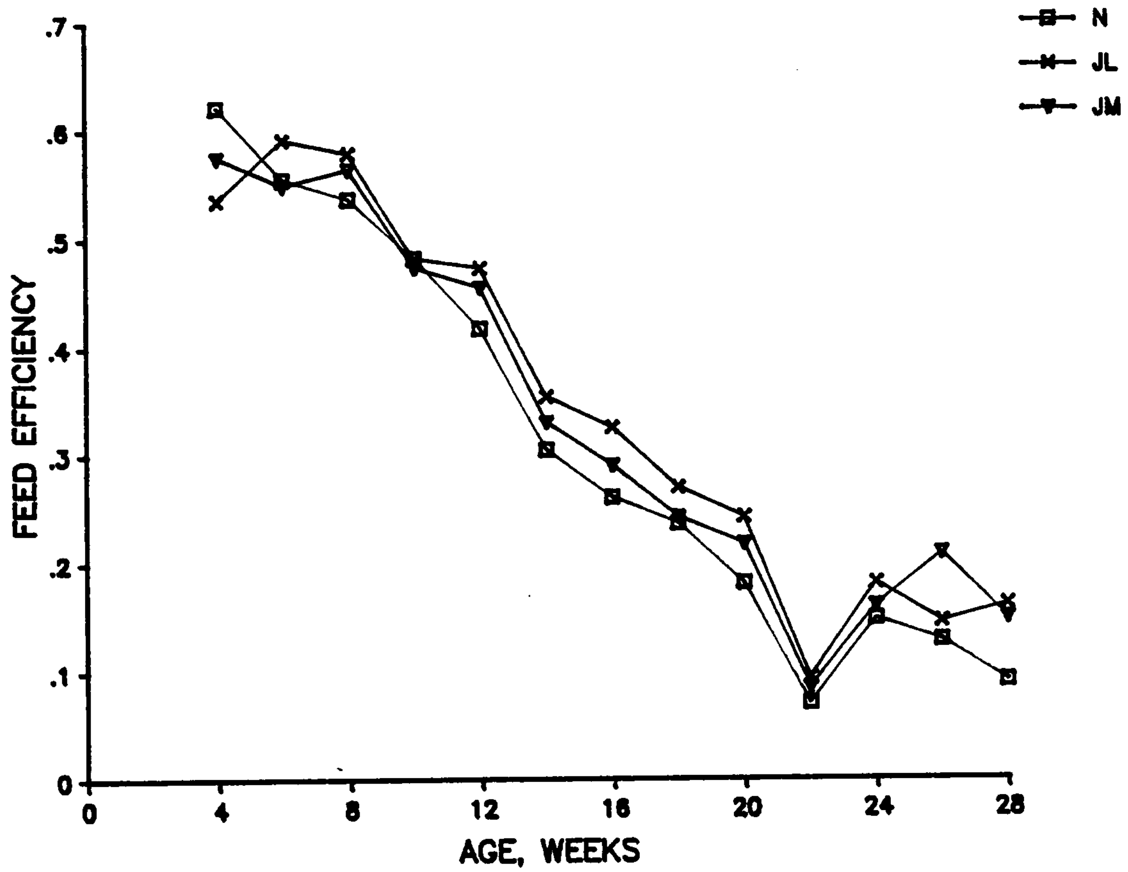

Figure 15. Average biweekly feed efficiencies of three strains of female turkeys from 8 to 28 weeks of age.

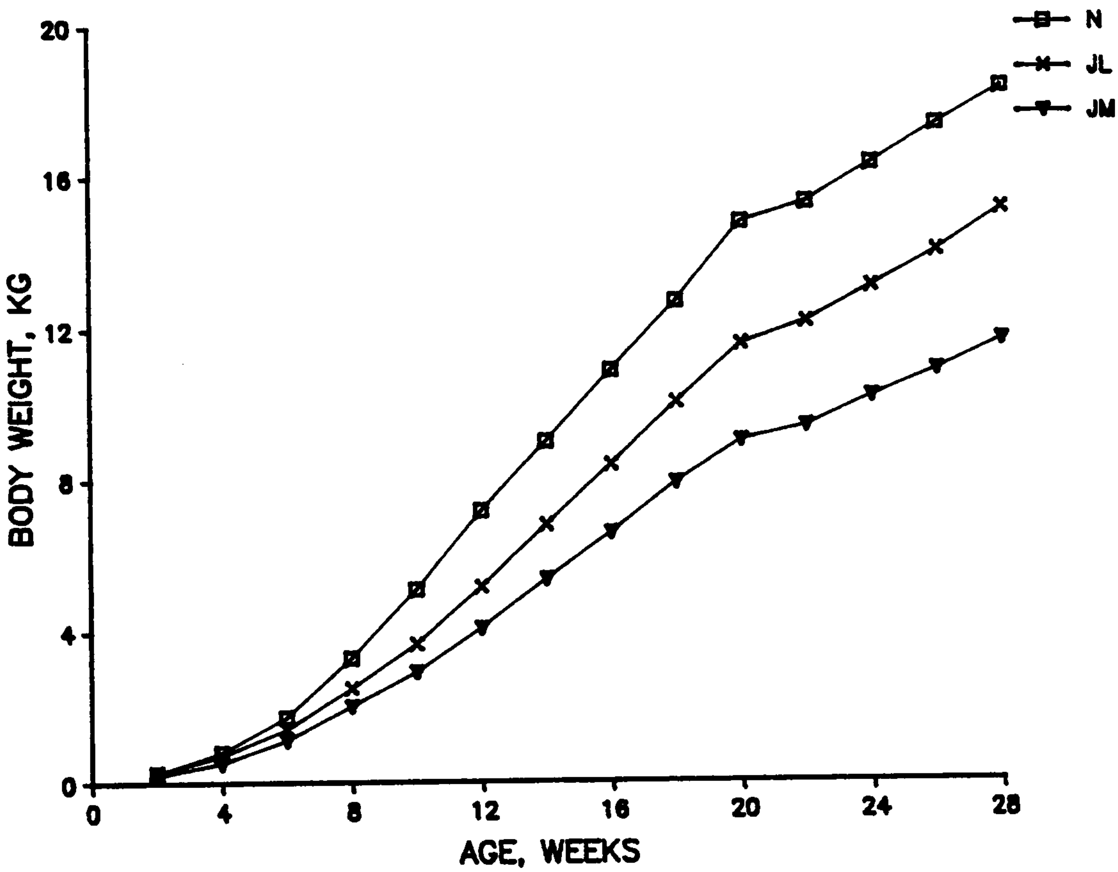

Figure 16. Average biweekly body weights of three strains of male turkeys from 8 to 28 weeks of age.

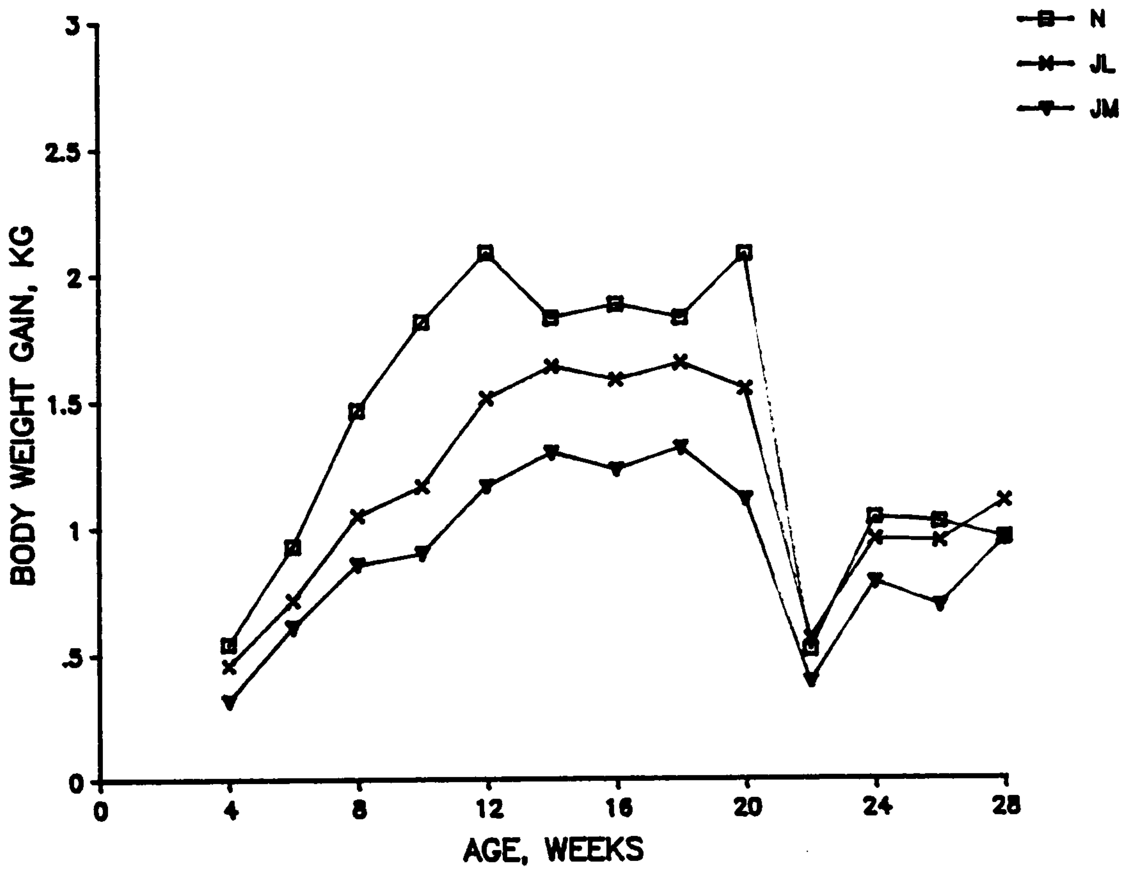

Figure 17. Average biweekly body weight gains of three strains of male turkeys from 8 to 28 weeks of age.

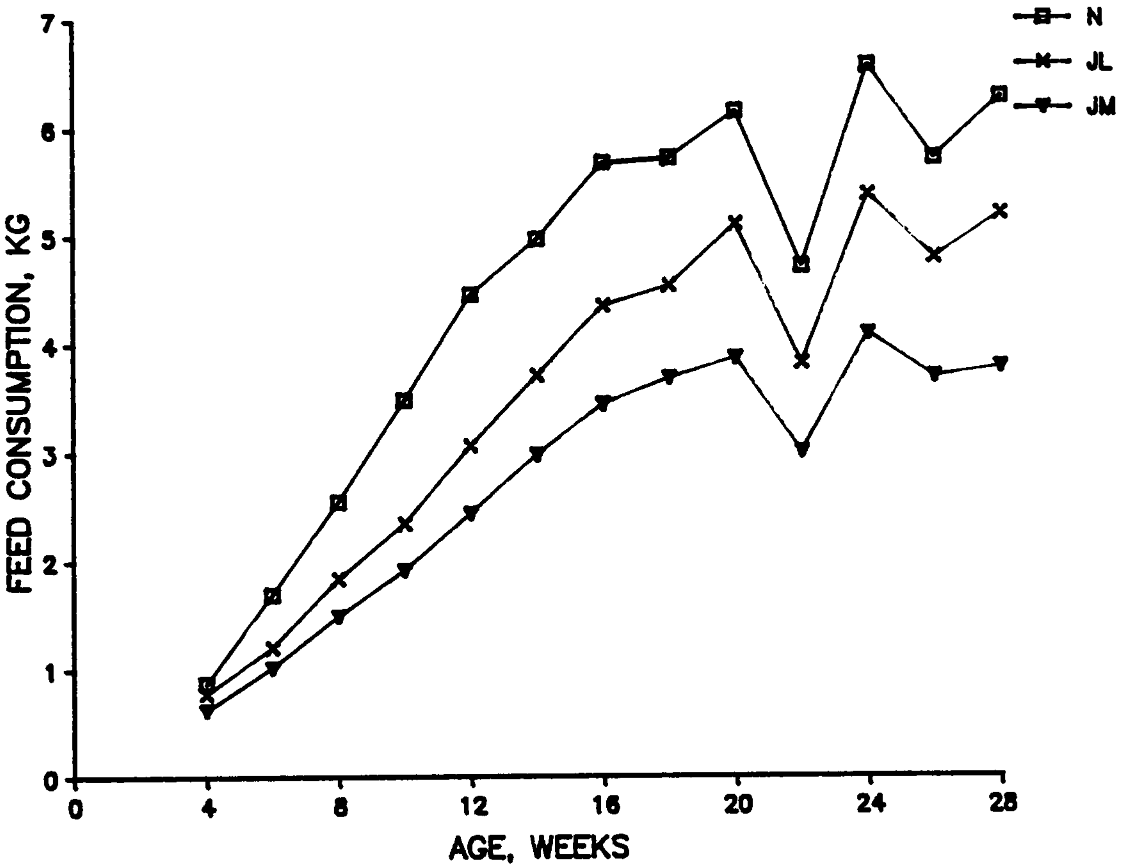

Figure 18. Average biweekly feed consumptions of three strains of male turkeys from 8 to 28 weeks of age.

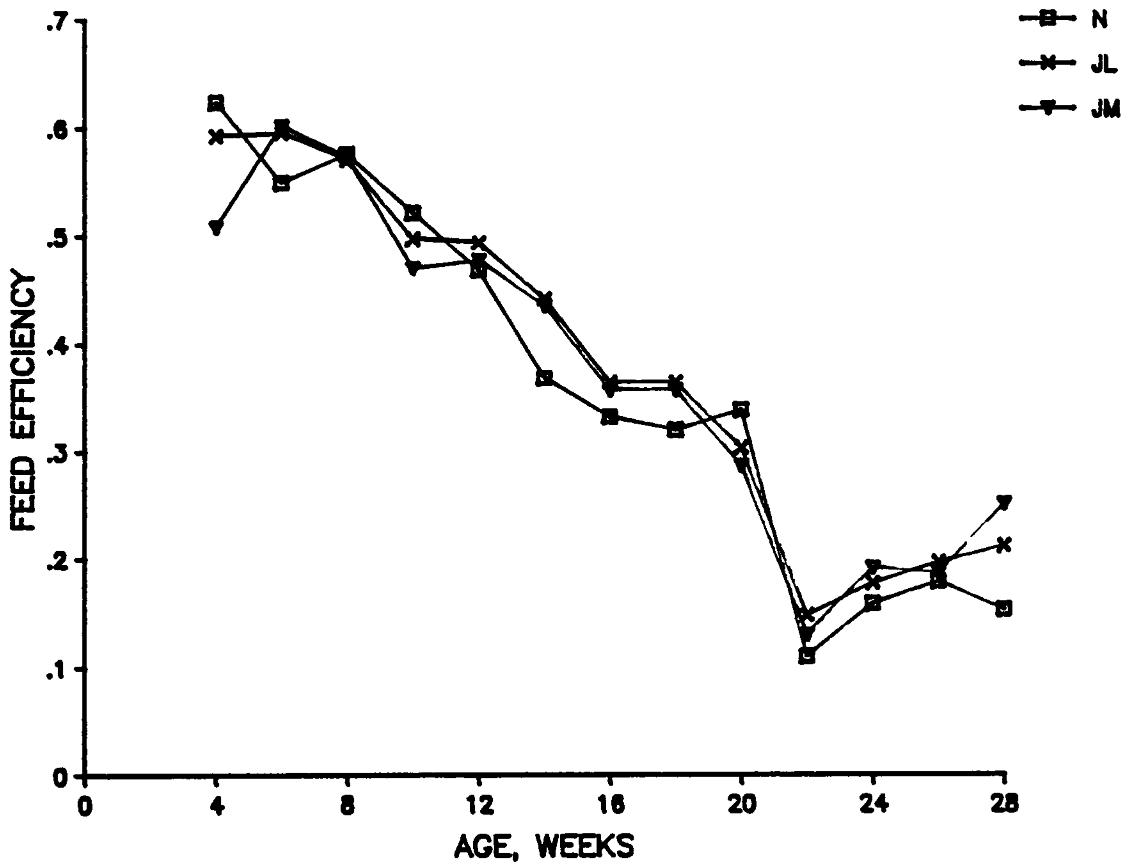

Figure 19. Average biweekly feed efficiencies of three strains of male turkeys from 8 to 28 weeks of age.

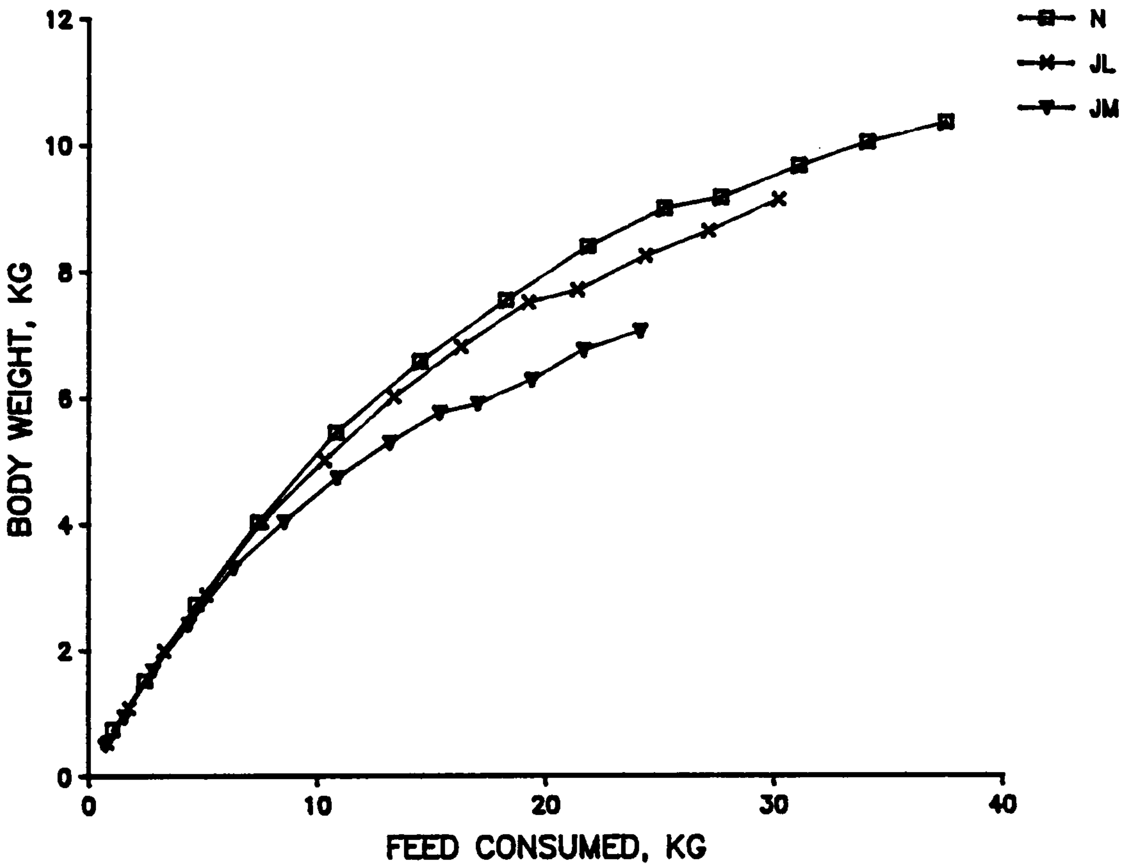

Figure 20. Plot of body weight on amount of feed consumed for three strains of female turkeys from 8 to 28 weeks of age.

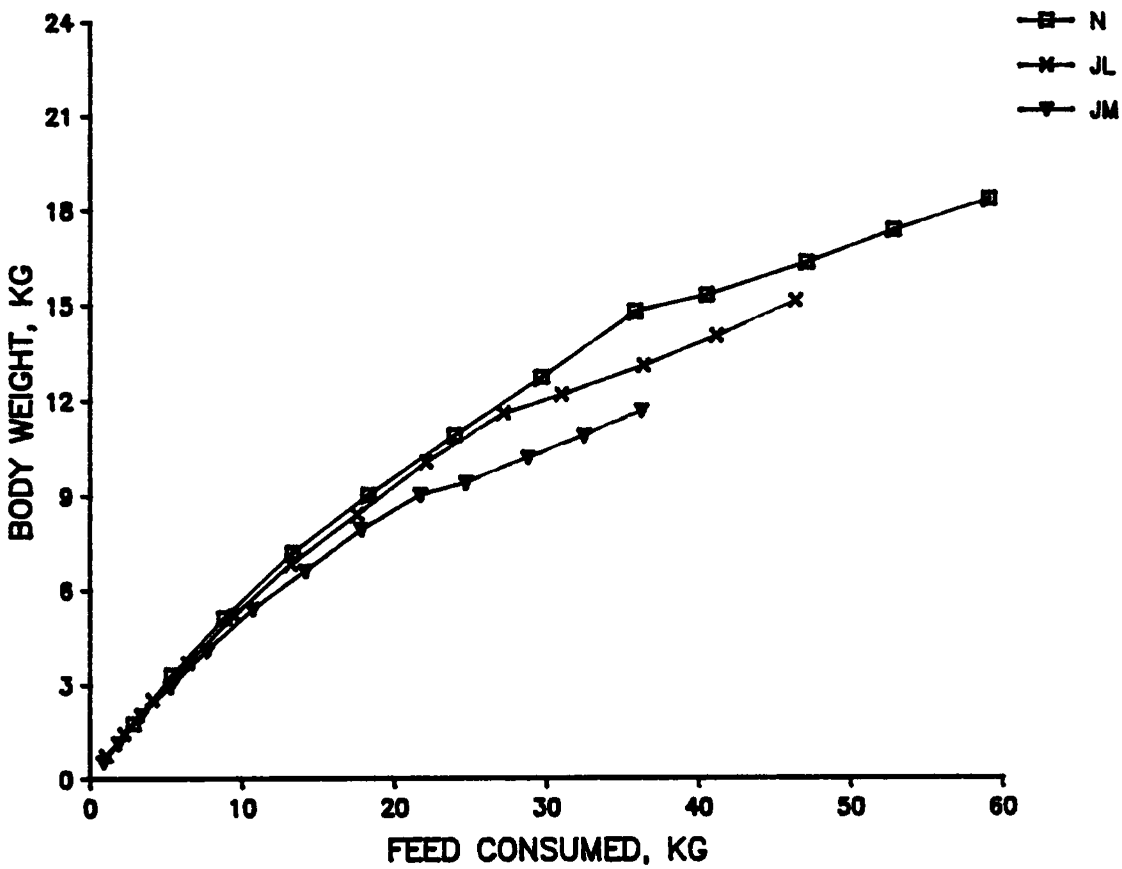

Figure 21. Plot of body weight on amount of feed consumed for three strains of male turkeys from 8 to 28 weeks of age.

PART IIB. EFFECTS ON CARCASS CHARACTERISTICS

Materials and Methods

The marketing schedule for Experiment 2 is presented in Table 16. On November 11, one-quarter of the female turkeys were transported to Washington, Indiana (500 miles) for processing. At approximately 16:00 hr the next day, the turkeys in 18 groups were placed on the shackles by diet and strain. The N strain was processed first followed by the JL then JM strains. A similar procedure was followed on the next three processing dates, with males being processed before females.

After defeathering, a count of the number of turkeys in each group was taken at the transfer point to the evisceration line to assure accuracy of further data collection. On the evisceration line, the gizzards with associated fat and necks were collected, counted and weighed for each group. The fat was then removed from the gizzards of each group and weighed. The leaf fat was removed from each carcass and individually weighed.

After proceeding through the evisceration line, carcasses were placed into tanks without ice, by strain at 16 weeks of age and randomly at 20, 24 and 28 weeks of age. Carcasses, as identified by band number, were individually weighed after the leaf fat was removed. Each carcass was then cut into parts consisting of the wings, drumsticks, thighs, back, breast skin, breast meat and breast bone, and the parts weighed.

Analyses of breast meat

At 20, 24 and 28 weeks of age, one-half of the breast meat was secured from a single turkey of each sex of the N and JL strains for each dietary treatment. The breast meat was identified and frozen for subsequent analysis. Preparation of samples for analysis involved the double-grinding of the breast-half for a total of two minutes in a Hobart 8142 chopper. A 400 g representative sample of each breast was stored in air-tight canning jars. Moisture was determined by drying duplicate samples in a convection oven at 90^0 C for 24 hr. After moisture analysis, the same dried samples were ground by hand using a mortar and pestle, redried and petroleum ether extracted to determine lipid content. Protein values were determined in duplicate from a separate sample on a wet basis from Kjeldahl nitrogen.

Statistical analysis

The data for each turkey identified by band number and by age were entered into a computer file and checked for accuracy. Information from any turkey whose sum of parts did not add up within 5% of its respective carcass weight was considered unreliable and was removed from the data base. The parts of the turkeys were expressed as a percent of live weight, as a percent of carcass weight or as a percent of the breast. All data were subjected to analysis of variance. The independent variables of interest were age, sex, strain, level of added fat and protein level. Differences among treatment means were determined by the Least Significant Difference method.

Results

For the purpose of this dissertation, only the data from those turkeys processed at 20, 24 and 28 weeks of age are presented and discussed. The 16-week data for the females, however, is illustrated in graphs. The main effects of age, sex, strain, fat and protein on the carcass components of all turkeys processed at 20, 24 and 28 weeks of age are presented in Tables 24 through 28, respectively. Only the significant effects on the carcass components of most importance will be presented and discussed. Table 1 of Appendix C contains the analysis of variance with the first-order interactions for each of the important carcass components. The data for the significant interactions are presented in Tables 2 through 8 of Appendix C.

<u>Fresh carcass (without neck, leaf fat, and giblets) yield as percent of live weight</u>

Figure 22 contains the plot of fresh carcass yield on live weight by strain, sex and age. Fresh carcass yield increased with age of the turkey (Table 24). From 20 to 24 weeks of age, fresh carcass yield increased 2.30% with an additional increase of .87% at 28 weeks of age. These values represent changes of 3.0 and 1.1%, respectively. The fresh carcass yield of all females was .99% greater than that of males, or a change of 1.3% (Table 25).

Average fresh carcass yields of the N, JL and JM strains were 77.79, 78.67 and 77.67%, respectively (Table 26). The JL strain had a greater fresh carcass yield than either that of the N or JM strain. At 20 weeks of age, the fresh carcass yield of the N strain (76.30%) was similar to that of the JL strain (76.57%) and greater than that of the JM strain (75.79%)(Table 3; Appendix C).

The effects of fat and protein by strain of turkey on fresh carcass yield are illustrated in Figure 23. Addition of 10% fat to the diet decreased fresh carcass yield .41% or a change of .52% (Table 27). The feeding of high protein diets resulted in an increase in fresh carcass yield of .25% or a change of .32% (Table 28).

Wing yield as percent of fresh carcass weight

Wing yield plotted on fresh carcass weight by age, sex and strain is presented in Figure 24. For all turkeys, wing yield decreased .42% and .23% between 20 and 24 and between 24 and 28 weeks of age, respectively (Table 24). The males had a greater wing yield (.37%) than females at 20 weeks of age yet at 28 weeks of age the females yielded .37% more wing, as the wing yield of males decreased .35% between 24 and 28 weeks of age (Table 2; Appendix C). The wing yield of only the JM increased (.33%) between 24 and 28 weeks of age (Table 3; Appendix C).

The amount of wing yield differed between strains of turkey (Table 26). The JM strain had the greatest wing yield (12.12%) while the JL strain yielded more wing (11.80%) than the N strain(10.98%). The difference in wing yield between the JM and JL strain had diminished by 28 weeks of age (Figure 25). Differences in wing yields between sexes within strains occurred. The JL male yielded .27% more wing than the JL female, and the N male yielded .53% more wing than the N female (Table 4; Appendix C). A plot of wing yield on level of added fat by protein and strain is presented in Figure 25. The wing yield of all turkeys was decreased .15% from the addition of 10% fat to the diet (Table 27). The decrease in wing from added fat was associated primarily with the N strain, as 5 and 10% fat supplementation decreased wing yield .30 and .48%, respectively (Table 7; Appendix C). Those turkeys fed high protein diets yielded .11% less wing as compared with those fed standard protein diets (Table 28).

Drumsticks yield as percent fresh carcass weight

The effects of age, sex and strain on drumstick yield are illustrated in Figure 26. Drumstick yield for all turkeys decreased at each market age (Table 24). Drumstick yield decreased .19 and .59% between 20 and 24 and between 24 and 28 weeks of age, respectively. These values represent a change in drumstick yield of 1.5 and 4.9%.

Comparison of the sexes show that males yielded .37% more drumstick than females (Table 25). Within strains, the N and JM male yielded .61 and .36% more drumstick than the N and JM female, respectively (Table 4; Appendix C). Among strains, the JL strain yielded .34 and .40% more drumstick than the N and JM strains, respectively (Table 26).

Drumstick yield as affected by fat, protein and strain is shown in Figure 27. Addition of 10% fat resulted in a .20% greater yield of drumstick (Table 27). Those turkeys fed high protein diets yielded .15% less drumstick as compared with those fed standard protein diets (Table 28). This effect was associated with JL and JM strains, as those fed high protein diets yielded .32 and .24% less drumstick as compared to those fed standard protein diets, respectively (Table 8; Appendix C).

Thigh yield as percent of fresh carcass weight

A plot of thigh yield *versus* fresh carcass weight by age, sex and strain is presented in Figure 28. Thigh yield decreased .64% between 24 and 28 weeks of age (Table 24). Males yielded .46% more thigh than females (Table 25). The JL strain had .25 and .32% greater thigh yield than the N and JM strains, respectively (Table 26).

Those males fed diets containing 5 and 10% added fat yielded .81 and .35% more thigh than females fed the same diets, respectively (Table 5; Appendix C). Feeding high protein diets to the JM resulted in a decrease of .49% in thigh yield (Table 8; Appendix C).

Breast meat (without skin and bone) yield as percent fresh carcass weight

The effects of age, sex and strain on breast meat yield are graphically presented in Figure 29. Of the various parameters, breast meat yield was influenced the most by the variables under study. For all turkeys, breast meat yield increased between 20 and 24 weeks of age (Table 24). Breast meat yields were 31.86, 34.11 and 34.20% at 20, 24 and 28 weeks of age, respectively. Breast meat yield increased 2.25% at 24 weeks as compared to 20 weeks of age, or a change of 7.1%. Between 24 and 28 weeks of age, the breast meat yield of the JL strain increased .58% (Table 3; Appendix C).

The females had a greater breast meat yield than the males (Table 25). The average breast meat yield for all females was 1.57% greater than that for all males, a change of 4.8%. Of the three strains of turkeys, the JM strain had the greatest breast meat yield (34.55%), 2.82 and .65% greater than the N and JL strains, respectively (Table 26). The JL strain yielded 2.17% more breast meat than the N. The differences in breast meat yield between the female and male of the JL and JM strains were 1.92 and 1.98%, respectively, in contrast to a .80% difference of the N strain (Table 4; Appendix C).

Breast meat yield plotted on the level of added fat is presented in Figure 30. Addition of 5 and 10% fat to the diet decreased the breast meat yield of all turkeys .36 and .65%, respectively (Table 27). Increasing the protein content of the diet 3% increased breast meat yield .47%, a change of 1.4%. The increase in breast meat yield from feeding high protein diets was associated with the JL, as those fed high protein diets had a 1.28% greater breast meat yield as compared to those fed standard protein diets (Table 8; Appendix C).

Breast skin yield as percent of fresh carcass weight

Breast skin yield plotted on fresh carcass weight by age, sex and strain is shown in Figure 33. The breast skin yield of all turkeys decreased .66% between 20 and 24 weeks of age and increased .20% between 24 and 28 weeks of age, yet the breast skin yield at 28 weeks of age was .46% less than that at 20 weeks of age (Table 24). The breast skin yield of males was .43% greater than females (Table 25). Males yielded .39 and .75% more breast skin than females between 20 and 24 and between 24 and 28 weeks of age, respectively (Table 2; Appendix C). The male of the N and JM strains yielded .84 and .33% more breast skin than the female, respectively (Table 4; Appendix C).

Among strains, the N yielded 2.04 and 1.89% more breast skin than the JL and JM, respectively (Table 26). A plot of breast skin yield on level of added fat by protein and strain is presented in Figure 34. Addition of 10% fat to the diet significantly increased the breast skin yield of all turkeys .22% (Table 27). Males fed standard protein diets yielded .21% more breast skin than those fed high protein diets (Table 6; Appendix C).

Leaf fat deposition as percent fresh carcass weight

The amount of leaf fat deposited expressed as a percentage of fresh carcass weight at each age and for each sex and strain plotted against fresh carcass weight is presented in Figure 35. The amount of leaf fat deposited by all turkeys decreased at 24 weeks of age and increased at 28 weeks of age (Table 24). The decrease in leaf fat deposition along with breast skin yield at 20 weeks of age is attributed to the decrease in feed consumption when the lighting was changed at at 20 weeks of age. Leaf fat deposition by the females was .087% greater than that by the males at 20 weeks of age (Table 2; Appendix C).

Strain had the most dramatic effect on leaf fat deposition. The N strain deposited 4.4 and 6.1 times more leaf fat per unit of fresh carcass weight than the JL and JM strains, respectively, (Table 26). Between 20 and 28 weeks of age, the leaf fat deposition of the N strain increased 80.0% (Table 3; Appendix C). The female of the N strain deposited 13.2% more leaf fat than the male (Table 4; Appendix C).

Figure 36 contains the plot of leaf fat deposition on level of added fat by protein and strain. Addition of 5 and 10% fat to the diet increased leaf fat deposition 25.9 and 45.3% over diets containing 0% added fat, respectively (Table 27). This effect was associated solely with the N strain, as 5 and 10% added fat increased leaf fat deposition 26.4 and 47.9% over 0% added fat, respectively (Table 7; Appendix C). Males fed high protein diets deposited 21.2% less leaf fat per unit of fresh carcass weight than females (Table 6; Appendix C).

Breast meat composition

The effects of age, sex and strain on the breast meat composition of the N and JL strains are presented in Table 29. Deposition of lipid within the breast meat increased with age. The lipid content of breast meat was 1.44, 1.69 and 2.19% at 20, 24 and 28 weeks of age, respectively. The difference in lipid content at 28 compared to 20 weeks of age was associated with a decrease in protein of .32%. The females deposited .31% more protein and .50% less moisture within the breast meat than the males. The strain of turkey had the greatest effect on breast meat composition. The JL strain deposited .72% more protein, 1.05% less lipid and .33% less moisture within the breast meat as compared to the N strain.

Table 30 contains the effects of added fat and protein on breast composition. A similar pattern of effects was observed to that for carcass yield; i.e., dietary effects were minor relative to age, sex and strain effects. Addition of 10% fat resulted in a .25% decrease in the protein content of the breast meat.

Discussion

Of the independent variables under study in Experiment 2, the age, sex and strain of turkey had a much greater influence on the yield of carcass parts and on the deposition of fat than did the fat or protein content of the diet. Fresh carcass yield increased with age for all three strains of turkeys, agreeing with other reports dealing with the effect of age on the carcass yield of turkeys (Salmon, 1974; Leeson and Summers, 1980; Moran, 1982; Salmon, 1983; Moran *et al.*, 1984). Breast yield as percent fresh carcass weight increased with age at the expense of wing, drumstick and thigh yield. These results are in agreement with findings by other researchers for both large-type (Salmon, 1974; Leeson and Summers, 1980; Moran *et al.*, 1984) and small-type (Salmon, 1983) turkeys. Increase of breast size (meat, bone and skin) with age was expected, as breast conformation and size is one of the primary selection criteria in genetic selection programs for turkeys.

The age at which the male or female turkey is marketed is dependent on a variety of factors. Growing and processing costs and consumer demand for the final products all contribute to the decision. The common market ages for the female and male large-type turkey are 16 and 20 weeks of age, respectively. However, results from this study show that the growth potential of the turkey at these ages has not been fully realized. From 16 to 24 weeks of age, the fresh carcass and breast meat yields of the N and JL females increased 4.0 and 4.2%, respectively. The fresh carcass and breast meat yield of the N and JL males increased 3.0 and 1.9% from 20 to 24 weeks of age, respectively. By marketing the female at 16 instead of 24 weeks of age and the male at 20 instead of 24 weeks of age, maximum yields of are not realized. While the concept of more yield equals more profit is not necessarily true, consideration should be given to the marketing of turkeys at older ages to take advantage of the meat-producing capability of the turkey and for maximum profit.

Comparison of the strains revealed that the JL and JM strain produced a carcass with a greater percentage yield of lean carcass parts and a minimum amount of fat deposition as compared with the N turkey. A model for live weight gain for poultry has been presented and discussed by Soller and Eitan (1984), and aids in explaining the results observed in this study. According to the model, gain is a function of the amount of intake energy over maintenance, with growth being partitioned towards lean or fat deposition. Excess energy intake (appetite) over maintenance results in increased fat deposition at the expense of lean. Hood and Pym (1982) have reported data that support this model, as broilers selected for increased appetite (energy intake) deposited excessive fat in comparison to broilers selected for rapid growth rate or feed conversion.

The results from this study have demonstrated that the model also applies to the turkey. The N strain of turkey has been genetically selected for increased growth rate which has also resulted in an increased appetite (as demonstrated in Part II A). The increased appetite has resulted in an excess energy intake and consequently increased fat deposition within the carcass, as verified by the leaf fat data and breast meat analyses. Conversely, the JL and JM strains have been genetically selected for breast meat yield (lean deposition). The JL strain had a lower energy intake (appetite) as compared with the N strain, thus, deposited less fat in the carcass. The results of this study with turkeys are in agreement with those by Nestor (1982) and Bacon *et al.* (1986), who have reported that strains of turkeys selected for a heavy body weight had greater abdominal fat deposition as compared with a randombred control population. The selection for a rapid-growing turkey (N strain) has resulted in a fatter turkey due to an excess energy intake. Selection for a leaner turkey has been successful, but has occurred at the expense of growth rate (JL and JM strains).

The genetic influence on fat deposition for the JL and JM appeared to predominate when fat was added to the diet. Increasing the level of added fat up to 10% the diet failed to increase fat deposition by the JL and JM in contrast to that by the N strain. The resistance to fat deposition can be of a disadvantage, as the JL and JM strains of turkey must be grown to older ages (near sexual maturity) to obtain a satisfactory finish. Visual appraisal of the JL and JM carcasses indicated an unsatisfactory amount of finish at 16 and 20 weeks of age.

The biochemical and physiological basis for the difference in fat deposition between the JL or JM and the N strains as well as between the broiler and the turkey remains to be determined (Borron *et al.*, 1977). Fat retention (fat intake - fat excreted) studies would be a logical first step in determining differences, as this study has demonstrated that fat deposition by the JL and JM strains failed to increase, even when triglycerides were made available through the diet.

The lack of a fat by protein interaction for yields of carcass parts have indicated that fat and protein exert independent effects on carcass growth. Increasing the level of dietary fat decreased fresh carcass and breast meat yield. Others have shown inconsistent effects from added dietary fat on the carcass part yields of large-type turkeys (Salmon, 1974; Hasiak, 1979; Sell *et al.*, 1985). Dietary fat had the greatest influence on the increase of fat deposition under the skin and within the abdomen of the N strain. Dietary fat has consistently been shown to increase the breast skin yield and the abdominal fat of turkeys (Essary, 1971; Salmon, 1974; Leeson *et al.*, 1985; Sell *et al.*, 1985). The feeding of diets containing a higher protein content than normally recommended increased fresh carcass and breast meat yield of all turkeys. This increase was associated mainly with the JL strain, and is likely due to the fact that it has been genetically selected for breast meat yield and thus uses dietary protein more efficiently for lean deposition within the breast tissue, as indicated by the greater protein content of the breast meat. Increasing the protein content of the diet above that which is recommended failed to increase breast meat yield of N turkeys as shown in Experiment 1 and by Sell *et al.* (1985). As reported in Part IIA, feeding high protein diets to the females increased body weight gain to 16, 24 and 28 weeks of age. The benefit observed from feeding high protein diets during the growth phase of this was reflected in a greater breast meat yield for females as compared with males.

While the influence of dietary variables was minor relative to age, sex and strain in this study, several important observations were made. Fat addition to the diet improved the feed efficiency of the JL and JM strains without increasing fat deposition. Lipid deposition within the breast meat and, thus, the appeal of turkey being a lean meat to the consumer was unaffected by fat addition to the diet. A genetic base for resistance to fat deposition does exist in the turkey which predominates over dietary manipulations, and may aid in controlling fat deposition in fast-growing strains in the future if the genome can be identified and transferred through genetic engineering. Increasing the protein level of the diet counteracted the increase in fat deposition from added fat in the N male as demonstrated in Part I, and increased fresh carcass and breast meat yields. The results of Part II A and B have offered insight to the nutritionist and processor as to how dietary fat and protein affect growth and carcass characteristics of turkeys of different ages, sex and strains.

Summary and Conclusions

An experiment was conducted to determine the effect of age, sex, added fat and protein on the growth and carcass quality of two strains of large-type turkeys (N and JL) and a strain of medium-type turkey (JM). Males and females of each strain were fed standard protein or high protein diets containing 0, 5 or 10% added fat from 8 to 28 weeks of age. Samples of females and males were processed at 16, 20, 24 or 28 and 20, 24 or 28 weeks of age, respectively. Treatment effects on growth performance to each market age as measured by body weight gain, feed consumption and feed efficiency were determined. The effects of treatments on carcass quality were determined by the yield of carcass parts and fat deposition as leaf fat among the three strains and within the breast meat tissue for the N and JL strains.

The N strain of turkey had a greater growth rate than the JL strain. The growth rates of the N male and female were 1.40 and 1.25 times greater than those of the JL male and female, respectively. While the JL and JM strains had superior feed efficiencies to a given age, the N strain consumed less feed to reach a given weight. Added fat improved the body weight gain of female turkeys to 20 weeks of age 3.3%. Feed consumption was decreased approximately 12% and feed efficiency improved approximately 17% when 10% fat was added to the diet.

Results from the processing of the turkeys demonstrated that fresh carcass yield increased with age for all turkeys. Breast meat yield also increased with age at the expense of wing, drumstick and thigh yields. The JL and JM strains averaged 2.17 and 2.82% more breast meat yield than the N strain, respectively. The greater breast meat yield of the JL and JM strains was associated with leaner carcasses as compared with the N strain. The N strain deposited .45% leaf fat as percent of fresh carcass weight and 2.30% lipid within the breast meat, 4.36 and 1.84 times more than the comparable values for the JL strain, respectively.

Added dietary fat decreased the fresh carcass, wing, and breast meat yield of all turkeys. Increased fat deposition from added fat occurred only in the N strain, as 5 and 10% added fat increased leaf fat deposition per unit of fresh carcass weight .096 and .174%, respectively.

In conclusion, the age, sex and strain of turkey had the greatest influence on the growth and processing results in this experiment, while the influence of the dietary variables was relatively minor. The superior growth rate of the N turkey is due primarily to a greater appetite (feed consumption). However, this greater appetite results in an excess energy intake and a fatter carcass. The genetic selection for breast meat yield by the JL and JM has resulted in a turkey which is more efficient in producing a leaner carcass, but occurs at the expense of growth rate. Added dietary fat failed to increase fat deposition in the JL and JM strains, indicating that a genetic base for resistance to fat deposition can predominate within the turkey. The increase in fresh carcass and breast meat yield with age warrants the consideration of marketing turkeys at older ages to take advantage of the meat-producing capabilities of the modern turkey and to maximize profit.

Table 24. Effect of age on carcass components of all turkeys processed (averaged over sex, strain, fat and protein)

Measurement	Age, weeks 20	24	28	Difference 24-20	28-24	DRS[1]
Carcass yield (%)	76.22	78.52	79.39	2.30***	.87***	.26
As % of carcass						
Leaf fat	.223	.131	.278	- .092***	.147***	.031
Wings	11.99	11.57	11.34	- .42***	-.23***	.11
Drumsticks	12.32	12.13	11.54	- .19*	-.59***	.15
Thighs	15.55	15.42	14.78	- .13	-.64***	.20
Back	14.47	12.63	13.03	-1.84***	.40*	.31
Breast	45.60	48.06	48.84	2.56***	.78***	.35
	99.93	99.88	99.53			
Breast meat	31.86	34.11	34.20	2.25***	.09	.33
Breast skin	4.00	3.34	3.54	- .66***	.20**	.13
Breast bone	9.73	10.60	11.09	.87***	.49***	.24
As % of breast						
Breast meat	69.89	70.94	69.98	1.05***	-.96***	.52
Breast skin	8.79	6.98	7.29	-1.81***	.31*	.26
Breast bone	21.32	22.08	22.73	- .24	.65	.47

[1]Difference required for significance between ($P \leq .05$) 36 *vs*. 36 groups containing the surviving birds of 12 females or 9 males per group.
*$P \leq .05$, **$P \leq .01$, ***$P \leq .001$.

Table 25. Effect of sex on carcass components of all turkeys processed (averaged over age, strain, fat and protein)

Measurement	Sex: Females	Sex: Males	Difference: Females - Males	DRS[1]
Carcass yield (%)	78.54	77.55	.99***	.21
As % of carcass				
Leaf fat	.216	.205	.011	.026
Wings	11.65	11.61	.04	.09
Drumsticks	11.81	12.18	- .37***	.12
Thighs	15.02	15.48	- .46***	.17
Back	13.42	13.32	.10	.25
Breast	47.93	47.07	.86***	.28
	99.83	99.67		
Breast meat	34.18	32.61	1.57***	.27
Breast skin	3.41	3.84	- .43***	.10
Breast bone	10.34	10.61	- .27**	.20
As % of breast				
Breast meat	71.27	69.27	2.00***	.42
Breast skin	7.19	8.18	- .99***	.21
Breast bone	21.54	22.54	-1.00***	.38

[1]Difference required for significance between ($P \leq .05$) 54 vs. 54 groups containing the surviving birds of 12 females or 9 males per group.

*$P \leq .05$, **$P \leq .01$, ***$P \leq .001$.

Table 26. Effect of strain on carcass components of all turkeys processed (averaged over age, sex, fat and protein).

Measurement	Strain[1] N	JL	JM	Difference N-JL	N-JM	JL-JM	DRS[2]
Carcass yield (%)	77.79	78.67	77.67	- .88***	.12	1.00***	.26
<u>As % of carcass</u>							
Leaf fat	.453	.104	.074	.349***	.379***	.030	.031
Wings	10.98	11.80	12.12	- .82***	-1.14***	-.32***	.11
Drumsticks	11.90	12.24	11.84	- .34***	- .06	.40***	.15
Thighs	15.19	15.44	15.12	- .25*	- .07	.32**	.20
Back	14.49	13.01	12.62	1.48***	1.87***	.39*	.31
Breast	47.09	47.24	48.16	- .15	-1.07	.92	.35
	99.65	99.73	99.86				
Breast meat	31.73	33.90	34.55	-2.17***	-2.82***	-.65***	.33
Breast skin	4.94	2.90	3.05	2.04***	1.89***	-.15	.13
Breast bone	10.43	10.44	10.56	- .01	- .13	-.12	.24
<u>As % of breast</u>							
Breast meat	67.36	71.73	71.71	-4.37***	-4.35***	.02	.52
Breast skin	10.51	6.19	6.36	4.32***	4.15***	-.17	.26
Breast bone	22.11	22.08	21.93	.03	.18	.15	.47

[1]N=Nicholas Large White, JL=Jaindl Large White, JM=Jaindl Medium White.

[2]Difference required for significance between (P≤.05) 36 *vs*. 36 groups containing the surviving birds of 12 females or 9 males per group.

*P≤.05, **P≤.01, ***P≤.001.

Table 27. Effect of fat on carcass components of all turkeys processed (averaged over age, sex, fat and protein).

Measurement	Added fat, % 0	5	10	Difference 10-0	DRS[1]
Carcass yield (%)	78.23	78.08	77.82	- .41**	.26
As % of carcass					
Leaf fat	.170	.214	.247	.077***	.031
Wings	11.72	11.61	11.57	- .15**	.11
Drumsticks	11.91	11.98	12.11	.20**	.15
Thighs	15.24	15.25	15.27	.03	.20
Back	13.08	13.57	13.48	.40*	.31
Breast	47.84	47.37	47.29	- .55**	.35
	99.79	99.78	99.72		
Breast meat	33.73	33.37	33.08	- .65***	.33
Breast skin	3.54	3.58	3.76	.22***	.13
Breast bone	10.56	10.42	10.44	- .12	.24
As % of breast					
Breast meat	70.48	70.40	69.93	- .55*	.52
Breast skin	7.44	7.61	8.01	.57***	.26
Breast bone	22.07	21.99	22.06	- .01	.47

[1]Difference required for significance between (P≤.05) 36 *vs*. 36 groups containing the surviving birds of 12 females or 9 males per group.
*P≤.05, **P≤.01, ***P≤.001.

Table 28. Effect of protein on carcass components of all turkeys processed (averaged over age, sex, fat and protein).

Measurement	Protein level Standard	High	Difference High-Standard	DRS[1]
Carcass yield (%)	77.92	78.17	.25*	.21
<u>As % of carcass</u>				
Leaf fat	.212	.209	-.003	.026
Wings	11.69	11.58	-.11*	.09
Drumsticks	12.08	11.92	-.14*	.12
Thighs	15.32	15.18	-.14	.17
Back	13.35	13.40	-.05	.25
Breast	47.31	47.69	.38**	.28
	99.74	99.77		
Breast meat	33.16	33.63	.47***	.27
Breast skin	3.66	3.60	-.06	.10
Breast bone	10.49	10.46	-.03	.20
<u>As % of breast</u>				
Breast meat	70.06	70.48	.42*	.42
Breast skin	7.78	7.60	-.18	.21
Breast bone	22.16	21.92	-.24	.38

[1]Difference required for significance between ($P \leq .05$) 54 *vs*. 54 groups containing the surviving birds of 12 females or 9 males per group.
*$P \leq .05$, **$P \leq .01$, ***$P \leq .001$.

Table 29. Effect of age, sex and strain of turkey on the moisture, protein, and lipid content of breast meat tissue.

Variable	Moisture	Protein	Lipid
Age, weeks			
20	71.71	24.67	1.44
24	71.91	24.41	1.69
28	71.64	24.35	2.19
Difference			
24-20	.20	- .26*	.25*
28-20	- .07	- .32**	.75***
28-24	- .27	- .06	.50***
Sex			
Males	72.00	24.32	1.72
Females	71.50	24.63	1.83
Difference	.50***	- .31***	-.11
Strain			
Nicholas	71.59	24.12	2.30
Jaindl Large	71.92	24.84	1.25
Difference	- .33**	- .72***	1.05***
Difference required for significance			
48 *vs*. 48 samples	.29	.22	.20
72 *vs*. 72 samples	.24	.18	.17

*P≤.05, **P≤.01, ***P≤.001.

Table 30. Effect of added dietary fat and protein on the moisture, protein, and lipid content of breast meat tissue.

Variable	Moisture	Protein	Lipid
Fat, %			
0	71.66	24.53	1.79
5	71.79	24.62	1.78
10	71.82	24.28	1.76
Difference			
5-0	.13	.09	-.01
10-0	.16	-.25*	-.03
10-5	.03	-.34**	-.02
Protein			
High	71.80	24.39	1.73
Standard	71.70	24.56	1.82
Difference	.10	-.17	-.09
Difference required for significance			
48 *vs*. 48 samples	.29	.22	.20
72 *vs*. 72 samples	.24	.18	.17

*P≤.05, **P≤.01, ***P≤.001.

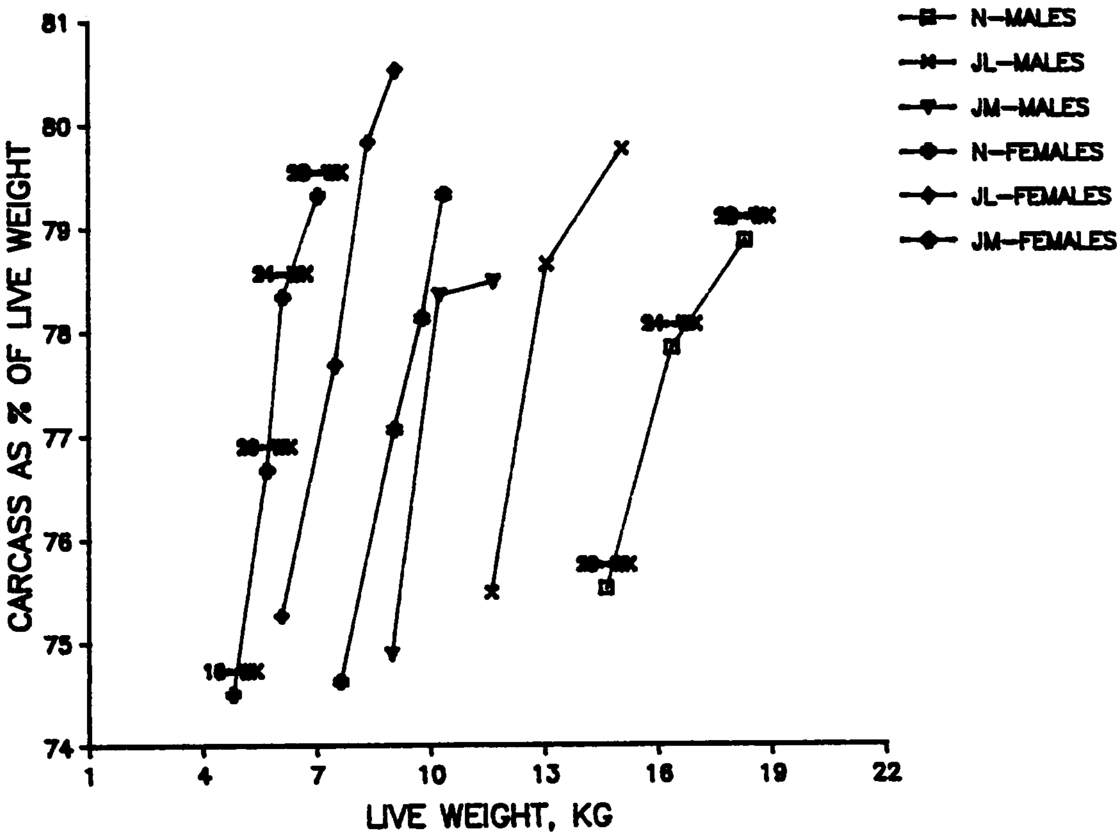

Figure 22. Effects of age, sex and strain of turkey on fresh carcass (without neck, leaf fat and giblets) yield.

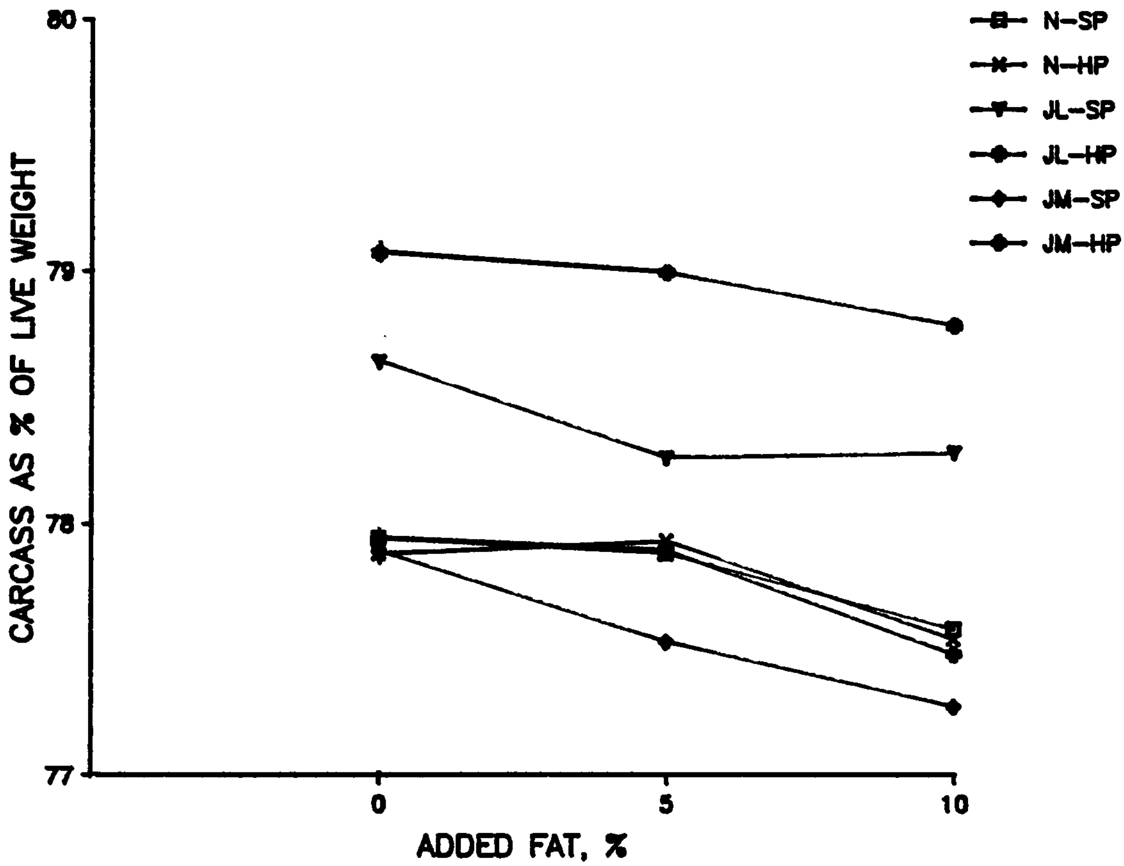

Figure 23. Effects of fat and protein on the fresh carcass (without neck, leaf fat and giblets) yield of male and female turkeys from three strains processed at 20, 24 and 28 weeks of age.

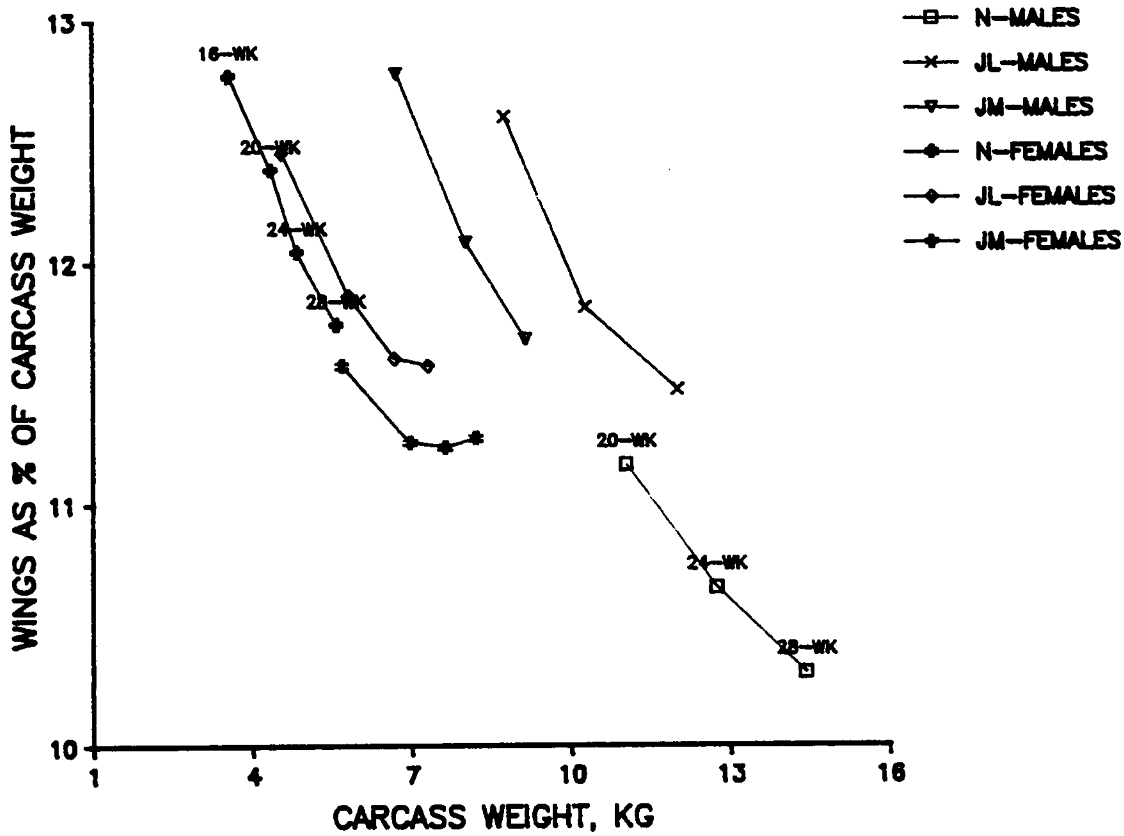

Figure 24. Effects of age, sex and strain of turkey on wing yield.

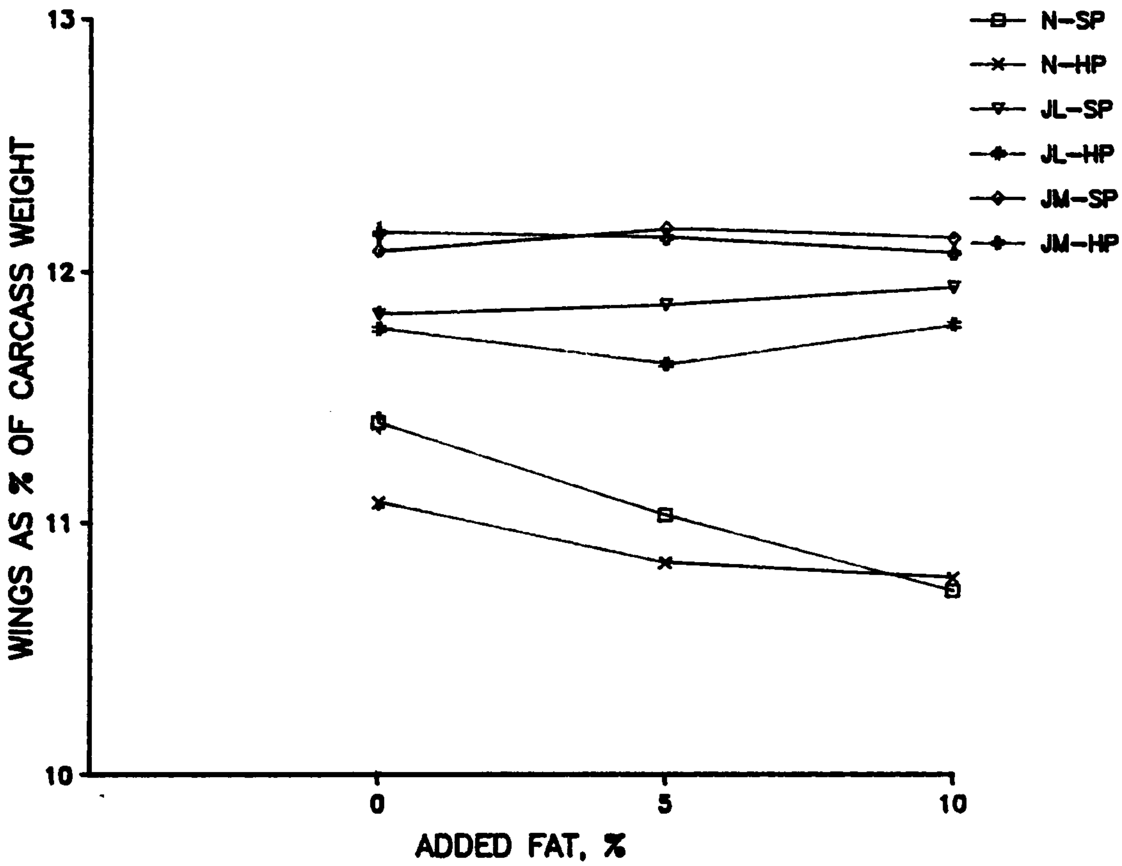

Figure 25. Effects of added fat and protein on the wing yield of male and female turkeys from three strains processed at 20, 24 and 28 weeks of age.

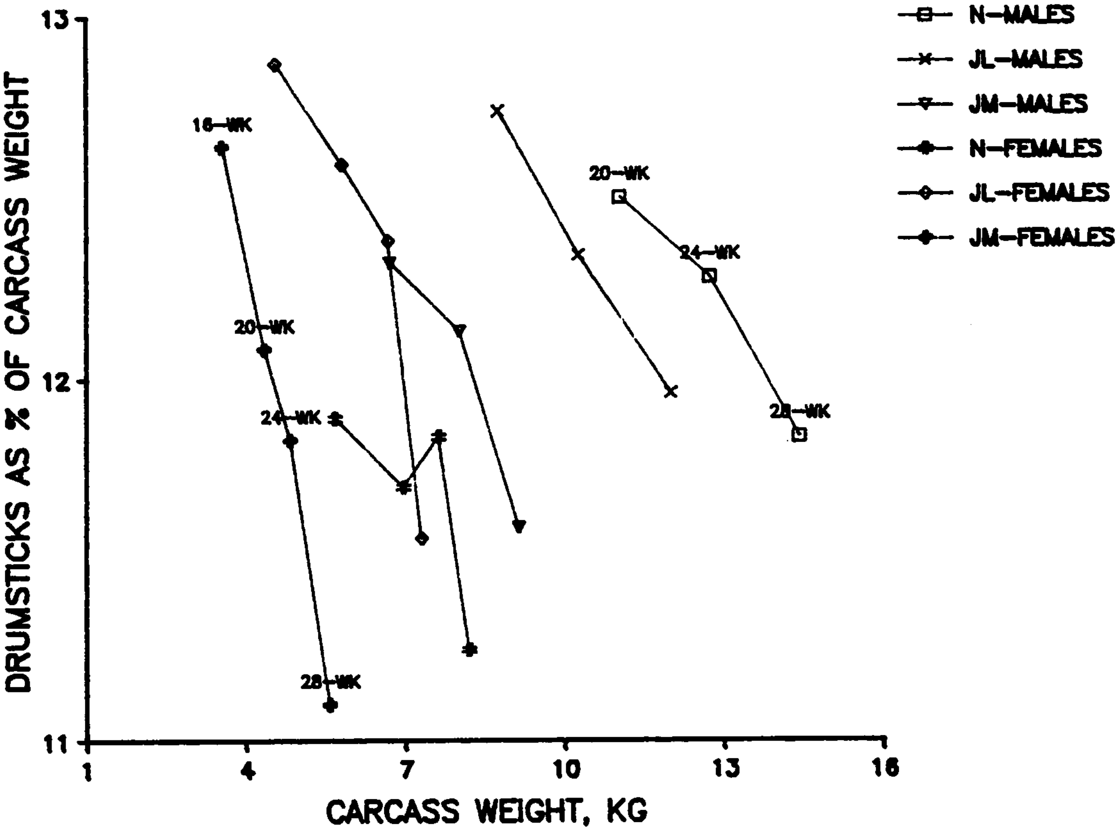

Figure 26. Effects of age, sex and strain of turkey on drumstick yield.

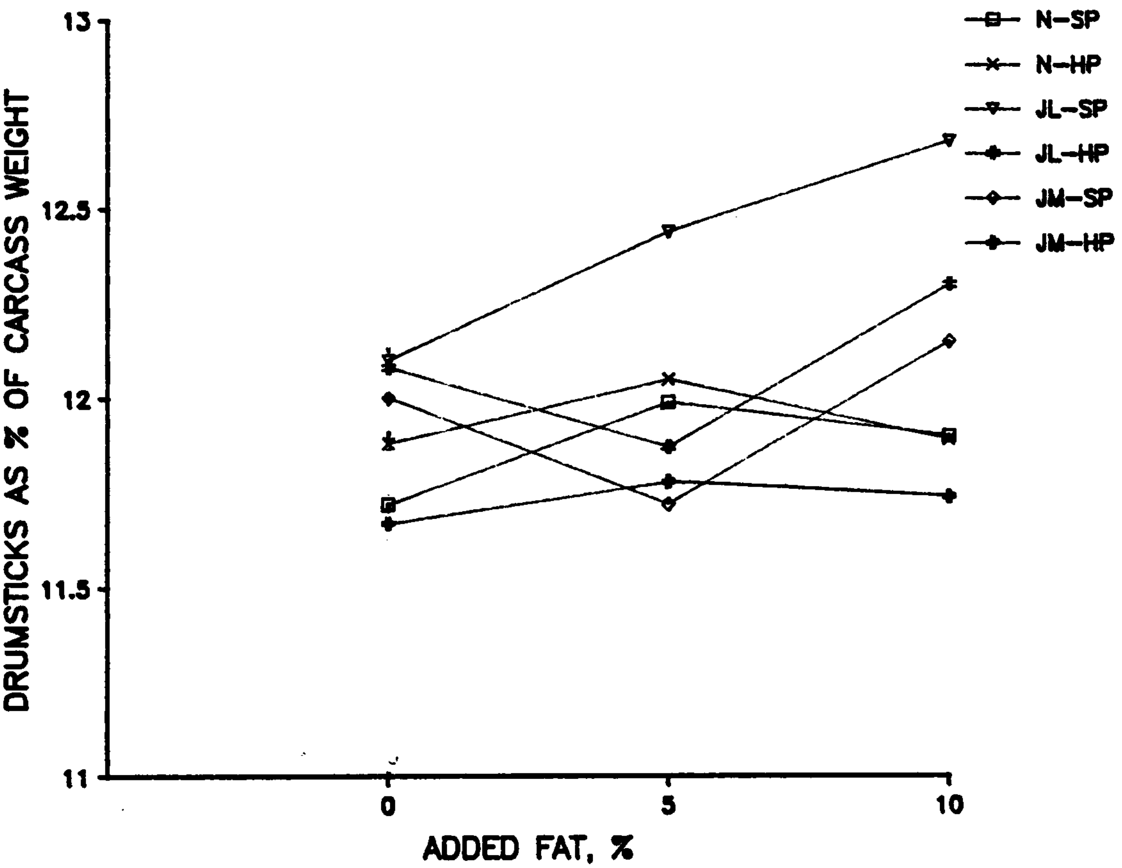

Figure 27. Effects of added fat and protein on the drumstick yield of male and female turkeys from three strains processed at 20, 24 and 28 weeks of age.

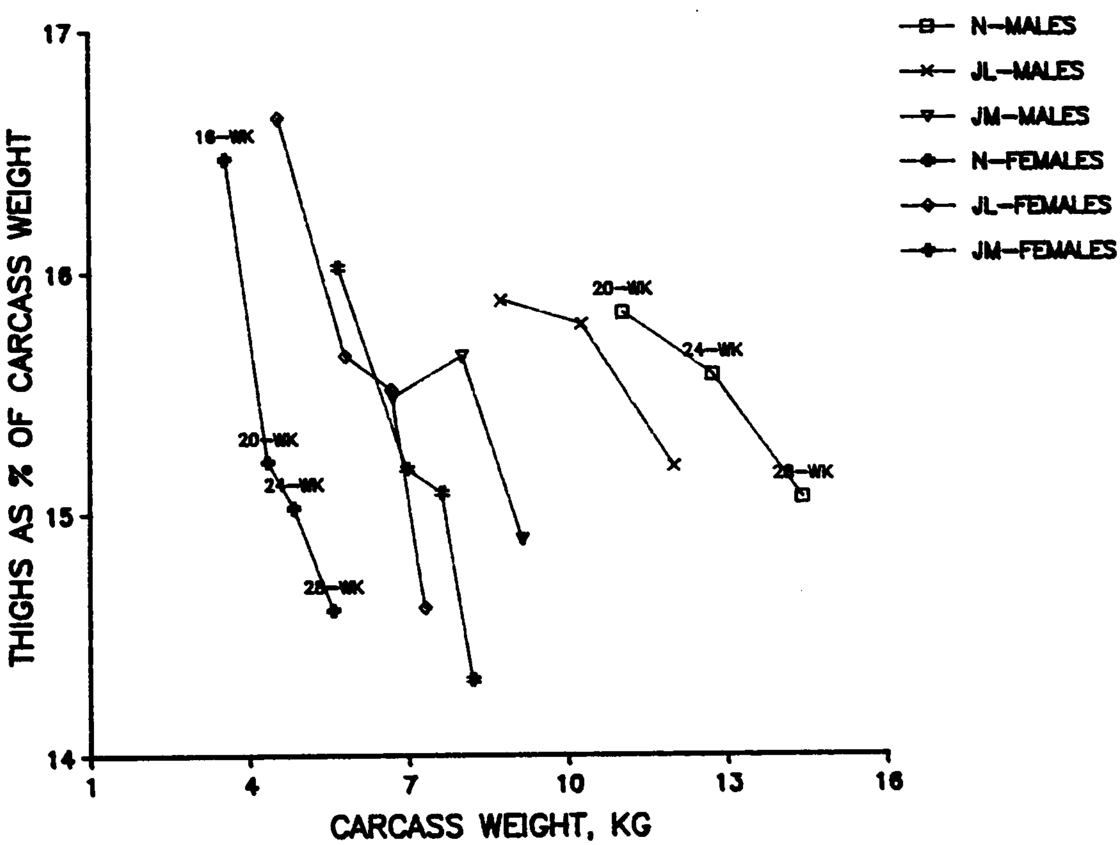

Figure 28. Effects of age, sex and strain of turkey on thigh yield.

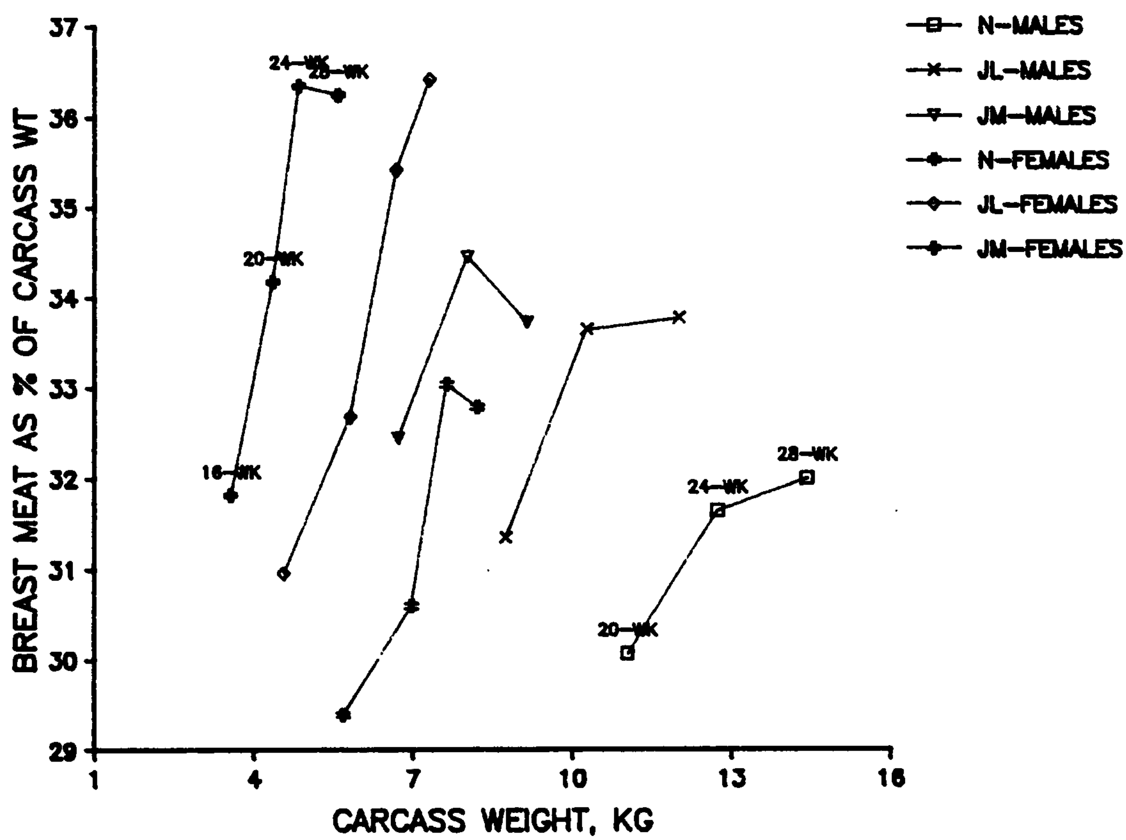

Figure 29. Effects of age, sex and strain of turkey on breast meat yield.

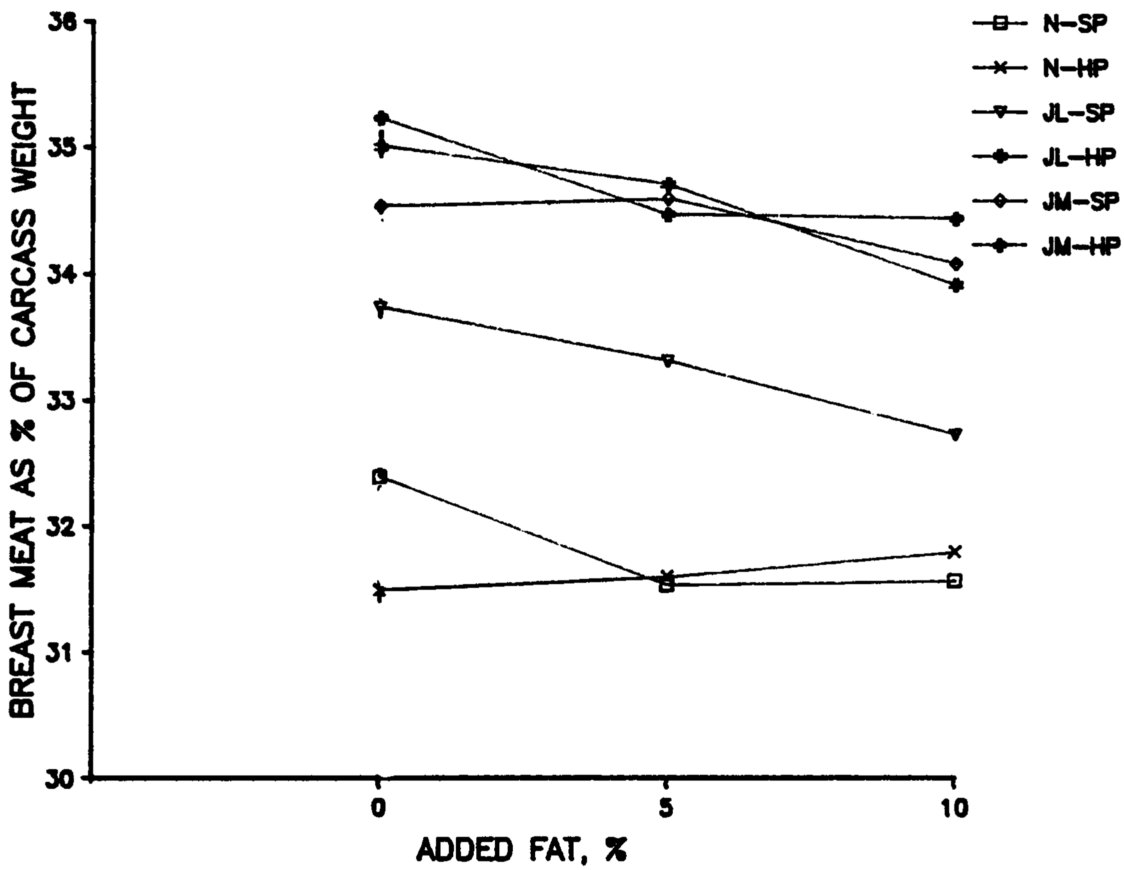

Figure 30. Effects of added fat and protein on the breast meat yield of male and female turkeys from three strains processed at 20, 24 and 28 weeks of age.

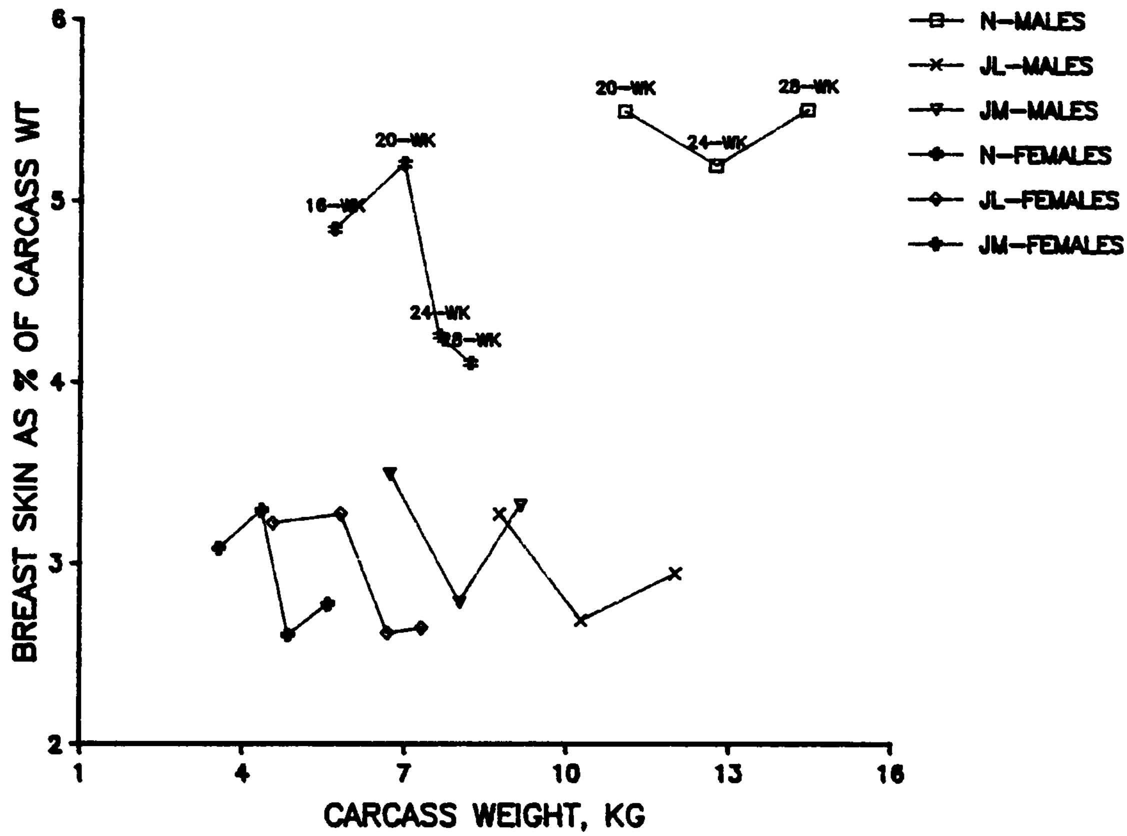

Figure 31. Effects of age, sex and strain of turkey on breast skin yield.

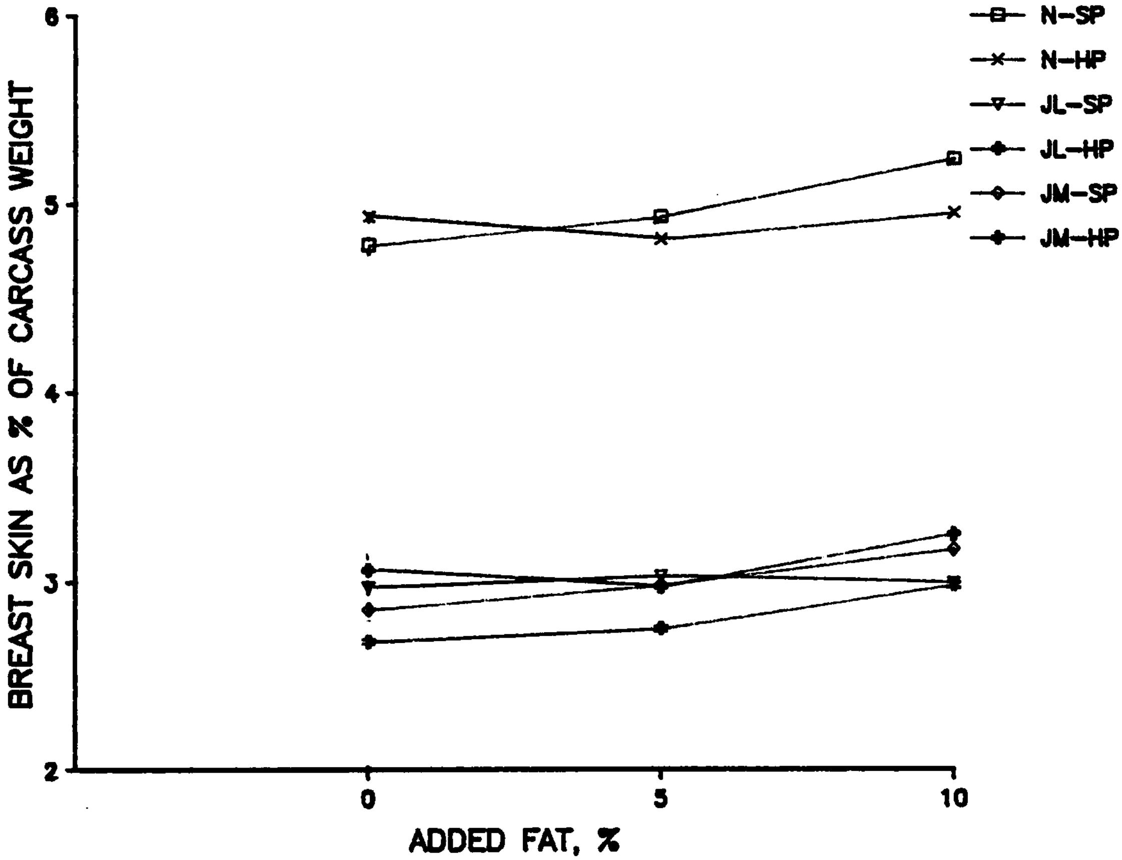

Figure 32. Effects of added fat and protein on the breast skin yield of male and female turkeys from three strains processed at 20, 24 and 28 weeks of age

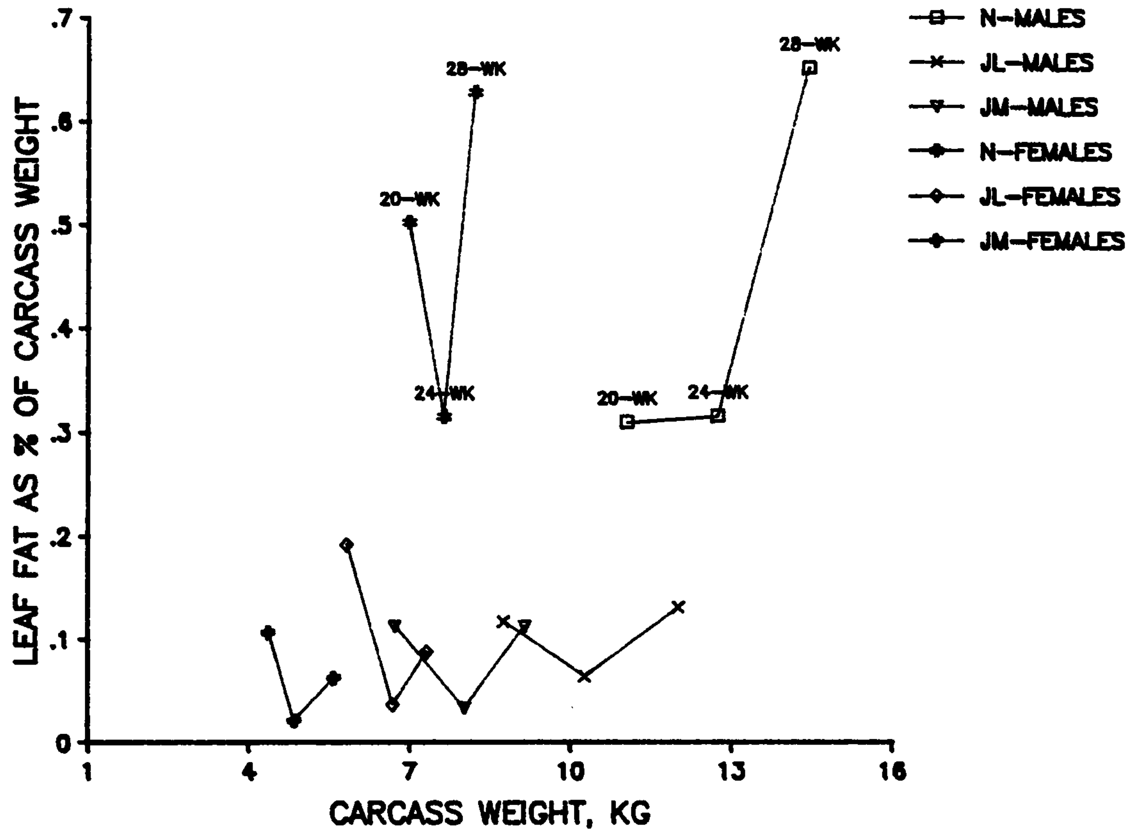

Figure 33. Effects of age, sex and strain of turkey on leaf fat deposition.

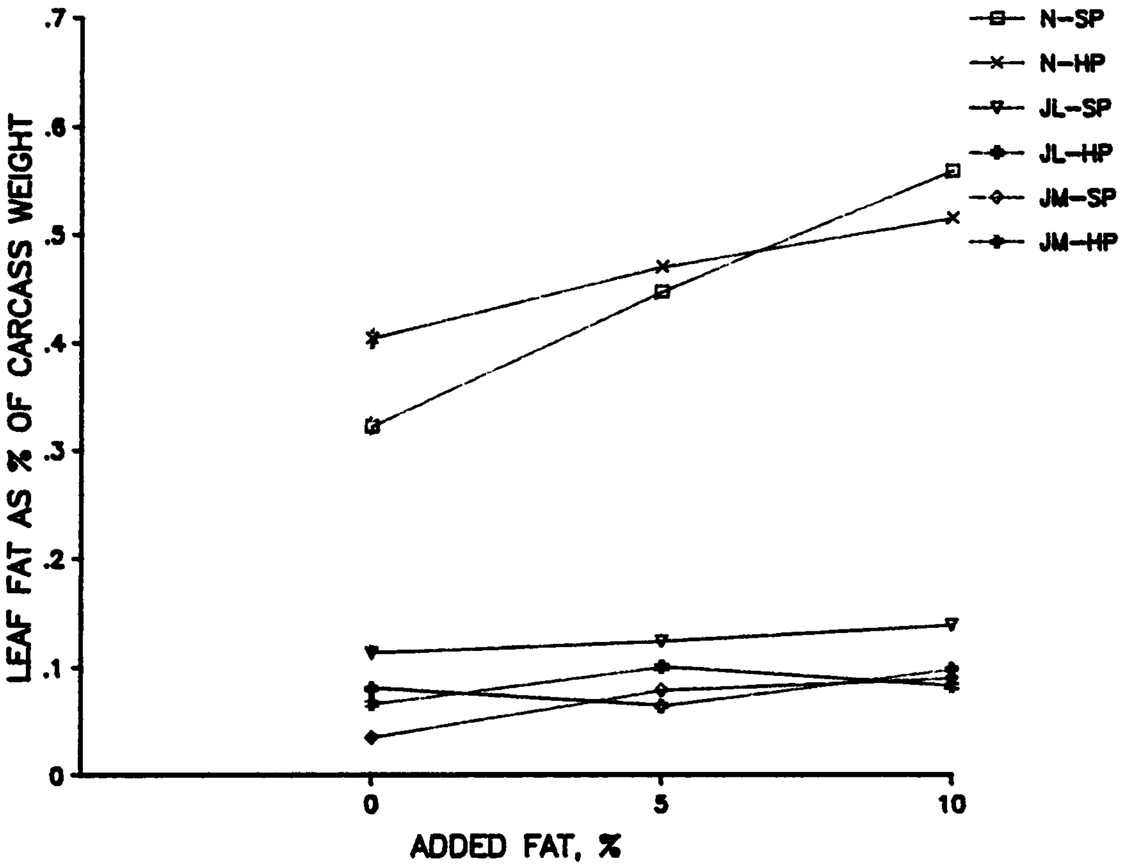

Figure 34. Effects of added fat and protein on leaf fat deposition of male and female turkeys from three strains processed at 20, 24 and 28 weeks of age.

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APPENDIX A

Table 1. Change in the metabolizable energy content of the diet when fat is added

1. Metabolizable energy (ME) content of standard protein diet with 0% added fat.

Ingredient	Amount, kg	NRC (1984) ME (kcal/kg)	ME content of diet (kcal/kg)
Ground yellow corn	.66274	3,350	2,220
Dehulled soybean meal	.2674	2,440	652
Meat and bone meal	.04	1,960	78
			2,950

2. Change in ME content of diet from 5% fat addition.

Ingredient	Amount %	NRC (1984) values Protein, %	ME(kcal/kg)	Protein %	ME (kcal/kg)
Fat	+5.0	0	8,220	0	410
Dehulled soybean Meal	+1.1	.485	2,440	.53	27
				+.53	+437
Ground yellow Corn	-6.1	.088	3,350	-.53	-204
Net change				0	+233

233/2,950 = 7.90% increase in ME per 5% added fat
or 7.90/5 = 1.58% increase in ME per 1% added fat

APPENDIX B

Table 1. Effects of fat and protein in the diets of three strains of female turkeys from eight to sixteen weeks of age

Dietary variable	Body weight gain (kg)	Feed consumption (kg)	Feed efficiency
		Nicholas Large White	
Protein			
High	4.90[1]	13.83	.3552
Standard	4.74	13.25	.3578
Difference	.16	.58	-.0026
Fat (%)			
0	4.60[2]	13.94	.3298
5	4.81	13.46	.3575
10	5.05	13.22	.3822
Difference			
5 over 0	.21	- .48	.0277*
10 over 0	.45*	- .72	.0524*
10 over 5	.24	- .24	.0247*
		Jaindl Large White	
Protein			
High	3.99	9.88	.4056
Standard	4.04	10.26	.3947
Difference	-.05	- .38*	.0109*
Fat (%)			
0	4.02	10.78	.3727
5	4.02	10.04	.4009
10	4.01	9.39	.4269
Difference			
5 over 0	0	- .74**	-.0282**
10 over 0	-.01	-1.39***	-.0542***
10 over 5	-.01	.65*	-.0260**
		Jaindl Medium White	
Protein			
High	3.17	8.31	.3822
Standard	2.93	7.78	.3777
Difference	.24*	.53*	.0045
Fat (%)			
0	3.09	8.63	.3574
5	3.00	7.97	.3763
10	3.06	7.54	.4063
Difference			
5 over 0	-.09	- .66**	.0189
10 over 0	-.03	-1.09***	.0489**
10 over 5	.06	- .43*	.0300*

[1]Each value represents the average of 3 pens of female turkeys with 48 birds per pen.

[2]Each value represents the average of 2 pens of female turkeys with 48 birds per pen.

*$P \leq .05$, **$P \leq .01$, ***$P \leq .001$.

Table 2. Effects of fat and protein in the diets of three strains of female turkeys from eight to twenty weeks of age

Dietary variable	Body weight gain (kg)	Feed consumption (kg)	Feed efficiency
		Nicholas Large White	
Protein			
High	6.40[1]	20.91	.3069
Standard	6.15	20.06	.3069
Difference	.35	.85	.0000
Fat (%)			
0	6.07[2]	21.40	.2838
5	6.27	20.32	.3089
10	6.47	19.74	.3280
Difference			
5 over 0	.20	-1.80	.0251*
10 over 0	.40	-1.66	.0442*
10 over 5	.20	- .58	.0191
		Jaindl Large White	
Protein			
High	5.48	15.61	.3526
Standard	5.55	16.29	.3419
Difference	- .07	- .68*	.0107
Fat (%)			
0	5.42	17.08	.3174
5	5.59	15.94	.3510
10	5.54	14.85	.3734
Difference			
5 over 0	.17	-1.14*	.0336*
10 over 0	.12	-2.23**	.0560**
10 over 5	-.05	-1.09*	.0224*
		Jaindl Medium White	
Protein			
High	4.18	12.85	.3265
Standard	3.97	12.21	.3267
Difference	.21	.64*	-.0002
Fat (%)			
0	4.11	13.54	.3036
5	4.02	12.36	.3251
10	4.10	11.69	.3510
Difference			
5 over 0	-.09	-1.18*	.0215*
10 over 0	-.01	-1.85**	.0474**
10 over 5	.08	- .67*	.0259*

[1]Each value represents the average of 3 pens of female turkeys with 36 birds per pen.

[2]Each value represents the average of 2 pens of female turkeys with 36 birds per pen.

*$P \leq .05$, **$P \leq .01$.

Table 3. Effects of fat and protein in the diets of three strains of female turkeys from eight to twenty-four weeks of age

Dietary variable	Body weight gain (kg)	Feed consumption (kg)	Feed efficiency
		Nicholas Large White	
Protein			
High	6.80[1]	26.81	.2655
Standard	7.09	25.96	.2620
Difference	- .29	.81	.0035
Fat (%)			
0	6.78[2]	27.59	.2459
5	6.97	26.16	.2665
10	7.08	25.40	.2789
Difference			
5 over 0	.19	-1.43	.0206*
10 over 0	.30	-2.19	.0330*
10 over 5	.11	- .76	.0124
		Jaindl Large White	
Protein			
High	6.41	20.89	.3085
Standard	6.08	21.23	.2874
Difference	.33*	- .34	.0211*
Fat (%)			
0	6.30	22.80	.2765
5	6.22	20.88	.2981
10	6.22	19.50	.3194
Difference			
5 over 0	.08	-1.92**	.0216*
10 over 0	.08	-3.30***	.0429**
10 over 5	0	-1.38*	.0213*
		Jaindl Medium White	
Protein			
High	4.72	16.89	.2802
Standard	4.47	16.24	.2765
Difference	.24	.65	.0037*
Fat (%)			
0	4.75	18.04	.2633
5	4.42	16.38	.2701
10	4.61	15.28	.3017
Difference			
5 over 0	-.33	-1.66*	.0068*
10 over 0	-.14	-2.76*	.0384***
10 over 5	.19	- .86	.0316***

[1]Each value represents the average of 3 pens of female turkeys with 24 birds per pen.

[2]Each value represents the average of 2 pens of female turkeys with 24 birds per pen.

*P≤.05, **P≤.01, ***P≤.001.

Table 4. Effects of fat and protein in the diets of three strains of female turkeys from eight to twenty-eight weeks of age

Dietary variable	Body weight gain (kg)	Feed consumption (kg)	Feed efficiency
		Nicholas Large White	
Protein			
High	7.89[1]	33.41	.2370
Standard	7.39	32.18	.2297
Difference	.50	1.23	.0073
Fat (%)			
0	7.48[2]	34.35	.2176
5	7.60	32.56	.2334
10	7.84	31.47	.2492
Difference			
5 over 0	.12	-1.79	.0158
10 over 0	.36	-2.88	.0316
10 over 5	.24	-1.09	.0158
		Jaindl Large White	
Protein			
High	7.34	26.87	.2745
Standard	6.95	26.95	.2588
Difference	.39	- .08	.0157*
Fat (%)			
0	7.11	29.19	.2434
5	7.05	26.44	.2664
10	7.28	25.10	.2901
Difference			
5 over 0	-.06	-2.75*	.0230*
10 over 0	.17	-4.09*	.0467**
10 over 5	.23	-1.34	.0237*
		Jaindl Medium White	
Protein			
High	5.44	21.41	.2553
Standard	5.28	21.23	.2498
Difference	.16	.18	.0055
Fat (%)			
0	5.51	23.23	.2373
5	5.07	20.87	.2430
10	5.51	19.85	.2774
Difference			
5 over 0	-.44*	-2.36**	.0057
10 over 0	0	-3.38**	.0401***
10 over 5	.44*	-1.02*	.0344**

[1]Each value represents the average of 3 pens of female turkeys with 12 birds per pen.

[2]Each value represents the average of 2 pens of female turkeys with 12 birds per pen.

*P≤.05, **P≤.01, ***P≤.001.

Table 5. Effects of fat and protein in the diets of three strains of male turkeys from eight to twenty weeks of age

Dietary variable	Body weight gain (kg)	Feed consumption (kg)	Feed efficiency
		Nicholas Large White	
Protein			
High	11.58[1]	30.91	.3759
Standard	11.39	29.99	.3810
Difference	.19	.92	-.0051
Fat (%)			
0	11.06[2]	31.82	.3478
5	11.82	31.18	.3791
10	11.58	28.35	.4086
Difference			
5 over 0	.76*	- .64	.0313*
10 over 0	.52	-3.47**	.0608**
10 over 5	-.24	-2.83*	.0295*
		Jaindl Large White	
Protein			
High	9.30	23.49	.3971
Standard	8.83	22.68	.3906
Difference	.47	.81	.0065
Fat (%)			
0	8.95	24.42	.3666
5	9.18	23.40	.3925
10	9.06	21.44	.4225
Difference			
5 over 0	.23	-1.02	-.0259
10 over 0	.11	-2.98*	-.0559*
10 over 0	-.12	1.96	-.0300
		Jaindl Medium White	
Protein			
High	7.12	18.48	.3868
Standard	6.85	18.16	.3796
Difference	.27	.32	.0072
Fat (%)			
0	7.16	20.07	.3568
5	6.91	18.35	.3768
10	6.88	16.54	.4161
Difference			
5 over 0	-.25	-1.72*	.0200*
10 over 0	-.28	-3.53*	.0593***
10 over 5	.03	-1.81*	.0393***

[1]Each value represents the average of 3 pens of male turkeys with 27 birds per pen.

[2]Each value represents the average of 3 pens of male turkeys with 27 birds per pen.

*P≤.05, **P≤.01, ***P≤.001.

Table 6. Effects of fat and protein in the diets of three strains of male turkeys from eight to twenty-four weeks of age

Dietary variable	Body weight gain (kg)	Feed consumption (kg)	Feed efficiency
		Nicholas Large White	
Protein			
High	13.38[1]	42.61	.3154
Standard	12.78	40.85	.3138
Difference	.60	1.76	.0016
Fat (%)			
0	12.58[2]	44.16	.2846
5	13.38	42.23	.3170
10	13.28	38.80	.3424
Difference			
5 over 0	.80	-1.93	.0324*
10 over 0	.70	-5.36*	.0578*
10 over 5	-.10	-3.43	.0254*
		Jaindl Large White	
Protein			
High	10.94	33.13	.3317
Standard	10.21	31.43	.3256
Difference	.73	1.70	.0061
Fat (%)			
0	10.72	34.39	.3116
5	10.20	32.50	.3142
10	10.80	29.96	.3603
Difference			
5 over 0	-.52	-1.89	.0026
10 over 0	.08	-4.43*	.0487*
10 over 5	.60	-2.54	.0461*
		Jaindl Medium White	
Protein			
High	8.27	25.50	.3258
Standard	8.04	25.31	.3190
Difference	.23	.19	.0068
Fat (%)			
0	8.16	27.53	.2963
5	8.22	25.60	.3210
10	8.08	23.09	.3499
Difference			
5 over 0	.06	-1.93*	.0247
10 over 0	-.08	-4.44**	.0536*
10 over 5	-.14	-2.51*	.0289*

[1]Each value represents the average of 3 pens of male turkeys with 18 birds per pen.

[2]Each value represents the average of 2 pens of male turkeys with 18 birds per pen.

*P≤.05, **P≤.01.

Table 7. Effects of fat and protein in the diets of three strains of male turkeys from eight to twenty-eight weeks of age

Dietary variable	Body weight gain (kg)	Feed consumption (kg)	Feed efficiency
		Nicholas Large White	
Protein			
High	15.46[1]	55.60	.2795
Standard	14.63	51.86	.2826
Difference	.83	3.74	-.0031
Fat (%)			
0	14.36[2]	56.40	.2548
5	15.54	54.66	.2843
10	15.23	50.12	.3040
Difference			
5 over 0	-1.18	1.74	.0295*
10 over 0	.87	-6.28*	.0492**
10 over 5	- .31	-4.54	.0197
		Jaindl Large White	
Protein			
High	13.16	43.18	.3058
Standard	12.36	41.36	.2998
Difference	.80	1.82	.0060
Fat (%)			
0	12.83	44.96	.2854
5	12.29	42.00	.2932
10	13.15	39.86	.3298
Difference			
5 over 0	-.54	-2.96	.0078
10 over 0	.32	-5.10*	.0444*
10 over 5	.86	-2.14	.0366
		Jaindl Medium White	
Protein			
High	9.59	32.76	.2953
Standard	9.67	33.00	.2948
Difference	-.08	-.24	.0005
Fat (%)			
0	9.23	35.54	.2597
5	9.64	33.32	.2894
10	10.01	29.79	.3361
Difference			
5 over 0	.41	-2.22**	.0297*
10 over 0	.78	-5.75***	.0764**
10 over 5	.37	-3.53***	.0467*

[1]Each value represents the average of 3 pens of male turkeys with 9 birds per pen.

[2]Each value represents the average of 2 pens of male turkeys with 9 birds per pen.

*P≤.05, **P≤.01, ***P≤.001.

APPENDIX C

Table 1. Analyses of variance of processing data from turkeys 20, 24 and 28 weeks of age

	Fresh carcass yield, (%)	As % of fresh carcass weight					
		Wings	Drums	Thighs	Breast meat	Breast skin	Leaf fat
Age (A)	***	***	***	***	***	***	***
Sex (X)	***	NS[1]	***	***	***	***	NS
Strain	***	***	***	**	***	***	***
Fat (F)	*	*	*	NS	**	**	***
Protein (P)	*	*	*	NS	***	NS	NS
A x X	***	***	NS	NS	NS	***	***
A x S	**	*	NS	NS	*	NS	***
A x F	NS	NS	NS	NS	NS	NS	NS
A x P	NS	NS	NS	NS	NS	NS	NS
X x S	NS	***	*	NS	***	***	*
X x F	NS	NS	NS	*	NS	NS	NS
X x P	NS	NS	NS	NS	NS	*	*
S x F	NS	**	NS	NS	NS	NS	**
S x P	NS	NS	*	*	***	NS	NS
F x P	NS	NS	NS	NS	NS	NS	NS
Standard deviation	.56	.23	.32	.44	.71	.28	.067

*P≤.05, **P≤.01, ***P≤.001.
[1]NS = Non-Significant.

Table 2. Significant age x sex effects on carcass measurements of turkeys processed at 20, 24 and 28 weeks of age

Sex	Age, weeks			Difference		
	20	24	28	24-20	28-24	DRS[1]
	Carcass as % of live weight					
Males	75.29	78.28	79.07	2.99***	.79**	.37
Females	77.15	78.76	79.71	1.61***	.95***	
Difference	-1.86***	-.48*	-.64			
	Wings as % fresh carcass weight					
Males	12.18	11.51	11.16	-.67***	-.35***	.15
Females	11.81	11.63	11.53	-.18*	-.10	
Difference	.37***	-.12	-.37***			
	Breast skin as % fresh carcass weight					
Males	4.08	3.54	3.92	-.54***	-.38***	.18
Females	3.92	3.15	3.17	-.77***	.02	
Difference	.16	.39***	.75***			
	Leaf fat as % fresh carcass weight					
Males	.179	.137	.298	-.042**	.161***	.044
Females	.266	.124	.259	-.142***	.135***	
Difference	-.087***	.013	.039			

[1]Difference required for significance between (P≤.05) 18 *vs*. 18 groups containing the surviving birds of 12 females or 9 males per group.

*P≤.05, **P≤.01, ***P≤.001.

Table 3. Significant age x strain effects on carcass measurements of turkeys processed at 20, 24 and 28 weeks of age

Strain[1]	Age, weeks 20	24	28	Difference 24-20	28-24	DRS[2]
			Carcass as % of live weight			
N	76.30	77.98	79.10	1.68***	1.12***	.45
JL	76.57	79.25	80.18	2.68***	.93***	
JM	75.79	78.34	78.88	2.55***	.54*	
Difference						
N over JL	-.27	-1.27***	-1.08***			
N over JM	.51*	-.36	.22			
JL over JM	.78***	.91***	1.30***			
			Wings as % fresh carcass weight			
N	11.18	10.95	10.79	-.23*	-.16	.19
JL	12.23	11.68	11.50	-.55***	-.18	
JM	12.56	12.07	11.74	-.49***	-.33***	
Difference						
N over JL	-1.05***	-.73***	-.71***			
N over JM	-1.38***	-1.12***	-.95***			
JL over JM	-.33***	-.39***	-.24*			
			Breast meat as % fresh carcass weight			
N	30.32	32.37	32.49	2.05***	.12	.57
JL	32.02	34.55	35.13	2.53***	.58*	
JM	33.25	35.42	34.97	2.17***	-.55	
Difference						
N over JL	-1.70***	-2.18***	-2.64***			
N over JM	-2.93***	-3.05***	-2.48***			
JL over JM	-1.23***	-.87**	.16			
			Leaf fat as % fresh carcass weight			
N	.405	.315	.639	-.090**	.324***	.054
JL	.154	.050	.109	-.104**	.059*	
JM	.109	.027	.087	-.082**	.060*	
Difference						
N over JL	.251***	.265***	.530***			
N over JM	.296***	.288***	.552***			
JL over JM	.045	.023	.022			

[1]N=Nicholas Large White, JL=Jaindl Large White and JM=Jaindl Medium White.

[2]Difference required for significance between ($P \leq .05$) 12 vs. 12 groups containing the surviving birds of 12 females or 9 males per group.

*$P \leq .05$, **$P \leq .01$, ***$P \leq .001$.

Table 4. Significant strain x sex effects on carcass measurements of turkeys processed at 20, 24 and 28 weeks of age

	Strain[1]			Difference			
Sex	N	JL	JM	N-JL	N-JM	JL-JM	DRS[2]
			Wings as % fresh carcass weight				
Males	10.71	11.94	12.20	-1.23***	-1.49***	-.26**	.15
Females	11.24	11.67	12.04	-.43***	-.81***	.38***	
Difference	-.53***	.27***	.14				
			Drums as % fresh carcass weight				
Males	12.21	12.32	12.02	-.11	.19	.30**	.21
Females	11.60	12.17	11.66	-.57***	-.06	.51***	
Difference	.61***	.15	.36**				
			Breast meat as % fresh carcass weight				
Males	31.33	32.94	33.56	-1.61***	-2.23***	-.62**	.47
Females	32.13	34.86	35.54	-2.73***	-3.41***	-.68**	
Difference	-.80***	-1.92***	-1.98***				
			Breast skin as % fresh carcass weight				
Males	5.36	2.96	3.21	2.40***	2.15***	.25*	.18
Females	4.52	2.84	2.88	1.68***	1.64***	-.04	
Difference	.84***	.12	.33***				
			Leaf fat as % fresh carcass weight				
Males	.425	.103	.086	.322***	.339***	.017	.044
Females	.481	.105	.063	.376***	.418***	.042	
Difference	.056*	-.002	.023				

[1]N=Nicholas Large White, JL=Jaindl Large White, JM=Jaindl Medium White.

[2]Difference required for significance between (P≤.05) 18 vs. 18 groups containing the surviving birds of 12 females or 9 males per group.

*P≤.05, **P≤.01, ***P≤.001.

Table 5. Significant sex x fat effects on carcass measurements of turkeys processed at 20, 24 and 28 weeks of age

	Added fat, %			Difference		
Sex	0	5	10	5-0	10-5	DRS[1]
	Thighs as % of live weight					
Males	15.34	15.65	15.44	.31*	-.21	.29
Females	15.13	14.84	15.09	-.29*	.25	
Difference	.21	.81***	.35*			

[1]Difference required for significance between ($P \leq .05$) 18 *vs*. 18 groups containing the surviving birds of 12 females or 9 males per group.

*$P \leq .05$, **$P \leq .01$, ***$P \leq .001$.

Table 6. Significant sex x protein effects on carcass measurements of turkeys processed at 20, 24 and 28 weeks of age

Sex	Protein level: Standard	Protein level: High	Difference: High-Standard	DRS[1]
	Breast skin as % fresh carcass weight			
Males	3.95	3.74	-.21**	.15
Females	3.38	3.45	.07	
Difference	.57***	.29***		
	Leaf fat as % fresh carcass weight			
Males	.220	.189	-.031	.036
Females	.204	.229	.025	
Difference	.016	-.040*		

[1]Difference required for significance between (P≤.05) 54 *vs*.54 groups containing the surviving birds of 12 females or 9 males per group.

*P≤.05, **P≤.01, ***P≤.001.

Table 7. Significant strain x fat effects on carcass measurements of turkeys processed at 20, 24 and 28 weeks of age

	Strain[1]			Difference			
Fat,%	N	JL	JM	N-JL	N-JM	JL-JM	DRS[2]
	Wings as % fresh carcass weight						
0	11.24	11.80	12.12	-.56***	-.88***	-.32***	.19
5	10.94	11.75	12.15	-.81***	-1.21***	-.40***	
10	10.76	11.86	12.10	-1.10***	-1.34***	-.24*	
Difference							
5 over 0	-.30**	-.05	.03				
10 over 5	-.18	.11	-.05				
	Leaf fat as % fresh carcass weight						
0	.363	.089	.057	.274***	.306***	.032	.054
5	.459	.112	.071	.347***	.388***	.041	
10	.537	.110	.094	.427***	.443***	.016	
Difference							
5 over 0	.096***	.023	.014				
10 over 5	.078**	-.002	.023				

[1]N=Nicholas Large White, JL=Jaindl Large White, JM=Jaindl Medium White.

[2]Difference required for significance between ($P \leq .05$) 12 vs.12 groups containing the surviving birds of 12 females or 9 males per group.

*$P \leq .05$, **$P \leq .01$, ***$P \leq .001$.

Table 8. Significant strain x protein effects on carcass measurements of turkeys processed at 20, 24 and 28 weeks of age

	Strain [1]			Difference			
Protein level	N	JL	JM	N-JL	N-JM	JL-JM	DRS[2]
	Drums as % fresh carcass weight						
High	11.94	12.08	11.72	-.14	.22*	.36**	.21
Standard	11.87	12.40	11.96	-.53***	-.09	.44***	
Difference	.07	-.32**	-.24**				
	Thighs as % fresh carcass weight						
High	15.37	15.47	14.88	-.10	.49**	.59***	.29
Standard	15.18	15.42	15.37	-.24	-.19	.05	
Difference	.19	.05	-.49**				
	Breast meat as % fresh carcass weight						
High	31.63	34.54	34.71	-2.91***	-3.08***	-.17**	.47
Standard	31.83	33.26	34.39	-1.43***	-2.56***	-1.13***	
Difference	-.20	1.28***	.32				

[1]N=Nicholas Large White, JL=Jaindl Large White, JM=Jaindl Medium White.

[2]Difference required for significance between ($P \leq .05$) 18 vs.18 groups containing the surviving birds of 12 females or 9 males per group.

*$P \leq .05$, **$P \leq .01$, ***$P \leq .001$.

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EFFECTS OF ADDED DIETARY FAT AND PROTEIN ON THE GROWTH AND CARCASS CHARACTERISTICS OF TURKEYS

by

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(ABSTRACT)

Two experiments were conducted to quantitate the effects of several parameters on the growth, carcass characteristics and fat deposition of the turkey. In the first experiment, 0, 5, 10 or 15% fat from three sources (Fat 1, Fat 2 or Fat 3) was added to low (18%), standard (21%) or high (24%) protein diets fed to Nicholas Large White male turkeys from 8 to 22 weeks of age. Carcass quality as measured by fat deposition, carcass yield and breast meat yield was determined.

The addition of each 1% added fat up to 10% increased body weight gain .72%. Feed consumption decreased 1.3% and feed efficiency increased 2.3% for each 1% added fat up to 15%. Addition of Fat 2 to the diet resulted in significantly better feed efficiencies as compared with Fat 1 or Fat 3. The feeding of low protein diets as compared with standard protein diets decreased body weight gain, feed consumption and feed efficiency 13.2, 5.7 and 8.1%, respectively.

Addition of fat to the diet increased 22-week body weight and the amount of breast meat produced per kg feed consumed. For each 1% added fat to low and standard protein diets, leaf and gizzard fat deposition increased 10.2 and 8.0%, respectively. Feeding low protein diets resulted in a 10.4% decrease in body weight and a 19.5% decrease in breast meat yield. The increase in leaf and gizzard fat deposition from each 5% increment of added fat up to 10% was counteracted by a 3% increase in dietary protein.

In the second experiment, both sexes of the Nicholas Large White, Jaindl Large White and Jaindl Medium White strains were fed standard (21%) or high (24%) protein diets containing 0, 5 or 10% added dietary fat from 8 to 28 weeks of age. Carcass quality as measured by yield of carcass

parts, fat deposition and the composition of breast meat was determined at 16, 20, 24 and 28 weeks of age.

The Nicholas strain of turkey had a greater growth rate and consumed less feed to reach heavier weights than the Jaindl Large strain. Addition of 10% fat to the diet decreased feed consumption 12% and increased feed efficiency 17%. Fresh carcass and breast meat yield increased with age of the turkey, indicating that marketing at younger ages does not take full advantage of the meat producing capability of the turkey. The Jaindl Large and Medium White strains averaged 6.8 and 6.9% more breast meat yield than the Nicholas strain. The Nicholas strain deposited 4.36 times more leaf fat and 1.84 times more lipid within the breast meat as compared to the Jaindl Large strain. Added dietary fat decreased fresh carcass yield .41% and breast meat yield .65%. Feeding high protein diets increased fresh carcass yield and breast meat yield .25 and .47%, respectively.