INFLUENCE OF DIETARY ENERGY ON THE UTILIZATION OF RAPESEED MEAL BY LAYING HENS

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ABSTRACT

INFLUENCE OF DIETARY ENERGY ON UTILIZATION OF RAPESEED MEAL BY LAYING HENS

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A STUDY EMPLOYING 400 COMMERCIAL LAYING HENS WAS CONDUCTED TO EVALUATE THE EFFECT OF DIETARY ENERGY ON RAPESEED MEAL UTILIZATION. DIETARY TREATMENTS INCLUDED TWO LEVELS (2530 AND 2750 KCAL/KG) OF METABOLIZABLE ENERGY SUPPLIED AT FOUR LEVELS (0, 8, 10 AND 12%) OF RAPESEED MEAL.

EGG PRODUCTION, EFFICIENCY OF FEED UTILIZATION, EGG WEIGHT, BODY WEIGHT , EGG QUALITY, SHELL THICKNESS, THYROID:BODY WEIGHT RATIO, CECA LENGTH, LIVER WEIGHT, LIVER LIPID, SPLEEN WEIGHT, MORTALITY DUE TO FATTY LIVER, AND LEUKOSIS MORTALITY WERE MEASURED DURING THE EXPERIMENT WHICH COVERED 10 PERIODS OF 28 DAYS EACH.

RESULTS SHOWED THAT EGG PRODUCTION SIGNIFICANTLY IMPROVED BY INCREASING THE ENERGY LEVEL OF DIETS CONTAINING 10 AND 12% RAPESEED MEAL. THE LOW ENERGY DIETS SHOWED NO SIGNIFICANT DIFFERENCE IN FEED EFFICIENCY BETWEEN THE CONTROL AND THE 8 AND 12% RAPESEED MEAL WHEREAS A SIGNIFICANT DEPRESSION OCCURED AT THE 10% LEVEL BUT ONLY COMPARED WITH EIGHT PERCENT RAPESEED MEAL. ANALYSED METABOLIZABLE ENERGY WAS SIMILAR FOR SOYBEAN AND RAPESEED MEAL

RATIONS BUT LOWER THAN CALCULATED VALUES. A RAPESEED MEAL X ENERGY INTERACTION RESULTED IN DEPRESSED EGG WEIGHT WITH INCREASING RAPESEED MEAL AT BOTH ENERGY LEVELS. BIRDS RECEIVING 12% RAPESEED MEAL AND THE HIGH ENERGY RATION PRODUCED SIGNIFICANT MORE AND LARGER EGGS THAN DID THOSE FED THE SAME LEVEL OF RAPESEED MEAL ON THE LOW ENERGY DIET.

EGG QUALITY (HAUGH UNITS) OF EGGS FROM THE RAPESEED MEAL TREATED GROUPS WERE LOWER WHILE EGG SHELL THICKNESS WAS THE SAME AS THOSE FROM HENS FED SOYBEAN MEAL. THE THYROID TO BODY WEIGHT RATIO INCREASED WITH DIETARY RAPESEED MEAL. CECA LENGTH WAS SHORTER AND BODY WEIGHT GAIN PER BIRD SHOWED A NON-SIGNIFICANT BUT CONSISTENT DECREASE WITH EACH ADDITION OF RAPESEED MEAL AT BOTH LEVELS OF DIETARY ENERGY EXCEPT FOR HIGH ENERGY DIET CONTAINING 12% MEAL. LIVER WEIGHT AS A PERCENT OF BODY WEIGHT REMAINED UNCHANGED IRRESPECTIVE OF EITHER THE RAPESEED OR ENERGY LEVELS EMPLOYED. THE PERCENT LIVER LIPID OF DRY TISSUE INCREASED AS THE ENERGY LEVEL IN RAPESEED MEAL DIETS WAS ELEVATED. ENERGY HAD A SIGNIFICANT POSITIVE EFFECT ON SPLEEN WEIGHT. MORTALITY CAUSED BY FATTY LIVER AND LEUKOSIS WAS NOT AFFECTED BY DIETARY ENERGY OR RAPESEED MEAL BUT WAS INCREASED BY LENGTH OF THE EXPERIMENTAL PERIOD.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDIX TABLES

TABLE PAGE

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INTRODUCTION

THERE IS AN INCREASING DEMAND FOR ANIMAL PROTEIN BY THE RAPIDLY GROWING POPULATION OF THE WORLD. IN ORDER TO MEET THIS URGENT DEMAND, THE IMMEDIATE EXPANSION OF ANIMAL PRODUCTION, USING THE MOST ECONOMICAL METHODS IS ESSENTIAL. THE RATE AT WHICH POULTRY PRODUCTS CAN BE PRODUCED PROVIDES AN EXCELLENT MEANS OF MEETING A LARGE PART OF WORLD PROTEIN REQUIREMENTS. BIRDS ARE CAPABLE OF EFFICIENTLY UTILIZING A POOR QUALITY PLANT PROTEIN IN THE PRODUCTION OF MEAT AND EGG. HIGH PROTEIN POULTRY MEAT IS LOW IN FAT AND THE EGG IS A "COMPLETE" HUMAN FOOD.

RAPESEED IS AN EXCELLENT SOURCE OF PLANT PROTEIN THAT CAN BE PRODUCED UNDER CLIMATIC CONDITIONS THAT ARE NOT FAVOURABLE FOR SOYBEAN PRODUCTION. RAPESEED *PER SE* CONTAINS RELATIVELY HIGH LEVELS OF OIL. A HIGH PROTEIN MEAL IS PRODUCED UPON EXTRACTION OF THE OIL. UNDER SUITABLE MANUFACTURING CONDITIONS RAPESEED MEAL IS A HIGH QUALITY PROTEIN PRODUCT. IT PROVIDES AN EXCELLENT SUPPLY OF AMINO ACIDS FOR ANIMALS. CLANDININ *ET AL.* (1961) SHOWED THAT UNDER RIGIDLY TEMPERATURE CONTROLLED PROCESSING RAPESEED MEAL YIELDS MORE LYSINE AND PROVIDES OTHER AMINO ACIDS IN MORE FAVOURABLE AMOUNTS THAN SOYBEAN MEAL.

THE MEAL CONTAINS A HIGHER CONCENTRATION OF CHOLINE AND NIACIN AND A SIMILAR AMOUNT OF RIBOFLAVIN COMPARED WITH SOYBEAN MEAL (KLAIN *ET AL.*, 1956). IT ALSO CONTAINS APPROXIMATELY 0.6 AND 1.0

PERCENT CALCIUM AND PHOSPHORUS, RESPECTIVELY, COMPARED TO 0.3 AND 0.7 PERCENT FOR SOYBEAN MEAL.

THE LIMITING FACTOR IN USING RAPESEED MEAL IN POULTRY FEED IS BELIEVED TO BE THE CONCENTRATION OF ITS TOXIC COMPONENTS. PREVIOUS STUDIES HAVE SHOWN, HOWEVER, THAT UP TO 10% RAPESEED MEAL CAN BE USED IN LAYER DIETS WITHOUT DETRIMENTAL EFFECTS (O'NEIL, 1957).

THE ENERGY REQUIREMENTS FOR LAYING HENS HAVE RECEIVED CONSIDERABLE ATTENTION AND WIDE VARIATION IN VALUES HAS BEEN REPORTED. IT WAS ALSO REPORTED THAT GOITRIN PRESENT IN RAPESEED MEAL HAD A DETRIMENTAL EFFECT ON ENERGY METABOLISM (LOHDI ET AL., 1969) IN CHICKS. THE EFFECT OF GOITRIN ON THE ENERGY REQUIREMENT OF THE LAYING HEN, HOWEVER, REMAINS UNKNOWN.

THE PRESENT STUDY WAS DESIGNED TO INVESTIGATE THE USE OF RAPESEED MEAL IN LAYING RATIONS AT TWO LEVELS OF DIETARY ENERGY. EGG PRODUCTION, EFFICIENCY OF FEED UTILIZATION, BODY WEIGHT, EGG WEIGHT, EGG QUALITY, LIVER WEIGHT, LIVER LIPIDS, SPLEEN WEIGHT, THYROID:BODY WEIGHT RATIO, CECA LENGTH AND MORTALITY WERE MEASURED IN ORDER TO EVALUATE THE EFFECT OF DIETARY ENERGY ON THE UTILIZATION OF RAPESEED MEAL BY LAYING HENS.

LITERATURE REVIEW

GOITROGENIC PROPERTIES OF RAPESEED MEAL

PREVIOUS RESEARCH FINDINGS HAVE DEMONSTRATED THAT RAPESEED CONTAINS CERTAIN COMPOUNDS THAT ARE TOXIC TO MONOGASTRIC ANIMALS. ASTWOOD ET AL. (1949) AND CARROLL (1949) ISOLATED GOITRIN FROM RAPESEED AND IDENTIFIED THE COMPOUND AS L-5-VINYL-2-THIOOXAZOLIDONE. THE THIOGLUCOSIDES, SINIGRIN AND GLUCONAPIN, WERE ALSO ISOLATED FROM RAPESEED (ARMSTRONG ET AL., 1931) AND RAPESEED MEAL (MATET ET AL., 1949 AND FROLICH, 1952) AND IDENTIFIED AS THE PRECURSORS OF THE TOXIC ALLYL AND CROTONYL ISOTHIOCYANATES.

RAPESEED MEAL FED UP TO 20% OF THE DIET TO CHICKS CAUSED THYROID HYPERTROPHY. (TURNER, 1946, 1948, AND PETTIT ET AL., 1944). A SIMILAR FINDING WAS MADE BY CLANDININ ET AL. (1960) THROUGH FEEDING 15% POLISH (*BRASSICA CAMPESTRIS*) OR FIVE PERCENT ARGENTINE (*BRASSICA NAPUS*) EXPELLER MEAL TO CHICKS. THESE RESEARCHERS OBSERVED A DOUBLE THYROID:BODY WEIGHT RATIO. IT WAS SUGGESTED THAT THE THYROID:BODY WEIGHT RATIO DIFFERENCE WAS DUE TO THE VARIATION IN GOITROGEN CONTENT BETWEEN THE TWO TYPES OF MEAL.

THE ADDITION OF 20% RAPESEED MEAL TO A TURKEY POULT RATION CAUSED A FIVE TO SIX FOLD INCREASE IN THE THYROID WEIGHT (BLAKELY ET AL., 1948). HUSSAR ET AL. (1959) REPORTED THAT THE GOITROGENIC EFFECT WAS EVIDENT WHEN 10% ARGENTINE MEAL WAS ADDED TO A RATION FED TO RATS. A SIMILAR RESULT WAS OBSERVED WITH MICE

BY BELL (1957) AS WELL AS A REDUCED METABOLIC RATE UPON PROLONGED FEEDING OF THE ARGENTINE MEAL.

THE GOITROGENIC EFFECT OF FEEDING RAPESEED MEAL TO SWINE HAS ALSO BEEN DEMONSTRATED BY SEALE (1952), HUSSAR ET AL. (1959) AND MANNS ET AL. (1963). GOITROGENIC PROPERTIES OF THE MEAL WERE ALSO DEMONSTRATED WHEN FED TO LAYING HENS (CLANDININ ET AL., 1960 AND SNETSINGER ET AL., 1968).

VARIOUS PRECAUTIONARY METHODS EMPLOYED TO CONTROL THE GOITROGENIC NATURE OF RAPESEED HAVE BEEN MET WITH VARYING DEGREES OF SUCCESS. THESE PRECAUTIONS FALL INTO VARIOUS CATEGORIES SUCH AS LIMITING THE LEVEL OF GOITRIN IN EXPERIMENTAL DIETS (PETTIT ET AL., 1944 AND BLAKELY ET AL., 1948), ADDING IODINE (PURVES, 1943; ALLEN ET AL., 1952; DOW ET AL., 1954; KRATZER ET AL., 1954; KLAIN ET AL., 1956; CLANDININ ET AL., 1960 AND BELL ET AL., 1963), AND ADDING DIIODOTYROSINE OR THYROXINE (PURVES, 1943; BLAKELY ET AL., 1948; BELL, 1957 AND CLANDININ ET AL., 1960) TO THE RATION. THE FEEDING VALUE OF RAPESEED MEAL WAS MODIFIED BY COOKING (WAGNER-JAUREGG ET AL., 1947) INCLUDING A STEAM TREATMENT, HOT WATER EXTRACTION (HERCUS ET AL., 1936) OR ETHANOL EXTRACTION (FROLICH, 1952).

KENNEDY ET AL. (1941) FOUND THAT FEEDING RAPESEED TO RATS FOR 30 DAYS PRODUCED ENLARGED THYROIDS (22 TO 25 MG/100 G OF BODY WEIGHT). THESE WORKERS SUGGESTED THAT THE GLUCOSIDES IN RAPESEED EXHIBITED THE GOITROGENIC PROPERTY AND CONCLUDED THAT A RAPESEED DIET PRODUCED THYROID HYPERTROPHY BY INTERFERING WITH THE SYNTHESIS OF THYROXINE. CONSEQUENTLY, THE ANTERIOR PITUITARY WAS STIMULATED

TO PRODUCE A THYROTROPHIC STIMULATING HORMONE WHICH ACTED ON THE THYROID AND CAUSED HYPERTROPHY AND HYPERPLASIA. THE SAME RESULT WAS OBSERVED BY HERCUS ET AL. (1936), GRIESBACH (1941), GRIESBACH ET AL. (1943) AND PURVES (1943). UNDER THESE CONDITIONS, THE FEED-BACK MECHANISM FOR THYROID CONTROL WAS INTERRUPTED AND HENCE GOITROGENESIS CONTINUED.

ASTWOOD ET AL. (1949) REPORTED THAT THE ENZYME MYROSINASE PLAYED A PART IN RELEASING GOITRIN FROM THE GLUCOSIDE. THESE RESEARCHERS DESTROYED THE ENZYMES IN RAPESEED BY SUSPENDING THE GROUND SEED IN BOILING WATER AND FOUND NO GOITRIN FORMATION; SUBSEQUENT TREATMENT OF THE FILTRATE WITH MYROSINASE LIBERATED GOITRIN.

ETTLINGER ET AL. (1956) PROPOSED THAT HYDROLYTIC ACTION OF MYROSINASE ON THIOGLUCOSIDES COULD GIVE RISE TO ISOTHIOCYANATES, THIOCYANATES OR NITRILES. SIMILARLY, ALTSCHUL (1958) REPORTED THAT MYROSINASE CATALYZED DECOMPOSITION OF SINIGRIN AND SINALBIN WITH THE FORMATION OF MUSTARD OILS.

GREER ET AL. (1962) DEMONSTRATED THAT OXAZOLIDINETHIONE OR THE FORMATION OF OXAZOLIDINETHIONE FROM ISOTHIOCYANATES BY ENZYMATIC ACTION EXERTED THE ANTITHYROID ACTIVITY BY INTERFERING WITH THE ORGANIC BINDING OF IODINE. IT WAS SUGGESTED THAT THE COUPLING OF TWO IODINATED TYROSINE MOLECULES TO FORM THYROXINE COULD BE THE SENSITIVE STAGE AND THAT TYROSINE IODINATION WAS PROBABLY IMPAIRED. THESE RESEARCHERS ALSO SHOWED THAT ISOTHIOCYANATE COULD INTERFERE WITH THE CONCENTRATION OF IODINE IN THE THYROID GLAND BY A PROCESS OF COMPETITIVE INHIBITION.

ALTHOUGH CURRENT PROCESSING METHODS EMPLOYED IN PREPARING RAPESEED MEAL DESTROYS MYROSINASE, THERE ARE SEVERAL BACTERIA SUCH AS ESCHERICIA COLI THAT POSSESS ENZYMES CAPABLE OF HYDROLYSING THIOGLUCOSIDES IN THE GASTROINTESTINAL TRACT. THE TOXIC PRODUCTS CAN THEN BE ABSORBED AND EXERT THEIR THYROGENIC ACTION.

OTHER RESEARCH WORKERS DEMONSTRATED THE GOITROGENIC ACTIVITY OF THIOGLUCOSIDES. CLANDININ ET AL. (1966) REPORTED THAT (±)-5-VINYL-2-OXAZOLIDINE-THIONE CONSTITUTING 0.15% OF THE DIET OF CHICKS DEPRESSED GROWTH RATE AND INDUCED THYROID ENLARGEMENT. BACH (1942) FOUND RETARDATION OF THE TISSUE OXIDATION OF ASCORBIC ACID WHEN EITHER SINIGRIN OR ALLYLISOTHIOCYANATE WAS PRESENT IN A DIETARY CONCENTRATION OF 5.7×10^{-4}M. BENDA (1951) REPORTED THAT RESPIRATION IN GUINEA PIG LIVER SLICES WAS DEPRESSED BY 50% BY THE INFLUENCE OF SMALL CONCENTRATIONS (10^{-2}M) OF ALLYLISOTHIOCYANATE IN THE MEDIA.

FLICHENSTEIN ET AL. (1951) SHOWED THE INHIBITION OF DEHYDROGENATION REACTIONS INVOLVING PYRUVIC, LACTIC, CITRIC AND SUCCINIC ACIDS BY ALLYLISOTHIOCYANATE. THESE EFFECTS WERE INDEPENDENT OF THYROID GLAND FUNCTION.

LODHI ET AL. (1969) REPORTED THAT THE ADDITION OF GROUND MUSTARD SEED TO THE CHICK DIET CONTAINING 30% RAPESEED MEAL HAD NO SIGNIFICANT EFFECT ON ENERGY METABOLISM. THE MUSTARD SEED WAS ADDED AS A SOURCE OF MYROSINASE WHICH WAS NEEDED FOR THE RELEASE OF GOITRIN IN RAPESEED MEAL. THE ADDITION OF 0.09 PERCENT (±)-5-VINYL-OXAZOLIDINE-2-THIONE (GOITRIN) TO A SOYBEAN MEAL DIET (LEVEL CORRESPONDING TO 30% DIETARY RAPESEED MEAL) WAS SUFFICIENT

TO REDUCE THE DIETARY METABOLIZABLE ENERGY.

FEEDING VALUE OF RAPESEED MEAL

APART FROM THE GOITROGENIC EFFECT, GROWTH INHIBITION WAS ALSO OBSERVED AS A RESULT OF THYROID MALFUNCTION FOLLOWING THE CONSUMPTION OF RAPESEED MEAL. EXPELLER-PROCESSED MEAL USED AS A PROTEIN SUPPLEMENT IN CHICK STARTER RATIONS RESULTED IN GROWTH DEPRESSION UP TO 25% TOGETHER WITH A DECREASE OF 10% IN FEED EFFICIENCY, (PETTIT *ET AL.*, 1944; TURNER, 1946; WITZ *ET AL.*, 1950; KRATZER *ET AL.*, 1954; DOW *ET AL.*, 1954; KLAIN *ET AL.*, 1956 AND CLANDININ *ET AL.*, 1959).

BLAKELY *ET AL.* (1948, 1949) REPORTED THAT THE INCORPORATION OF RAPESEED MEAL IN A TURKEY STARTER RATION AS A REPLACEMENT FOR MEAT MEAL REDUCED THE GROWTH RATE. MACGREGOR *ET AL.* (1964) FOUND THAT THE RATE OF GROWTH WAS DEPRESSED SIGNIFICANTLY BY SUBSTITUTING 10% EXPELLER-PROCESSED RAPESEED MEAL FOR SOYBEAN MEAL IN RATIONS FED TO TURKEYS FROM ONE DAY TO 24 WEEKS OF AGE. ALTHOUGH MANY REPORTS ARE AVAILABLE ON GROWTH INHIBITION, GROWTH PROMOTING EFFECTS OF RAPESEED MEAL HAVE ALSO BEEN REPORTED (ALLEN *ET AL.*, 1952; FROLICH, 1952 AND KONDRA *ET AL.*, 1948).

KRATZER *ET AL.* (1954) AND KLAIN *ET AL.* (1956) DEMONSTRATED THAT THE LYSINE CONTENT OF EXPELLER-PROCESSED MEAL WAS LIMITING WHEN USED IN CHICK STARTER RATIONS. IT WAS SOON DISCOVERED THAT THE EXPELLER-PROCESSED RAPESEED MEAL USED PRIOR TO 1958 WAS INFERIOR TO SOYBEAN MEAL AS A PROTEIN SUPPLEMENT FOR CHICKS DUE TO OVERHEATING OF THE RAPESEED MEAL WHICH RESULTED IN A DECREASE IN

AVAILABLE LYSINE (CLANDININ ET AL., 1959). CONSEQUENTLY, SOLVENT PROCESSING HAS BEEN SUBSTITUTED FOR THE EXPELLER PROCESSING METHOD AND THE PROBLEM OF GROWTH INHIBITION HAS BEEN MARKEDLY ALLEVIATED.

CLANDININ ET AL. (1965) REPORTED THAT 5 AND 10% DIETARY PREPRESS SOLVENT AND SOLVENT-PROCESSED RAPESEED MEAL WERE USED AS A REPLACEMENT FOR PART OF THE SOYBEAN MEAL IN ISOCALORIC, ISONITROGENOUS TURKEY STARTER RATIONS. THE GROWTH OF POULTS WAS EQUAL TO THOSE FED THE CONTROL DIET. THESE SAME WORKERS (CLANDININ ET AL., 1966) REPORTED THAT WHEN 15% DIETARY COMMERICAL PREPRESS-SOLVENT AND SOLVENT-PROCESSED RAPESEED MEAL REPLACED PART OF THE SOYBEAN MEAL IN A 23% PROTEIN BROILER RATION ON AN ISOCALORIC AND ISONITROGENOUS BASIS, CHICK GROWTH AND FEED CONVERSION WERE EQUAL TO RATIONS CONTAINING SOYBEAN MEAL.

RAPESEED MEAL HAS ALSO BEEN USED IN THE RATIONS FOR LAYING AND BREEDING POULTRY. MACGREGOR ET AL. (1964) REPORTED THAT 10% EXPELLER OR PREPRESS-SOLVENT PROCESSED MEAL COULD BE USED IN TURKEY BREEDER RATIONS AS A REPLACEMENT FOR SOYBEAN MEAL WITHOUT ADVERSE EFFECT ON EGG PRODUCTION, EFFICIENCY OF FEED UTILIZATION, FEED CONSUMPTION, EGG SIZE, BODY WEIGHT AND FERTILITY OF HATCHING EGGS.

IN A RECENT REVIEW ON FEEDING VALUE OF RAPESEED MEAL FOR POULTRY, CLANDININ ET AL. (1966) REPORTED A TWO YEAR STUDY IN WHICH DUPLICATE GROUPS OF 72 TURKEYS WERE FED A BREEDER RATION CONTAINING SOYBEAN MEAL AS THE MAIN PROTEIN SUPPLEMENT AND SOLVENT-PROCESSED RAPESEED MEAL AS A REPLACEMENT FOR MOST OF THE SOYBEAN MEAL IN THE RATION. THEY FOUND THAT RAPESEED MEAL SUBSTITUTION FOR SOYBEAN MEAL HAD NO ADVERSE EFFECTS ON EGG

PRODUCTION, FEED CONVERSION OR HATCHABILITY. CLANDININ ET AL. (1966) REPORTED THAT 10% DIETARY PREPRESS-SOLVENT OR SOLVENT-PROCESSED RAPESEED MEAL FED TO LAYING AND BREEDING CHICKENS AND TURKEYS RESULTED IN SATISFACTORY EGG PRODUCTION, FEED CONVERSION, FERTILITY AND HATCHABILITY AS DID THE CORRESPONDING AMOUNTS OF PROTEIN FROM SOYBEAN MEAL.

ROBBLEE ET AL. (1967) CONDUCTED TWO EXPERIMENTS IN WHICH THE PERFORMANCE OF BREEDER TURKEYS FED RATIONS CONTAINING 10% PREPRESS-SOLVENT RAPESEED MEAL WAS COMPARED WITH THE PERFORMANCE OF BREEDERS FED AN ISOCALORIC AND ISONITROGENOUS CONTROL RATION WITHOUT RAPESEED MEAL. THESE WORKERS FOUND NO ADVERSE EFFECT ON MORTALITY, RATE OF EGG PRODUCTION, FERTILITY, HATCHABILITY OR MARKET QUALITY OF BREEDERS AT THE END OF THE BREEDING SEASON AS A RESULT OF THE RAPESEED MEAL SUBSTITUTION FOR OTHER PROTEIN SUPPLEMENTS. ALTHOUGH A SIMILAR DISTRIBUTION OF AMINO ACIDS WAS OBSERVED IN THE RATION WITH AND WITHOUT RAPESEED MEAL, THERE WAS AN INCREASE IN THE AMOUNT OF FEED REQUIRED TO PRODUCE A DOZEN EGGS WITH RAPESEED MEAL DIETS.

FANGUAF ET AL. (1938) AND WITZ ET AL. (1950) FOUND THAT WHEN RAPESEED OIL MEAL, PRESUMABLY EXPELLER-PROCESSED TYPE, WAS USED AT 10% IN THE DIET OF HENS, IT CAUSED AN INHIBITION OF GROWTH. CONTRARILY, NO APPARENT ILL-EFFECTS WERE FOUND BY FOLKE (1931) AND KONDRA ET AL. (1948) WHEN LEVELS BELOW 10% OF THE DIET WAS FED.

O'NEIL (1957) CONDUCTED THREE EXPERIMENTS IN WHICH EXPELLER-PROCESSED RAPESEED OIL MEAL WAS FED TO LAYING HENS. THE

FIRST TEST WAS WITH 10% RAPESEED MEAL IN RATIONS CONTAINING SOYBEAN OIL MEAL, TWO PERCENT MEAT MEAL AND ONE PERCENT FISH MEAL. SOYBEAN MEAL WAS REPLACED IN THE SECOND TEST BY RAPESEED MEAL ON A PROTEIN EQUIVALENT BASIS AND THE LEVELS OF CALCIUM AND PHOSPHORUS WERE ADJUSTED IN TEST DIETS. IN BOTH TESTS, NO SIGNIFICANT DIFFERENCES BETWEEN TREATMENTS WERE OBSERVED FOR EITHER PERCENT PRODUCTION OR AMOUNT OF FEED REQUIRED TO PRODUCE A DOZEN EGGS. SOYBEAN MEAL WAS REPLACED WITH RAPESEED MEAL IN THE THIRD TEST AND ANIMAL PROTEIN WAS SUPPLIED AT EITHER THE 1.5 OR 3 PERCENT LEVEL. AGAIN, NO SIGNIFICANT DIFFERENCE WAS OBSERVED BETWEEN TREATMENTS IN THE REPRODUCTIVE TRAITS STUDIED.

IN A RECENT REVIEW, CLANDININ ET AL. (1966) REPORTED RESULTS OF PREVIOUSLY UNPUBLISHED DATA COLLECTED DURING 1955-56. GROUPS OF 30 WHITE LEGHORN PULLETS IN BATTERIES WERE FED RATIONS CONTAINING 0.5 PERCENT FISH MEAL COMBINED WITH 0, 3, 6 AND 9 PERCENT EXPELLER-PROCESSED RAPESEED MEAL AS A REPLACEMENT FOR SOYBEAN MEAL. THE RATIONS WERE FED OVER A PERIOD OF 24 WEEKS. RATE OF LAY WAS SIMILAR FOR EACH OF THE TREATMENT GROUPS.

SELL ET AL. (1968) CONDUCTED FOUR EXPERIMENTS TO EVALUATE RAPESEED MEAL AS A POTENTIAL PROTEIN SOURCE FOR LAYING HENS. IT WAS SHOWN THAT DIETARY LEVELS OF 10% OR MORE RAPESEED MEAL CAUSED A SLIGHT BUT CONSISTENT DECREASE IN HEN-DAY EGG PRODUCTION AND THE RATE OF MORTALITY INCREASED MARKEDLY. RAPESEED MEAL IN THE DIETS CAUSED A DECREASE IN EGG WEIGHT, BUT FEED CONSUMPTION AND EFFICIENCY OF FEED UTILIZATION WERE NOT AFFECTED. THESE WORKERS OBSERVED THAT THE ADVERSE EFFECTS OF RAPESEED MEAL ON HENS AFTER

PEAK PRODUCTION WAS LESS, MORTALITY WAS HIGH AND HEN-HOUSE EGG PRODUCTION WAS POOR. HOWEVER, THESE STUDIES SHOWED THAT LEVELS OF RAPESEED MEAL OVER FIVE PERCENT RESULTED IN INFERIOR PERFORMANCE OF LAYING HENS AND HIGHER MORTALITY.

SNETSINGER ET AL. (1968) REPORTED THE SAME FINDINGS AS THE ABOVE WORKERS WITH COMMERCIAL LAYERS. IN ADDITION, IODINE SUPPLEMENTED TO THE DIET DID NOT ALLEVIATE MORTALITY. THE METHOD OF RAPESEED MEAL PROCESSING (DIRECT SOLVENT OR PREPRESS SOLVENT) AND THE ADDITION OF IODINE HAD NO EFFECT ON EGG WEIGHT AND THE AMOUNT OF FEED REQUIRED TO PRODUCE A DOZEN EGGS.

COMPOUNDS OTHER THAN THE BREAK-DOWN PRODUCTS OF GLUCOSIDES WERE ALSO SHOWN TO BE PRESENT IN RAPESEED MEAL. CLANDININ (1961) REPORTED THAT SINAPIN, THE BITTER COMPOUND IN RAPESEED MEAL, ADDED AS SINAPIN BISULPHATE TO CHICKS DIET AT 0.39% LEVEL DID NOT DEPRESS GROWTH. VOHARA ET AL. (1966) STUDIED THE EFFECT OF ADDING VARIOUS LEVELS OF TANNIN TO A SOYBEAN MEAL DIET OF GROWING CHICKS. RESULTS INDICATED THAT 0.59% TANNIN IN THE DIET REDUCED GROWTH. A LEVEL OF FIVE PERCENT RESULTED IN 70% MORTALITY WITHIN 7-11 DAYS. CLANDININ ET AL. (1968) REPORTED THAT TANNIN IS PRESENT IN RAPESEED IN SUFFICIENT AMOUNTS (THREE PERCENT) TO ADVERSELY AFFECT CHICK GROWTH AND THE METABOLIZABLE ENERGY VALUE OF RATIONS WITH HIGH LEVELS OF RAPESEED MEAL.

DIETARY ENERGY

THE ENERGY REQUIREMENT OF LAYING HENS HAS RECEIVED CONSIDERABLE ATTENTION FOR MANY YEARS AND NUMEROUS STUDIES HAVE

BEEN CARRIED OUT IN ORDER TO ESTABLISH THESE REQUIREMENTS. CONTROLLING THE FEED INTAKE OF HENS WAS USED IN EARLY STUDIES BECAUSE IT WAS BELIEVED THAT RESTRICTION OF FEED WOULD PREVENT EXCESSIVE ENERGY INTAKE.

HEYWANG (1940) OBSERVED A DRASTIC REDUCTION IN EGG PRODUCTION BUT NO EFFECT ON BODY WEIGHT OR EGG SIZE WHEN THE FEED INTAKE OF LEGHORN HENS WAS RESTRICTED TO 87½ AND 75% OF AD LIBITUM INTAKE. CONTRARILY, COMBS ET AL. (1961) INDICATED THAT RESTRICTION OF ENERGY INTAKE OF HEAVY TYPE HENS TO 81 AND 87% OF AD LIBITUM INTAKE HAD NO EFFECT ON EGG PRODUCTION, HAUGH UNIT SCORES OR MORTALITY, BUT DID CAUSE A REDUCTION IN BODY WEIGHT GAIN AND RATE OF INCREASE IN EGG WEIGHT.

SINGSEN ET AL. (1958) REPORTED THAT AD LIBITUM FEEDING OF A HIGH ENERGY DIET, 1014 CALORIES OF PRODUCTIVE ENERGY PER POUND, INCREASED BODY WEIGHT AND MORTALITY; EGG PRODUCTION, HOWEVER, WAS MAINTAINED. AD LIBITUM FEEDING OF A LOW ENERGY DIET, 857 CALORIES OF PRODUCTIVE ENERGY PER POUND, ALSO RESULTED IN SATISFACTORY PERFORMANCE BUT TO A SIGNIFICANTLY LESS DEGREE. IT WAS FOUND BY THE SAME WORKERS THAT EGG PRODUCTION WAS MAINTAINED, MORTALITY AND BODY WEIGHT GAIN WERE REDUCED WHEN FEED INTAKE WAS CONTROLLED. ON THE OTHER HAND, DONALDSON ET AL. (1962) REPORTED THAT ENERGY RESTRICTION ON LAYING HENS RESULTED IN LOWER EGG PRODUCTION, BODY WEIGHT AND EGG SIZE. IT WAS SUGGESTED THAT DIETARY PROTEIN, VITAMINS AND MINERALS WERE POORLY UTILIZED WHEN ENERGY INTAKE WAS RESTRICTED.

EARLY STUDIES ON DIETARY ENERGY FOR LAYING DIETS BY

Thayer (1953) indicated that niacin, riboflavin, pantothenic acid and folic acid levels should be increased in high energy laying diets to obtain maximum egg production and feed utilization. Berg et al. (1956), however, could not demonstrate the beneficial effect of increased levels of these vitamins when 1148 and 1331 Calories of metabolizable energy per pound of diet were fed to both New Hampshire and White Leghorn hens. It was noted that a 1331 Calorie diet improved feed efficiency (feed/dozen eggs) and increased body weight gains.

The fiber content of the laying hen diet has an influence on the dietary energy level. Heuser et al. (1945) and Bird et al. (1946) reported that low fiber rations supported a higher rate of egg production than similar rations high in fiber.

Following the establishment of the productive energy values of feedstuff by Fraps (1946), many research workers utilized these values to study the energy requirements of laying hens. Higher egg production and lower efficiency of feed utilization, measured as feed required to produce a dozen eggs, and greater weight gains were obtained with high energy as compared to low energy rations by Skinner et al. (1951), Singsen et al. (1952), Gerry (1954), Harms et al. (1957), and Petersen et al. (1957).

Griminger et al. (1954) indicated that 66 therms per pound of ration caused a decrease in egg production and body weight when compared to rations of higher energy content but egg shell thickness and egg weight were not affected by the rations.

Hill et al. (1954) reported that a marked reduction was

OBSERVED IN THE AMOUNT OF FEED REQUIRED TO PRODUCE A DOZEN EGGS BY INCREASING DIETARY ENERGY FROM 740 TO 930 CALORIES OF PRODUCTIVE ENERGY PER POUND OF DIET. TWO YEARS LATER THE SAME WORKERS (HILL ET AL., 1956) OBSERVED THAT HIGH ENERGY DIETS SUPPORTED A HIGH RATE OF EGG PRODUCTION DURING THE WINTER MONTHS. WHEN THE ENERGY LEVEL IN THE LAYER RATIONS WAS INCREASED BY THE USE OF FAT, THE FEED REQUIREMENT WAS REDUCED AT A RATE OF TWO PERCENT FOR EACH PERCENT OF ADDED FAT. THE FEED REQUIREMENT INCREASED BY ABOUT 12% WHEN THE ENERGY CONCENTRATION OF A 930 CALORIES (PE/LB.) DIET WAS REDUCED BY 100 CALORIES PER POUND. BODY WEIGHT, HOWEVER, WAS MAINTAINED BY HIGH ENERGY RATIONS AND THE TOTAL WEIGHT GAINED DURING THE PRODUCTION PERIOD SEEMED TO INCREASE WITH ENERGY CONCENTRATION.

ANDERSON ET AL. (1957) REPORTED THAT A HIGH ENERGY RATION CONTAINING 884 CALORIES OF PRODUCTIVE ENERGY PER POUND DID NOT RESULT IN GREATER EGG PRODUCTION OF SINGLE COMB WHITE LEGHORN PULLETS THAN A LOW ENERGY RATION CONTAINING 723 CALORIES OF PRODUCTIVE ENERGY PER POUND. FEED EFFICIENCY, HOWEVER, WAS SIGNIFICANTLY BETTER FOR HENS FED THE RATIONS CONTAINING 884 CALORIES OF PRODUCTIVE ENERGY PER POUND, AND THEIR BODY WEIGHTS INCREASED. IT WAS NOTED THAT LIVABILITY AND EGG WEIGHT WERE NOT AFFECTED BY ENERGY LEVELS. THE GROUPS FED THE HIGH ENERGY BASAL RATION PRODUCED EGGS OF SIGNIFICANTLY LOWER SPECIFIC GRAVITY THAN DID THE BIRDS ON OTHER RATIONS.

WIESE ET AL. (1957) REPORTED THE SAME FINDINGS AS THE ABOVE WORKERS. IN ADDITION, DIFFERENT LEVELS OF DIETARY ENERGY DID NOT

AFFECT SPECIFIC GRAVITY OF THE EGGS FROM GROUPS OF HENS DURING THE FIRST TWO MONTHS OF PRODUCTION BUT DURING THE LAST TWO MONTHS OF PRODUCTION.

HIGH PRODUCTIVE ENERGY PER POUND, 700-940 CALORIES, WERE REPORTED BY MACINTYRE ET AL. (1957) ON RATE OF EGG PRODUCTION, EGG WEIGHT, SPECIFIC GRAVITY OF THE EGGS, ALBUMEN HEIGHT OR BLOOD AND MEAT SPOTS IN THE EGGS. FEED CONSUMPTION AND FEED PER DOZEN EGGS, HOWEVER, WERE MARKEDLY AFFECTED BY THE ENERGY CONTENT OF THE DIET AND WHEN THE PRODUCTIVE ENERGY PER POUND OF DIET WAS DECREASED BY 100 CALORIES, THE FEED REQUIRED TO PRODUCE A DOZEN EGGS INCREASED BY ABOUT 11%.

CONTRARY TO THE FINDINGS OF MACINTYRE ET AL. (1957), BERG ET AL. (1957) REPORTED THAT HIGH DIETARY ENERGY RESULTED IN INCREASED EGG WEIGHT. EARLIER STUDIES ALSO SHOWED THAT DIETARY ENERGY LEVEL CAUSED LITTLE OR NO DIFFERENCES IN ALBUMEN QUALITY AS REPORTED BY THOMPSON ET AL. (1932), CARD ET AL. (1934), LEE ET AL. (1944) AND GRIMINGER ET AL. (1954).

MILLER ET AL. (1957) REPORTED THAT FEED EFFICIENCY IMPROVED AS THE ENERGY CONTENT OF THE LAYING DIETS CONTAINING 12 TO 21% PROTEIN INCREASED FROM 640, 745 TO 930 CALORIES OF PRODUCTIVE ENERGY PER POUND. NO DIFFERENCE WAS OBSERVED IN BODY WEIGHTS OR EGG PRODUCTION.

MCDANIEL ET AL. (1957) INDICATED THAT BY INCREASING THE PRODUCTIVE ENERGY LEVEL FROM 962 TO 1050 CALORIES PER POUND IN A 17-PERCENT PROTEIN LAYING DIET, FEED EFFICIENCY (FEED REQUIRED TO PRODUCE A DOZEN EGGS) WAS IMPROVED BY 12.2%. IT WAS ALSO NOTED

THAT THE SAME ENERGY INCREMENT IN 18% PROTEIN DIETS CAUSED AN 8.2 PERCENT REDUCTION IN FEED EFFICIENCY.

HOCHREICH ET AL. (1958) REPORTED THAT LESS ENERGY WAS REQUIRED TO PRODUCE EGGS WITH 17 OR 18% PROTEIN DIETS THAN WITH A 16% PROTEIN DIET. ON THE OTHER HAND, LILLIE ET AL. (1965) FOUND THAT DIETARY ENERGY HAD NO EFFECT ON EGG WEIGHTS, MORTALITY, FERTILITY, HATCHABILITY AND PROGENY PERFORMANCE OF PULLETS FED FOUR LEVELS OF DIETARY PROTEIN (12, 14, 16 AND 18%). PROTEIN X ENERGY INTERACTIONS WERE NOTED ONLY IN BODY WEIGHT GAIN IN TWO STUDIES AND IN EGG WEIGHTS IN ANOTHER STUDY.

COMBS ET AL. (1960) CARRIED OUT STUDIES WITH RATIONS CONTAINING 15-19% PROTEIN AND 909-1096 CALORIES OF PRODUCTIVE ENERGY PER POUND. THESE STUDIES SHOWED THAT A CALORIE:PROTEIN RATIO AS LARGE AS 66.6:1 WAS ADEQUATE TO SUPPORT 60% EGG PRODUCTION. SIMILARLY, MARCH ET AL. (1962) REPORTED THAT WHITE LEGHORNS FED THE RATION CONTAINING 1470 CALORIES OF METABOLIZABLE ENERGY PER POUND DID NOT GAIN WEIGHT AND THE METABOLIZABLE ENERGY INTAKE PER POUND OF EGGS PRODUCED WAS HIGHER THAN WITH THE RATIONS CONTAINING 1270 CALORIES OF METABOLIZABLE ENERGY PER POUND OF FEED.

KURNICK ET AL. (1961) FOUND THAT, ON THE AVERAGE, THE RATE OF LAY WAS FIVE TO SIX PERCENT LOWER WITH 765 CALORIES THAN WITH 865 AND 965 CALORIES OF PRODUCTIVE ENERGY PER POUND OF DIET. COLIGADO ET AL. (1967) INDICATED THAT FEEDING A HIGH ENERGY DIET AT THE ONSET OF PRODUCTION SIGNIFICANTLY DEPRESSED EGG NUMBERS AND BODY WEIGHT GAIN ALTHOUGH FEED EFFICIENCY AND EGG WEIGHT IMPROVED. ON THE OTHER HAND, LILLIE ET AL. (1965) REPORTED THAT

HIGH ENERGY HAD NO EFFECT ON EGG PRODUCTION OF NEW HAMPSHIRES, RHODE ISLAND REDS AND WHITE LEGHORNS BUT MARKEDLY IMPROVED FEED EFFICIENCY.

IT WAS NOTED BY MANY INVESTIGATORS THAT THE ADDITION OF ANIMAL FAT TO LAYING HENS RATIONS IMPROVED FEED EFFICIENCY AND EGG PRODUCTION (LILLIE ET AL., 1952; HOCHREICH ET AL., 1957 AND QUINSENBERRY ET AL., 1962). OTHER STUDIES SHOWED THAT HIGH DIETARY ENERGY INCREASED EGG SIZE AND EGG WEIGHT (HOCHREICH ET AL., 1957, 1958 AND QUINSENBERRY ET AL., 1962).

EXPERIMENTAL PROCEDURE

A STUDY CONDUCTED DURING TEN 28-DAY PERIODS (APRIL 22, 1969 TO JANUARY 26, 1970) WAS DESIGNED TO DETERMINE THE EFFECT OF DIETARY ENERGY ON THE PERFORMANCE OF LAYING HENS FED DIFFERENT LEVELS OF RAPESEED MEAL. FOUR HUNDRED WHITE LEGHORN PULLETS (DEKALB STRAIN) WERE DISTRIBUTED AT 24 WEEKS OF AGE INTO COMMUNITY CAGES WITH FIVE BIRDS IN EACH.

THERE WERE EIGHT DIETARY TREATMENTS IMPOSED IN A 2 X 4 FACTORIAL ARRANGEMENT IN A RANDOMISED BLOCK DESIGN WITH 10 CAGES PER DIETARY TREATMENT. TWO ADJACENT CAGES WERE ASSIGNED TO EACH TREATMENT IN A RANDOM BLOCK DESIGN (FIVE REPLICATIONS PER TREATMENT).

THE EXPERIMENTAL DIETS (TABLE 1) WERE FORMULATED USING FEEDSTUFFS' ANALYSIS TABLE FOR FEED INGREDIENTS (1968) TO SUPPLY CALCULATED METABOLIZABLE ENERGIES OF 2539 AND 2759 KILOCALORIES PER KILOGRAM OF DIET. WHEAT BRAN WAS ADDED TO RATIONS AT THE EXPENSE OF WHEAT, SOYBEAN MEAL AND ANIMAL TALLOW TO REDUCE DIETARY ENERGY. RAPESEED MEAL (SOLVENT EXTRACTED) WAS SUBSTITUTED ON AN EQUIVALENT PROTEIN BASIS FOR SOYBEAN MEAL TO OBTAIN 0, 8, 10 AND 12% DIETARY RAPESEED MEAL. METABOLIZABLE ENERGY VALUE USED FOR RAPESEED MEAL WAS 2120 KCAL/KG (SELL, 1966) AND A PROTEIN CONTENT OF 40% WAS USED IN THE CALCULATION OF DIETARY PROTEIN. ALL RATIONS WERE FORMULATED TO CONTAIN 17% PROTEIN AND WERE FED TO PULLETS IN PELLET (3/8 INCH) FORM. THE DIETS WERE ANALYZED FOR CRUDE PROTEIN

TABLE 1. COMPOSITION OF EXPERIMENTAL DIETS.

INGREDIENTS (%)	DIETARY TREATMENT NUMBER							
	1	2	3	4	5	6	7	8
GROUND WHEAT	72.5	64.0	70.0	62.5	68.5	61.0	68.0	61.0
RSM (41.5%)	--	--	8.0	8.0	10.0	10.0	12.0	12.0
SOYBEAN MEAL (50%)	10.5	9.5	4.5	4.0	3.5	2.5	2.0	1.0
FISH MEAL (70%)	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
ALFALFA MEAL (17%)	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
WHEAT BRAN	--	10.5	--	9.0	--	9.5	--	9.0
DEFLU. PHOSPHATE	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
LIMESTONE	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0
VIT. PREMIX (H-1)[1]	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
MIN. PREMIX (H-1)[2]	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
ANIMAL FAT	2.0	1.0	2.5	1.5	3.0	2.0	3.0	2.0
CALC. PROTEIN (%)	17.1	17.1	17.0	17.1	17.1	17.1	17.1	17.0
CALC. M.E. KCAL/KG	2754	2530	2750	2530	2759	2532	2750	2530

1. VITAMIN PREMIX SUPPLIED THE FOLLOWING AMOUNT PER KG OF DIET: VITAMIN A, 7150 I.U.; VITAMIN D_3, 818 I.C.U.; VITAMIN E, 5.5 I.U.; VITAMIN B_{12}, 11 MCG; RIBOFLAVIN, 2.2 MG; PANTOTHENIC ACID, 4.4 MG; NIACIN, 6.6 MG; CHOLINE, 110 MG AND METHIONINE 49.9 MG.

2. MINERAL PREMIX SUPPLIED THE FOLLOWING AMOUNT PER KG OF DIET: MANGANESE, 81.4 MG; ZINC, 44 MG AND SODIUM CHLORIDE, 4.82 MG.

(A.O.A.C., 1960).

Birds were individually weighed at the beginning of the study, at the end of the fifth period and at completion of the experiment (10 periods). Feed and water were supplied ad libitum throughout the experiment. Feed consumed and eggs laid were recorded daily and egg production (hen-day) was calculated at 28-day intervals. Feed efficiency as measured by gram of feed required to produce one gram of egg was calculated for each experimental period (28-day). All eggs from each replicate were weighed for three consecutive days during the first, second, fourth, sixth, eighth and tenth period of production.

Egg shell thickness for a total of 1600 eggs was measured during the first, fourth, seventh and tenth period (50 eggs per treatment per period). The interior egg quality was determined by measuring albumen height which was converted into Haugh units. The presence of blood and meat spots was also recorded.

Mortality was recorded daily and dead birds were examined to ascertain the cause of death. Twenty-four birds (three per dietary treatment) were sacrificed at the end of the fourth, seventh and tenth period and livers removed for fat determination. At the same time spleen and thyroid gland were removed from each bird, weighed separately, and the ceca length measured.

To determine percent liver lipid, a liver sample of six grams was homogenized in a Waring blender for two minutes, weighed and freeze-dried for 24 hours and weighed again. Approximately two grams of dried liver was weighed into alundum thimbles and

EXTRACTED WITH ETHER FOR FOUR HOURS IN A GOLDFISCH EXTRACTION APPARATUS. THE CRUDE FAT CONTENT WAS CALCULATED ON A DRY MATTER BASIS.

METABOLIZABLE ENERGY OF THE EXPERIMENTAL RATIONS WAS DETERMINED USING THE PROCEDURE DESCRIBED BY HILL AND ANDERSON (1958). CHROMIC OXIDE WAS ADDED TO THE RATIONS AS AN INDEX TO ESTABLISH THE AMOUNT OF EXCRETA PRODUCED PER UNIT OF FEED INTAKE. DETERMINATION OF METABOLIZABLE ENERGY WAS CARRIED OUT DURING THE SIXTH EXPERIMENTAL PERIOD AND UTILIZED ONE BIRD FROM EACH OF THREE EXPERIMENTAL PENS PER TREATMENT. EXPERIMENTAL RATIONS CONTAINING 0.3 PERCENT CHROMIC OXIDE WERE FED DURING A 7-DAY ADJUSTMENT PERIOD FOLLOWED BY TOTAL EXCREMENT COLLECTION FOR THREE CONSECUTIVE DAYS. THE EXCRETA COLLECTED WERE IMMEDIATELY FROZEN AFTER DAILY COLLECTION. THESE FROZEN EXCRETA WERE POOLED AND DRIED IN AN AIR CONVECTION OVEN AT A TEMPERATURE OF $70^{\circ}C$. SAMPLES WERE GROUND AFTER DRYING AND STORED IN SEALED GLASS CONTAINERS. THE AMOUNT OF CHROMIC OXIDE IN BOTH THE FEED AND EXCRETA WAS DETERMINED USING THE METHOD DESCRIBED BY CZARNOCKI ET AL. (1961).

HEAT OF COMBUSTION OF FEED AND EXCRETA WAS DETERMINED BY THE USE OF A PARR ADIABATIC CALORIMETER. FEED AND EXCRETA NITROGEN CONTENTS WERE DETERMINED BY THE MACRO-KJELDAHL TECHNIQUE, DESCRIBED BY THE A.O.A.C. (1960). METABOLIZABLE ENERGY WAS CALCULATED USING THE FOLLOWING FORMULA:

$$M.E. = A - B \times C/D - 8.22 (Y - Z \times C/D)$$

M.E. = METABOLIZABLE ENERGY (KCAL/G)

A = ENERGY (GROSS) OF FEED (KCAL/G)

B = ENERGY (GROSS) OF DRY EXCRETA (KCAL/G)

C = CHROMIC OXIDE CONTENT OF FEED (%)

D = CHROMIC OXIDE CONTENT OF EXCRETA (%)

Y = NITROGEN PER GRAM OF FEED

Z = NITROGEN PER GRAM OF EXCRETA

8.22 = HEAT OF COMBUSTION OF URIC ACID/G NITROGEN.

EXPERIMENTAL DATA WERE ANALYZED BY ANALYSIS OF VARIANCE, SNEDECOR (1956), AND THE TREATMENT DIFFERENCES WERE TESTED BY THE MULTIPLE RANGE TEST OF DUNCAN (1955).

RESULTS AND DISCUSSION

Egg production

The summary of results (Table 2) showed that energy had no significant effect on egg production of hens. Egg production (Table 2) significantly ($P < 0.01$) improved with the addition of 12% rapeseed meal compared with the control diet or 8 and 10% rapeseed meal. This is contrary to the findings of Sell *et al.* (1968a, 1968b), Snetsinger *et al.* (1968) and Clandinin (1969) that rapeseed meal levels varying from 4 to 16% in layers diet slightly decreased egg production as compared to soybean meal rations.

The difference between studies may be attributed in part to the length of each study which varied from 32 to 40 weeks of egg production. Also, the high protein level (19%, Table 4) of the 12% rapeseed meal rations probably had a definite influence on rate of production. This view is supported by Ingram (1956) and Milton *et al.* (1957) who found that 18 and 19% protein levels showed superior egg production to a 16% protein diet with caged layers.

There was no significant difference in egg production between the 10% rapeseed meal high energy level and its corresponding control nor was there a statistical difference between the low energy control and the low energy 10% rapeseed meal rations (Table 3). Also, no difference was recorded in egg

TABLE 2. SUMMARY OF THE EFFECT OF ENERGY AND RAPESEED MEAL (RSM) ON THE 40-WEEK LAYING HEN PERFORMANCE.

TREATMENTS	EGG PROD. (%)[1]	$\frac{\text{FEED (G)}}{\text{EGG (G)}}$	EGG WT. (G)[2]
ENERGY LEVEL (M.E.)			
2530 KCAL/KG	65.9	2.93	56.5
2750 KCAL/KG	66.6	2.84	56.6
RSM (%)			
0	65.4^{A}	2.99	57.5^{A}
8	65.2^{A}	2.88	56.0^{B}
10	65.5^{A}	2.87	56.5^{B}
12	68.8^{B}	2.81	56.3^{B}

1. MEANS NOT HAVING THE SAME SUPERSCRIPT ARE SIGNIFICANTLY DIFFERENT ($P < 0.01$).

2. MEANS NOT HAVING THE SAME SUPERSCRIPT ARE SIGNIFICANTLY DIFFERENT ($P < 0.05$).

TABLE 3. EFFECT OF ENERGY AND RAPESEED MEAL (RSM) OF LAYING RATIONS ON EGG PRODUCTION, EFFICIENCY OF FEED UTILIZATION AND EGG WEIGHT.

TREATMENTS		EGG PROD.[1]	FEED (G)[1]	EGG WT.[2]
RSM (%)	M.E. (KCAL/KG)	(%)	EGG (G)	(%)
0	2530	64.3^{AB}	2.97^{CDE}	57.3^{B}
8	2530	67.6^{C}	2.80^{ABCD}	56.7^{B}
10	2530	64.2^{AB}	3.09^{E}	56.7^{B}
12	2530	67.3^{C}	2.87^{ABCDE}	55.3^{AC}
0	2750	66.4^{BC}	3.01^{CDE}	57.6^{B}
8	2750	62.8^{A}	2.96^{BCDE}	55.2^{AC}
10	2750	66.7^{C}	2.64^{A}	56.3^{BC}
12	2750	70.4^{D}	2.75^{ABCD}	57.4^{B}

1. MEANS NOT HAVING THE SAME SUPERSCRIPT ARE SIGNIFICANTLY DIFFERENT ($P < 0.05$).

2. MEANS NOT HAVING THE SAME SUPERSCRIPT ARE SIGNIFICANTLY DIFFERENT ($P < 0.01$).

TABLE 4. PROXIMATE ANALYSIS OF EXPERIMENTAL DIETS.

TREATMENTS RSM (%)	ANALYZED VALUES M.E. (KCAL/KG)	C.P. (%)[1]	C.F. (%)[2]
0	2308	17.9	3.6
8	2323	18.6	3.9
10	2362	18.0	4.1
12	2332	19.2	4.2
0	2558	18.2	2.6
8	2544	16.5	3.1
10	2596	18.0	3.3
12	2570	19.1	3.4

1. C. P. INDICATES CRUDE PROTEIN VALUE.

2. C. F. INDICATES CRUDE FIBER VALUE.

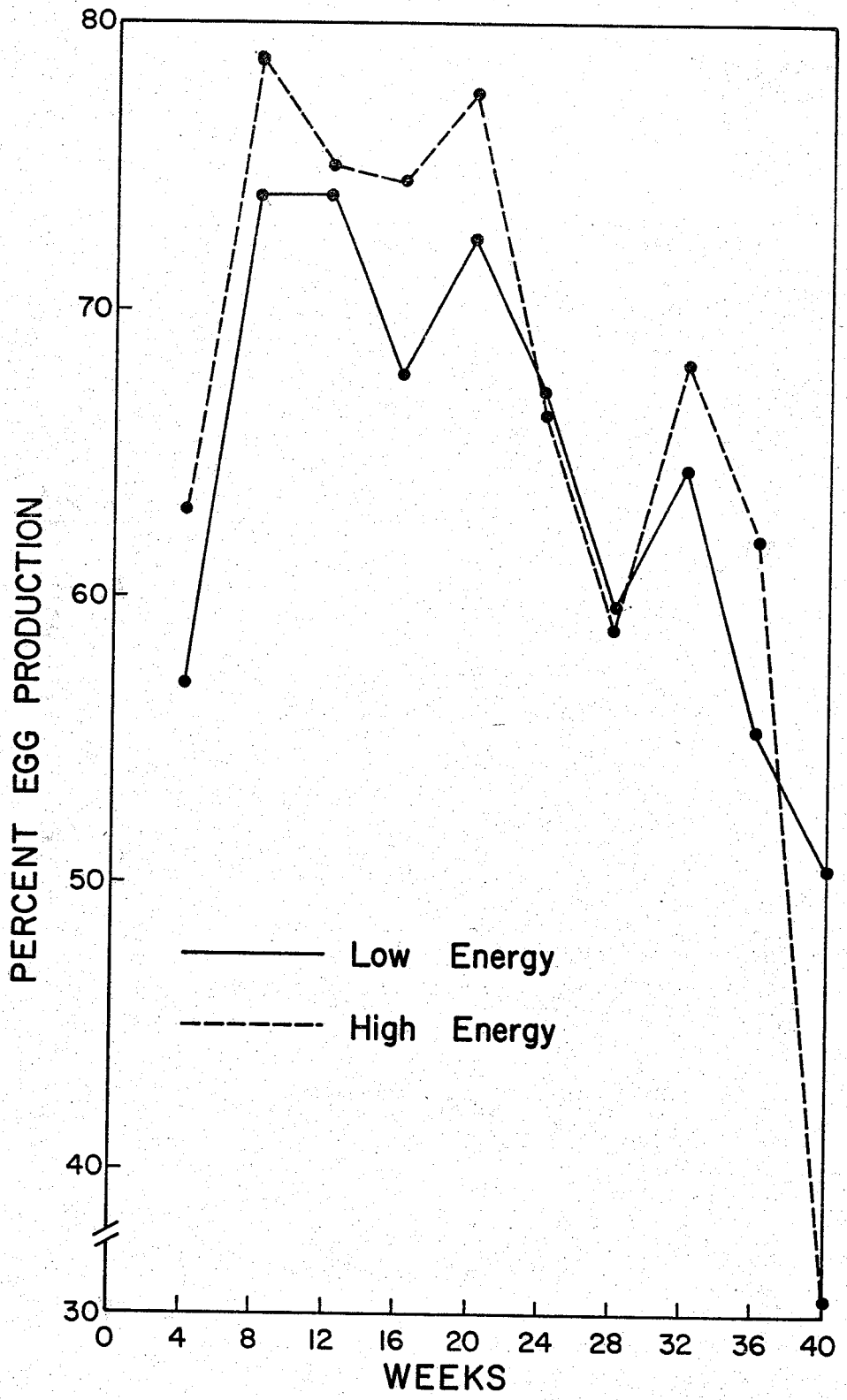

Fig. 1 Egg Production of Hens Fed Soybean Meal Diet.

PRODUCTION BETWEEN LAYERS FED 8 AND 12% RAPESEED MEAL ON LOW ENERGY INTAKE. ANALYSIS OF THE DATA SHOWED THAT EGG PRODUCTION OF LAYERS FED 10 AND 12% RAPESEED MEAL WAS IMPROVED WHEN THE ENERGY LEVEL WAS INCREASED FROM 2530 KCAL TO 2730 KCAL/KG. LOW DIETARY RAPESEED MEAL (8%) SHOWED THE REVERSE EFFECT OF ENERGY (FIG. 2) SINCE HENS FED THE LOW LEVEL OF DIETARY ENERGY MAINTAINED A HIGHER RATE OF LAY WITH EIGHT PERCENT RAPESEED MEAL.

SELL ET AL. (1968A) AND BRAGG (1968) FOUND THAT THE ADVERSE EFFECTS OF RAPESEED MEAL ON PRODUCTION CHARACTERISTICS WERE LESS SEVERE IF THE MEAL WAS NOT FED UNTIL THE HENS HAD PASSED THE USUAL PRODUCTION PEAK (36-40 WEEKS OF AGE). THIS SHOWED THAT HENS UTILIZED RAPESEED MEAL BETTER AT A CERTAIN AGE AND SUPPORTED THE FINDINGS THAT 10 AND 12% RAPESEED MEAL SUPPORTED HIGHER EGG PRODUCTION, PARTICULARLY AFTER 24 WEEKS OF PRODUCTION PROVIDED THAT SUFFICIENT ENERGY WAS AVAILABLE IN THE RATION (FIGS. 3 AND 4).

FEED EFFICIENCY

DIETARY ENERGY OR RAPESEED MEAL HAD NO SIGNIFICANT EFFECT ON THE EFFICIENCY OF FEED UTILIZATION (FEED PER GRAM OF EGG) FOR HENS FED THE CONTROL OR THE RAPESEED MEAL RATIONS (TABLE 2). THE FEED TO EGG RATIO, HOWEVER, SHOWED A NON-SIGNIFICANT TREND TOWARD IMPROVEMENT. SIMILAR RESULTS WERE OBSERVED BY SELL ET AL. (1968A), SNETSINGER ET AL. (1968) AND CLANDININ (1969).

EFFICIENCY OF FEED UTILIZATION (TABLE 3) WAS SIGNIFICANTLY DIFFERENT BETWEEN LAYERS FED 8 AND 10% RAPESEED MEAL IN THE LOW ENERGY RANGE. THERE WAS, HOWEVER, NO SIGNIFICANT DIFFERENCE AMONG THE 0, 8 AND 12% MEAL LEVELS IN THE SAME ENERGY RANGE. A

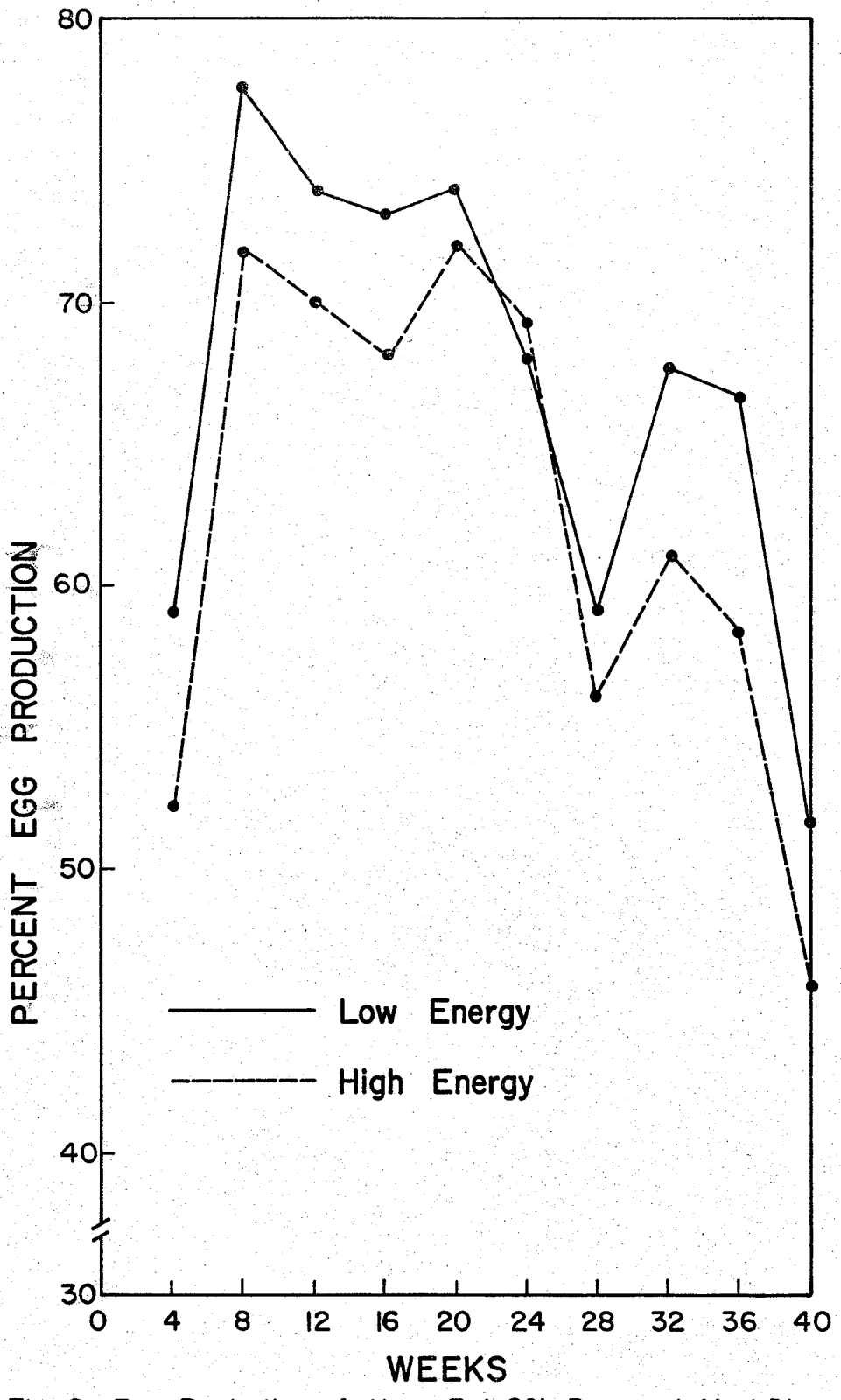

Fig. 2 Egg Production of Hens Fed 8% Rapeseed Meal Diet.

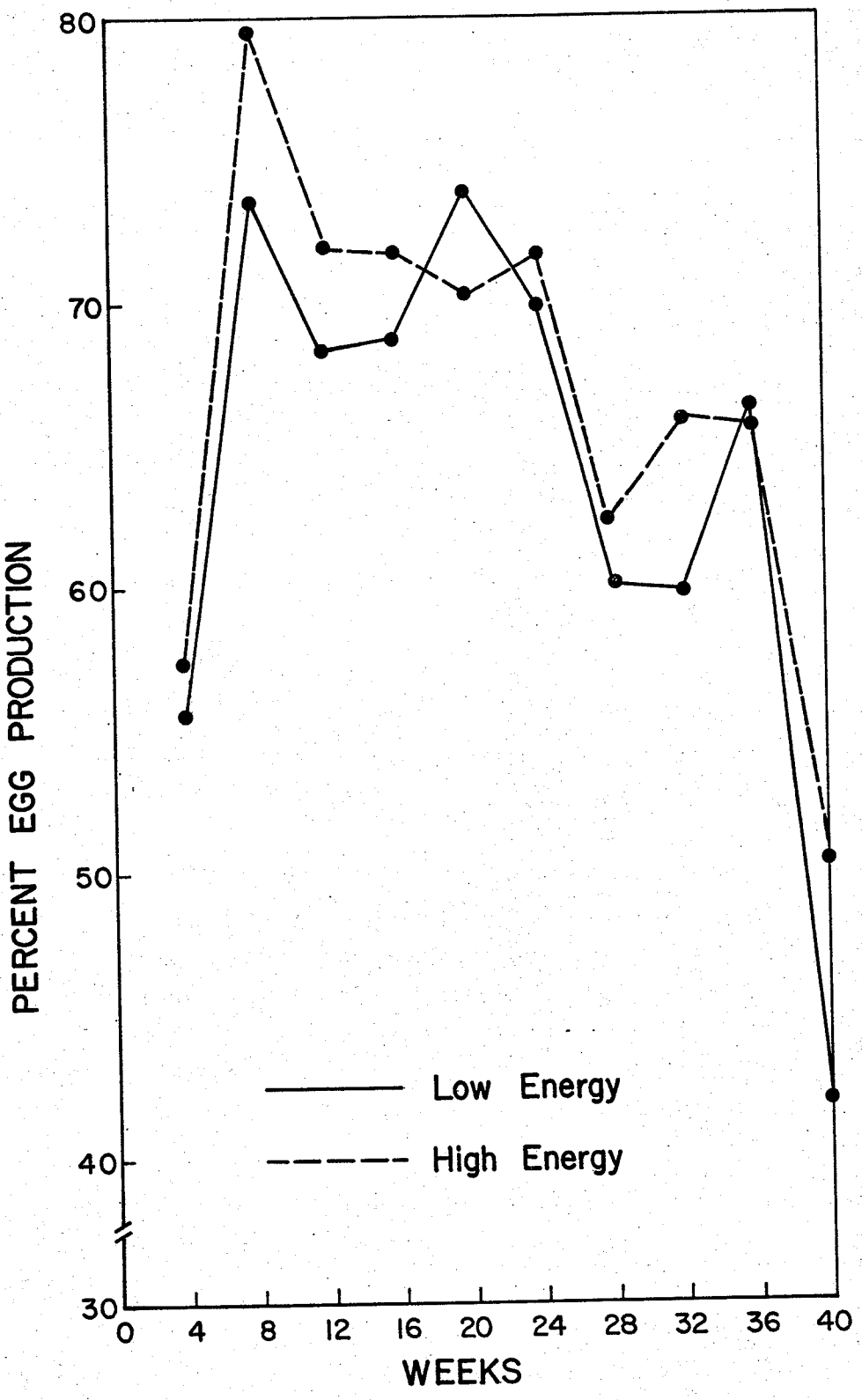

Fig. 3 Egg Production of Hens Fed 10% Rapeseed Meal Diet.

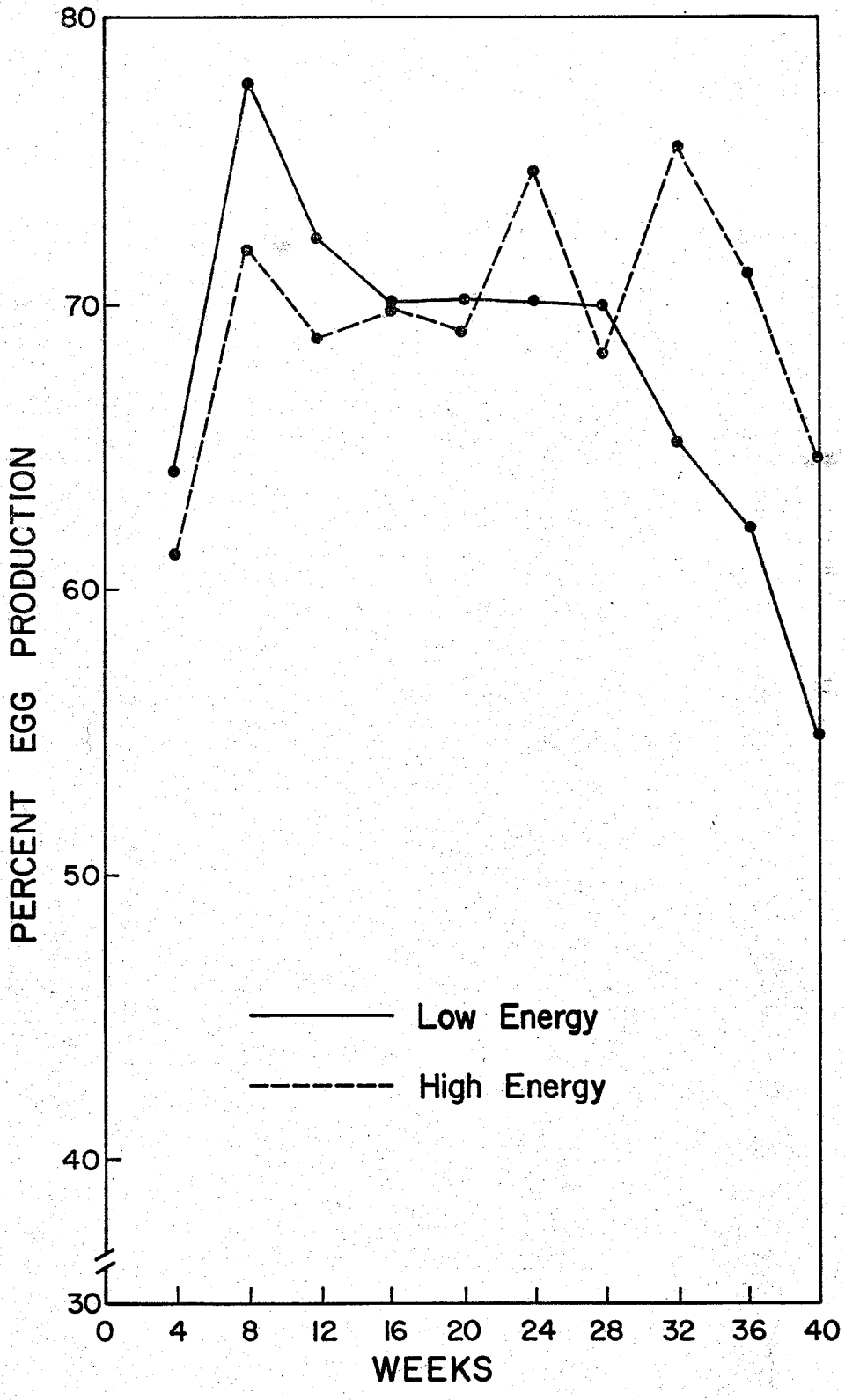

Fig. 4 Egg Production of Hens Fed 12% Rapeseed Meal Diet.

NON-SIGNIFICANT IMPROVEMENT WAS OBSERVED, HOWEVER, WITH LOW ENERGY RATIONS CONTAINING 8 AND 12% RAPESEED MEAL RATIONS WHEREAS A DEPRESSION OCCURED WITH A 10% RAPESEED MEAL RATION AS COMPARED WITH SOYBEAN RATION.

THERE WAS ALSO AN IMPROVEMENT IN FEED EFFICIENCY WITH HIGH ENERGY RATIONS CONTAINING 10% RAPESEED MEAL COMPARED TO THE SOYBEAN MEAL RATION. THE ENERGY X RAPESEED MEAL INTERACTION ($P < 0.01$) MAY BE ATTRIBUTED TO PERIOD AND RAPESEED MEAL X PERIOD INTERACTION EFFECTS (APPENDIX TABLE II). DIETARY RAPESEED MEAL OF 12, 10 AND 8% IN THAT ORDER WERE UTILIZED MORE EFFICIENTLY AFTER 32 WEEKS OF PRODUCTION COMPARED WITH SOYBEAN MEAL (FIG. 5).

THE ANALYZED VALUES (TABLE 4) FOR THE TWO LEVELS OF METABOLIZABLE ENERGY (2331 AND 2565 KCAL/KG AS THE MEANS OF 0, 8, 10 AND 12% RAPESEED MEAL) USED IN THIS STUDY WERE LOWER THAN THE CALCULATED VALUES (2530 AND 2750 KCAL/KG). HOWEVER, SOYBEAN MEAL RATIONS WERE ISOCALORIC WITH THE CORRESPONDING ENERGY LEVEL IN RAPESEED MEAL RATIONS AND SHOWED THAT ANIMAL TALLOW IMPROVED THE ENERGY LEVEL OF LAYERS RATIONS CONTAINING RAPESEED MEAL.

METABOLIZABLE ENERGY VALUES OBTAINED BY ANALYSIS IN THIS STUDY WERE MUCH HIGHER THAN THE VALUES (2290 AND 1782 KCAL/KG) OBTAINED WITH HENS BY SELL (1966) AND LOHDI ET AL. (1969), RESPECTIVELY. THE DIFFERENCE WAS PROBABLY DUE TO HIGHER PROTEIN LEVEL (41%) TOGETHER WITH LOWER FIBER (5.5 PERCENT) IN THE RAPESEED MEAL EMPLOYED IN THE PRESENT DIETARY TREATMENTS COMPARED WITH 35.9 TO 38.3% PROTEIN AND 13.2% FIBER IN THE RAPESEED MEAL USED BY THESE WORKERS.

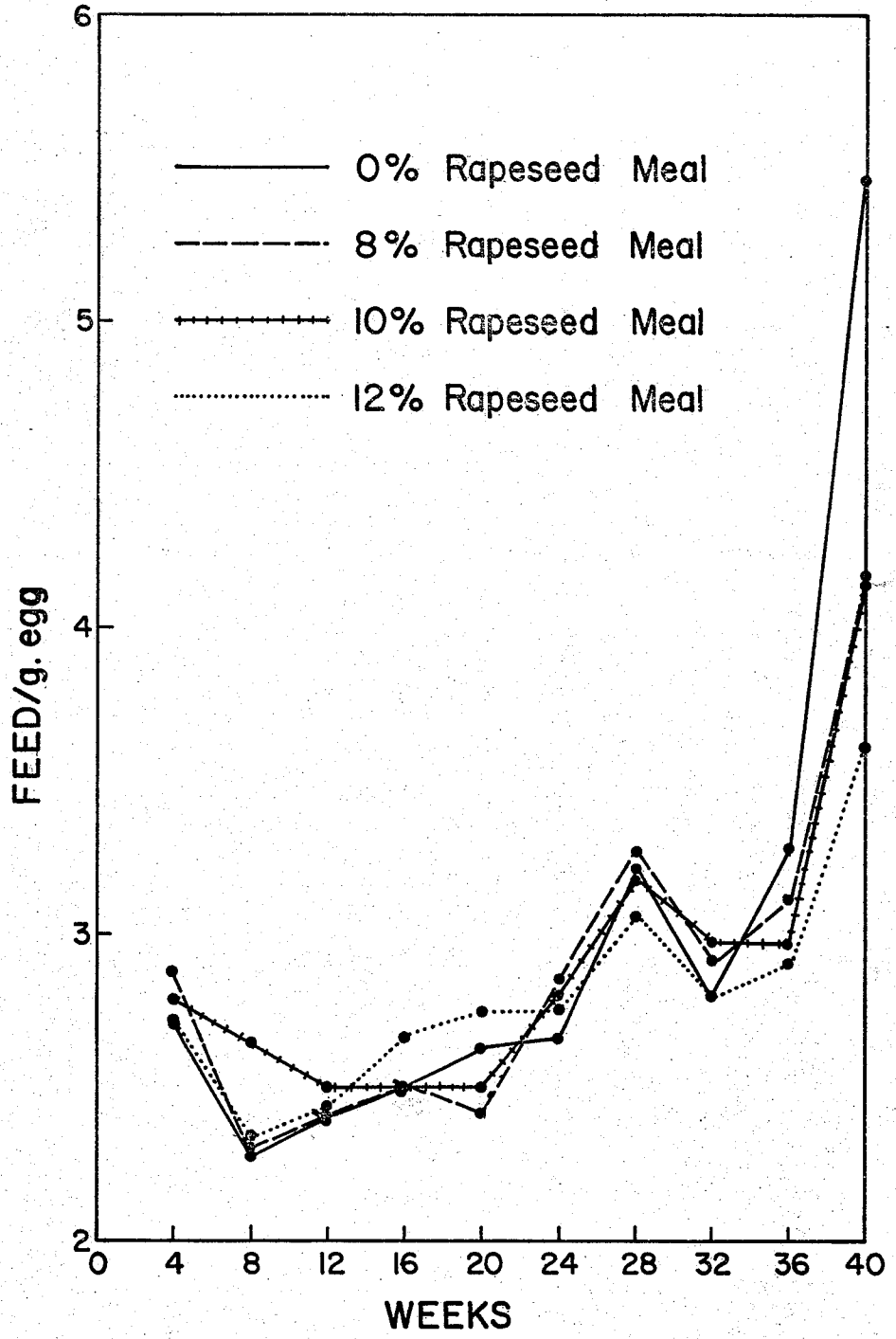

Fig. 5 Feed Per g. of Eggs of Hens Fed 0, 8, 10, 12% Rapeseed Meal.

It was shown (Blakely et al., 1965 and Summer et al., 1967) that pelleting rapeseed meal diets improved metabolizable energy. This may also account for higher values of metabolizable energy obtained since the rations were fed in pellet form.

Egg weight

Energy had no significant effect on egg weights (Table 2) of hens fed soybean and rapeseed meal rations. Egg weights (Table 2) significantly ($P < 0.05$) decreased with the addition of rapeseed meal compared with soybean meal diet. Similar results were observed by Sell et al. (1968a, 1968b). Egg weights of layers fed 8, 10 and 12% rapeseed meal rations, however, were not significantly different.

The egg weight (Table 3) of layers fed 12% rapeseed meal with rations low in energy was significantly ($P < 0.01$) smaller than those of layers fed soybean and 8 and 10% rapeseed meal rations with the same dietary energy (2530 kcal/kg). Also, egg weight of layers on eight percent rapeseed meal was significantly smaller than eggs of hens fed soybean meal and 12% rapeseed meal rations with the same level of dietary energy (2750 kcal/kg). This was probably due to an energy:protein relationship.

Analysis of variance (Appendix Table III) showed a significant ($P < 0.01$) rapeseed meal x energy interaction for egg weight. Results (Table 3) showed that this interaction was manifested in depressed egg weight only with the 12% rapeseed meal low energy ration and the eight percent rapeseed meal high energy ration. Egg weight was improved, however, with 12% dietary

RAPESEED MEAL AT THE HIGHER ENERGY LEVEL. SNETSINGER ET AL. (1968) OBSERVED SIMILAR RESULTS IN THE SECOND EXPERIMENT OF THEIR STUDY, I.E., THAT EGGS FROM HENS FED 12% RAPESEED MEAL WERE SLIGHTLY GREATER IN WEIGHT THAN EGGS OF HENS FED SOYBEAN MEAL, AND FOUR AND EIGHT PERCENT RAPESEED MEAL RATIONS.

EGG QUALITY

DIETARY ENERGY DID NOT SIGNIFICANTLY AFFECT THE INTERIOR QUALITY (TABLES 5 AND 6) OF EGGS (HAUGH UNITS) FROM HENS FED EITHER SOYBEAN OR RAPESEED MEAL. HAUGH UNITS (TABLE 5) OF LAYERS FED THE THREE LEVELS OF RAPESEED MEAL WERE SIGNIFICANTLY ($P < 0.01$) LOWER THAN THAT OF HENS FED SOYBEAN MEAL. SIMILAR RESULTS WERE OBTAINED BY CLANDININ (1969).

THYROID:BODY WEIGHT RATIO

THYROID:BODY WEIGHT RATIO (TABLES 5 AND 6) WAS NOT AFFECTED BY DIETARY ENERGY OF RATIONS CONTAINING EITHER SOYBEAN OR RAPESEED MEAL. THE RATIO (TABLE 5) INCREASED SIGNIFICANTLY ($P < 0.01$) WITH INCREASING LEVELS (0, 8, 10, 12%) OF RAPESEED MEAL IN LAYER DIETS. THE RESULT SUGGESTED THAT OXAZOLIDINETHIONE (GOITRIN) WAS PRODUCED FROM THE PARENT GLUCOSIDE IN THE DIETARY RAPESEED MEAL AND EXERTED ANTITHYROID ACTIVITY BY INTERFERING WITH THE ORGANIC BINDING OF IODINE AND SYNTHESIS OF THYROXINE AS REPORTED BY KENNEDY ET AL. (1941), GRIESBACH, (1941), GRIESBACH ET AL. (1941), GRIESBACH ET AL. (1943), GREER ET AL. (1962) AND CLANDININ ET AL. (1966).

THE ENZYME MYROSINASE PLAYS A PART IN PRODUCING GOITRIN

TABLE 5. SUMMARY OF THE EFFECT OF ENERGY AND RAPESEED MEAL (RSM) ON HAUGH UNITS, THYROID:BODY WEIGHT RATIO (T:B) AND CECA LENGTH.

TREATMENTS	HAUGH[1] UNITS	T:B[1] (MG/100 G)	CECA LENGTH[2] (CM.)
ENERGY LEVEL (M.E.)			
2530 KCAL/KG	78.8	19.5	16
2750 KCAL/KG	78.2	19.5	16
RSM (%)			
0	80.8^{A}	15.4^{A}	17^{A}
8	77.6^{B}	19.3^{B}	16^{B}
10	78.3^{B}	20.3^{C}	16^{B}
12	77.3^{B}	23.0^{D}	16^{B}

1. MEANS NOT HAVING THE SAME SUPERSCRIPT ARE SIGNIFICANTLY DIFFERENT ($P < 0.01$).

2. MEANS NOT HAVING THE SAME SUPERSCRIPT ARE SIGNIFICANTLY DIFFERENT ($P < 0.05$).

TABLE 6. EFFECT OF ENERGY AND RAPESEED MEAL (RSM) OF LAYING RATIONS ON INTERNAL EGG QUALITY, THYROID:BODY WEIGHT RATIO (T:B) AND CECA LENGTH.

TREATMENTS		HAUGH[1]	T:B[1]	CECA LENGTH[2]
RSM (%)	M.E. (KCAL/KG)	UNITS	(MG/100 G)	(CM.)
0	2530	81.3^{A}	15.5^{A}	17.6^{A}
8	2530	78.5^{B}	19.2^{B}	15.7^{B}
10	2530	78.8^{B}	20.3^{C}	16.7^{B}
12	2530	76.7^{B}	23.2^{D}	15.5^{B}
0	2750	80.4^{A}	15.4^{A}	17.1^{A}
8	2750	76.7^{B}	19.4^{B}	15.8^{B}
10	2750	77.9^{B}	20.4^{C}	15.3^{B}
12	2750	78.0^{B}	23.0^{D}	16.2^{B}

1. MEANS NOT HAVING THE SAME SUPERSCRIPT ARE SIGNIFICANTLY DIFFERENT ($P < 0.01$).

2. MEANS NOT HAVING THE SAME SUPERSCRIPT ARE SIGNIFICANTLY DIFFERENT ($P < 0.05$).

FROM ITS GLUCOSIDE (ASTWOOD ET AL., 1949). ALTHOUGH THE SOLVENT-PROCESSING METHOD EMPLOYED IN PREPARING RAPESEED MEAL SHOULD HAVE DESTROYED THE MYROSINASE, THERE WERE PROBABLY SOME MICROORGANISMS THAT POSSESSED ENZYMES CAPABLE OF HYDROLYZING THIOGLUCOSIDES IN THE GASTROINTESTINAL TRACT OF THE HENS.

THE THYROID:BODY WEIGHT RATIO HAS BEEN SHOWN TO INCREASE WITH DIETARY RAPESEED MEAL IN CHICKS (PETTIT, 1944; TURNER, 1948; FROLISH, 1952 AND CLANDININ ET AL., 1960), IN TURKEY POULTS (BLAKELY AND ANDERSON, 1948) AND IN LAYING HENS (CLANDININ ET AL., 1960 AND SNETSINGER ET AL., 1968). THESE STUDIES HAVE SHOWN THAT AS LITTLE AS FIVE PERCENT RAPESEED MEAL IN THE DIET WAS SUFFICIENT TO INFLUENCE THE THYROID:BODY WEIGHT RATIO.

ANALYSIS OF VARIANCE (APPENDIX TABLE V) SHOWED A SIGNIFICANT ($P < 0.01$) PERIOD EFFECT FOR THE RATIO. HOWEVER, FIG. 6 SHOWED A RATIO DIFFERENCE AT 16 WEEKS OF PRODUCTION WITH INCREASING LEVEL (0, 8, 10 AND 12%) OF RAPESEED MEAL. THE INCREASE IN THE RATIO AFTER 16 WEEKS OF PRODUCTION WAS A NORMAL ONE PROBABLY DUE TO LOSS IN BODY WEIGHT CAUSED BY MOLTING.

IT HAS BEEN SHOWN WITH CHICKS THAT COMPENSATORY CHANGES OCCUR IN THE THYROID GLAND WHICH PERMIT A RETURN TO NORMAL RATE OF THYROXINE SECRETION AFTER THREE TO FOUR WEEKS OF FEEDING DIETS CONTAINING RAPESEED MEAL (CLANDININ ET AL., 1966). IT APPEARS, HOWEVER, THAT LAYING HENS NEED A LONGER ADJUSTING PERIOD TO DIETARY RAPESEED MEAL. THIS VIEW IS SUPPORTED BY THE FINDINGS OF SELL ET AL. (1968A) AND BRAGG (1968) THAT PRODUCTION CHARACTERISTICS WERE LESS SEVERELY AFFECTED IF THE MEAL WAS NOT FED UNTIL THE HENS WERE 36-40 WEEKS OLD.

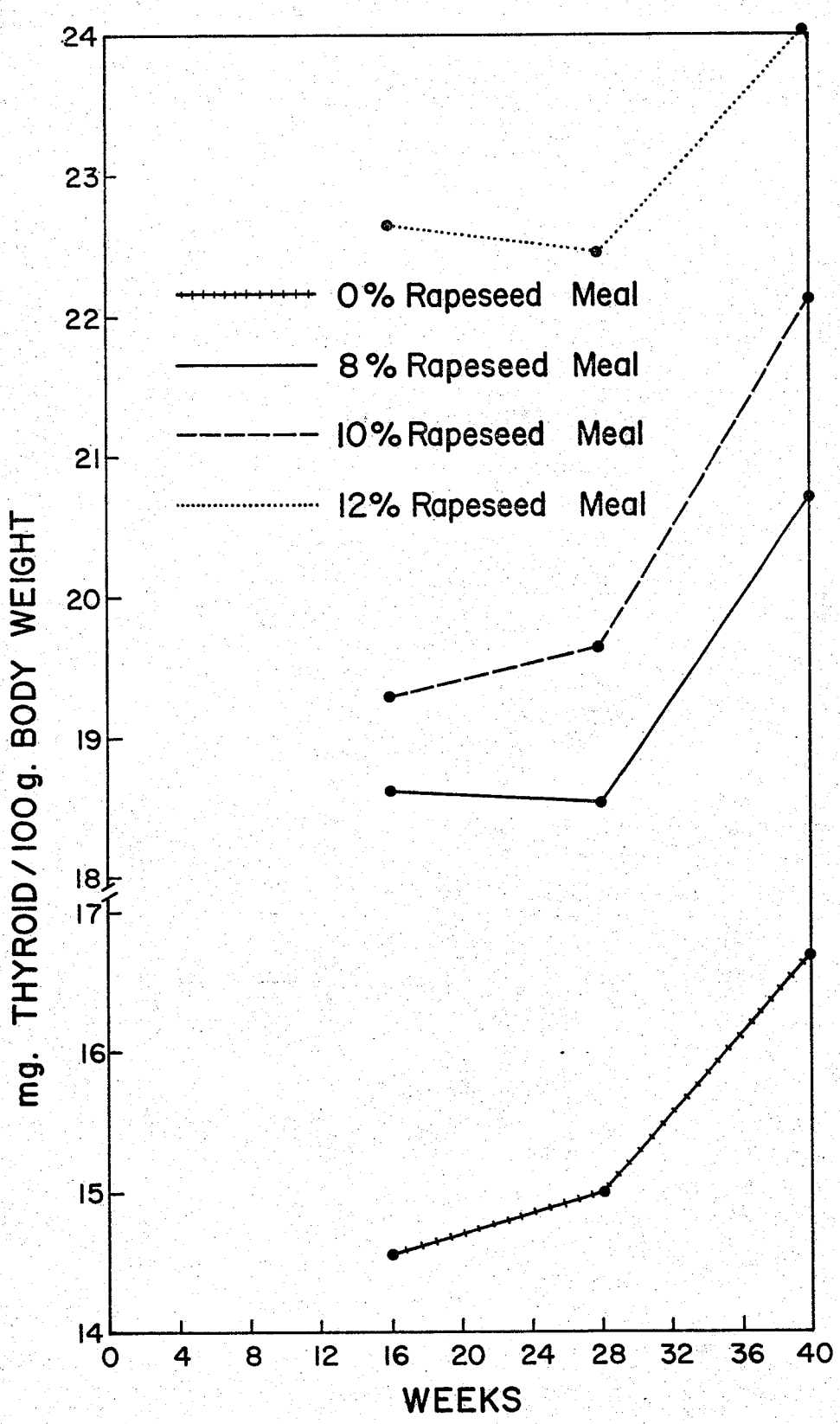

Fig. 6 THYROID: Body Weight Ratio of Hens Fed 0, 8, 10, 12% Rapeseed Meal.

Ceca length

Ceca length (Tables 5 and 6) was not affected by dietary energy of soybean or rapeseed meal diets. The ceca (Table 5) of hens fed rapeseed meal rations were, however, significantly ($P < 0.05$) shorter in length than those of hens fed soybean meal.

There is no conclusive evidence to show that the ceca plays a significant role in poultry digestion. It was observed, however, (Muller et al., 1968) that empty cecal weights of chicks on a sagebrush fiber diet (25-29% fiber) were significantly greater than those on the basal diet (20% cellulose).

Insufficient information is available on the effect of the components of rapeseed meal on the cecal microorganisms which probably play some role in poultry digestion and nutrition. Analysis of variance (Appendix Table VI) showed a significant rapeseed meal ($P < 0.05$) and period ($P < 0.01$) effects for ceca length.

Since dietary fiber increased with increasing levels (0, 8, 10 and 12%) of dietary rapeseed meal (Table 4), it is reasonable to expect longer ceca for hens fed rapeseed meal than for hens fed soybean meal. The reverse was found in this case which may be due to a lower microbiological activity or the ceca developed at a slower rate compared with controls. This view was also supported by the difference in ceca length (Fig. 7) of hens fed rapeseed meal diet from those of the hens fed the soybean meal supplemented diet. It was found, however, that the ceca length of the hens fed both soybean and rapeseed meal gradually decreased

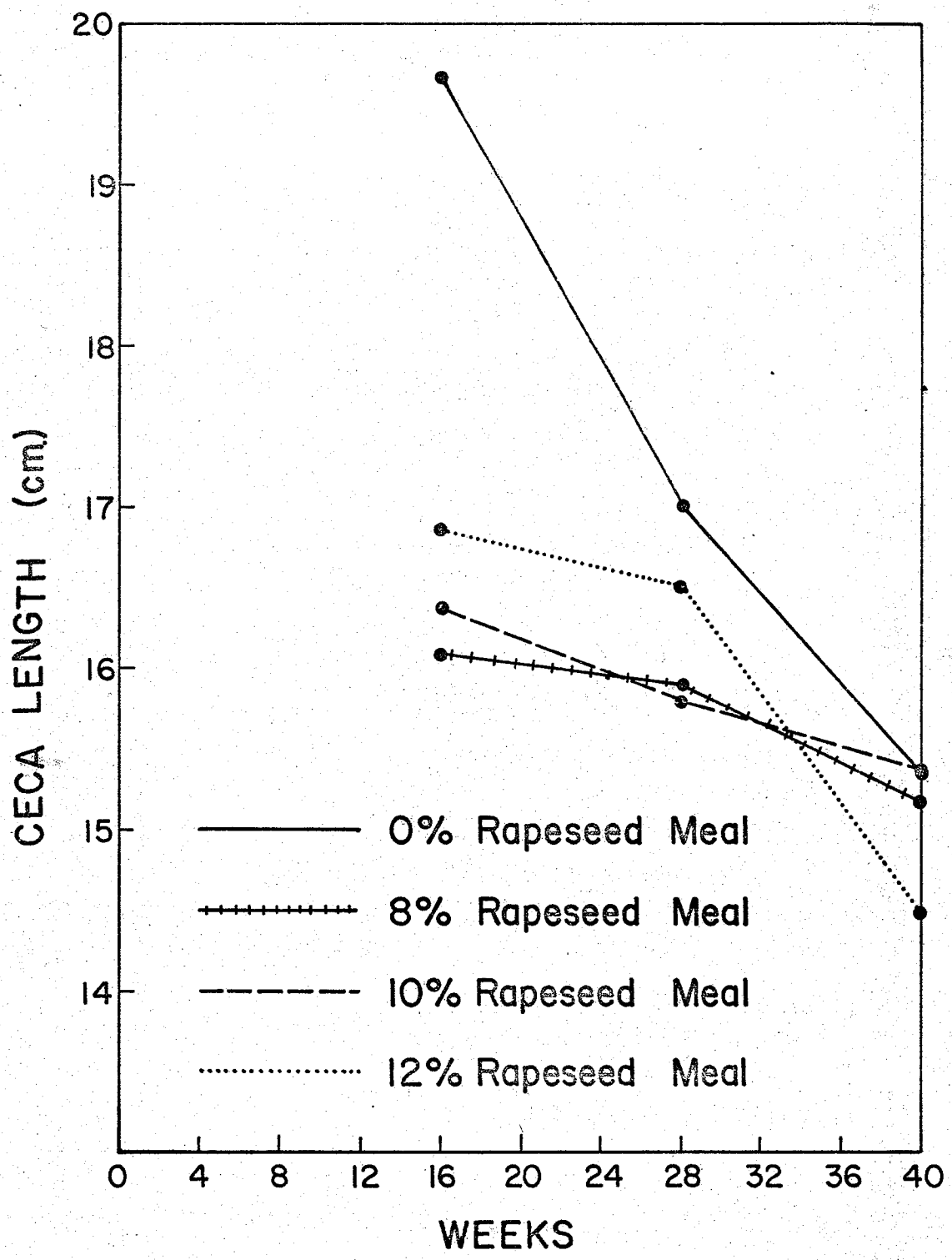

Fig. 7 Cecal Length of Hens Fed 0, 8, 10, 12% Rapeseed Meal.

DURING THE EXPERIMENT (FIG. 7).

EGG SHELL THICKNESS

NEITHER ENERGY NOR DIETARY LEVELS OF RAPESEED MEAL AFFECTED EGG SHELL THICKNESS (TABLES 7 AND 8). THIS WAS EXPECTED, HOWEVER, SINCE THE DIETARY TREATMENTS PROVIDED ADEQUATE DIETARY CALCIUM. CLANDININ (1969) OBSERVED NO SIGNIFICANT DIFFERENCE IN SPECIFIC GRAVITY OF EGGS OF HENS FED SOYBEAN AND RAPESEED MEAL RATIONS, WHICH WAS IN AGREEMENT WITH THE RESULTS OBTAINED IN THIS STUDY, SINCE EGG SHELL THICKNESS AND SPECIFIC GRAVITY ARE MEASUREMENTS OF THE SAME PARAMETER (EGG SHELL QUALITY).

BODY WEIGHT GAIN PER BIRD

BODY WEIGHT GAIN PER BIRD (TABLE 7 AND APPENDIX TABLE XI) WAS NOT AFFECTED BY DIETARY RAPESEED MEAL OR ENERGY CONTENT OF THE RATION. BODY WEIGHT GAIN PER BIRD (TABLE 8), DECREASED NON-SIGNIFICANTLY WITH THE ADDITION OF RAPESEED MEAL AT BOTH LEVELS OF DIETARY ENERGY EXCEPT WITH THE 12% RAPESEED MEAL HIGH ENERGY DIET. THIS WAS PROBABLY DUE TO A DECREASE IN FEED CONSUMPTION (TABLE 9) BY ADDING RAPESEED MEAL. BODY WEIGHT WAS OBSERVED TO DECREASE IN A PREVIOUS STUDY BY THE REPLACEMENT OF SOYBEAN MEAL WITH 10% SOLVENT-PROCESSED RAPESEED MEAL IN A LAYER DIET (CLANDININ, 1969).

LIVER WEIGHT AS A PERCENT OF BODY WEIGHT

DIETARY ENERGY HAD NO EFFECT ON LIVER WEIGHT AS A PERCENT OF BODY WEIGHT (TABLES 7 AND 8). THE PERCENT OF LIVER WEIGHT AT

TABLE 7. SUMMARY OF THE EFFECT OF ENERGY AND RAPESEED MEAL (RSM) ON EGG SHELL THICKNESS, BODY WEIGHT GAIN PER BIRD AND LIVER WEIGHT:BODY WEIGHT RATIO.[1]

TREATMENTS	SHELL THICKNESS (0.001 INCH)	BODY WT.[2] GAIN (G)	LIVER WT.[3] (%)
ENERGY LEVEL (M.E.)			
2530 KCAL/KG	13.6	203.5	2.2
2750 KCAL/KG	13.6	206.6	2.3
RSM (%)			
0	13.7	218.6	2.3
8	13.6	209.1	2.1
10	13.4	195.5	2.2
12	13.6	197.0	2.4

1. MEANS NOT HAVING THE SAME SUPERSCRIPT ARE SIGNIFICANTLY DIFFERENT ($P < 0.05$).

2. BODY WEIGHT GAIN PER BIRD.

3. LIVER WEIGHT AS PERCENT BODY WEIGHT.

TABLE 8. EFFECT OF ENERGY AND RAPESEED MEAL (RSM) OF LAYING RATIONS ON EGG SHELL THICKNESS, BODY WEIGHT GAIN AND PERCENT LIVER WEIGHT.[1]

TREATMENTS		SHELL THICKNESS	BODY WT.[2]	LIVER WT.[3]
RSM(%)	M.E. (KCAL/KG)	(0.001 INCH)	GAIN (G)	(%)
0	2530	13.7	224.3	2.1
8	2530	13.7	217.0	2.1
10	2530	13.4	196.6	2.2
12	2530	13.5	176.2	2.5
0	2750	13.7	212.9	2.4
8	2750	13.6	201.1	2.2
10	2750	13.4	194.3	2.1
12	2750	13.8	217.9	2.4

1. MEANS NOT HAVING THE SAME SUPERSCRIPT ARE SIGNIFICANTLY DIFFERENT ($P < 0.05$).

2. BODY WEIGHT GAIN PER BIRD.

3. LIVER WEIGHT AS PERCENT BODY WEIGHT.

TABLE 9. FEED INTAKE OF LAYERS FED SOYBEAN AND RAPESEED MEAL (RSM) DIETS.

TREATMENTS		
RSM (%)	M.E. (KCAL/KG)	FEED INTAKE (KG)[1]
0	2530	2.05
8	2530	2.10
10	2530	2.15
12	2530	2.00
0	2750	2.28
8	2750	1.93
10	2750	1.85
12	2750	2.01
0	--	2.17[2]
8	--	2.02[2]
10	--	2.00[2]
12	--	2.00[2]

1. FEED INTAKE PER BIRD DURING TEN 28-DAY PERIODS.

2. THE RESPECTIVE MEANS OF THE COMBINED FEED INTAKE AT THE CORRESPONDING LOW AND HIGH DIETARY ENERGY LEVELS SHOWN IN THIS TABLE.

BOTH THE LOW AND HIGH LEVEL OF DIETARY ENERGY WAS THE SAME IRRESPECTIVE OF DIETARY RAPESEED MEAL LEVEL. THIS IS SIMILAR TO THE RESULTS OBTAINED WITH 12-WEEK OLD GROWING RATS, RATS FOLLOWING REPRODUCTION AND PIGS AT 200 LBS. LIVE WEIGHT BY BOWLAND ET AL. (1963) THAT THE RATIO OF LIVER WEIGHT TO BODY WEIGHT INCREASED NON-SIGNIFICANTLY BY FEEDING HIGH LEVELS OF DIETARY RAPESEED MEAL.

LIVER LIPID AS A PERCENT OF DRY TISSUE

LIVER LIPID AS A PERCENT OF DRY LIVER TISSUE (TABLES 10 AND 11) WAS NOT AFFECTED SIGNIFICANTLY BY DIETARY ENERGY. LIPID IN THE LIVER OF HENS FED EIGHT PERCENT RAPESEED MEAL WAS SIGNIFICANTLY LOWER ($P < 0.05$) THAN THOSE OF HENS FED SOYBEAN MEAL, AND 10 AND 12% RAPESEED MEAL RATIONS AT A LOW OR HIGH LEVEL OF DIETARY ENERGY. PERCENT LIVER LIPID OF LAYERS, HOWEVER, INCREASED AS THE ENERGY LEVEL IN RAPESEED MEAL DIETS WAS INCREASED WHILE THAT OF HENS FED THE CONTROL DIET DECREASED. ERUCIC ACID PRESENT IN RAPESEED OIL HAS BEEN SHOWN TO FAVOUR LIVER LIPID ACCUMULATION (SIM, 1970). IT IS NOT KNOWN WHETHER THE AMOUNT OF ERUCIC ACID PRESENT IN RAPESEED MEAL OR THE PRESENCE OF TOXIC COMPONENTS OF RAPESEED MEAL AFFECT LIPID METABOLISM IN THE LIVER. MCDANIEL ET AL. (1957), HOWEVER, HAS SHOWN THAT LIVER FAT INCREASED SLIGHTLY WITH AN INCREASE IN ENERGY CONTENT OF THE DIET AND DECREASED SLIGHTLY WITH AN INCREASE IN DIETARY PROTEIN AT A GIVEN LEVEL OF DIETARY ENERGY.

SPLEEN WEIGHT AS A PERCENT OF BODY WEIGHT

SPLEEN WEIGHT AS A PERCENTAGE OF BODY WEIGHT (TABLES 10 AND

TABLE 10. SUMMARY OF THE EFFECT OF ENERGY AND RAPESEED MEAL (RSM) ON LIVER LIPIDS, SPLEEN WEIGHT AS A PERCENT OF BODY WEIGHT (S:B) AND MORTALITY.

TREATMENTS	LIVER LIPIDS[1] (%)	S:B[2]	MORTALITY (%)
ENERGY LEVEL (M.E.)			
2530 KCAL/KG	24.3	0.08[A]	13
2750 KCAL/KG	26.1	0.09[A]	12
RSM (%)			
0	30.2[A]	0.09	10
8	18.9[B]	0.09	11
10	23.9[A]	0.08	14
12	28.0[A]	0.08	15

1. MEANS NOT HAVING THE SAME SUPERSCRIPT ARE SIGNIFICANTLY DIFFERENT ($P < 0.05$).

2. MEANS NOT HAVING THE SAME SUPERSCRIPT ARE NOT SIGNIFICANTLY DIFFERENT ($P < 0.01$).

TABLE 11. EFFECT OF ENERGY AND RAPESEED MEAL (RSM) OF LAYING RATIONS ON PERCENT LIVER LIPIDS, SPLEEN WEIGHT AS A PERCENT OF BODY WEIGHT AND MORTALITY.

TREATMENTS		LIVER LIPIDS (%)[1]	S:B	MORTALITY (%)[2]
RSM (%)	M.E. (KCAL/KG)			
0	2530	32.7	0.07	8
8	2530	17.3	0.08	14
10	2530	20.8	0.08	18
12	2530	26.7	0.07	12
0	2750	27.6	0.10	12
8	2750	20.5	0.10	8
10	2750	27.0	0.08	10
12	2750	29.3	0.09	18

1. LIVER LIPIDS AS PERCENT OF DRY LIVER TISSUE.

2. PERCENT OF BIRDS THAT DIED FROM FATTY LIVER AND LEUKOSIS.

11) were not significantly ($P < 0.01$) influenced by rapeseed meal. However, the analysis of variance (Appendix Table VIII) showed a significant ($P < 0.01$) energy effect for spleen weight.

Mortality caused by fatty liver and leukosis

Dietary energy and rapeseed meal levels did not affect mortality (Tables 10 and 11) caused by fatty liver and leukosis. However, it was found (Table 12 and Appendix Table IX) that mortality was significantly ($P < 0.05$) affected by period. Moreover, it was observed that higher mortality was caused by leukosis than fatty liver. Similar results were reported by Snetsinger et al. (1968).

TABLE 12. EFFECT OF PERIOD ON MORTALITY DUE TO FATTY LIVER AND LEUKOSIS.[1]

PERIOD	MORTALITY (%)[2]
1	2^{A}
2	7^{AB}
3	15^{ABC}
4	20^{BC}
5	30^{C}
6	5^{AB}
7	7^{AB}
8	17^{ABC}
9	10^{AB}
10	10^{AB}

1. PERCENT OF BIRDS THAT DIED FROM FATTY LIVER AND LEUKOSIS.

2. MEANS NOT HAVING THE SAME SUPERSCRIPT ARE SIGNIFICANTLY DIFFERENT ($P < 0.05$).

SUMMARY AND CONCLUSIONS

A STUDY WAS CONDUCTED WITH FOUR HUNDRED LAYING HENS TO DETERMINE THE INFLUENCE OF ENERGY ON RAPESEED MEAL UTILIZATION BY HENS. TWO ENERGY LEVELS (2530 AND 2750 KCAL M.E./KG) WERE EMPLOYED AT EACH RAPESEED MEAL LEVEL (0, 8, 10 AND 12%). TRAITS STUDIED WERE EGG PRODUCTION, FEED EFFICIENCY, EGG AND BODY WEIGHTS, EGG QUALITY, EGG SHELL THICKNESS, THYROID:BODY WEIGHT RATIO, CECA LENGTH, LIVER WEIGHT, LIVER LIPIDS, SPLEEN WEIGHT AND MORTALITY.

1. RESULTS SHOWED THAT ENERGY PER SE HAD NO SIGNIFICANT EFFECT ON TRAITS STUDIED EXCEPT SPLEEN WEIGHT. EGG PRODUCTION OF LAYERS FED 10 AND 12% RAPESEED MEAL RATIONS DID, HOWEVER, SHOW SIGNIFICANT IMPROVEMENT AS THE ENERGY INCREASED FROM 2530 TO 2750 KCAL/KG. DIETARY RAPESEED MEAL AT THE 12% LEVEL IN HIGH ENERGY RATIONS SUPPORTED APPRECIABLY HIGHER EGG PRODUCTION, PARTICULARLY AFTER 24 WEEKS OF LAY, THAN DID THE CONTROL OR 8 AND 10% RAPESEED MEAL DIETS.

2. THERE WAS NO SIGNIFICANT IMPROVEMENT IN EFFICIENCY OF FEED UTILIZATION WITH HIGH ENERGY RATIONS OR 8, 10 AND 12% RAPESEED MEAL COMPARED WITH SOYBEAN MEAL RATIONS.

3. METABOLIZABLE ENERGY WAS SIMILAR FOR SOYBEAN AND RAPESEED MEAL RATIONS, SHOWING THAT ANIMAL TALLOW TOGETHER WITH PELLETING OF RAPESEED MEAL DIETS IMPROVED METABOLIZABLE ENERGY.

4. THERE WAS A SIGNIFICANT RAPESEED MEAL X ENERGY

INTERACTION FOR EGG WEIGHT, MANIFESTED IN DEPRESSED EGG WEIGHT WITH THE 12% RAPESEED MEAL LOW ENERGY RATION AS WELL AS WITH THE EIGHT PERCENT RAPESEED MEAL HIGH ENERGY RATION. EGG WEIGHT, HOWEVER, WAS IMPROVED WITH 12% DIETARY RAPESEED MEAL AND HIGH DIETARY ENERGY COMPARED TO 8 AND 10% RAPESEED MEAL DIETS AT THE SAME HIGH LEVEL OF ENERGY. BIRDS RECEIVING 12% RAPESEED MEAL AND THE HIGH ENERGY RATION PRODUCED SIGNIFICANTLY MORE AND LARGER EGGS THAN DID THOSE FED THE SAME LEVEL OF RAPESEED MEAL ON THE LOW ENERGY DIET.

5. HAUGH UNITS OF EGGS FROM RAPESEED MEAL TREATMENTS WERE SIGNIFICANTLY LOWER THAN THOSE OF THE CONTROL DIET.

6. EGG SHELL THICKNESS WAS NOT AFFECTED BY DIETARY TREATMENT.

7. THYROID:BODY WEIGHT RATIO INCREASED SIGNIFICANTLY WITH INCREASING LEVELS OF RAPESEED MEAL IN THE LAYER DIET. THIS INDICATED THAT RAPESEED MEAL CONTAINED CHEMICAL COMPOUNDS HAVING THYROGENIC PROPERTIES. PERIOD ALSO HAD A SIGNIFICANT EFFECT ON THE THYROID:BODY WEIGHT RATIO.

8. THE CECA OF HENS FED RAPESEED MEAL RATIONS WERE SIGNIFICANTLY SHORTER IN LENGTH THAN THOSE OF HENS FED SOYBEAN MEAL RATIONS.

9. BODY WEIGHT GAIN PER BIRD DECREASED BUT NON-SIGNIFICANTLY AT ALL LEVELS OF RAPESEED MEAL. THIS DECREASE WAS RELATED TO A DECLINE IN FEED CONSUMPTION.

10. LIVER WEIGHT AS A PERCENT OF BODY WEIGHT REMAINED THE SAME IRRESPECTIVE OF DIETARY RAPESEED MEAL OR ENERGY LEVELS. LIVER LIPID, HOWEVER, INCREASED AS THE ENERGY LEVEL IN RAPESEED MEAL DIETS WAS ELEVATED WHILE THAT OF HENS FED THE CONTROL DIET DECREASED.

11. MORTALITY CAUSED BY FATTY LIVER AND LEUKOSIS WAS NOT AFFECTED BY DIETARY RAPESEED MEAL OR DIETARY ENERGY.

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APPENDIX

APPENDIX TABLE 1. ANALYSIS OF VARIANCE OF EGG PRODUCTION (HEN-DAY) OF LAYING HENS FED DIFFERENT LEVELS OF DIETARY ENERGY AND RAPESEED MEAL.

SOURCE	DF	SS	MS	F
TOTAL	399	21309.00	--	--
ENERGY	1	26.25	26.25	0.81
RAPESEED MEAL	3	338.13	112.70	3.46*
ENERGY X RAPESEED MEAL	3	370.00	123.33	3.78*
PERIOD	9	8263.45	918.16	28.17**
ENERGY X PERIOD	9	100.31	11.15	0.34
RAPESEED MEAL X PERIOD	27	1098.75	40.70	1.25
ENERGY X RAPESEED MEAL X PERIOD	27	675.00	25.00	0.77
ERROR	320	10431.33	32.60	--

*STATISTICALLY SIGNIFICANT AT $P < 0.05$.

**STATISTICALLY SIGNIFICANT AT $P < 0.01$.

APPENDIX TABLE II. ANALYSIS OF VARIANCE OF FEED PER GRAM OF EGG OF LAYING HENS FED DIFFERENT LEVELS OF DIETARY ENERGY AND RAPESEED MEAL.

SOURCE	DF	SS	MS	F
TOTAL	399	2933952.00	--	--
ENERGY	1	8850.00	8850.00	2.22
RAPESEED MEAL	3	17710.00	5903.33	1.48
ENERGY X RAPESEED MEAL	3	52415.05	17471.68	4.39**
PERIOD	9	1233041.00	137004.50	34.39**
ENERGY X PERIOD	9	7320.00	813.33	0.20
RAPESEED MEAL X PERIOD	27	193095.75	7151.69	1.80**
ENERGY X RAPESEED MEAL X PERIOD	27	146400.06	5422.22	1.36
ERROR	320	1274793.00	3983.73	--

**STATISTICALLY SIGNIFICANT AT $P < 0.01$.

APPENDIX TABLE III. ANALYSIS OF VARIANCE OF EGG WEIGHTS OF LAYING HENS FED DIFFERENT LEVELS OF DIETARY ENERGY AND RAPESEED MEAL.

SOURCE	DF	SS	MS	F
TOTAL	399	6692.00	--	--
ENERGY	1	10.31	10.31	2.13
RAPESEED MEAL	3	128.44	42.81	8.84**
ENERGY X RAPESEED MEAL	3	160.63	53.54	11.06**
PERIOD	9	4737.50	526.39	108.74**
ENERGY X PERIOD	9	4.06	0.45	0.09
RAPESEED MEAL X PERIOD	27	59.06	2.19	0.45
ENERGY X RAPESEED MEAL X PERIOD	27	39.06	1.45	0.30
ERROR	320	1549.13	4.84	--

**STATISTICALLY SIGNIFICANT AT $P < 0.01$.

APPENDIX TABLE IV. ANALYSIS OF VARIANCE OF HAUGH UNITS OF EGG ALBUMEN OF LAYING HENS FED DIFFERENT LEVELS OF DIETARY ENERGY AND RAPESEED MEAL.

SOURCE	DF	SS	MS	F
TOTAL	159	4127.88	--	--
ENERGY	1	13.44	13.44	1.36
RAPESEED MEAL	3	299.69	99.90	10.14**
ENERGY X RAPESEED MEAL	3	51.25	17.08	1.73
PERIOD	3	2311.25	770.42	78.21**
ENERGY X PERIOD	3	33.13	11.04	1.12
RAPESEED MEAL X PERIOD	9	68.75	7.64	0.78
ENERGY X RAPESEED MEAL X PERIOD	9	85.31	9.48	0.96
ERROR	128	1260.82	9.85	--

**STATISTICALLY SIGNIFICANT AT $P < 0.01$.

APPENDIX TABLE V. ANALYSIS OF VARIANCE OF THYROID WEIGHT PER 100 GRAMS BODY WEIGHT OF LAYING HENS FED DIFFERENT LEVELS OF DIETARY ENERGY AND RAPESEED MEAL.

SOURCE	DF	SS	MS	F
TOTAL	71	645.10	--	--
ENERGY	1	0.16	0.16	0.26
RAPESEED MEAL	3	540.13	180.04	289.90**
ENERGY X RAPESEED MEAL	3	0.18	0.06	0.09
PERIOD	2	70.00	35.00	56.35**
ENERGY X PERIOD	2	0.13	0.07	0.10
RAPESEED MEAL X PERIOD	6	3.69	0.62	0.99
ENERGY X RAPESEED MEAL X PERIOD	6	1.04	0.17	0.28
ERROR	48	29.81	0.62	--

**STATISTICALLY SIGNIFICANT AT $P < 0.01$.

APPENDIX TABLE VI. ANALYSIS OF VARIANCE OF CECA LENGTH OF LAYING HENS FED DIFFERENT LEVELS OF DIETARY ENERGY AND RAPESEED MEAL.

SOURCE	DF	SS	MS	F
TOTAL	71	307.28	--	--
ENERGY	1	1.58	1.58	0.52
RAPESEED MEAL	3	30.06	10.10	3.29*
ENERGY X RAPESEED MEAL	3	10.59	3.53	1.16
PERIOD	2	55.83	27.91	9.16**
ENERGY X PERIOD	2	3.56	1.78	0.58
RAPESEED MEAL X PERIOD	6	34.13	5.69	1.87
ENERGY X RAPESEED MEAL X PERIOD	6	25.27	4.21	1.38
ERROR	48	146.29	3.05	--

*STATISTICALLY SIGNIFICANT AT $P < 0.05$.

**STATISTICALLY SIGNIFICANT AT $P < 0.01$.

APPENDIX TABLE VII. ANALYSIS OF VARIANCE OF PERCENT LIVER LIPID OF LAYING HENS FED DIFFERENT LEVELS OF DIETARY ENERGY AND RAPESEED MEAL.

SOURCE	DF	SS	MS	F
TOTAL	71	10964.51	--	--
ENERGY	1	54.62	54.62	0.40
RAPESEED MEAL	3	1336.17	445.39	3.28*
ENERGY X RAPESEED MEAL	3	308.68	102.90	0.76
PERIOD	2	1054.62	527.31	3.89*
ENERGY X PERIOD	2	162.33	81.16	0.60
RAPESEED MEAL X PERIOD	6	855.56	142.59	1.05
ENERGY X RAPESEED MEAL X PERIOD	6	680.71	113.45	0.84
ERROR	48	6511.89	135.66	--

*STATISTICALLY SIGNIFICANT AT $P < 0.05$.

APPENDIX TABLE VIII. ANALYSIS OF VARIANCE OF SPLEEN WEIGHT AS A PERCENT OF BODY WEIGHT OF LAYING HENS FED DIFFERENT LEVELS OF DIETARY ENERGY AND RAPESEED MEAL.

SOURCE	DF	SS	MS	F
TOTAL	71	0.0442	--	--
ENERGY	1	0.0044	0.0044	7.47**
RAPESEED MEAL	3	0.0025	0.0008	1.40
ENERGY X RAPESEED MEAL	3	0.0019	0.0006	1.07
PERIOD	2	0.0007	0.0004	0.62
ENERGY X PERIOD	2	0.0004	0.0002	0.37
RAPESEED MEAL X PERIOD	6	0.0039	0.0006	1.10
ENERGY X RAPESEED MEAL X PERIOD	6	0.0025	0.0004	0.71
ERROR	48	0.0280	0.0006	--

**STATISTICALLY SIGNIFICANT AT $P < 0.01$.

APPENDIX TABLE IX. ANALYSIS OF VARIANCE OF MORTALITY (DUE TO FATTY LIVER AND LEUKOSIS) OF LAYING HENS FED DIFFERENT LEVELS OF DIETARY ENERGY AND RAPESEED MEAL.

SOURCE	DF	SS	MS	F
TOTAL	399	45.75	--	--
ENERGY	1	0.01	0.01	0.09
RAPESEED MEAL	3	0.17	0.06	0.51
ENERGY X RAPESEED MEAL	3	0.37	0.12	1.11
PERIOD	9	2.45	0.27	2.45*
ENERGY X PERIOD	9	0.59	0.07	0.59
RAPESEED MEAL X PERIOD	27	1.93	0.07	0.64
ENERGY X RAPESEED MEAL X PERIOD	27	4.63	0.17	1.54*
ERROR	320	35.60	0.11	--

*STATISTICALLY SIGNIFICANT AT $P < 0.05$.

APPENDIX TABLE X. ANALYSIS OF VARIANCE OF EGG SHELL THICKNESS OF LAYING HENS FED DIFFERENT LEVELS OF DIETARY ENERGY AND RAPESEED MEAL.

SOURCE	DF	SS	MS	F
TOTAL	159	35.33	--	--
ENERGY	1	0.25	0.25	1.12
RAPESEED MEAL	3	1.82	0.61	2.66
ENERGY X RAPESEED MEAL	3	0.45	0.15	0.66
PERIOD	3	0.74	0.25	1.09
ENERGY X PERIOD	3	-0.08	-0.03	-0.11
RAPESEED MEAL X PERIOD	9	1.00	0.11	0.49
ENERGY X RAPESEED MEAL X PERIOD	9	2.19	0.24	1.07
ERROR	128	29.08	0.23	--

APPENDIX TABLE XI. ANALYSIS OF VARIANCE OF BODY WEIGHT GAIN BY LAYING HEN FED DIFFERENT LEVELS OF DIETARY ENERGY AND RAPESEED MEAL.

SOURCE	DF	SS	MS	F
TOTAL	79	307467.00	--	--
ENERGY	1	187.19	187.19	0.05
RAPESEED MEAL	3	7120.94	2373.65	0.63
ENERGY X RAPESEED MEAL	3	10473.44	3491.15	0.93
PERIOD	1	6513.44	6513.44	1.74
ENERGY X PERIOD	1	4155.94	4155.94	1.11
RAPESEED MEAL X PERIOD	3	25066.57	8355.52	2.23
ENERGY X RAPESEED MEAL X PERIOD	3	13929.07	4643.02	1.24
ERROR	64	240014.38	3750.23	--

APPENDIX TABLE XII. ANALYSIS OF VARIANCE OF LIVER WEIGHT AS A PERCENT OF BODY WEIGHT OF LAYING HENS FED DIFFERENT LEVELS OF DIETARY ENERGY AND RAPESEED MEAL.

SOURCE	DF	SS	MS	F
TOTAL	71	9.18	--	--
ENERGY	1	0.04	0.04	0.38
RAPESEED MEAL	3	0.82	0.27	2.38
ENERGY X RAPESEED MEAL	3	0.51	0.17	1.47
PERIOD	2	0.52	0.26	2.26
ENERGY X PERIOD	2	0.13	0.07	0.58
RAPESEED MEAL X PERIOD	6	0.78	0.13	1.13
ENERGY X RAPESEED MEAL X PERIOD	6	0.89	0.15	1.30
ERROR	48	5.50	0.12	--