series of runs in which the stability of the fat decreased in each successive run to quite low stability values. These changes were unexplained except that the renderings were made during periods of extremely hot weather. Subsequent renderings have produced fats with improved stabilities.

It is apparent that there are numerous problems to be solved before the practice of rendering with antioxidant in the charge can be actively recommended. On the other hand, there are many encouraging results which indicate that the practice has much promise. A number of renderers are producing stabilized fat by this method. Many others may be able to market their product for use in feeds without the expense of added equipment for stabilizing fat by subscribing to this technique and obeying good rendering practice.

### Summary

Studies have been made to determine the feasibility of stabilizing inedible animal fats with antioxidants during rendering. Results show that in many instances a very high stability fat and meat and bone scrap can be obtained from this practice. Factors affecting the variability of results are discussed.

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# The Use of Animal Fats in Poultry Feeds[1]

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THE poultryman is interested in any feed or feedstuff that will enable him to produce a dozen eggs, or a pound of chicken a little bit cheaper. This is especially true today since poultry products and electricity are about the only items of which we can buy as much for a dollar now as we could 10 years ago. He is also interested in his personal comfort and consequently any item that will decrease the dustiness of either the mixed feed or its components will be readily accepted by him as well as by the feed man. Of course the product must not be lowered in grade by any material added.

The idea of increasing the caloric content per pound of broiler, starting and laying rations is not a new one. Scott *et al.* (6) reported that a high energy diet for growing chickens out-performed rations of lower energy content. Since that time Slinger *et al.* (8) have presented data in which soybean oil increased the growth rate slightly and improved the efficiency of feed utilization of young chicks. Experiments conducted by Lillie, Sizemore, Milligan; and Bird (3) with laying hens show that up to 8% lard can be fed to hens without decreasing egg production. In fact, the fat containing diet was about 16% more efficient than similar diets without fat. Recently Siedler and Schweigert (7) have reported that levels of stabilized white grease up to 8% can be incorporated into broiler diets without affecting the growth rate. They also reported that the calories in white grease were utilized efficiently up to 4% added fat in the diet. More recently Yacowitz (9) presented data using lard, cottonseed oil, and soybean oil which substantiated the work of Siedler and Schweigert. The experiments reported here extend the above observations with chicks to prime tallow and compare soybean oil, white grease, and prime tallow when fed to turkey poults.

### Experimental Methods

Straight run, day-old chicks, the progeny of New Hampshire males and S.C.W. Leghorn females, were used in the first three experiments. The chicks were raised in standard electric batteries, and when the experiments were continued to 10 weeks, the chicks were transferred at 4 weeks to growing batteries with raised wire floors. The dams of the chicks in the first three experiments were fed diet $B_1$ of Robblee *et al.* (5). Twenty-five chicks were used per group. The chicks used in the fourth experiment were the progeny of New Hampshire males and Barred Plymouth Rock females which had been fed an adequate breeder diet. Twenty-one male and 21 female day-old chicks were used in each group. Four by 6-ft. houses with attached sand yards were used in this experiment, which continued for 10 weeks. The basal diet is shown in Table I. Additions were made to the basal in such a way as to keep the protein level constant. This was done by decreasing the corn and increasing the soybean oil meal. The high energy basal diet also is shown in Table I.

TABLE I
Basal Diets Used for Chicks and Turkey Poults

| | Chicks | | Turkeys |
|---|---|---|---|
| | Basal | High energy basal gms./kg. | |
| Ground yellow corn | 430 | 550 | 180 |
| Ground oats | | | 50 |
| Wheat bran | 50 | | 50 |
| Wheat middlings | 50 | | 50 |
| Alfalfa meal | 50 | | 50 |
| Soybean oil meal | 320 | 360 | 500 |
| Condensed fish solubles | 30 | 30 | 25 |
| Torula yeast | | | 25 |
| Chick size oyster shell | 20 | 20 | 20 |
| Granite grit (chick size) | 10 | 10 | 10 |
| Bone meal | 30 | 30 | 30 |
| Iodized salt | 5 | 5 | 5 |
| Feeding oil (300D-1500A) | 2 | 5 | 5 |
| Vitamin $B_{12}$ and antibiotic feed supplement[a] | 1 | 1 | 1 |
| DL methionine | 0.5 | 0.5 | 0.5 |
| $MnSO_4$ | .22 | .22 | .33 |
| Riboflavin mgs | 3.2 | 3.2 | 6 |
| Niacin mgs | 6 | 6 | 10 |
| Ca. pantothenate mgs | 4 | 4 | 5 |
| Choline | | | 1 |

[a] Merck 626.

Broad Breasted Bronze turkeys obtained from a commercial hatchery were used in the first turkey experiment. Nebraskans from a commercial hatchery

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were used in the second experiment. Twenty-five and 24 poults, respectively, were used per group in the two experiments. The poults were weighed, and feed weigh-backs were taken at regular intervals. Standard electric batteries were used until three weeks, and growing batteries with raised wire floors were used from then on until the experiment was terminated. The basal diet fed the turkeys is shown in Table I. The ingredients were varied so that the protein content was constant. When the caloric content was increased with the addition of more corn, the oats were eliminated and the alfalfa meal and wheat bran were lowered to 3 or 4%. In order that diets containing calories from either corn or fat could be compared on an isocaloric basis, the data of Fraps (1) were used to determine the productive therms per hundred pounds. Butylated hydroxyanisole, citric acid, and propyl gallate were added to prevent rancidity of the white grease in Experiments 4, 5, and 6 at the levels of 0.02%, 0.01%, and 0.005%, respectively.

## Results and Discussion

The results of experiments 1 and 2 are presented in Table II. The reason for the odd percentage figures for the soybean oil is as follows. Early work seemed to indicate that sucrose increased the early growth rate of the chicks. In order to determine whether this supposed stimulation was due to energy or to changes in the texture of the feed, soybean oil was added to equal the calories in 5 and 10% sucrose. Subsequent experiments failed to show any growth stimulation with sucrose although the feed efficiency appeared to be improved slightly. The data here show generally an improvement in feed efficiency and in one case an increase in growth. This is in general agreement with the work of Slinger *et al.* (8) and Yacowitz (9).

TABLE II
The Effect of Different Levels of Soybean Oil on Performance of Chicks

| Experiment | Addition to the Basal | 4 week wt., gms. | gms. feed/ gm. wt. |
|---|---|---|---|
| 1 | None | 330 | 2.06 |
| | 2.2% soybean oil | 344 | 2.14 |
| | 4.4% soybean oil | 375 | 1.94 |
| 2 | None | 334 | 1.96 |
| | 2.2% soybean oil | 326 | 1.85 |
| | 4.4% soybean oil | 343 | 1.92 |

The data in Table III show the effect of soybean oil, white grease, and prime tallow on the growth rate and efficiency of feed conversion. Because of limitations in growing battery capacity certain groups were not continued beyond 4 weeks. No increase in the growth rate could be ascribed to feeding fat at 4 weeks. However by 10 weeks the two groups fed the basal diet were smaller than any of the other groups. The group fed the 10% sucrose was only 27 g. heavier on the average than the two control groups. Efficiency of feed conversion in all supplemented groups at 4 or 10 weeks was better than either of the controls.

TABLE III
The Effect of Different Fats on Performance of Chicks

| Additions to basal | Weights | | gms. feed/gm. wt. | |
|---|---|---|---|---|
| | 4 wks. | 10 wks. | 4 wks. | 10 wks. |
| | *gms.* | *gms.* | | |
| None | 302 | 1165 | 2.07 | 2.88 |
| | 327 | 1165 | 2.12 | 3.06 |
| 4.4% SBO | 327 | 1258 | 1.92 | 2.64 |
| 2.2% WG | 321 | | 1.86 | |
| 4.4% WG | 310 | 1235 | 1.98 | 2.71 |
| 2.2% PT | 328 | | 2.03 | |
| 4.4% PT | 318 | 1212 | 2.02 | 2.75 |
| 10% sucrose | 322 | 1192 | 2.05 | 2.87 |
| High energy basal | 333 | | 1.86 | |
| High energy basal plus WG | 327 | | 1.88 | |

SBO is soybean oil.
WG is white grease.
PT is prime tallow.

Thus far, all data available have been obtained on raised wire floors in batteries. It was of considerable interest to us to see if the fat would improve the utilization of feed when added to rations for broilers in floor pens. The 4-wk. and 10-wk. data of the 4th experiment are presented in Table IV. Here no improvement in growth was observed when white grease was added to the rations. In each comparison between the group not receiving the fat and the corresponding group receiving the fat an improvement in feed efficiency was noted. Therefore, with chickens at least, the improvement in feed efficiency is similar in both battery and floor-pen-raised chicks.

TABLE IV
The Effect of Fat on Performance of Broiler Chicks

| Additions to basal | Weight | | gms. feed/gm. wt. | |
|---|---|---|---|---|
| | 4 wks. | 10 wks. | 4 wks. | 10 wks. |
| | *gms.* | *gms.* | | |
| 1. none | 335 | 1286 | 2.33 | 3.45 |
| 2. 5% dried whey | 326 | 1260 | 2.46 | 3.52 |
| 3. as 2 + 5% W.G. | 351 | 1321 | 2.21 | 3.42 |
| 4. 5% Torula yeast | 333 | 1219 | 2.43 | 3.72 |
| 5. as 4 + 5% W.G. | 320 | 1184 | 2.31 | 3.56 |
| 6. as 4 + 5% dried whey | 358 | 1286 | 2.34 | 3.53 |
| 7. as 6 + 5% W.G. | 342 | 1272 | 2.26 | 3.38 |

W.G. = white grease.

The growth data for the turkeys are presented in Table V. The data from the first experiment show a nice consistent growth response from the various levels of fat. However in the second experiment only the poults fed the prime tallow were much larger than those fed the basal diet. The Nebraskan is a smaller variety than the Broad-Breasted Bronze turkey. The use of high levels of corn to raise the productive energy to levels similar to those that were present in the diets containing 2.5 and 5.0% fat improved the growth rate in the first experiment but did not in the second. In either case however the improvement was

TABLE V
The Effect of Different Fats and Energy on Growth of Turkey Poults

| Addition to Basal | Experiment I | | | Experiment II | | |
|---|---|---|---|---|---|---|
| | 2 wks. | 4 wks. | 6 wks. | 2 wks. | 4 wks. | 6 wks. |
| | *gms.* | *gms.* | *gms.* | *gms.* | *gms.* | *gms.* |
| None | 219 | 569 | 1199 | 203 | 550 | 1146 |
| | 216 | 563 | 1154 | 212 | 554 | 1106 |
| 2.5% S.B.O. | 247 | 627 | 1274 | ...... | ...... | ........ |
| 5% S.B.O. | 241 | 647 | 1285 | 197 | 541 | 1108 |
| 2.5% W.G. | 233 | 621 | 1245 | 208 | 567 | 1170 |
| 5% W.G. | 233 | 602 | 1226 | 205 | 555 | 1139 |
| 2.5% P.T. | 235 | 642 | 1279 | ...... | ...... | ........ |
| 5% P.T. | 237 | 637 | 1280 | 209 | 590 | 1256 |
| Energy[a] ≈ 2.5% fat | 223 | 626 | 1252 | 208 | 556 | 1113 |
| Energy[a] ≈ 5.0% fat | 232 | 611 | 1227 | 207 | 572 | 1171 |

S.B.O.—Soybean Oil.
W.G.—White Grease.
P.T.—Prime Tallow.
[a] Supplied by extra yellow corn.

not as great as with the prime tallow even though the energy level was the same. The ability of the turkey poult to convert feed to body weight is shown in Table VI. The figures shown are actually the grams of feed required to produce one gram of turkey. In the first experiment, feed conversion was better in all the fat-containing rations than in the control rations. Supplying the extra energy from corn in this experiment did not improve the utilization of feed over that of the control groups. In the second experiment the high corn groups were about as good as the most efficient control group and considerably better than the other one. In the second experiment no advantage in feed conversion was evident for the soybean oil or the low level of white grease. Again the prime tallow improved the utilization of the feed.

TABLE VI

The Effect of Different Fats and Energy on Feed Conversion of Turkey Poults

| Addition to Basal | Gms. feed/gms. of weight | | | | | |
|---|---|---|---|---|---|---|
| | Experiment I | | | Experiment II | | |
| | 2 wks. | 4 wks. | 6 wks. | 2 wks. | 4 wks. | 6 wks. |
| None | 1.40 | 1.71 | 1.89 | 1.42 | 1.89 | 2.08 |
| | 1.40 | 1.93 | 2.02 | 1.24 | 1.71 | 1.87 |
| 2.5% SBO | 1.16 | 1.64 | 1.84 | ...... | ...... | ...... |
| 5% SBO | 1.14 | 1.51 | 1.72 | 1.22 | 1.70 | 1.94 |
| 2.5% WG | 1.32 | 1.68 | 1.88 | 1.20 | 1.75 | 1.95 |
| 5% WG | 1.28 | 1.52 | 1.75 | 1.18 | 1.65 | 1.83 |
| 2.5% PT | 1.30 | 1.62 | 1.84 | ...... | ...... | ...... |
| 5% PT | 1.24 | 1.56 | 1.75 | 1.20 | 1.58 | 1.75 |
| Energy $\approxeq$ 2.5% fat | 1.30 | 1.82 | 2.01 | 1.16 | 1.62 | 1.92 |
| Energy $\approxeq$ 5% fat | 1.28 | 1.77 | 1.93 | 1.17 | 1.72 | 1.91 |

SBO—Soybean Oil.
WG—White Grease
PT—Prime Tallow.

These experiments show that animal fats can be used in both turkey and chicken starting rations. There is no evidence that at these levels the growth will be retarded at all. Most of these experiments and those reported previously show that the addition of these fats either improves growth slightly or that the growth rate is unaffected. Whether the extra energy is supplied from plant or animal fats seems to make little difference. One of the chief advantages that the addition of fats has in poultry starting rations is an improvement of feed utilization or of feed conversion. Nearly all experiments that have been reported to date indicate an improvement in this respect of from 5 to 10%. Slinger's data show an average of 4.2%. Siedler's and Schweigert's data with White Rock chicks showed 7.5 to 10%. Yacowitz's data showed from 3 to 14%. The data presented here show from 0 to 12% improvement in feed utilization. The data with turkeys show from 3% to 23% improvement when 2-, 4-, and 6-wk. efficiencies are considered. It is evident that improvements in feed utilization can be made by the additions of fat.

The reason for the improved feed utilization is not well understood. That the fat is supplying some essential nutrient that is found normally in limiting amounts is rather unlikely. If this were the case, then improved growth should be obtained regularly.

Another advantage of the use of fats in poultry feed has not been stressed thus far. This is a change in physical properties of the feed. The addition of small amounts of fat to poultry feeds decreases the amount of dust. Dust is a serious problem with the feed manufacturer and a source of harassment for the producer. As little as ½ or 1% added fat cuts down on the dust appreciably. Also accompanying additions of fat to poultry feeds is a change in texture. The feed appears more crumbly, and the green color of the alfalfa present in the feed improves the over-all appearance to the producer. It is hard to believe without actually seeing the change that a small amount of fat will change the appearance of a feed so radically.

What then are the limitations of incorporating fats in poultry feeds? Much more research work must be done before this can be answered. We do not know how much fat the laying or breeding hen will tolerate. Most poultry rations have from 3 to 5% fat before any extra additions are made. The total amount tolerated will be above 11 or 12%. Lillie *et al.* (3) used 8% additional fat without harmful effects. Siedler and Schweigert (7) used up to 8% white grease as added fat in a commercial broiler ration with no harmful effects. Yacowitz (9) reported that 15% additional cottonseed oil resulted in poor feathering. Reiser *et al.* (4) fed 20% lard to chicks on a purified type diet without harmful effects. However 20% cottonseed oil resulted in poor growth. Probably then the upper satisfactory limit has been exceeded. The cost of the material and the diminished response to additional amounts probably will limit its use to from 2.5 to 5% of the entire ration. In some of these trials the chicks and poults receiving 2.5% of additional fat performed as well as the 4.4 or 5.0% levels, but usually the higher levels gave the best response. When mixed feeds containing fats are placed in commercial channels, the problem of rancidity becomes acute. In the trials of Siedler and Schweigert the white grease was stabilized with butylated hydroxyanisole. The antioxidant was also used in our white grease. All diets were mixed at least weekly, and no noticeable rancidity occurred in the diets containing soybean oil or prime tallow even though no antioxidant was used. The fats were stored at 32°F. prior to the time of mixing. At that time they were melted and poured into small portions of corn or soybean oil meal or onto the entire rations, and then the feed was mixed in the normal way. We need to know also whether or not we can use the lower grade inedible fats in poultry feeds. Additional research is needed on this point.

The use of animal fats in commercial poultry feeds presents additional problems. Probably the antioxidant should be mixed in immediately after rendering when the fat is still liquid and in tanks equipped to provide even distribution of the antioxidant throughout the fat. Adequate mixing and incorporation of the fat into the poultry ration is also an important problem facing the feed manufacturer. Another consideration is of grave importance to him. Will the supply of fat be adequate and at a price that will make it economically feasible to use the material? The price must also have some stability because certain modifications in equipment will be necessary.

Feed formulation can also be affected. Fats do not supply protein. Rations which contain added fat must be reevaluated and the percentage of protein carriers increased to make allowances for the fat addition. With the birds eating less, perhaps vitamin and mineral additions will have to be increased slightly so that the bird will still have adequate amounts of these essential nutrients even if consumption is decreased. Of course, no material can be used if the ultimate product is not palatable. Klose *et al.* (2) have reported that roasted carcasses of turkeys from groups fed beef fat, corn oil and soybean oil were essentially free of fishy off-flavors. In fact, if anything, the beef fat showed a stability better than the control diet.

## Summary

White grease, prime tallow, and soybean oil have been fed to chicks and to turkey poults at the levels of 2.2 to 5.0%. No consistent improvement in growth has been observed with chickens. A slight improvement was noted with turkeys with prime tallow. However feed utilization was improved when the various levels of fat were fed to either chickens or turkey poults. The addition of fat to poultry feeds reduces the amount of dust and improves the texture and color of the feed.

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# Use of Animal Fats in Poultry and Dog Rations[1]

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WITH the decline in the market for animal fats in soap and other industrial uses in recent years, interest has been markedly increased for developing new uses for animal fats. One of the major new uses developed has been in animal feeds. The relatively low fat content of mixed feeds (approximately 5%) and the potential value of increasing the fat content of feeds prompted the initiation of intensive studies on the value of adding fats to dry dog meals and poultry rations three years ago.

In the course of these studies the effect of adding graded levels of animal fat (choice white grease) stabilized with an antioxidant mixture (butylated hydroxyanisole, propyl gallate, and citric acid) to the ration on the growth, maintenance, food utilization, and reproduction and lactation performance of dogs was investigated. Similar studies on the growth, food utilization, and general performance of chicks raised to broiler age were carried out. It also was of importance to determine the stability of vitamin A (fish liver oil) added to feeds containing either no added fat or 6% of stabilized fat. In addition, studies were conducted by L. R. Dugan and associates on the stability of animal fats treated with different antioxidants when added to feeds.

These studies were designed to obtain basic information of two types: a) the nutritional performance of dogs and chicks fed different levels of fats; and b) the prevention of rancidity and destruction of nutrients by stabilizing the animal fats in the feeds with suitable antioxidants.

The results of our studies clearly show that the performance of dogs (Cocker spaniels) fed 4% animal fat in addition to the basal ration (a total of 8% fat in the ration) was equal to or superior to the performance of dogs fed the basal ration. The performance of the dogs fed 6 or 8% added fat also was excellent while the performance of the dogs fed sucrose (equivalent in crude calories to 8% added fat) in addition to the basal ration was less satisfactory. The composition of the ration used, designed to include ingredients commonly used in commercial meals, is shown in Table I. This ration contained 29.1% protein and 3.7% fat.

TABLE I
Composition of Experimental Ration

| Ingredient | % |
|---|---|
| Corn flakes | 26.75 |
| Wheat flakes | 26.70 |
| Soybean grits (HI-PRO-CON) | 19.00 |
| Meat and bone scrap | 15.00 |
| Fish meal (Menhaden) | 3.00 |
| Wheat germ meal (defatted) | 5.00 |
| Dried skim milk | 2.50 |
| A and D oil (Nopco xx2250 U.S.P. units A, 400 A.O.A.C. units D/gm. | 0.50 |
| Iodized salt | 0.25 |
| Brewers' yeast (non debittered) | 0.50 |
| Riboflavin supplement (BY-500) | 0.80 |
| | 100.00 |

The results obtained in the growth studies (Table II) are for one of two experiments conducted. It will be noted here that the dogs fed 4% animal fat grew at a more rapid rate than those fed the basal ration while the performance of those fed 8% or sucrose approximated that for when the basal ration was fed.

TABLE II
Effect of Feeding Different Levels of Fat on the Rate of Gain

| Ration | No. of Dogs | Avg. Gain/Wk. |
|---|---|---|
| | | *grams* |
| Experimental Ration | 7 | 339 |
| Experimental Ration + 4% Fat | 7 | 360 |
| Experimental Ration + 8% Fat | 6 | 334 |
| Experimental Ration + 18% Sucrose | 5 | 328 |

Food consumption data showed that the fat and sucrose supplements were well utilized. Subsequent studies were conducted on the maintenance and reproduction and lactation performance of these dogs. Pertinent results are tabulated in Table III.

Food and caloric utilization during the first four weeks of lactation (based on weight change of the

[1] Journal Paper No. 80, American Meat Institute Foundation. Presented at the 27th Fall Meeting, American Oil Chemists' Society, Chicago, Nov. 3, 1953.