

Director's Digest



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FAT UTILIZATION IN BROILER RATIONS

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With feed cost representing 60 to 65 percent of the total cost of producing a live broiler, nutritionists have searched for ways to help improve the efficiency of feed utilization. In the early 1950's, researchers indicated that the addition of fats to broiler diets would improve the efficiency of feed utilization and growth rate, however the results were inconsistent.

Donaldson et. al., 1955, Donaldson et. al., 1956 and Leong et. al., 1955, all demonstrated a calorie to protein relationship as measured by growth rate, feed efficiency, abdominal fat pad or feathering. Baldini and Rosenberg, 1955, presented data which indicated that the methionine requirement varied as a direct function of the productive energy of the diet. They went on to state that other nutrients should also be considered in relation to the energy level. With this knowledge, nutrients in most broiler diets are at a level in proportion to the energy level.

Young, 1961, investigated the absorbability of individual fatty acids in various fatty acid mixtures and concluded that the utilization of saturated fatty acids was greater in mixtures containing higher amounts of the unsaturated fatty acids. Artman, 1964, confirmed

Young's results by showing that the utilization of saturated fats increased when mixed with unsaturated fats but stated that the response was not linear. Brue and Latshaw, 1985, demonstrated a disproportionately greater use of the unsaturated fatty acids for carcass lipid as determined by carcass analysis. Ketels and De Grotte, 1989, fed broilers diets with varying ratios of saturated to unsaturated fatty acids to determine the utilization and apparent metabolizable energy (AMEn) of added fats. A best fit regression equation for added fat utilization and fat AMEn were exponential and showed that fat utilization increased very steeply in the unsaturated to saturated (U:S) range of zero to 2.5, reaching a near asymptotical maximum at an U:S of four or more. It was also reported that about 75 percent of the variation in fat utilization and AMEn in young broilers was due to the differences in the chemical composition of the fat.

In the 1960's, the linoleic acid requirement for growth was established at a dietary level of approximately one percent. Whitehead, 1984, reported that 0.8 percent may satisfy the growth requirements for poultry. With the requirement of linoleic acid established, most nutritionists require a minimum of 18 percent linoleic acid in their fat sources.

Broiler diets in the United States today have fat additions ranging from 1.5 to 6.0 percent with an industry average of approximately three percent (1991 Agri Stats Report). With the trend toward more further processed poultry products and a health conscious consumer, most broiler diets are formulated to optimize gain and efficiency yet minimize the amount of carcass fat accumulation.

Fat blends in the future may take into consideration the manipulation of fatty acid profiles in diets for production of edible poultry meats. Hulan et. al., 1989, have shown that you can increase the omega-3 fatty acid content of broiler meats which could be of interest in the field of cardiovascular diseases.

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EFFECTS OF POULTRY FAT AND YELLOW GREASE ON BROILER PERFORMANCE
AND PROFITABILITY

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INTRODUCTION

Poultry fat (PF) is the feed fat of choice for broiler producers because of its relatively high ME and superior effect on feed conversion (Fuller and Rendon, 1977). A relative cost advantage is often obtained with PF because it is frequently rendered from processing plant offal (as part of vertically integrated broiler firm operations) and recycled in their feeds. Poultry fat is tentatively defined for trading purposes as an animal fat primarily obtained from the tissue of poultry in commercial processes of rendering or extraction. It should contain not less than 90% total fatty acids and not more than 3% unsaponifiables and impurities and have a minimum titer of 33 C (Association of American Feed Control Officials, 1990).

Yellow grease (YG), a recycled restaurant grease, is defined for trading purposes as an inedible tallow or grease with a minimum titer of 36 C, maximum free fatty acid content of 15% and minimum Fat Analysis Committee (FAC) color value of 37 (National Provisioner Daily Market Service, 1988). Yellow grease is further tentatively classified as a Fat Product, Feed Grade (Association of American Feed Control Officials, 1990). Burton

(1989) explained that although low-titer composite oils, dark color, and relatively high free fatty acid content had kept YG out of market channels for high-quality tallows, it has been long used as a feed fat. Additionally, both quality and quantities of YG have increased as a result of the development of the United States fast and convenience food industries. However, concern exists in some regions regarding the use and quality of YG. Much of that concern is associated with its lack of resistance to oxidation as measured by methods commonly used in the feed industry.

Halloran (1986a,b) reviewed the topic of feed fats for poultry diets. He reported that: 1) potential exists for wide variations in commercial laboratory values for fat oxidation levels (expressed as initial peroxide value or IPV) and levels of stability against oxidation (expressed as 20-h active oxidation method, or AOM value); 2) AOM tests are not applicable in determining oxidation potential of free fatty acids; 3) study of the effect of oxidation on feed value of fats has concentrated on fats rapidly oxidized using very high temperatures that are not common to normal fat storage conditions; and 4) little practical information was available to correlate commonly used fat quality standards with bird performance results.

The use of blends of fats such as those from animal and plant sources has resulted in improved performance due to certain fat synergisms (Garrett and Young, 1975; Sibbald and Kramer, 1977; Hulan et al., 1984). Also, logistics problems in some geographic locations may require blending of PF with other feed grade fats during times of peak chick placements. Additional chick placements create conditions where the demand for feed fats outstrips the supply of PF. Prices of alternative fats as well as return over feed cost when different fats are fed are important in finding solutions to such logistics problems.

Few economic analyses utilizing various input and output values are available. Adams and Craig (1985) summarized the results of a number of laying hen studies and showed that statistical analysis of economic information over a variety of feed and egg prices could yield potentially meaningful management decision information. Hulan et al. (1984) analyzed returns over feed and chick costs in a study of various fats. No significant differences were found due to source of fat. However, feed costs remained constant regardless of fat source used.

Several studies have evaluated PF as a feed ingredient (Edwards et al., 1973; Fuller and Rendon, 1977; Griffiths et al., 1977; Hulan et al.,

1984). Seidler et al. (1955), Young (1961), and Cullen et al. (1962) all reported the effects of YG on broiler performance. Among these, only Cullen et al. (1962) specifically compared PF and YG and found similar bird performance. Little information is available comparing these two fats and their blends in association with laboratory analyses for fat quality when stabilized and held under normal feed mill conditions. Therefore, three experiments were conducted to evaluate the use of PF, YG, or a blend of both to compare their suitability for broiler feeding.

Abstract

Three experiments were conducted to evaluate the use of poultry fat (PF) or yellow grease (YG) when fed to broilers. Experiments 1 and 2 were duplicate, 21-day studies, and experiment 3 compared the fats over a 42-day period. Treatments for Experiments 1 and 2 consisted of six replicates of eight battery-housed chicks that were fed 5% added fat as all PF, all YG or PF: YG blends of 90:10, 80:20, 70:30, 60:40, or 50:50. In Experiment 3, five replicate pens of 70 day-old broiler chicks were floor-reared and fed either all PF, all YG, or a 50:50 blend in diets containing 3.0 and 3.5% added fat in starter and finisher diets, respectively. Factored across fat source were two different fat stabilization times: 1) fresh from the rendering plant; and 2) held under feed mill conditions for 7 days.

All fat combinations performed comparably in terms of body weight, feed intake, feed conversion, and mortality rate. Fatty acid content and fat quality factors, including 20-h active oxygen method (AOM) determinations, were similar among fat sources. In Experiment 3, no differences were found due to stabilization time. Return over feed cost was not affected by any of the fat and stabilization time treatment combinations. No association was found between bird performance and AOM, suggesting that a better analytical procedure of fat quality was warranted. At levels tested, YG and PF-YG blends were found to be as suitable a feed fat source as PF.

(Key words: broilers, poultry fat, yellow grease, economic analysis, fat stabilization times)

Results and Discussion

Table 2 shows laboratory analysis values for samples of pure forms of fats used in experimental diets. Variation was found between fat sources and for the same fat compared across experiments. Nonetheless, values

for moisture content, insoluble impurities, free fatty acid content, and IPV were all within suggested quality specifications for feed fats recommended by Ostby (1986). Similar levels of ethoxyquin were detected in all samples.

Stability against oxidation expressed as AOM values (Table 2) were all higher than the 20 meq peroxides/kg level suggested by Ostby (1986). The AOM values for both fats were 2.9 to 3.8 times higher in Experiment 3 as compared with average AOM values from Experiments 1 and 2. These results agree with Halloran (1986a), who reported considerable variations in both IPV and AOM measurements in checking the results from various commercial laboratories. He found AOM values to be the most variable, citing inadequate test equipment, cleanliness, inefficient temperature control, and improper procedures regarding test length as some of the reasons for variability.

Table 3 shows Experiment 3 IPV and AOM values from fats sampled at three different times: upon arrival from supplier and 10 and 21 days thereafter. The IPV values were not consistent over time within fat source. However, with the exception of the initial sample of PF stabilized after 7 days (5.2 meq peroxide/kg), the values all fell within the acceptable range of less than 5.0 meq peroxide/kg as reported by Ostby (1986). On the other hand, AOM values exceeded, by 4.4 to 8.4 times, the limits of 20 meq peroxides/kg (Ostby, 1986). Additionally, AOM values of fats over time showed higher values suggesting that the fats' potential for oxidation increased with time regardless of fat source and degree or time of stabilization.

The fatty acid profiles of samples are shown in Table 4. Overall, average composition values indicated that both PF and YG contained predominantly the same fatty acids. Fatty acids $C_{18:1}$, $C_{16:0}$, $C_{18:2}$, $C_{18:0}$, $C_{16:1}$, $C_{14:0}$, and $C_{18:3}$ made up over 94% of each fat source. Additionally, rank order of fatty acids was similar for poultry fat and yellow grease except that $C_{16:0}$ and $C_{18:2}$ were reversed as the second and third most prevalent. Minor differences were found for rank order and presence or absence of minor fatty acids (those present in one or both fats at less than .5%).

Pooled values for 21-day feed consumption, feed conversion, and body weight from Experiments 1 and 2 indicated no significant differences due to dietary fat treatment (Table 5). Similarly, no significant differences

were found among these response variables for either fat source or stabilization time at 21 or 42 days of age for broilers in Experiment 3 (Table 6). In all three experiments mortality was very low (less than 3%) and not related to treatment. Therefore, data have not been presented.

Comparison of pooled 21-day data from Experiment 1 and 2 versus Experiment 3 (Tables 5 and 6) indicated similar growth responses. Feed conversions were slightly higher and body weights slightly lower, however, for the floor-reared birds in experiment 3 as compared with those from battery-reared birds in Experiments 1 and 2. Feed conversion rates were somewhat higher in Experiment 3 due to cool evening growing conditions and the fact that diets were not pelleted.

These results agree with those of Seidler et al. (1955), Young (1961), and Cullen et al. (1962), who reported similar performance for broilers fed YG when compared with other feed fats. The agreement of the current results with previous studies is particularly important in the context of reported quality improvements in YG over recent years (Burton, 1989).

Results due to stabilization time (Experiment 3) suggest that holding fats under feed mill conditions did not alter them in a way that resulted in significantly poorer bird performance (Table 6). This supports the report of Halloran (1986b), indicating that fat quality concerns regarding oxidation should not be based on results where fats had been subjected to very high (60 to 230 C) temperatures.

Laboratory values for AOM agreed with Halloran (1986a,b) in that exceptionally high values were found. These results coupled with growth responses consistently demonstrated the lack of a relationship of AOM values with broiler growth or feed efficiency.

Table 6 shows the return over feed cost results generated from performance response variables in Experiment 3. Neither fat source nor stabilization time resulted in significant differences in returns. These results agree with Hulan et al. (1984).

The present data show that the fat sources (PF, YG, or blends of the two) were equally effective. Also, results of Experiment 3 indicated that a 7-day delay in final stabilization did not significantly affect performance. The absence of a positive relationship between AOM and performance results supports Halloran's (1986b) suggestion that a better analytical procedure needs to be developed to evaluate feed fat quality.

Economic analysis results supported the growth data and indicated that all fat sources were equally suitable for use in broiler diets. Furthermore, results show that a blend of PF and YG could be used effectively to supply regional poultry fat shortages associated with high chick placements.

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TABLE 1. Composition of experimental diets (Experiments 1, 2, and 3)¹

Ingredients	Experiments 1 and 2		Experiment 3	
	Starter diet ²	Starter diet ³	Starter diet ³	Finisher diet ³
	(%)			
Yellow corn	53.59	55.24	62.40	
Soybean meal (48.5% CP)	37.45	37.43	30.20	
Fat source ⁴	5.00	3.00	3.50	
Limestone	1.08	1.18	1.10	
Dicalcium phosphate (22% Ca:18.5% P)	1.75	2.04	1.82	
DL-methionine	.18	.18	.05	
Iodized salt	.35	.33	.33	
Microingredients ⁵	.50	.50	.50	
Monensin	.10	.10	.10	

¹All diets calculated to contain amino acids to meet National Research Council (1984) specifications for broiler starter and finisher diets.

²Calculated to contain 3,170 kcal ME/kg.

³Calculated to contain 3,027 and 3,135 kcal ME/kg for starter and finisher diets, respectively.

⁴Fat sources: all poultry fat (PF), all yellow grease (YG), or various PF:YG blends; all fats calculated to contain 8,184 kcal ME/kg.

⁵Supplied the following activities per kilogram of diet: vitamin A, 6,600 IU; cholecalciferol, 2,200 ICU; menadione dimethylpyrimidinol bisulfite, 2.2 mg; riboflavin, 4.4 mg; pantothenic acid, 13.2 mg; niacin, 39.6 mg; choline chloride, 499 mg; vitamin B₁₂, .022 mg; ethoxyquin, 125 mg; manganese, 60 mg; iron, 50 mg; copper, 6 mg; iodine, 1.1 mg; zinc, 35 mg; selenium, .1 mg.

TABLE 2. Fat analysis values for Experiments 1, 2, and 3¹

Measurement	Average for Experiments 1 and 2 ²		Experiment 3	
	Poultry fat	Yellow grease	Poultry fat	Yellow grease
Moisture content, %	.10	.40	.41	.44
Insoluble impurities, %	.40	.02	.05	.04
Free fatty acid content, %	10.79	19.40	7.85	7.93
Initial peroxide number oxidation value, meq/kg	1.40	4.30	1.60	3.40
20-h Active oxygen method oxidation value, meq/kg	34.00	32.00	98.00	120.00
Ethoxyquin content, mg/kg	108.00	109.00	108.00	109.00

¹All analysis values were determined from duplicate, coded samples of each fat upon delivery from the fat rendering firm.

²Consistent values were found for fats of Experiments 1 and 2 and are expressed as average values.

TABLE 3. Fat analysis values for initial peroxide value (IPV) and 20-h active oxygen method (AOM) determinations over time (Experiment 3)

Treatment combination	Initial ¹		Initial plus 10 days ²		Initial plus 21 days ³	
	IPV	AOM	IPV	AOM	IPV	AOM
	(meq peroxide/kg)					
Poultry fat						
Stabilized fresh	1.6	98	1.8	102	1.0	130
Stabilized after 7 days	5.2	88	1.6	132	4.2	146
Yellow grease						
Stabilized fresh	3.4	120	2.6	112	4.0	156
Stabilized after 7 days	3.1	9.2	4.0	104	2.6	168

¹Samples taken prior to final stabilization with 300 ppm ethoxyquin at two different times; for "stabilized fresh", sampled when delivered from fat rendering firm; for "stabilized after 7 days", sampled after being held 7 days under feed mill conditions.

²Samples taken after final stabilization with 300 ppm ethoxyquin; all samples taken after 10 days storage at 4 C when starter diets were mixed.

³Samples taken after final stabilization with 300 ppm ethoxyquin; all samples taken after 21 days storage at 4 C when finisher diets were mixed.

TABLE 4. Fatty acid content of poultry fat and yellow grease (Experiments 1, 2, and 3)¹

Fatty acid	Poultry fat			Yellow grease		
	Average for Experiments 1 and 2 ²	Experiment 3	Overall average	Average for Experiments 1 and 2 ²	Experiment 3	Overall average
	(%)					
Oleic (C _{18:1})	43.30	43.61	43.46	47.70	45.83	46.62
Palmitic (C _{16:0})	21.10	19.64	20.37	17.60	16.74	17.17
Linoleic (C _{18:2})	18.20	18.62	18.41	17.70	18.78	18.24
Stearic (C _{18:0})	7.90	8.49	8.20	11.00	10.50	10.75
Palmitoleic (C _{16:1})	5.80	4.92	5.36	2.30	2.04	2.17
Myristic (C _{14:0})	1.00	.96	.98	1.20	1.06	1.13
Arachidic (C _{20:0})	1.00	0	.50	1.10	0	.55
Linolenic (C _{18:3})	.60	1.14	.87	.70	1.50	1.10
Behenic (C _{22:0})	0	.54	.27	.40	.58	.49
Gadoleic (C _{20:1})	0	.47	.24	0	.70	.35
Myristoleic (C _{14:1})	.30	.18	.24	.20	.24	.22
Hexadecanoic (C _{16:2})	0	.38	.19	0	.59	.30
Lignoceric (C _{24:0})	0	.38	.19	0	.32	.16
Heptadecanoic (C _{17:0})	.30	0	.15	.40	0	.20
Margaraleic (C _{17:1})	0	.23	.12	0	.32	.16
Arachadonic (C _{20:4})	.20	0	.10	0	0	0
Lauric (C _{12:0})	.10	.10	.10	0	.10	.05
Pentadecanoic (C _{15:0})	.10	.10	.10	.10	.18	.14

¹Total fatty acid contents that do not add to 100% are due to rounding of individual fatty acid values.

²Consistent values were found for fats of Experiments 1 and 2 and are expressed as average values.

TABLE 5. Means for 21-day feed consumption, feed conversion, and body weight (Experiments 1 and 2)¹

Treatments	Feed consumption	Feed conversion (feed:body weight)	Body weight
(Poultry fat:yellow grease)	(g per bird per day)	(g:g)	(g)
100:0	41	1.43	618
90:10	40	1.40	612
80:20	40	1.44	601
70:30	41	1.44	608
60:40	40	1.38	611
50:50	42	1.45	616
0:100	40	1.46	605

¹Data pooled over two, 21-day experiments.

TABLE 6. Means for 21-day and 42-day feed consumption, feed conversion, body weight, and 42-day return over feed cost (Experiment 3)

Treatments	Feed consumption		Feed conversion (feed:body weight)		Body weight		Return over feed cost (42-day) ¹
	21-day	42-day	21-day	42-day	21-day	42-day	
	(g per bird per day)		—— (g:g) ——		—— (g) ——		(\$ per 1,000 birds) ²
Fat source							
All poultry fat	39	76	1.46	1.96	558	1,640	423.80
All yellow grease	39	76	1.46	1.96	558	1,646	425.20
Blend ³	40	76	1.47	1.96	562	1,640	425.40
Stabilization time ⁴							
Stabilized fresh	39	77	1.46	1.96	564	1,650	428.30
Stabilized after 7 days	39	76	1.46	1.97	555	1,635	421.20
Sex							
Male					568 ^a	1,721 ^a	
Female					550 ^b	1,563 ^b	

^{a,b}Means within a column and treatment with no common superscripts are different (P<.05).

¹Feed price assumptions calculated (without price of added fat) were \$176.20/metric ton and \$162.40/metric ton for starter and finisher diets, respectively (based on reported prices of feed ingredients). Added fat prices (based on average reported prices) were assumed to be 22.5 and 23.8¢/kg for poultry fat and yellow grease, respectively. Feed cost per treatment combination was based on pen 42-day feed consumption values without adjustment due to mortality.

²Returns were calculated based on bird income values derived from 42-day pen body weight values assuming the live bird price of 63.9¢/kg.

³Treatment consisted of a 50:50 blend of poultry fat and yellow grease.

⁴Treatments varied by time of addition of 300 ppm ethoxyquin.