

THE EFFECT OF ADDED ANIMAL FAT TO A BASIC
POULTRY RATION ON PELLET PRODUCTION

by

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INTRODUCTION

The use of added animal fat¹ in poultry feeds has increased greatly in the past few years. This is due partly to the contribution it plays in increasing the total caloric content of a ration. In addition to its nutritive value, added fat, properly blended with ground grains and other dry solid ingredients, reduces dust and results in a brighter looking feed. It has also been observed that a feed with high-fat content can be pelleted with less power than a low-fat feed.

For the past few years, animal fat has been almost as economical an ingredient in formula feeds as other feed stuffs. A surplus of inedible fat, totaling a billion pounds yearly, was made available by the national use of detergents, replacing part of the soap, for household cleaning. However, the market price of fats is reflected by its use in chemical industries and export demand.

The greatest factor which contributed to the acceptance of animal fat in poultry feeds was the formulation of high-energy rations. Fat is an ingredient which has 2.25 more calories than the same weight of a carbohydrate ingredient, such as corn. Scott (14) while at the University of Connecticut was a leader in developing high energy rations. His experimental results led nutritionists to revive the study of energy requirements for poultry.

Combs (3) has expressed energy requirements in terms of a ratio to the crude protein in the diet. He concluded that starting birds should have approximately 42 calories of energy to each per cent of crude protein. This ratio is difficult to obtain without added fat. Since the trend in poultry

¹Animal fat is a mixture of fats of a quality suitable for feeding, obtained from animal tissues in the commercial processes of rendering (2).

nutrition work is to increase the per cent of crude protein in starting rations from 20 to 22 per cent, it is practically impossible to produce the desirable calorie protein ratio without the use of added fat.

Since added fat appears to be necessary from the nutrition aspect in poultry rations, this investigation was conducted to determine if added fat had additional value, such as lowering the production cost of pelleting feeds. This was studied by evaluating the effects animal fat, when added to a basic poultry ration, upon the rate of pellet production and energy consumption.

REVIEW OF LITERATURE

Use of Animal Fat in Lubricants

There are many publications on the use of fat or fat derivatives in the manufacture of lubricants. In 1940 Lincoln, et al. (11) reported the use of fats, fatty acids, and derivatives as a "lubricant-improver" in the petrolatum industry. Fat improved lubricants in their wetting ability or oilness. The fats serve to carry active elements such as elemental sulphur and phosphorus for improvement of load-carrying capacity, resistance to oxidations, and decrease excess wear during use. Greases are compounded from whole fats and fatty acids, which serve as lubricating oils under suitable conditions.

George and Stucker (5) in 1947 reported that Lithium-Soap greases are made very similar to Aluminum-base lubricants but a temperature of 400° Fahrenheit is required to disperse the Lithium-Soap in the mineral oil. The fats and fatty acids employed are the same, although for the preparation of Lithium-Soap, stearic acid and hydrogenatic fish oil acid are preferred.

In 1953 Jahn (8) concluded that animal fats can fortify lubricants when introduced as low as one per cent. It was stated as follows:

A roll lubricant which is stable, non-corrosive, and resists the washing action of water sprayed under pressure, non-staining, and easily removed from the surface, is made by adding to a sulfuric acid, treated light with liquid hydrocarbon, boiling at 300-700° Fahrenheit, three to ten per cent lanolin; ethyl alcohol, olien or a mixture there of. These lubricants can be fortified by introducing in them less than one per cent of any of the following: animal, vegetable, or marine oils.

Work done in India in 1952 by Kuleor (10) determined the lubricating effectiveness of fatty acids. Values of the coefficient of friction were measured of lubricated mild steel on brass at bearing loads of two-tenths to ten kilogram per square centimeter and speeds of 80-180 revolutions per minute. The lubricating effectiveness of fatty acids increased in the following order:

Butyric, palmitic, stearic, behenic, lauric at 300° Kelvin and behenic, butyric, lauric palmitic, stearic at 100° Kelvin. The order was stearic, oleic linoleic and ricinoleic at 300° Kelvin and ricinolic, oleic, linoleic, and stearic at 100° Kelvin. The sequence at 100° Kelvin of one tenth per cent solution in isopentane was lauric, palmitic, behenic and stearic. Lubricating properties of the fatty acids deteriorated as the temperature lowered.

Use of Animal Fat in Pelleted Feeds

Very few reports are found in the literature dealing with the influence of animal fat, mixed with a ration, upon the rate of pellet production. This is probably due to the fact that animal fat has been considered in the feed industry a standard feed ingredient for only a few years. Literature that was found on this subject deals with the use of fat more as a nutrient, not a lubricant.

Mac Gregor (12) reported that with the advent of high energy corn and solvent process soybean rations,¹ the pellet mill capacity has been cut due to the low level of fat in solvent process soybean meal. Also the elimination of

¹Referring to rations predominantly (up to 85 per cent) corn and soybean oil meal.

mill-feeds and high-fat oil meal has very materially cut pellet mill capacity. He further states as follows: "Practical past experience has shown that one per cent of added animal fat will produce a considerable increase in pellet mill production."

Norton (15) interviewing pellet mill operators, reported that they seemed to agree that somewhere between four to six per cent of added fat would be the top level that may be added to feeds mixed for pelleting. A question he asked a number of operators was, "How much do you feel that your power requirements have been lowered from the lubricating effects of fat-enriched feeds?"

He summarized the answers as follows:

The operators felt that the power requirement was lowered from this lubricating effect, but the power saving was rather insignificant. Further beliefs were stated that steam requirements have been somewhat lessened when pelleting fat-enriched feeds. Also dies seem to last as much as 25 per cent longer when fat enriched feeds were pelleted due to the decrease in friction.

Fleming (4) concluded that when fat was added to dehydrated alfalfa at the hammer mill this addition was beneficial in that it increased pellet production and the useful life of pellet mill dies and rollers.

Grahek (6) related the factors involved in the manufacture of hard pellets and states them as follows: "Formulation, moisture, fineness of grind and whether or not that particular formula has materials which act as binding agents."

The last three of the above factors are rather definite in meaning whereas formulation includes such things as type of ingredients and proportion of ingredients. This indirectly means that kind of fat and the amount of fat influences the hardness of pellets.

He discussed the effects of pressure applied to form pellets as follows:

Laboratory and actual plant production experiments have conclusively shown that the hardness of a pellet is a function of the

pressure applied to form the pellet. The harder your pellets the less production you will get for the same horse power applied.

From pelleting work using different formulas he constructed an empirical formula to enable one to estimate the rate of production and hardness of the pellets. This formula is:

$$R = \frac{HP \times 10^5 \times B}{436} \frac{D}{P}$$

Where R is the rate of production in pounds per minute; HP is horse power applied, B is bulk density of the mixed formula in pounds per cubic foot; D is the numerical increase in true density of the pellet compared to the bulk density of the formula, and P is the pressure in pounds per square inch.

STATEMENT OF THE PROBLEM

Because of the difference in reported increased rates of pellet production when fat was added to a ration, these investigations were designed to determine whether added animal fat had any positive influence on the rate of pellet production. It was also of interest to determine whether pellet production varied with different levels of added fat.

Another matter of interest was also to determine if the increase in pellet production was in any way due to the lubricating qualities of fat in reducing friction of the feed through the pelleting die.

Another object of the present study was to determine if the added animal fat had any influence on the energy consumption and whether the power consumption varied with different levels of added fat.

MATERIALS

A stabilized, inedible animal fat was used in this experiment. This fat product was produced by a meat packing company.

The ingredients used in this study were feed ingredients common to the

feed industry in this area such as mill-feeds, ground cereal grains and protein supplements.

Steam was furnished by the physical plant on the Kansas State College campus.

APPARATUS USED

The Kansas State College Pilot Feed Mill was the site where this investigation was conducted. The feed mill consisted of standard commercial feed manufacturing equipment.

The equipment directly involved in this study is as follows: Batch mixer, pellet mill, ammeter, power testing panel, Dewar flask, thermometer, sample spoon, moisture equipment, bulk density apparatus, digit counter and stop watch.

Description of the above pieces of equipment will be found below:

Batch Mixer

A Strong Scott, 20 cubic feet, twin flight double spiral ribbon agitator, horizontal batch mixer was employed in this study. The shell of the mixer was five feet long and 25 inches wide with a depth of 28 inches. The mixer was designed to operate at a volume of 15 cubic feet. It was powered by a seven and one-half horse power motor rotating at 1800 revolutions per minute. This motor turned the agitator, through a Dodge gear reducer, at 80 revolutions per minute.

Pellet Mill

A California Master Model Pellet Mill was used in this study. It was

equipped with a volumetric feeder, having fully enclosed ratchet feeder drive supplied with 60 positions from "Stop" to nearly complete rotation. (Plate I). The ratchet feeder drive was used in controlling the rate of flow. Following the screw conveyor feeder was an 11 inch diameter by 36 inch long mixer or conditioner operating at 113 revolutions per minute. The mixing action was supplied by agitating paddles on a single shaft. The conditioner was equipped with an adjustable dam type gate at the discharge end for control of the quantity discharged. Steam and water nozzles were located at the inlet end of the conditioner. The die was 3 1/2 inches wide and had an inside diameter of 12 inches. It was perforated to the size required for making the pellets. (Plate II). In this study a die having perforation 3/16 inch in diameter was employed. The thickness of the die varied with the size of the perforated holes and the pelletability of the ration. The pellet rollers were 5 3/32 inches in diameter by 2 1/4 inches wide with serrated face mounted on an assembly for individual adjustment against the die to perform the extrusion. (Plate III). Adjustable knives were located to cut off extruded pellets to the desired length. (Plate III). The entire die and roller housing assembly was located in a removable chamber for die change and inspection. Dies were held in place by a two-piece clamp and the removal of two bolts and two stud bolt nuts allowed the clamp to be separated, thus the removal of the die.

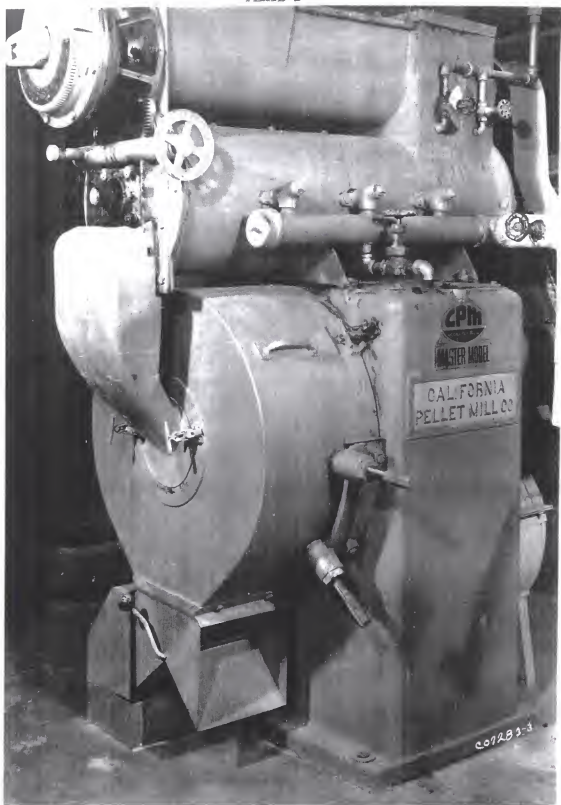
Ammeter

An ammeter indicates the amount of amperes that are passing through an electrical system. This ammeter was connected in the circuit with the pellet mill motor and located at the operators position to enable him to regulate feed flow for maximum motor efficiency.

EXPLANATION OF PLATE I

Photograph of the pellet mill intact.

PLATE I



EXPLANATION OF PLATE II

Photograph of the 12 inch inside diameter die having
performances three-sixteenth inch in diameter.

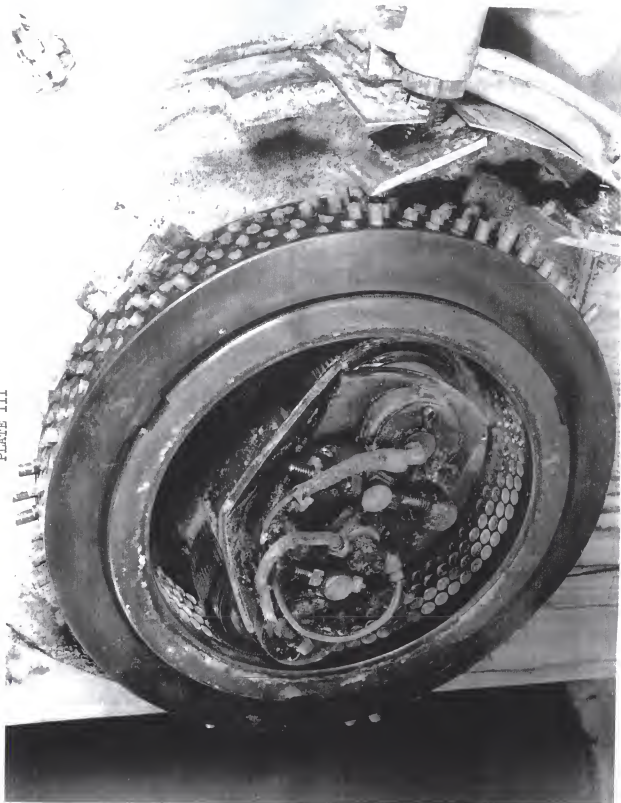
PLATE II



EXPLANATION OF PLATE III

Photograph of the serrated rollers along with a die
and the two knives.

PLATE III



Power Testing Panel

The power testing panel was a unit used to determine the exact amount of power consumed at any instant or the energy used for any period of time. This panel consisted of a volt meter, ammeter, power factor meter, watt meter, and a watt hour meter. (Plate IV).

The first four meters mentioned above provided the data for checking the accuracy of the power testing panel and especially the watt hour meter. (The computations used are exemplified in the chapter on Computation Methods.)

The watt hour meter consisted of four kilowatt hour dials, a demand meter and a rotating disk, the reading of which denoted kilowatt hours consumed. This power testing panel was connected into the electric system of the pellet mill motor.

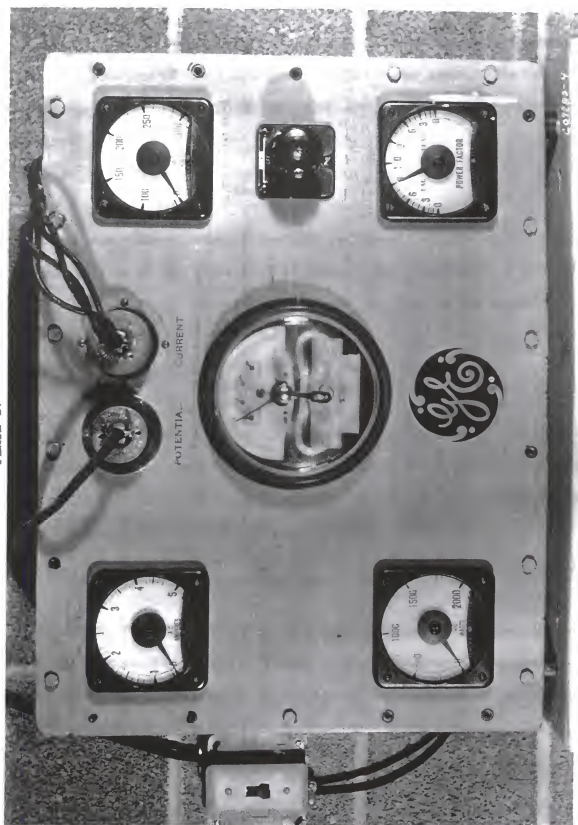
Dewar Flask

The Dewar flask was a double wall glass flask with a vacuum between the two walls. It was used to hold feed samples while determining their temperatures. Each glass wall had a mirror surface; the inside wall had its mirror surface facing the inside of the flask while the outside wall had its mirror surface facing toward the outside of the flask. This flask had the mirrored surfaces because less energy would be lost due to radiation and conduction than in normal containers. This was of value when determining the temperature of substances above or below the surrounding atmosphere. This flask was cylindrical in shape with a diameter of 2 1/2 inches and a height of seven inches.

EXPLANATION OF PLATE IV

Photograph of the power testing panel.

PLATE IV



Thermometer

The thermometer was marked to read in centigrade and was used to determine the temperature of the samples held in the Dewar flask. The range for this thermometer was minus 20° to plus 110° and could be read accurately to the nearest degree.

Sample Scoop

This was a volumetric scoop designed to contain samples approximately two grams in size of the mixed feed as it left the conditioner or pelleted feed at the die. These samples were used for determining the moisture at the respective locations.

Moisture Equipment

All equipment used in determining the moisture content of the feed was standard equipment as set forth by the Association of Official Agriculture Chemists (7). This included such equipment as the moisture dishes, balance scales, desiccator and electric, forced air oven.

Bulk Density Apparatus

The stand, funnel, container, scale and stroke stick employed in determining the bulk density of the different samples was standard apparatus for determining the bushel weight as prescribed by the Handbook of Official Grain Standards of the United States (1).

Digit Counter

A hand tally digit counter providing tallies up to 999 was used in this

study. A finger ring was provided to facilitate the ease of handling. A digit was registered by operating a counter button located on the side of the instrument. The tally could be reset to zero by turning the small knobs on the back of the digit counter. This instrument was used to count the revolutions of the rotating disk.

Stop Watch

The stop watch was calibrated to read to the nearest $\frac{2}{10}$ of a second. There was a long hand which swept a large face and completed a turn in 60 seconds. The smaller hand indicated the number of revolutions the large hand completed and would register as many as 30 turns or 30 minutes on a small face. The watch was started - stopped - started by depressing the crown and was reset to zero by depressing a pin on the side of the watch case.

PROCEDURE

The level of added animal fat was varied in a commercially formulated 20 per cent laying ration. Corn was removed from the ration when fat was added, on an equal weight replacement basis. The formulas for the basic ration, henceforth called BR, and combinations of BR with added fat are found in Table 1.

To have atmospheric conditions, such as relative humidity and temperature nearly the same, each trial¹ was completed during eight consecutive operating hours. The pelleting equipment was flushed and preheated by pelleting ground corn for 20 minutes just prior to starting the study. This was done mainly

¹ A trial consisted of pelleting the BR and BR plus increments of fat and taking the necessary data.

Table 1. Formula of the rations used in this investigation.

Ingredients	: BR : lbs.	: BR 1% ^F : lbs.	: BR 2% ^F : lbs.	: BR 3% ^F : lbs.
Ground yellow corn	100.0	98.0	95.0	92.0
Ground Milo	75.0	72.0	70.0	68.0
Constant 1/ ingredients	326.25	326.25	326.25	326.25
Fat, animal		5.0	10.0	15.0
Total	501.25	501.25	501.25	501.25

1/ These ingredients remain constant in all rations and include 12# Ground Oats, 11# Wheat Shorts, 100# Soybean Oil Meal (44%), 50# Dehydrated Alfalfa Meal (17%) 25# Meat Scraps, 12.5# Bone Meal, 6.25# Lime Stone, 5# Salt, and 2.5# Vitamin Premix.

to heat and clean the pellet die and clean out such pieces of equipment as the elevator legs, conveyors, and pellet conditioner.

The necessary ingredients were added to the mixer in no set pattern except for the liquid ingredient. All dry ingredients were added to the running mixer simultaneously from a scale hopper after which fat, heated to 80° Centigrade, was poured slowly through a top opening three inches in diameter onto the dry ingredients. The mixer was then allowed to operate six minutes before discharging. As the mixer discharged samples of the mixed ingredients were taken in a two quart sample can.

These samples were obtained by using a butterfly valve built into the discharge spout. This valve could be hand operated so as to take a portion of the stream of mixed ingredients while being discharged. These portions of the mixed ingredients were taken every 20 seconds during the discharge period of one minute and 20 seconds. The combined sample, as taken, was used for determining the temperature. It was then spread on a table top, halved

and quartered until approximately a two gram sample was obtained for the moisture determination. Approximately one half of the total sample was used to determine bulk density of the mixed ingredients.

The pellet mill was then started and production was gradually increased to maximum by adjusting the steam and the ratchet drive screw feeder. The pellet mill was considered adjusted when the ammeter, connected in the circuit with the pellet mill motor, indicated 31 amperes. The pellets that were produced during the adjustment period were run continuously into the sack-off bin. After the pellet mill had operated for a brief time at peak production, the run was ready to begin. At this point three things were done simultaneously. (1) The power testing panel was put into operation, (2) the stop watch was started and (3) the pellet cooler was allowed to fill with pellets.

The pellets accumulated in the sack-off bin during the adjustment period were removed so they would not be weighed with the pellets produced during the run.¹

A sample of approximately two grams of the mixed ingredient was obtained as it fell from the pellet conditioner. This was done four times in each run approximately five minutes apart. These samples were placed in moisture dishes and put in a container with a tight fitting lid. At about the same time the above samples were obtained samples were taken in the Dewar flask for determining the temperature.

Also during the run, samples of approximately two grams were taken of the pellets with the aid of the sample scoop as they fell from the die. These samples were placed in moisture dishes and put into same container as mentioned

¹A "Run" denoted completion of the pelleting of any one of the rations, such as BR, and the proper data recorded.

above with a tight fitting lid. Samples of the pellets were also obtained in the Dewar flask for temperature determination.

As the power testing panel started operating the revolutions of the rotating disk, denoting kilowatt hours, were counted by an assistant with the digit-counter until the end of the run.

At regular time intervals during the run, the voltmeter, ammeter, power factor meter, and watt meter were read simultaneously and recorded, for checking the accuracy of the watt hour meter.

When the ration was almost depleted from the surge bin, above the pellet mill, the power testing panel was switched off, the stop watch was stopped and the material being pelleted was directed away from the cooler.

The pellets were then sacked from the sack-off bin and weighed to the nearest pound. During this operation samples of the pelleted product were obtained in the sample scoop and placed in moisture dishes. They were then put into the sealed container holding the other samples that were to be used for moisture determination. Samples of the pellets were also taken in the Dewar flask for final temperature measurements along with samples in a metal sample can for bulk density determinations.

ANALYTICAL METHODS

The mash and pellets were analyzed for moisture, temperature, and bulk density during this investigation.

Moisture Determination Method

Soft feed samples obtained at the batch mixer and conditioner, and pellets obtained at the die and sack off bin were used for determining the respective moistures. The moisture of the samples was determined by the

Association of Official Agricultural Chemists method (7).

Method Used for Determining the Temperatures

The samples used for temperature determination were uniform in volume because when obtained in the Dewar flask it was filled within two inches of the top. The centigrade thermometer was placed in each sample approximately one inch from the bottom of the Dewar flask. The thermometer remained in the sample for four minutes and during this time the highest temperature registered on the thermometer was considered the temperature of the sample.

The above method was used for all temperature determinations except for the samples of the mixed ingredients as obtained from the batch mixer. Since these samples were approximately at room temperature they were left in the sample cans for the temperature analysis. This was the only variance in the temperature determination method as described above.

Bulk Density Determination Method

The bulk density was first determined in terms of weight per bushel as prescribed by the Handbook of Official Grain Standards of the United States (1). The weight per bushel was then converted to pounds per cubic foot.

COMPUTATION METHODS

It was necessary in this investigation to make several calculations, placing the individual runs on a standard energy consumption basis and expressing the kilowatt hours needed to pellet a ton of feed. These calculations were also necessary to check the operation of the power testing panel.

Before analyzing the results, computations were necessary to determine:

I. The approximate amount of power consumed. To calculate the watts that would be consumed for an hour's operation, simultaneous readings taken from the power panel meters were used in the following formula:¹

$$P = \sqrt{3} \times V \times I \times pf$$

where P = power in watts
 V = volts
 I = amperes
 pf = power factor

The calculated watts obtained in the above formula should be very nearly that registered on the watt meter, read simultaneously. If these two values had not correlated, the run would have been discarded and the power panel checked to determine an electrical or mechanical failure.

II. The exact amount of energy consumed. The kilowatt hours consumed during each run was computed by using the following data: The disk revolutions counted during the particular run, the K_h factor, and the correction factor. The K_h factor was taken from the identification plate of the kilowatt hour meter and for this equipment was 1.2. The correction factor, necessary for this panel was 20, due to the use of the panel designed for 220 volts and connected to a 440 line voltage. When incorporating this data in the equation below, the kilowatt hours consumed can be determined.

Disk revolutions $\times K_h \times 20/1000$ equals kilowatt hours (9).

If for any reason the pellet mill chocked down or failed to operate at capacity, shown by drops in watt and amperage meters, and a slowing down of the rotating disk, the watch was stopped, and the power panel turned to "off" and the pellets were not allowed to run into the cooler until normal operations resumed.

¹This is the formula for determining watts being consumed instantaneously when the current is three phase alternating (9).

III. The weight of pellets produced per kilowatt hour. The exact amount of energy in kilowatt hours as determined by paragraph II, divided into the weighed pellets produced during the run gave pounds produced per kilowatt hour.

IV. The weight of pellets produced per hour for standard energy consumption. This computation was made as follows: Multiply the pounds produced per kilowatt hour (calculated in paragraph III) by the established standard kilowatt hours.¹ The results were the pounds of pellets produced per hour based on standard kilowatt hour consumption.

V. Kilowatt hours consumed per ton of produced pellets. The kilowatt hours consumed per ton of produced pellets was determined by using the following computation: The pounds per ton divided by the pound produced per kilowatt hour (as calculated in paragraph III) gave the amount of kilowatt hours consumed per ton of produced pellets.

RESULTS AND DISCUSSION

Temperature, moisture and bulk density data tabulated in Tables 2 and 3 supply useful information in understanding some of the physical changes the soft feed underwent when pelleted. The temperature and moisture results were of value in showing the per cent of moisture added at the conditioner and the temperature increase at the conditioner and the pellet die. The moisture increased uniformly about three per cent in the conditioner due to condensation of steam. Most, but not all, of this added water was lost during subsequent

¹The established standard kilowatt hours was that amount of energy needed to operate the pellet mill motor at optimum efficiency. This was determined by using the following values in the equation as set forth in paragraph II. Volts (V) = 440; Amperes (I) = 31; and power factor (pf) = .89 which gives 17.12 kilowatt hours.

cooling and drying in the pellet cooler. The temperature of the soft feed at the batch mixer tended to increase as the fat content increased. For example, the temperature of the basic ration was 27.6°C while the ration containing three per cent added fat was 32.3°C. This was due to the fact that the fat was 80°C when added to the dry ingredients. Temperature of the soft feed was raised from that of the batch mixer to about 77°C in the conditioner due to added heat of condensation of steam. A further temperature increase was observed in the mechanical pelleting process. It was interesting to note that this pelleting temperature was less with feeds containing added fat. For instance, the temperature was approximately 90.5°C when no fat was added and 85.5°C at the two per cent added fat level. This indicates that the added fat acted as a lubricant, assuming that the temperature drop of the pellets was due to a decrease in friction between the die and product being pelleted.

Table 2. A summary of the temperature and moisture readings obtained during trial two.¹

Ration	Mixer		Conditioner		Pellet Die		End Product	
	Temp : °C	Moist : %	Temp : °C	Moist : %	Temp : °C	Moist : %	Temp : °C	Moist : %
BR	27.6	10.12	77.0	13.18	90.5	13.61	38.1	10.87
BR 1%F	29.9	10.18	77.5	12.78	89.0	13.30	41.0	10.37
BR 2%F	31.1	9.95	77.0	12.99	85.5	13.21	38.5	10.64
BR 3%F	32.3	9.75	76.0	12.72	84.0	12.72	38.0	10.24

1. The temperatures and moisture shown represent the average temperature or moisture as determined from four samples which were taken approximately five minutes apart.

This reduction in friction and temperature is not only a production asset to the manufacturer but is a nutritional asset as well because the reduction

Table 3. Bulk density of the soft feed and the cool pellets.^{1/}

Ration	Mash lbs. / cu. ft.	Pellets lbs. / cu. ft.
BR	30.66	40.56
BR 1% F	30.34	39.28
BR 2% F	30.15	38.00
BR 3% F	30.27	37.92

^{1/} The bulk densities shown in this table represent average bulk densities for five independent samples.

in temperature means a less likely loss of thermo-labile nutrients.

The bulk density results were of value in showing the increase in density of soft feed when pelleted. The mash bulk density variations due to added animal fat were not significantly different from that of the basal ration but pelleted feed containing added fat appeared to be less heavy per unit volume than non-added-fat feed. Since bulk density of the pelleted product varied directly with the pressure applied (6) these data tend to indicate that there was less pressure needed to form the pellet when the fat content increased.

When the pressure was calculated by using the formula as expressed by Grahek (6), the pressure did appear to decrease as the fat content increased (Table 4).

Table 4. Pressure necessary for pellet extrusion.

Ration	Pressure ^{1/} lbs. / sq. in.
BR	6820
BR 1% F	6570
BR 2% F	5600
BR 3% F	5125

^{1/} Pressure calculated by Grahek formula (6).

This again indicated that the added fat was acting as a lubricant between the pellet die and the product being pelleted.

The rate of production was determined by two methods (Table 5). These methods were (1) rate of production in pounds per hour as determined by the weight of the pellets produced per minute and (2) the rate of production in pounds per hour as determined by the weight of pellets produced per kilowatt hour (Computation Method, paragraph IV).

Table 5. Rate of pellet production and kilowatt hours consumed.

Ration	Production				Energy per hour
	lbs. $\frac{1}{hr.}$	increase over BR %	lbs. $\frac{2}{hr.}$	increase over BR %	KWH
BR	4580	--	4340	--	18.1
BR 1%F	5620	22.78	4820	11.07	19.92
BR 2%F	6000	31.02	5380	23.98	19.11
BR 3%	6500	42.05	5820	34.15	19.16

1/ Production based on Time.

2/ Production based on a standard kilowatt hour consumption.

The second method is the more valuable because there was an elimination of one variable, that being energy. For example, the production determined by the weight of pellets produced per minute was 4580 pounds per hour when no fat was added, and 6500 pounds per hour when three per cent fat was added (Table 5). The amount of energy consumed per hour was 18.1 kilowatt hours when no fat was added and 19.16 when three per cent fat was added. Thus 1.06 more kilowatt hours were used to produce the three-per cent-added-fat-ration, and this additional energy was partially responsible for the production increase between the ration containing three per cent added fat and the basic-

ration.

The 1.06 kilowatt hours involved may not seem to be a significant factor over an hours operation, but it influenced the results by about eight per cent. For instance there was only 34 per cent increase in production when based on a standard kilowatt hour consumption as compared to 42 per cent increase in production when based strictly on time (Table 5). Therefore all discussion was directed to the production results based on a standard kilowatt hour consumption.

The slopes of the production curve as determined from this investigation have been shown to be significantly positive at the five-tenths per cent level (Fig. 1). This was derived by analyzing the linear regression curve, developed by the method of least squares, from the production data and then submitting it to the *t* test (Snedecor, 15). It can further be stated that the slope of the production curve for trial two lies between 26.66 to 32.74 with 95 per cent confidence.

This investigation was ended at the three per cent level of added fat because the limit of delivery of the volumetric feeder was reached. Specifically, the ratchet feeder drive was at position 60 meaning that the volumetric feeder was delivering capacity. Further levels of added fat would have been to no avail because there was no satisfactory method of analyzing the results.

When this investigation was repeated the results obtained indicated a high degree of correlation. The two production curves plotted from the data obtained from two independent trials tend to show similar slopes (Fig. 1). The distance between the curves was due to a magnification of the variables involved in this study. For instance, the ingredients were not from the same supply for both studies and the condition of the die was different due to

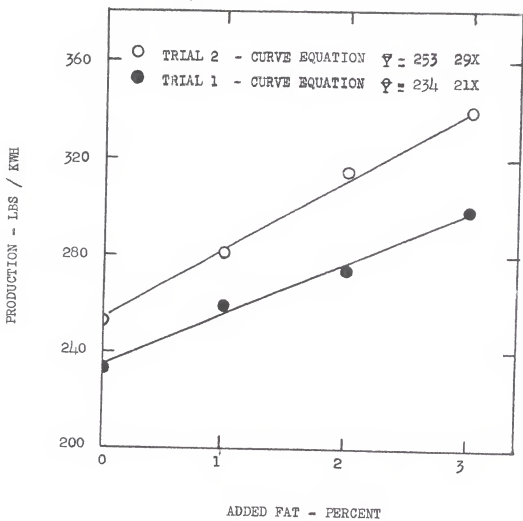


Fig. 1. Rate of pellet production versus the per cent added fat.

use during the time lapse. The rate of production expressed in the per cent increase over the basic ration showed more clearly the correlation between the independent trials (Fig. 2).

It is evident from Fig. 2 that added fat resulted in a noticeable percentage increase in production over the basic ration. For example, the ration containing three per cent added fat produced 28 per cent more tonnage than the basic ration during the first trial and 34 per cent during the second trial. The two trials gave an average increase of 30 per cent in production for the three per cent added fat ration.

Since production was based on a standard kilowatt hour consumption it was easy to convert the data to show the kilowatt hours required to pellet a ton of feed. These results are graphically shown in Fig. 3. The results indicated a decrease in energy consumption from the basic ration to the three per cent level of added fat. For instance the average energy consumed for the basic ration was 8.25 kilowatt hours per ton and 6.25 kilowatt hours per ton for the ration containing three per cent added fat; this was a decrease of about 24 per cent.

The slopes of the power consumption curves for both independent trials have been shown to be significantly negative at the five-tenths per cent level. This was deduced by analyzing the linear regression curve, derived by the method of least squares, from the power consumption data and then submitting it to the t test (Snedecor, 15).

SUMMARY AND CONCLUSION

When inedible animal fat was added to a 20 per cent poultry laying ration, as noted in this study, the following conclusions were reached:

With fat and corn being the only known variables it was found that temperature

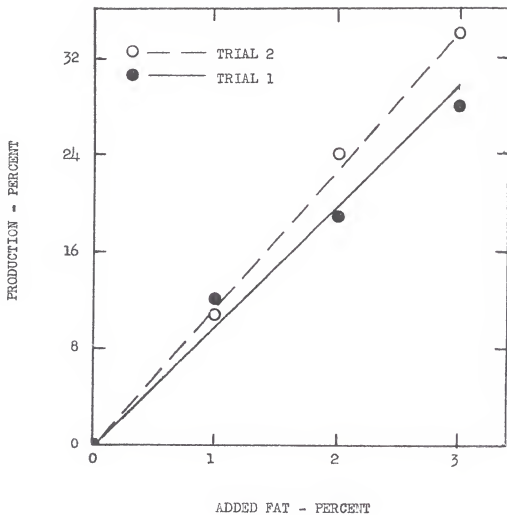


Fig. 2. Per cent increase in the rate of production each level of added fat expressed over the basic ration.

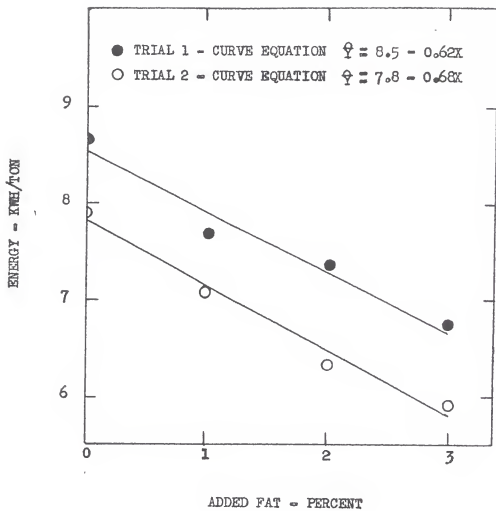


Fig. 3. The energy consumption per ton of pellets versus per cent added fat.

changes were observed in the mash at the pellet conditioner and the pellets leaving the die. The difference between these temperatures tended to decrease as the fat content increased. This indicated that fat was acting as a lubricant, assuming the decrease in temperature was due to the lessening of friction as the product passed through the die.

The bulk density of the pelleted ration decreased when the fat per cent increased, while the bulk density of the mash tended to remain constant. This indicated that less pressure was applied to the pellets as the fat content increased. This was substantiated by using Grahek's (4) formula for determining the pressure required to extrude the pellets. Again this indicated that the animal fat was acting as a lubricant.

The measured rate of production, when fat was added to the basic ration at varying levels, statistically indicated a linear advance up to the three per cent level of fat.

The ration containing three per cent added animal fat produced approximately a 30 per cent production increase over the basic ration.

This investigation indicated that it required less energy to pellet a feed containing added fat than feed not containing added fat.

The energy (KWH per ton) required, when pelleting the ration containing three per cent added fat, decreased about 24 per cent compared to the energy required when pelleting the basic ration.

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THE EFFECT OF ADDED ANIMAL FAT TO A BASIC
POULTRY RATION ON PELLET PRODUCTION

by

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This investigation was conducted to determine if animal fat added to a formula feed had a significant effect on the rate of pellet production and electrical energy consumption. It was also of interest to determine if different levels (1, 2, and 3 per cent) of animal fat effected the production and energy requirements.

The addition of the dry ingredients to the mixer were made simultaneously, after which animal fat, heated to 80°C, was added. Samples were taken of the mixed ingredients for measurements of bulk density, moisture and temperature. The pellet mill was then adjusted for maximum production by regulating the steam and the volumetric flow of feed.

After the pellet machine had operated at peak production for a brief time, a power testing panel, used for measuring KWH, volts, amperes and power factor, was started and the pellets directed into an empty cooler. The pellet mill was allowed to operate about 25-30 minutes, depending on the amount of feed to be pelleted. At this time the power testing panel was stopped and the pellets directed away from the cooler. This permitted the production to be calculated both in terms of weight per unit of time and weight per unit of energy.

During the pelleting period samples were taken of the mash as it fell from the conditioner, and of pellets at the die and sack off point for the purpose of obtaining the temperature, moisture and bulk density values.

The temperature and moisture results were of value in showing the per cent of moisture added at the conditioner and the temperature increase at the conditioner and pellet die. The moisture increased uniformly, about three per cent, in the conditioner due to condensation of steam. Most, but not all, of this added water was lost during subsequent cooling and drying in the pellet cooler. Temperature of the soft feed was raised from that of the batch

mixer to about 77°C in the conditioner due to added heat of condensation of steam. A further temperature increase was observed in the mechanical pelleting process but increased less with feeds containing added fat. This indicated that the added fat acted as a lubricant, assuming that the temperature drop of the pellets was due to a decrease in friction between the die and product being pelleted.

The bulk density results were of value in showing the increase in density of soft feed when pelleted. The mash bulk density variations due to added animal fat were not significantly different from that of the basal ration but pelleted feed containing added fat appeared to be less heavy per unit volume than non-added-fat feed. This indicated there was less pressure needed to form the pellet when the fat content increased.

Production results expressed in pounds per KWH were used in this study. When these production results were plotted on a scattered diagram the curve appeared to be linear up to the three per cent level of added fat. The slope of this production curve was shown to be significantly positive at the .5 per cent level. The production appeared to increase as much as 30 per cent over the ration containing no added fat.

Since production was expressed in pounds per KWH it was easy to convert the data to show the kilowatt hours required to pellet a ton of feed. The results indicated a decrease in energy consumption from the basic ration to the three per cent level of added fat; this was a decrease of about 24 per cent.