The Use of Fats in Feed

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The story of the use of fat in feeds is an account of the success of one of the livestock industry's own by-products being used to improve the animal industry. It began in a small way more than 25 years ago, during a period of low prices for fat, when research workers around the country were looking for cheaper methods of growing hogs and poultry. During the early '30's feeding experiments were carried on at the Ohio Agricultural Experiment Station under the direction of W. E. Robison, who added fat to his hog feeds and observed that the pigs gained weight faster than could be accounted for on a basis of the calculated energy level added. At about the same time a feed manufacturer in Illinois was incorporating fat into crate-fattener feeds for short-term feeding of poultry. Within a very short time another feed manufacturer was adding fat to dry dog foods for working dogs. Both of these feed manufacturers were having notable success.

These early users of fat in feeds apparently got good results as long as high-quality fat was used and the feed was consumed soon after it was prepared. However, if the feed was not consumed soon after mixing, the added fat had a tendency to turn rancid. This, coupled with higher prices for fat during war years, discouraged its use. Later an increased production of fats and decreased consumption in other fields led to a surplus that needed only a stabilizer to make fat applicable as a source of energy for use in feeds. The development by the American Meat Institute Foundation of suitable and effective antioxidant mixtures for stabilizing fat against oxidative rancidity made it possible to inhibit rancidity development and established the basis for the later work that culminated in the announcement, by the American Meat Institute Foundation in 1952, that fat-fortified feeds could be successfully used in feeds for chickens and dogs. It has since been successfully used in commercial feeds for swine, beef cattle, sheep, turkeys, and fur animals. The advent of low-fiber, high-efficiency feeds at about the same time was a factor in creating interest in this high-energy feed ingredient.

A large proportion of manufactured feeds in this country today contain added fat, and its use is growing here and in other countries wherever feeds are made and wherever fat is available.

Broadly speaking, there are two main reasons for using fats in feeds. One has to do with the feed-manufacturing process, and the other relates to the improved performance of the feed when fed to the animal. Both reasons are related to the economics of feed manufacture in that the use of fat improves the efficiency of feed-mill operation and also improves the efficiency of the feed when fed. Specifically some of the reasons for using fats in feeds may be listed as follows: control of dust (increased comfort of workers and decreased fire hazard); reduction of wear on mixing and handling machinery through its lubricating action; reduction of power requirement (25% less power required in pelleting); increased palatability of feed; increased vitamin stability; improved appearance and "feel" of feed; reduction of feed wastage in handling and feeding; faster weight gain when fed; and improved feed conversion.

Poultry feeds account for the largest proportion of manufactured feeds and the largest volume of fat that is used in feeds today. The young, growing bird appears to benefit greatly from higher energy levels, and many broiler feeds contain this ingredient to raise the energy content to the desired level. It is in broiler feeds that we generally see the greatest improvement in feed conversion when fats are added, although weight gains are not always affected. The improved feed conversion will result in lower cost gains and can easily make the difference between profit and loss in the broiler-growing operation.

Some typical results of adding fat to broiler rations are shown in Table I. The basal diet in this test contained 24.7% protein. Chicks were a broiler strain, mixed sexes, fed in batteries.

TABLE I
Effect of Added Fat in Broiler Diet

Fat added (%)	8-Wks. wt. (lbs.)	Feed conversion	Performance efficiency index
0	2.55	2.27	4.95
6.49	2.94	2.02	6.44
7.90	2.94	1.96	6.65
9.31	2.97	1.94	6.76
10.72	3.00	1.90	6.98
12.13	2.96	1.90	6.87
14.95	2.96	1.87	7.01
16.34	3.06	1.80	7.52

In this test, improvements in both weight gain and feed conversion were observed as the level of fat was increased up to 16.34%. Even higher levels of fat have been fed in several laboratories, and, in some instances, further improvement in feed conversion has been observed as long as the protein and vitamin level was adjusted upward to compensate for the higher energy levels. A report from the University of Maryland (Feedstuffs, July 12, 1958) showed that properly balanced rations containing 30% corn oil or tallow could produce 3-lb. male broilers in about six weeks with a feed conversion of 1.1 lb. of feed per lb. gain in weight. Such high levels of fat are not presently economically practical, but levels of 2 to 5% are giving excellent results in commercial operations. The lower levels often do not give significant growth responses, but feed conversions are improved sufficiently to make the use of fat well worthwhile.

In layer diets the story is somewhat different in that the adult hen cannot always utilize high levels of fat to advantage. There are reports in the literature of increased egg size and improved feed conversion. This seems to be dependent however on the hen remaining in high production. If the hen stops laying for any reason, the high-energy diets may result in body fat deposition and fatty livers. For this reason, most research workers now recommend not more than 5% added fat in layer rations, and 2 to 3% is often used.

Turkeys respond to added fat in much the same fashion as do chickens, and many poult starting and growing rations now contain a substantial level of added fat.

There have been many experiments run with added fat in swine rations. Growing-fattening pigs respond to added fat by both improved daily weight gains and improved feed conversion. Some typical results have been reported from the North Carolina Agricultural Experiment Station (E. R. Barrick, T. N. Blumer, and W. L. Brown, A.H. 2, Jan. 10, 1954). These workers reported that, in two trials conducted with pigs from weaning to market weight, 10% added animal-fat reduced feed required per 100 lbs. gain by approximately 60 lbs. The first trial was conducted in winter, and pigs consuming diets containing 10% beef fat gained 2.37 lbs. per day compared to 2.02 lbs. per day for the controls. In the second trial the difference was less marked, but still the response was quite favorable, as shown in Table II.

TABLE II
Response of Pigs to Added Fat

	Control	10% Beef fat	10% Brown grease
Av. daily gain in lbs.	1.57	1.76	1.67
Av. daily feed in lbs.	5.68	5.02	4.84
Av. feed/100 lbs. gain	360	286	291

The addition of 10% beef fat or brown grease resulted in 6 to 12% increased rate of gain and about a 20% feed saving over the controls without added fat.

There have been some reports of increased backfat thickness when the diet contained added fat while others reported no significant change in fat deposition. This probably varies with the protein in the diet, rate of growth, and type of hogs used in the experiments.

Beef cattle-fattening rations can also contain added fat, and if the feeds are properly formulated, the cattle often make more rapid and efficient gains. One of the early tests was made at North Carolina by Barrick, Dillard, and Brown (A.H. 3, North Carolina Agr. Expt. Station, Feb. 17, 1954). They used 5% fat in the ration and reported that fat could be used effectively by cattle as a substitute for part of the grain in the ration. Cattle receiving 5% fat made more rapid and efficient gains, as shown in Table III.

TABLE III
Effect of Fat in Beef Cattle Rations

	Control	5% Fat
Av. initial wt., lbs.	580	584
Gain per animal, lbs.	306	338
Av. daily gain, lbs.	2.17	2.40
Av. lbs. feed/100 lbs. gain		
Mixed diet, lbs.	719	658
Hay, lbs.	290	250
Carcass grades, no.		
Prime	1	1
Choice	4	7
Good	5	3

The addition of 5% fat resulted in approximately a 10% better daily gain on 10% less feed per 100 lbs. gain, and the carcasses graded slightly higher because of a better finish. The 5% fat in this ration was equivalent to about 0.79 lb. fat per head per day. This level has been found about optimum for fattening cattle since higher levels appear to affect digestion in the rumen in some cases.

The fat appears to have other effects on rumen microflora also in that it tends to prevent bloat in those animals that are chronic bloaters. Boda, at the University of California (Feedstuffs *31*, 141, 49, 1959), reported that feeding a concentrate containing animal tallow has been found to prevent bloat in cattle being fed fresh, bloatable legumes. Feeding 0.5 to 0.85 lbs. of tallow per head per day reduced both the incidence and severity of bloat. Tallow appeared to act as an antifoaming agent, preventing the formation of foam which seemed to be the principal cause of bloat. Similar results were obtained by Erwin and co-workers at the University of Arizona (Arizona Agr. Exp. Station, Tech. Paper No. 419, 1959), where tallow markedly reduced the incidence and severity of bloat.

The foregoing are but a few of the many tests that have shown improved results from feeding fat. Not all experiments have shown such favorable results as there are many factors to be considered in feed formulation and management to take advantage of fat as an energy source. However some of the larger beef cattle feed-lots now use fat in their rations. One large feed-lot is using more than 6,000,000 pounds of fat per year in beef cattle feeds.

The amount of fat used in beef cattle feeds is only a small portion of the total tonnage of fat used by the manufactured feed industry. It has been estimated (Feeds Illustrated, *11* (4) 58, 1960) that all beef cattle feeds accounted for about 22,104,000 lbs. of fat in 1959. This may be a low estimate, considering the amounts used per year by some of the large feed-lots.

TABLE IV
Effect of Grade of Fat on Chick Growth and Feed Conversion

Type and grade of fat	8-Week wt. (lbs.)	Feed conversion
Choice white grease	3.45	1.91
Bleachable fancy tallow (a)	3.53	1.83
Bleachable fancy tallow (b)	3.46	1.88
Tallow fatty acids (from b)	3.51	1.99
Yellow grease	3.49	1.93
Brown grease	3.43	1.96
All-beef tallow (44.0 titer)	3.24	1.90
No fat	3.27	2.36

Swine feeds in 1959 were estimated to have used 41,440,000 lbs. of fat, and food for pets and fur-bearing animals used 129,866,000 lbs. of fat. The greatest amount of fat used in feeds was in feeds for poultry, estimated at about 359,190,000 lbs. in 1959. The total fat in all feed uses for 1959 was estimated by the U. S. Census Bureau at 552,600,000 lbs. This is nearly five times the amount used in 1954.

There are a number of different grades of animal fats being offered to the feed trade, and all of them appear to give satisfactory results. Table IV shows results of an 8-week chick test in which various grades of animal fats were used at a 10% level in a broiler diet.

The chicks in this test were Vantress-Arbor Acres cross-cockerels. All fat samples allowed improved feed conversion, and all but the high-titer beef tallow gave greater weight gains at 8 weeks than the control diet without added fat. The two bleachable fancy tallows had titers in the 40–41° range and gave results as good as the lower titer greases. Tallow fatty acids derived from tallow sample (b) gave good results also.

Palatability of the darker grades does not appear to be a factor in the acceptability of fat by chickens. However palatability may be a factor in feeds for cattle or dogs. The lighter grades of fats are generally used in dog foods and in some beef cattle rations.

Cattle usually will consume the darker grades of fat if it is used with molasses, which has a strong odor of its own that cattle seem to like.

The rapid expansion in the use of fat in feeds has not been without certain difficulties. The feed industry had to learn how to handle fat. They had to learn how to store it, heat it, and mix it into feed during the cold winter months when other feed ingredients were cold and the fat had a tendency to form fat balls. Since large tonnages of feed are pelleted, the industry had to learn how to make a hard pellet containing fat.

It was mentioned earlier that fat in the feed resulted in a lowered power requirement in pelleting but that some lubricating action in the pellet mill resulted in a softer pellet if more than 5% fat was used. The feed industry soon learned that better pellets could be made by first mixing about 3% fat into the feed, running it through the pellet mill, and then spraying hot fat onto the pellets as they emerged from the mill. It was found that high levels of fat could be incorporated into pellets by allowing them to absorb hot fat in this way and the pellets remained hard.

The industry also learned that as the energy content of the feed was increased, the protein and vitamin content had to be readjusted to take advantage of the increased energy level. Most of the problems of handling fat in the feed industry had been solved by the latter part of 1957 when a strange new disease of chickens appeared in certain areas of the country, the causative factor of which appeared to be in some of the fat that had been used. The material causing the trouble, later called the chick edema factor, was found in certain fat-like materials that had somehow found their way into the fat. The factor has been isolated, but as yet we do not know what it is. We think that we know enough about it to prevent its recurrence, and the chick disease caused by it has not reappeared for quite some time.

The increase in the use of fat in feeds since 1957 indicates that the feed industry has confidence in the product and all indications are that fat usage in feeds will continue to grow.

Refining, Bleaching, Stabilization, Deodorization, and Plasticization of Fats, Oils, and Shortening

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ALTHOUGH the final products from our industry may be only the words, "hydrogenated vegetable oils" or "refined cottonseed oil" on a label to the ultimate housewife, to us who make them they are the result of painstaking care in each process from refining to packaging. Each step must be "right," first to make a quality product but, equally important, to insure efficiency in the operation. While this efficiency does, of course, affect the profits of each company, the elimination of "waste," whether it be of raw materials, processing materials, equipment, or labor, eventually reflects on the cost of our products to the consumer and thus has its part in making the standard of living of our country. For our purpose the start of this trail is in the refining of crude oils.

Refining of Crude Oils

In addition to neutral fatty glycerides, the crude oils of commerce contain free fatty acids, phosphatides and gums, coloring matter, insoluble matter and settlings, and such miscellaneous unsaponifiable materials as sterols. The purpose of the refining step is to lower the level of these nonfatty glyceride materials to zero or at least to negligible values. The quantities of these materials present in the crudes vary with the type of oil (cottonseed, soybean, coconut, lard), with the manner in which the oil is obtained from the original raw material (expelling, extraction, wet or dry rendering), with any pretreatment that the oil may be given, such as degumming, as well as with the season and geographical source. For these reasons the refining process cannot be set on a fixed procedure for optimum results but must be varied to suit the characteristics of the crude stock.

In the very early days fats were washed with mineral acids in order to coagulate the impurities; this is still the case for some fats intended for inedible use. While one process now being practiced uses an organic acid for degumming, practically all edible fats the world over are refined with some type of alkali. The addition of an alkali solution to a crude oil brings about a number of chemical and physical reactions. The alkali combines with the free fatty acid present to form soaps; the phosphatides and gums absorb alkali and are coagulated through hydration or degradation; much of the coloring is degraded, absorbed by the gums, or made water-soluble by the alkali; and the insoluble matter is probably entrained with the other coagulable material. With heat and time the excess caustic can also bring about the saponification of some of the neutral oil. While all of these reactions have not been completely explained because of their complexity, it is of interest to note some of the physical changes that occur. The sketches shown in Figure 1 are representative of the appearance, under a microscope, of various stages of the refining of cottonseed oil with caustic soda solution. When the lye is first added (A), the mixture appears to be an emulsion with the individual drops clearly seen and evenly dispersed. Each drop seems to be surrounded by a darker layer and this outer "skin" in turn by very small individual droplets that are near the skin surface but do not touch it. A cloudy,