USE OF FATS IN ANIMAL FEEDS

INTRODUCTION

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ABOUT two and one-half billion pounds of inedible tallows and greases will be produced in this country in 1954. The efficient utilization of these fats is of importance to the entire national economy. For many years the meat packing industry has sold the beef carcass at wholesale at a price equal to or less than the cost of the live animal. This has been possible because of efficient utilization of by-products and a sustained demand for such products.

The prices paid for livestock are higher than would be warranted if there were no by-product recovery and if the price were determined solely by what the consumer is willing and able to pay for the edible products. A strong demand for by-products means better prices for the livestock producer. Higher livestock prices stimulate increased livestock production. Thus the consumer and livestock producer, as well as the meat processing industry, benefit when maximum value is realized from by-products.

In recent years the margin between the cost of the live animal and the value of the by-products has been decreasing sharply. The relative price of tallow is a typical illustration. From 1910 to 1920 the average price of tallow per pound was very close to that of the live animal. From 1920 to 1947 the price fluctuated from 47 to 90% of that of the live animal. Recently the price has been as low as from 10 to 20% of the average cost of the live animal.

In addition to the tallow and grease produced by the meat packing industry considerable quantities are available from the rendering industry. This industry performs an important service in the national economy by recovering useful products that otherwise would be wasted and would require expenditure of public funds for disposal in order to avoid public health hazards. Greases and tallows represent a substantial part of the value of the products produced by the rendering industry. Depressed prices of tallows and greases during recent years have made it very difficult for the rendering industry to operate successfully.

In 1952 there was a surplus of about 777 million pounds of these fats. Raymond Ewell of the Stanford Research Institute recently made an extensive study of the production and utilization of tallow and grease. He concluded that by 1957 an animal surplus of 1.1 billion pounds will be available and that, based on current usage, this level of surplus will be maintained for several years.

This symposium presents a number of papers on the use of stabilized fats in feeds. If, through research, we can find new uses for these surplus fats, it certainly is a much more effective and economical method of alleviating the price-depressing effect of surplus agricultural commodities than the method of purchase and storage by the federal government.

The Stabilization of Animal Fats with Antioxidants During Rendering[1, 2]

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THE requirement for stability in inedible grades of animal fats seldom has been stressed as it has for edible fats. The proteinaceous residue from rendering generally has been considered free from rancidity problems although almost all who store these products have been aware of rancidity at one time or another. The rapidly developing practice of adding animal fats to feeds has imposed a new requirement for stability in inedible grades of animal fat. This requirement stems from both the known and suspected vitamin- and other nutrient-destroying capabilities of rancid fats.

It is common practice to stabilize lard after rendering, and this involves the use of extra tanks and agitating devices. Since many rendering plants would be required to invest more capital to produce stabilized fats for use in feeds, it was decided to investigate the feasibility of stabilizing during the rendering process. If successful, this practice should produce not only a stable fat for use in feeds but also a more stable meat scrap, which also would be desirable for feed use.

A number of studies have been conducted on both pilot-plant scale and commercial dry rendering operations. These have produced variable results which will be discussed.

Pilot Plant Rendering Tests

All pilot plant renderings were performed in a standard design Albright-Nell dry melter reduced in size to contain 19.86 gallons. This readily will accommodate a charge of approximately 100 pounds of fatty animal tissues.

The data in Table I were obtained from rendering hashed and washed hog entrails in the pilot-plant dry melter. The materials were hashed to about 1-in. pieces and washed until free from fecal and food materials. Ten pounds of unstabilized lard were added to each charge of 100 pounds to provide a good fat content and fat saturation of all contents in the

[1] Presented at the 27th Fall Meeting of the American Oil Chemists' Society, Nov. 2-4, 1953, Chicago, Ill.
[2] Journal Paper No. 81, American Meat Institute Foundation.

TABLE I

Effect of Adding Antioxidant Before and After Rendering

Run Number	Antioxidant	A.O.M. Stability of Fat (Hrs.)	Accelerated Stability of Meat Scrap (Hrs.)
1	Control	10	16
	BHA[a] after cook	16	25
	BHA[a] before cook	200	>300
2	Control	8	44
	BHA[a] after cook	28	>300
	BHA[a] before cook	170	>300
3	Control	18	20
	Tx-2[b] after cook	40	32
	Tx-2[b] before cook	220	>300

[a] Added to provide 0.01% BHA in the fat.
[b] Added to provide 0.05% Tenox-II in the fat.

melter. In order to evaluate the effect of adding antioxidant before and after rendering, the procedure followed was to render a charge essentially to completion.[3] A small sample (to be used as control sample) was run out of the melter. The antioxidant in 10 cc. of 95% ethanol solution then was added to the melter to provide approximately 0.01% butylated hydroxyanisole (BHA), based on the estimated fat content of the charge. The charge then was agitated for about 10 minutes at 40 r.p.m. and dumped. The fat and press cake from this operation were used as the sample for antioxidant added after cook.

A comparable cook then was made with identical charge and rendering conditions with the exception that the antioxidant was added to the charge before the cook was begun.

The data in Table I indicate a decided advantage for the method of dry rendering with antioxidant in the charge. The addition of antioxidant after rendering increased the stability of the fat by factors ranging from 1.6 to 3 whereas the addition of antioxidant before rendering resulted in stability increases by factors of 10 to 20. A comparable situation was found in the meat scrap from each rendering operation. The stability values reported are for an accelerated method based on formation of volatile carbonyl compounds as reported by Neumer and Dugan (2). All samples obtained from rendering operations in which antioxidant was present during rendering had stabilities greater than 300 hours by this test. This would indicate an indefinitely prolonged keeping time under ordinary conditions of storage.

In another test with hashed and washed hog entrails the effects of some variations in handling and processing were examined. These data were obtained from the fat resulting from rendering 100 pounds of entrails with 5 pounds of unstabilized lard added. The data in Table II indicate that overcooking may

[3] All samples were rendered at atmospheric pressure with a jacket pressure of 35 p.s.i. Near the end of the operation the jacket pressure was dropped to zero. The contents of the melter were discharged when they attained a uniform "sandy feel." The first and third series of runs were completed in about 1.5 hrs. and the second series in a 2-hr. cook.

TABLE II

Stability of Fat from Rendered Hog Entrails

Sample	A.O.M. Stability (Hrs.)
Hog Entrails, Overcooked	29
Hog Entrails, Properly Cooked	35
Hog Entrails, Properly Cooked + BHA[a] before cook	101
Hog Entrails, Partially Decomposed	>310

[a] Added to provide 0.01% BHA in the fat.

lower the stability but that incorporation of BHA before rendering of this type material may have a very enhancing effect on stability. An interesting observation was that when hog entrails were allowed to decompose partially at room temperature and then were rendered, a very high stability fat was obtained. This fat and the resulting press cake had very nauseous odors.

Another test was designed to establish the importance of citric acid in the rendering operation, the effectiveness of different levels of BHA, and the feasibility of using 2,6-di-*tert*-butyl paracresol alone or in combination with BHA. This test provided results which were surprising in the light of earlier findings because of the low stability values abtained (Table III).

TABLE III

Effect of Antioxidant Variation on Stability of Rendered Fats

Sample	Antioxidant		A.O.M. Stability (Hrs.)	Sample	Antioxidant		A.O.M. Stability (Hrs.)
1	Control		¾	5	BHA CA	0.01 % 0.005%	4½
2	BHA[a]	0.005%	1¼	6	DTBPC[c]	0.005%	1¼
3	BHA	0.01 %	6½	7	DTBPC CA	0.005% 0.005%	10
4A	BHA CA[b]	0.005% 0.005%	>300	8	DTBPC BHA	0.005% 0.005%	12
4	BHA CA	0.005% 0.005%	3	9	DTBPC BHA CA	0.005% 0.005% 0.005%	25

[a] BHA—Butylated Hydroxyanisole.
[b] CA—Citric Acid.
[c] DTBPC—2,6-di-*tert*-butyl paracresol.

Fifty-pound charges of washed and hashed hog entrails without added fat were rendered in these tests, and the yield was 6-7 pounds of fat. The runs were made as nearly reproducible[4] as possible with the exception of run number 4A. Antioxidant was added prior to rendering in each case except for the control sample. The use of BHA at 0.005% provided very little improvement in stability and at 0.01% achieved a stability of only 6 hours. The use of citric acid with BHA provided no significant advantage.

The use of 2,6-di-*tert*-butyl paracresol at 0.005% was equally unsatisfactory, but the use of citric acid with this compound appeared to be advantageous. The combination of BHA with the alkylated cresol provided more stability, and the use of citric acid with this combination provided a major increase in stability of the fat although the value of 25 hours did not compare with the very high values achieved in earlier tests. It is interesting to note that in run number 4A a variation in procedure occurred inadvertently, and the contents of the melter were under 34 pounds internal pressure for 10 minutes. An extremely stable product was obtained from this run.

There are factors which may contribute to the results obtained in this test. The first is the rendering

[4] Samples were rendered at atmospheric pressure with a jacket pressure of 38 p.s.i. When the rendering operation was approximately one-half complete, a 15-inch vacuum was applied for 5 minutes. In run number 4A the internal pressure inadvertently was allowed to rise to 34 p.s.i. for 10 minutes near the beginning of the cook. Near the end of the operation, the jacket pressure was dropped to zero, and the contents of the melter were discharged when they had attained a uniform "sandy feel."

for a short period under vacuum, which may have had an accelerating effect on steam stripping of the antioxidant from the charge. The second factor is the fact that the charge was rendered without the added fat which was used in earlier tests when hog entrails were rendered. The added fat in earlier tests may have provided a better distribution and incorporation of antioxidant in the charge.

A comparable series was run with fat backs as the fat source.[5] In this instance the fat backs were expected to provide a greater fat content than was obtained from entrails, and it was hoped to determine the feasibility of rendering lard with antioxidant in the charge. Samples were taken from each charge 7 minutes after the lard melted, approximately one hour after the start of cook, and finally from the run-off and pressed grease at the end of cook. All of the control samples were rancid, as determined by peroxide determination (Table IV). This, of course, indicated a poor base from which to build stability. The use of antioxidants increased stability however. The first, or 7-min. sample, was the most stable in each case. The sample taken after 1 hr. of cooking time was least stable in each case, and the press grease from the meat scrap was more stable than the run-off grease at the end of cook. The use of 2,6-di-*tert*-butyl paracresol was effective in providing stability, and in combination with BHA it provided a very satisfactory stability. These data also show the effect of processing on antioxidant behavior. The higher stability of the first run-off sample is explainable on the basis of minimum loss of antioxidant by steam distillation or other factors. The fact that the sample taken after 1 hr. of cooking time is the least stable sample in all cases is somewhat puzzling. Since the press grease is second in stability only to that taken after 7 minutes, it appears possible that as the moisture is cooked out of the tissues, the fat soluble antioxidants tend to be absorbed into the fat in the tissues.

TABLE IV
Stability of Fat Backs Rendered with Antioxidant

Antioxidant		A.O.M. Stability of Grease (Hrs.)			
		7 Minutes Cook	1 Hour Cook	Final	Press
Fat Back—No antioxidant		0	0	0	0
BHA	0.01 %	8½	½	1	3
BHA CA	0.01 % 0.002%	16	4½	5	16
DTBPC	0.01 %	34	4	4	10
DTBPC CA	0.01 % 0.002%	27½	1	4	10½
DTBPC BHA	0.01 % 0.01 %	64	5	11	21½
DTBPC BHA CA	0.01 % 0.01 % 0.002%	42	7	8	27

Commercial Rendering Tests

Commercial rendering tests were made in order to evaluate the effectiveness of rendering with antioxidant in the rendering charge. These tests were made on composites of fat-bearing materials. A typical example of charge is 4,220 pounds of butcher shop scrap and 1,960 pounds of dead animals which included cattle, a horse, hogs, dogs, and cats. After rendering 3¼ hours, a yield of 2,087 pounds of fat was obtained with an estimated 180 pounds of fat remaining in the meat and bone scrap.

Three runs were made without antioxidant, three runs with BHA added to the rendering charge to approximate 0.005% based on estimated fat yield, and three runs with BHA added to provide a level of approximately 0.01%. Results are shown in Table V.

TABLE V
Stability of Fat from Commercial Rendering Operation

Antioxidant	A.O.M. Stability (Hrs.)
Control	34
Control	40
Control	48
0.005% BHA	135
0.005% BHA	92
0.005% BHA	160
BHA 0.01%	170
BHA 0.01%	190
BHA 0.01%	200

All products were quite stable even without antioxidant. This probably explains the very good stability values obtained with antioxidant in the rendering charge. The unstabilized fats ranged between 34 and 48 hrs. A.O.M. stability, those with 0.005% BHA ranged from 92 to 160 hours while with 0.01% BHA added the stabilities ranged from 170 to 200 hours A.O.M. stability.

The effectiveness of using a suitable antioxidant in the rendering charge of a commercial dry rendering operation was demonstrated clearly in this test.

Discussion

Much of the data obtained indicate that the practice of adding antioxidant to a dry rendering charge will provide both fat and protein residue with good keeping qualities. There are certain discrepancies both in our results and others reported to us (1) which require a word of caution. Whereas under the conditions used in our first test the practice of adding antioxidant before rendering a charge provided greatest stability, others have observed instances in which the greater stability is achieved through adding the antioxidant after rendering. This latter practice would seem reasonable on the basis of loss of antioxidant by steam distillation during rendering. On the other hand, there is the known fact that many operators are obtaining very high stability fats even without the use of antioxidants, and the use of antioxidants during rendering then serves to boost the stability to almost fantastic values.

There is much to learn about the effect of variation of ingredients in the rendering charge, the effect of greater temperature and pressure, and length of rendering time. We note with interest the extreme stability obtained in fat rendered from the partially decomposed hog entrails, also the markedly more stable fat rendered under slightly different conditions in run number 4A illustrated in Table III.

We also are aware of commercial operations which initially produced exceptionally stable fats by adding BHA to the rendering charge. There were then a

[5] Samples were rendered at atmospheric pressure with a jacket pressure of 26 p.s.i. for 45 minutes and at a jacket pressure of 36 p.s.i. for 5 minutes. The jacket pressure was dropped to zero, and contents of the melter were discharged when the "cook" was complete.

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

[1] Published with the approval of the director of the Agricultural Experiment Station, College of Agriculture, Madison, Wis.