TABLE I.

Moisture in Cottonseed and Products Under Variations of Drying Time and Temperature

	Whole Seed				Crimped Seed			Cottonseed Meal	
	16 hr. 101°C.	1 hr. 130°C.	2 hr. 130°C.	3 hr. 130°C.	1 hr. 130°C.	5 hr. 101°C.	8 hr. 101°C.	2 hr. 101°C.	3 hr. 101°C.
Hoffpauir (From Curves)	8.2	7.5	8.1	8.3	8.1	7.7	7.9	5.75	5.8
Cox	12.13		11.62	12.20	11.52	11.68	11.84	8.12	8.17
Haire	13.57G		13.30		13.17	13.03	13.25	7.15	7.03G
McIsaac	11.67		11.42	11.80	11.40	11.36	11.64	7.34	7.39
Pope	(9.40)	(8.43)	(8.65)	(8.95)	(9.53)	(9.47)	(9.49)	8.25	8.36
Rettger	11.70	10.76	11.62	11.82	11.88	11.36	11.62	7.64	7.66
Wilkins	12.98		12.70	13.06	12.70	12.56	12.98	5.97	5.98
Avg. of 5	11.35		11.09	11.44	11.12	10.93	11.20		
Avg. of 6	11.72		11.46		11.46	11.28	11.54		
Avg. of 7	11.39				11.19	11.02	11.25	7.17	7.20

Note: Each result above except those from weight loss curves is the average of 3 to 5 determinations. Each collaborator furnished his own samples. Ovens used were forced draft, Freas, Despatch, or DeKhotinsky except two results by glycerine jacketed oven indicated by "G". Results in parentheses indicate determinations reported in this line were on two different lots of seed.

were obtained even when the drying period was extended to 8 hours.

3. There is need for a quicker method than (1) above for emergencies. Drying whole seed 2½ hours at 130°C. appears to give results in close agreement with (1). Further work should be done toward justifying this procedure as an optional official method for moisture in cottonseed.
4. No change in the 2-hour drying period for fumed ground cottonseed is indicated.
5. There appears to be no substantial reason for the present difference in drying periods of 2 hours for fumed ground seed and 3 hours for cottonseed meal. The weight loss curves and the collaborative work showed a negligible increase in loss during the third hour of drying. It is recommended that the drying periods be made uniform for the two materials, viz., 2 hours at 101°C.

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The report and recommendations of the Subcommittee have been unanimously approved by the Seed and Meal Analysis Committee, with the exception that one member is of the opinion that further work should be done on the determination of moisture in cottonseed meal. Hence, it is recommended that (1) the method for determining moisture in whole cottonseed specifying crimping and drying for 5 hours at 101°C. be removed from the official methods and (2) the drying period at 101°C. for the determination of moisture in cottonseed meal be reduced from 3 to 2 hours.

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The Role of Various Substances in Stabilizing Animal Tissues*

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TWO factors known to affect the stability of fats are (a) their fatty acid composition and (b) the presence of antioxidants or pro-oxidants.

Lea (1,2) has shown that the inclusion of cod-liver oil in the food of hogs results in an increased susceptibility of the body fats to oxidation (**Figure 1**). To explain this he assumed that the very highly unsaturated fatty acids, normally present in traces in pig fat, were increased in amount when the fish oil was fed. The effects were so striking that he suggested that it would be highly desirable to feed A and D concentrates and avoid the introduction of the unsaturated fish oil acids into the body fat.

He also suggested that in addition to changing the fatty acid composition of the body fat the diet might also affect its antioxidant content. In 1942 Overman (3) attempted to change the keeping time of the body fat of rats by feeding ascorbic acid and hydroquinone but found no definite improvement in stability.

In the laboratory at the University of Minnesota (4, 5, 6) several groups of young albino rats were put on different diets and kept for 30 to 150 days, killed, and the rendered abdominal fat tested for stability by measuring the increase in peroxide value at 63° C. or the oxygen absorption in Warburg flasks at 100° C. The results, some of which are shown in Figures 2-7, give clear evidence of the following effects on the keeping quality of body fats of rats:

1. Common mixed diets differ greatly in this regard.
2. The Minnesota stock diet was not improved by addition of food said to be rich in antioxidants.
3. Protein level was not important.
4. The type of fat in a purified diet is very important, butterfat being much more effective than lard. Fresh lard is much better than rancid lard but rancid lard does not introduce pro-oxidants or greatly reduce the antioxidants in a period of four weeks.
5. The feeding of tocopherols to vitamin E-free rats greatly improves the stability of the body fat whereas hydroquinone and wheat germ oil actually have deleterious effects.
6. The effect of tocopherol is so uniform that the length of induction period may be used as a method of estimation of the amount of tocopherol in the body fat.

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7. The tocopherols differ among themselves in their effect on the keeping time of body fat. The alpha form is about twice as effective as the gamma when fed to rats but when added directly to rendered body fat the gamma form is several times as active as an antioxidant. This work has been repeated recently using alpha, beta, and gamma forms. The alpha and

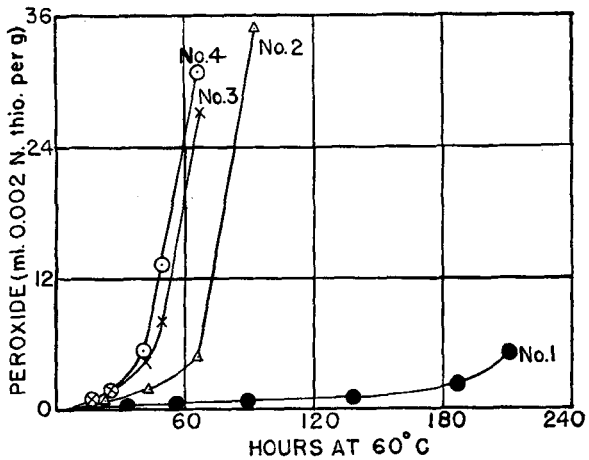

FIG. 1. Relative susceptibility to oxidation of the back fat of groups of pigs receiving (1) basal ration, (2) basal ration plus 1 oz. cod-liver oil to 100 lbs. weight, (3) and (4) basal ration plus 1 oz. cod-liver oil to killing weight (200 lbs.). (After Lea.)

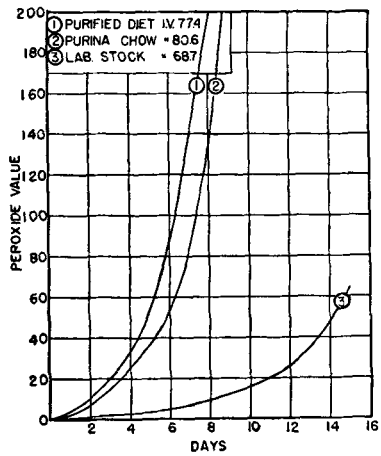

FIG. 2. The relative keeping time of depot fats of three groups of rats fed a highly purified diet and two mixed stock diets. The Minnesota laboratory stock diet is made of ground whole wheat, milk powder, casein, butter and salts. Iodine values of the body fats are listed adjacent to each diet.

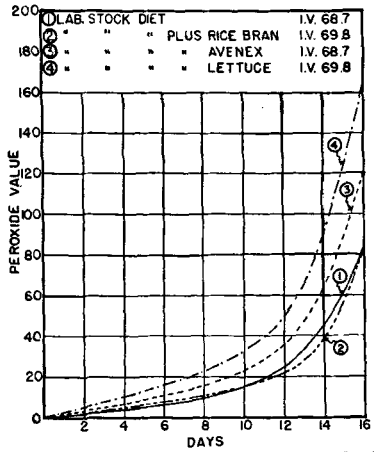

FIG. 3. Effects of supplements to the stock diet on iodine values and stabilities of the body fats.

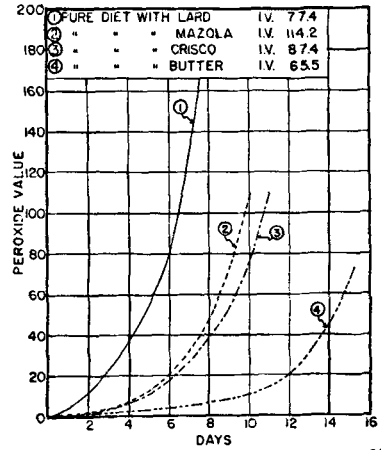

FIG. 4. Effects of purified diets containing 20% of different fats on iodine values and stabilities of body fats.

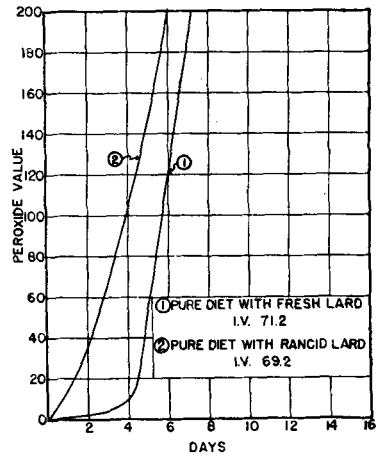

FIG. 5. Effects of fresh lard and rancid lard in diet on stabilities of body fats.

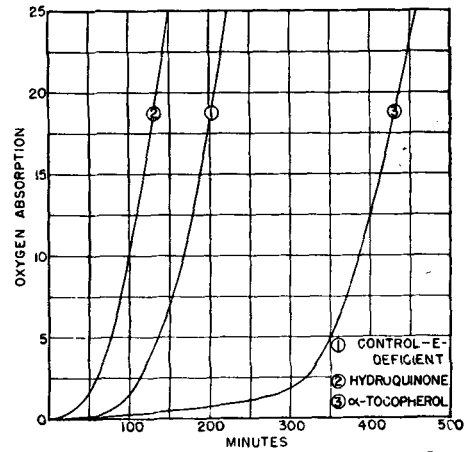

FIG. 6. The effect of dietary hydroquinone and alpha-tocopherol on the keeping time of the body fat of vitamin E-deficiency rats.

beta give results much alike when fed to rats while the gamma again was not more than one-half as effective as the other two.

Recently several samples of fat were taken from the fresh carcasses of two hogs and their fatty acid composition, tocopherol content, and keeping time measured. An improved method of measuring tocopherol was employed which gave reproducible results. The average values given in Table II bring out the following points:

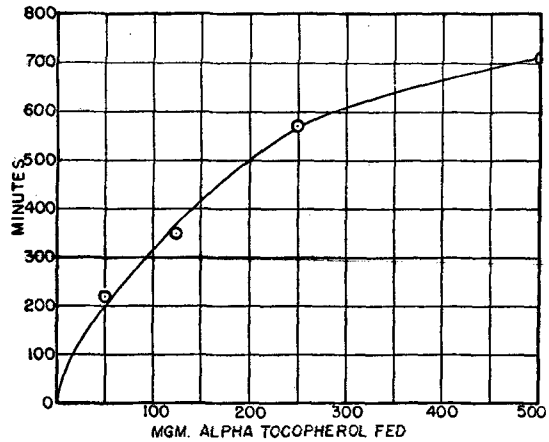

FIG. 7. The relation of induction period of body fats to the amount of alpha-tocopherol fed.

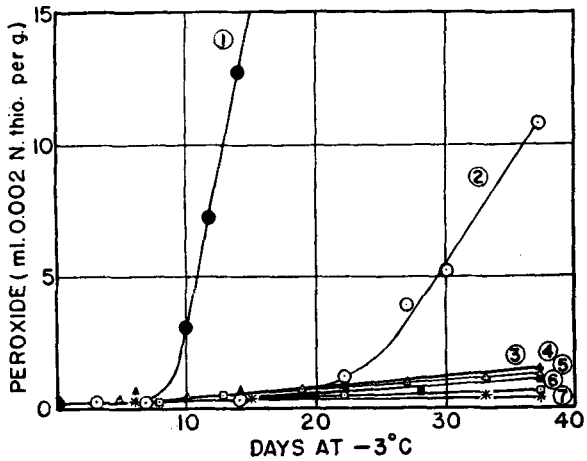

FIG. 8. The effect of pork-muscle lipoxidase on the oxidation of extracted pork fat. (After Lea.)

(1) Fat (100 g.)—muscle-juice (15 g.)—sodium chloride (1 g.).
(2) Fat—muscle-juice.
(3) Fat—heated muscle-juice—sodium chloride.
(4) Fat—heated muscle-juice.
(5) Fat—water (15 g.)—sodium chloride.
(6) Fat—water.
(7) Dry fat.

1. The keeping time decreases with increasing linoleic acid content, tocopherol being constant.

2. The keeping time increases with increasing tocopherol content, the linoleic acid being constant.

The effects thus far discussed represent the simplest case, i.e., the stability of rendered body fat in relation to composition and antioxidant content. Some studies have also been made of butter fat stability as related to diet. It is well known that butter fat is markedly affected by diet and that there are large seasonal variations in fatty acid composition, carotene and vitamin A content and the content of substances with spectral bands in the far ultraviolet. The susceptibility of milk and butter fat to the development of oxidized flavors may be reduced by the feeding of various materials which presumably add natural antioxidants. The effect of tocopherols was tested at the University of Minnesota by feeding 6.2 grams of synthetic alpha-tocopherol each week to the vitamin E-free basal diet of a cow. The control received only the basal diet. Butter fat from these two animals was tested in the Warburg microrespirometers at 100° C. The induction period of the E-free butter fat was essentially zero while that from the E-fed cow was distinctly increased, an additional 30 minutes being required before full rate of O_2 uptake was begun.

Finally, the most difficult problem to study is that of the stability of meat or other whole tissues. Here again fat is frequently the chief contributor to flavors developing during storage. Rancidity is ofen encountered in such foods as bacon, pork, poultry, game, and fish. The addition of antioxidants to such material is much more difficult than in the case of purified fats. There is reason to believe that diet may be of considerable importance by reason of its effect on both the fatty acid composition and the antioxidant content. (See Table I and II.)

TABLE I

Stabilities of Rendered Abdominal Fats From Rats Fed Various Antioxidants

Group	Compound	Amount fed, mg.	Induction period	
			By O_2 absorption, 100° C., min.	By peroxide accumulation 63° C., days
1	Control	....	31	1.5
2	Alpha tocopherol	50	418	21.0
3	Ascorbic acid	20	17	1.2
4	Gamma tocopherol	50	211	13.0
5	Lecithin (soybean)	85	25	2.0
6	Alpha naphthol	17	23	1.0
7	Hydroquinone	13	42	1.5
8	Nordihydroguaiaretic acid (NDGA)	28	22	1.1

TABLE II

Relation of Induction Periods to Fatty Acid Glycerides Compositions and Tocopherol Contents

Lard sample	Saturated fatty acid glyceride	Oleic acid glyceride, %	Linoleic acid glyceride, %	Tocopherol content per gram of fat, micrograms	Induction period, min.
a. Hog No. 1					
1. Ruffle fat	43.4	49.3	7.3	28.7	430
2. Leaf fat	41.7	47.4	10.9	21.3	270
b. Hog No. 2					
3. Ruffle fat	43.3	51.0	5.7	7.8	170
4. Leaf fat	39.0	51.6	9.4	6.7	115
5. Ham facing	31.3	58.6	10.1	5.3	88
6. Back fat	35.9	52.8	11.3	6.4	53

The recent experiments of Houchin and Mattill (7, 8, 9) have demonstrated that the oxygen uptake of muscle slices from vitamin E-deficient animals may be two or three times as rapid as in the case of normal controls. Although Houchin has shown that this effect of tocopherol is more likely operating through an oxidase system rather than as an inhibitor to autoxidation, this reaction may nevertheless be important in the stability of meat products. If peroxide value of the tissue fats is measured, this may also be shown to be affected by an enzyme system. Figure 8, taken from Lea (2), illustrates the effect of inactivation of pork muscle lipoxidase by heat.

In summary, it may be concluded that diet exerts an important influence on the oxygen uptake of body fat and muscle tissue.

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