The Role of Dietary Fat in the Quality of Fresh and Frozen Storage Turkeys[1]

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THE influence of amount and type of fat in the feed on carcass quality of livestock has always been of practical importance. Although most of the investigations have been concerned with the "soft-pork" problem, several studies have been made on poultry. In 1934 Cruickshank (3) fed very high (28%) levels of mutton fat and hempseed oil to hens. In the course of several months' feeding the iodine number of the carcass fat fell from 80 to 65 on the mutton-fat diet and increased from 80 to 140 on the hempseed oil diet. No comparable work has been done with turkeys. The early studies on swine and poultry relied on iodine numbers to indicate changes in total amounts of unsaturated fatty acids since the more specific spectrophotometric methods for individual unsaturated acids had not been developed.

Studies on the effect of type of dietary fat on cooked flavor of freshly slaughtered birds have been confined mostly to the fishiness which is apparent in birds fed diets containing fish oil [Marble *et al.* (5); U.S.D.A. (7)]. Asmundson and others (1) in 1938 found that good-grade fish meal had no effect on flavor but that 2 or 5% levels of fish oils fed for six weeks prior to slaughter produced off flavors in the cooked meat. Although occasionally fishy-flavored turkeys have been reported in flocks that received very little or no fish products, the possibility of fishiness due to feed containing highly unsaturated fatty acids of vegetable origin has not, so far as we know, been investigated.

Very little work has been done on effect of dietary fat on the frozen storage stability of poultry although we can infer from results with pork that the effect is of economic interest. Information on this effect is also needed in our studies on the influence of processing methods on storage stability since diet variations in commercial lots of birds may introduce spurious variations into storage results. Kummerow and others (4) at Kansas State College have recently shown that turkey meat storage life may be significantly decreased by linseed oil in the diet.

Our experiments on turkeys were directed at the following questions: what are the effects of dietary fats of widely differing degrees of unsaturation on the fat composition, initial quality, and frozen storage stability of the turkey carcass? is the presence of fish products in the diet a necessary condition for occurrence of fishy flavor in turkey meat, or are there highly unsaturated vegetable oils that give the same qualitative effect? Organoleptic and chemical tests on the freshly slaughtered carcass and on turkey carcasses stored over one year at 0° F. have revealed large effects of 5% dietary levels of unsaturated oils on flavor, composition, and storage stability of turkey meat.

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Experimental

Production and processing of turkeys. The experimental Bronze tom turkeys were raised by the Poultry Division of the University of California at Davis. At 20 weeks of age the turkeys were removed from the stock ration, divided into four groups of six each, and fed the four experimental diets, respectively, for eight weeks. The basal diet mixture (82.5% of the complete diet) contained (expressed in percentages of complete diet) barley 35, wheat 33, wheat mill run 7.5, alfalfa 5, whey 1.5, and salt 0.5. Groups 3 and 4, which contained fish meal as protein supplement, had an additional 1.5% wheat and 1.0% ground limestone. The remaining supplements to the four groups, which represent imposed experimental variations, are listed in Table I.

At the end of the eight-week experimental feeding period the turkeys were slaughtered, eviscerated while warm, packaged in moisture-vapor-resistant bags, and frozen immediately at —35° F. After storage at —30° F. for two weeks two turkeys from each group were analyzed for iodine number, fatty acid composition, peroxide value, and organoleptic characteristics. Subsequently two turkeys were analyzed after three months at 0° F., and two after 13 months at 0° F.

Procedures. Iodine numbers of the feed fat and carcass fat were determined according to the method of Wijs. Determination of linoleic, linolenic, and arachidonic acids was made by the Brice and Swain modification (2) of the alkali isomerization, spectrophotometric method. Oleic acid was calculated from the percentages of the above three acids and the iodine number. The overall percentage of saturated fatty acids was calculated by difference. Peroxide values of the carcass fats were determined by a modification of Wheeler's iodometric method (6). Samples of fat for peroxide tests were cut from the unthawed

TABLE I

Effect of Type of Fat in Diet on Composition of Carcass Fat

Group	Diet Supplements	Iodine No. Diet Fat	Iodine No. Carcass Fat	Fatty Acids[a] in Carcass Fat (%)				
				Sat.	Oleic	Linoleic	Linolenic	Arachidonic
1	12.5% meat scrap + 5% coconut oil	39	58	50.5	33.1	10.2	1.5	0.16
2	12.5% meat scrap + 5% linseed oil	147	102	27.4	40.4	9.7	17.7	0.26
3	10.0% fish meal + 5% coconut oil	40	54	52.2	31.9	10.1	0.8	0.50
4	10.0% fish meal + 5% linseed oil	167	113	26.8	31.2	13.7	22.7	1.12
	Practical ration (average values)	110	75	32	45	16	1	0.1-1

[a] Values for groups 3 and 4 are subject to small but unknown corrections due to the small contribution to diene, triene, and tetraene conjugation of the pentaene and hexaene fatty acids contained in the 0.6% fish oil present in the fish meal.

carcass to eliminate measurement of any peroxide formed during thawing. Induction periods of fat taken from the gizzard region were determined by drying the fatty tissue *in vacuo* from the frozen state, pressing out the fat just above the melting point, and measuring the oxygen absorption of 0.5 ml. samples at 70° C. in a constant volume Warburg apparatus. The induction period was taken as the time corresponding to the intersection of the tangent of the curve of rapid absorption with the nearly horizontal line of little absorption.

Organoleptic characterization of the roasted carcasses was made by a trained taste panel of seven persons. Each carcass was cut lengthwise and crosswise to give four quarters. At any one tasting period only one quarter from each of the four experimental groups was tasted. Quarters were roasted in a 300° F., electric, rotating oven to an internal temperature of 180° F. for the front quarters, 185° F. for the rear quarters. Off-odor scores of the cooked quarters were assigned on a scale of 0 to 10; 0 signifying no off odor and 10 maximum off odor. Off flavors were scored on a similar scale for the light meat and the skin plus underlying fat of the front quarters, and for the dark meat and pan drippings of the rear quarters. The character of the off flavor or odor was always described by each judge whenever it was possible to do so.

Results and Discussion. The influence of dietary fat composition on carcass fat composition is clearly indicated in Table I. Differences between meat-scrap and fish-meal groups for a particular oil supplement were small in most cases. The markedly higher values for arachidonic acid in the fish-meal groups (3 and 4) apparently reflect the presence of arachidonic, or even more highly unsaturated fatty acids, in the 0.6% fish oil contributed by the 10% fish-meal supplement. A comparison of the coconut-oil and linseed-oil groups demonstrates the marked effect of the highly saturated coconut oil in reducing the content of unsaturated acids (and hence iodine number) normally found in turkeys on a practical ration. The high content of linolenic acid in linseed oil was carried over into the carcass fat, resulting in an abnormally high iodine number and content of linolenic acid.

Table II summarizes the effects of the changes in carcass fat composition on two chemical criteria of carcass-fat stability, induction period and peroxide value. Induction periods of the fat, probably the best available *a priori* estimates of frozen storage life, were about 25 times as large for the coconut-oil as for the linseed-oil groups. A much smaller but real difference was found between induction periods for meat-meal and fish-meal groups. Corresponding to the other analytical values, the peroxide values at the three periods studied indicate the marked accelerating influence of the linseed oil supplement on rancidification.

TABLE II

Effect of Type of Fat in Diet on Chemical Criteria of Carcass Fat Stability

Group	Diet Supplements	Induction Period of Fresh Carcass Fat at 70°C. (hours)	Peroxide Value (meq./kg.) of Visceral Fat Stored at 0°F. for		
			0 months[a]	3 months	13 months
1	12.5% meat meal + 5% coconut oil	43	0	0.9	21.2
2	12.5% meat meal 5% linseed oil	1.5	11.2	17.0	98.4
3	10.0% fish meal + 5% coconut oil	20	0.7	8.4	23.5
4	10.0% fish meal + 5% linseed oil	0.9	22.8	70.1	(50.9)[b]
	Practical rations (average value)	13	—	—	—

[a] These samples were actually evaluated after two weeks' storage at −35° F.

[b] This value represents only one turkey, compared to two for all other peroxide values.

The most interesting result of the odor and taste evaluation, as summarized in Table III, is the pronounced fishy odor and flavor in the linseed-oil groups, either with or without fish meal, and the contrasting lack of fishiness or other off flavors in the coconut-oil groups, with or without fish meal. With respect to diet groups the only statistically significant differences (1% level of probability, by analysis of variance) in off odors or flavors occurred between either group 1 or 3 (coconut oil) on the one hand and group 2 or 4 (linseed oil) on the other. Groups 1 and 3 were essentially the same. Group 4 had slightly worse off-flavor scores for fat and drippings than did group 2, which probably represents an augmenting effect of the small amount of fish oil in the fish meal on the linseed oil. Since it was impossible to have a standard sample of known off flavor available at the three taste periods, comparison of the off-flavor scores between storage periods should be made with caution. It is quite apparent however that there was no large increase in the intensity of the fishiness

TABLE III

Effect of Type of Fat in Diet on Sensory Criteria of Quality and Stability of the Carcass at 0° F.

Group	Diet Supplements	Off-Odor Scores[a] After Storage at 0° F.				Off-Flavor Scores[a] After Storage at 0° F. for				Character of Off-Odor, Off-Flavor
			0 Mo.	3 Mo.	13 Mo.		0 Mo.	3 Mo.	13 Mo.	
1	12.5% meat meal + 5% coconut oil.....	Front	0.6	0.6	0.7	Light meat	0.9	0.4	0.8	Not Fishy
		Rear	0.5	0.3	0.3	Skin fat	0.5	0.4	0.8	
						Dark meat	0.5	1.2	0.6	
						Drippings	0.5	0.9	1.6	
2	12.5% meat meal + 5% linseed oil.....	Front	2.2	2.8	3.1	Light meat	1.8	2.2	2.2	Fishy
		Rear	1.2	2.9	2.4	Skin fat	4.0	2.6	3.8	
						Dark meat	2.1	2.3	1.9	
						Drippings	4.6	4.0	5.0	
3	10.0% fish meal + 5% coconut oil.....	Front	0.4	0.5	0.4	Light meat	0.4	0.9	0.8	Not Fishy
		Rear	0.4	0.5	0.7	Skin fat	0.5	0.4	1.3	
						Dark meat	0.6	1.6	1.2	
						Drippings	0.8	1.8	1.6	
4	10.0% fish meal + 5% linseed oil.....	Front	2.2	3.6	3.3	Light meat	1.7	2.8	2.1	Fishy
		Rear	1.6	3.0	2.6	Skin fat	5.3	4.5	4.8	
						Dark meat	2.5	2.9	2.3	
						Drippings	6.3	5.3	6.3	

[a] A score of 0 was assigned to no off odor or flavor, a score of 10 to maximum off odor or flavor, in the roasted meat.

over a 13-month period. We may speculate that one of the essential components for the reaction producing the fishy flavor is a highly unsaturated fatty acid, whether supplied by linseed oil in the form of linolenic acid or by clupanodonic and the higher unsaturated fatty acids of fish oil.

The differences in unsaturation and the amounts of oil present are greater in our experimental diets than would normally be expected in practical diets. However the very large effects produced in stability (induction period) and other characteristics raises the question as to whether economically significant effects may occur as a result of smaller but similar differences in dietary fat composition which might be expected in practical commercial rations. Long-term feeding and storage experiments are under way to test this possibility.

Summary

Groups of turkeys were fed, for eight weeks prior to slaughter, diets varying in the type of animal protein concentrate (fish meal vs. meat scraps) and varying in degree of unsaturation and kind of vegetable oil present (coconut oil vs. linseed oil). Chemical and organoleptic analyses of the fresh and stored carcasses established the following points:

Differences in fatty acid composition of dietary fat of turkeys have a marked effect on the fatty-acid composition of carcass fat and correspondingly play a decisive role in the storage life of the turkey carcass.

Typically fishy flavors and odors in roasted turkey meat, which can be caused by feeding fish (oil) products, can also be produced in the absence of fish products by a highly unsaturated vegetable oil, linseed oil. The fishy flavor is present in the roasted, freshly slaughtered turkey and apparently increases very little if any in intensity during storage.

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Solvent Extraction of Cottonseeds With Hexane and Water as Co-Solvents[1]

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COTTONSEEDS are one of the major oilseeds consumed in international commerce. Their annual production in the United States is currently about 6,500,000 tons, from which a commercial yield of crude cottonseed oil is obtained amounting to about 10.5% by weight of the seed (1). It is estimated that more than 90% of this crude oil is produced by pressing methods.

Since solvent extraction processes have proven economically superior to other methods in the production of certain vegetable oils, notably soybean oil, attempts have been made continuously, since the early commercial successes with oil extraction, to apply solvent methods to cottonseed oil production (2). Fabricators of extraction processing equipment estimated that in 1949 solvent extraction offered potential savings of $5.88 per ton of cottonseed processed in a plant of 200 tons/day capacity, brought about by higher oil yield, lower labor requirements, and lower maintenance (3). Despite these advantages it is estimated that no more than 5% of the annual production of crude cottonseed oil is obtained by solvent extraction. This low percentage is probably due to inherent difficulties in the solvent extraction of cottonseed as well as to normal delays attending the introduction of new methods in an industry already heavily invested in another technique.

The chief disadvantages encountered in the solvent extraction of cottonseeds are the difficulties of filtering low oil content meal and of removing the toxic pigment, gossypol, which is protected in the meal by a resistant gland wall. If left in extracted meal, to any appreciable extent, gossypol renders the residue unfit for stock feed, thereby turning a valuable by-product into waste. The wall of the pigment gland remains unattacked in the presence of most solvents, which rapidly remove the oil. It has therefore been necessary in most cases to employ two solvents and/or two steps; one to liberate the gossypol by rupturing its protective wall; and the other to extract both oil and gossypol.

Water has been proven effective in disintegrating the pigment wall rapidly (13). This investigation undertook to study the effects of treating cottonseed meal in a single processing step, using high speed agitation with water and a suitable oil solvent immiscible with water, to obtain ready separation of resulting oil and aqueous phases. The latter is expected to contain little or no oil.

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