The Fatty Acid Content of Selected Foods Before and After Cooking[1]

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IT has been reported in a previous paper (1) by the authors that the fatty acid composition of the fat in meats and poultry was not substantially changed by various common methods of cooking. Under conditions of the above investigation the fat was in general present in intact tissue and, except for the surfaces and drippings, was not subjected to temperatures higher than the boiling point of water.

The present report is mainly concerned with fatty acid changes in commercial food fats (lard, butter, and vegetable oil) when used in baked products and hard candy and as a medium for deep fat frying. Several of these products involve the use of temperatures much higher than 100°C. for extended periods of time. In addition, some observations are reported on fatty acid changes after soaking and cooking of soybeans, an oil-bearing seed requiring prolonged cooking.

Materials and Methods

Baked products were all prepared by standard procedures from the same sample of analyzed lard, which was stored in the refrigerator during the week required to complete the baking tests. In all products studied (pastry, baking powder biscuits, ginger snaps) the lard was the only significant source of fat, therefore it was not considered necessary to analyze the unbaked dough.

The baked products were broken into small pieces by hand, then whirled in a Waring blendor with carbon tetrachloride and sufficient anhydrous sodium sulphate to absorb the moisture present and give a clear extract. This carbon tetrachloride extract was used for further fat analyses.

Butterscotch was prepared from a sample of butter obtained from a local market. The butter fat was separated from the original butter by centrifuging the melted sample. In preparing the candy, the syrup was first cooked to 250°F., the butter added and cooked 30 minutes to 300°F.

Samples for deep fat frying, two fats, lard and corn oil, were investigated. The fats were heated to 180°C. in a 6-quart deep fat frying pan. The temperature of the fat was kept as constant as possible by regulating the gas flame. Total fat heated was about three quarts in each case.

Batches of four doughnuts were fried in lard every five minutes. Frying time was 3½ to 4 minutes. Samples of fat were collected at the end of 10, 20, 30, 40, and 50 minutes of heating.

Potato chips in 100-g. lots were fried in corn oil (Mazola brand). Four minutes were required for each frying. Since both commercially and in the home fat for deep fat frying is usually used over and over for a long period of time, the corn oil was heated for two hours on the first day, cooled over night, and heated again for another two hours on the second day. Oil samples were collected every 20 minutes for peroxide value determination and at the end of one, two, three, and four hours of heating for fatty acid analysis.

Soybeans of the Bansei variety were soaked with three volumes of water over night at room temperature, drained, and cooked in a covered sauce pan with enough water to cover the beans. They were simmered for 3½ hours.

The fat extracting procedure used throughout this work did not effectively extract the oil from raw and cooked soybeans. Therefore they were extracted with di-ethyl ether for 16 hours in a Soxhlet.

The cooking water from soybeans contained little or no fat. It was therefore discarded without being analyzed.

Methods used for the determination of fat, peroxide value, iodine number, and fatty acids have been described elsewhere (1).

Results and Discussion

Fatty acid distribution in the fat of several selected foods analyzed is presented in Table I. The amount of fat in the samples is also included so that the fatty acid composition of the food consumed may be calculated if desired. Table II summarizes the effect of deep fat frying on the fatty acid composition of lard and corn oil.

Baked products. The fat recovered from various baked products did not differ significantly in its fatty acid make-up from the original fat used in the dough. This was true in spite of the fact that the fat selected (plain lard) is the least stable of the plastic fats generally used for shortening and that the preparation of pie crust probably subjects the fat to conditions as conducive to oxidative destruction as any encountered in baking. It would seem that there is little danger of loss of unsaturated fatty acids during ordinary baking procedures and that the essential fatty acid contribution of a baked product could therefore be calculated for dietetic purposes from the kind and quantity of fat used in the recipe.

Butter fat. This, extracted from butterscotch, did show a small loss of total unsaturation, when compared to the original, and, similar to the usual picture of oxidized fat from meats or poultry, this loss appeared mostly under oleic acid. The loss of linoleic, linolenic, and arachidonic acids may be concealed by the presence of oxidation products which are capable of producing diene, triene, or tetraene conjugation during alkali isomerization, similar to those produced by the polyunsaturated fatty acids, However as has been discussed in the previous paper (1), errors from this source are probably small.

Although with most foods conjugated dienes increased slightly with oxidation, they decreased somewhat in the case of butter when cooked in candy. Apparently this is due to the comparatively high value of conjugated diene in the original butter fat. Oxidation of polyunsaturated fatty acids increases the

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TABLE I

Fatty Acid Distribution in the Fat of Raw and Cooked Foods

Sample analyzed	Fat in sample, %	Peroxide value	Iodine number (Wijs)	Fatty acids—% in total triglycerides					
				Conjugated diene	Saturated	Oleic	Linoleic	Linolenic	Arachidonic
Baked products									
Lard as shortening	100[a]	0	65.1	0.18	37.0	46.1	11.4	0.56	0.35
Pie crust	32.7	0	65.0	0.32	36.8	46.4	11.2	0.53	0.30
Ginger snaps	16.3	31.4	66.0	0.25	35.2	47.6	11.7	0.51	0.33
Biscuit	14.2	0	65.5	0.22	37.1	45.4	12.0	0.56	0.33
Butterscotch									
Butter raw	81.0[a]	0	35.8	1.02	66.1	26.6	1.00	0.56	0.34
Butter in candy	17.0	0	34.5	0.89	67.2	25.7	1.09	0.50	0.31
Soybeans									
Raw	18.8	Trace	128.5	0.54	20.2	16.3	51.5	6.82	0.37
Cooked	6.4	9.24	129.0	0.62	20.1	16.1	52.0	6.71	0.33

[a] Assumed value.

absorption at 2320 Å, before isomerization (3), but oxidation of conjugated diene acids decreases absorption in this region (2). When the original diene conjugation is low, as in most meats and poultry, the amount destroyed is negligible. Therefore its formation from oxidized fatty acids results in a net increase. But in the case of butter fat the original concentration of conjugated diene was as high as 1%. The destruction rate apparently exceeded the formation rate, and a net decrease was observed.

Soybeans. In spite of the high content of unsaturated fatty acids in their fat, soybeans showed little change in fatty acid composition as a result of soaking and cooking. Apparently neither enzymatic action during the soaking period nor the heat of the prolonged cooking period are likely to bring about significant oxidative changes in the fat.

Deep fat frying. The peroxide value of lard increased to a maximum of about 10 m.e./1,000 g., when the lard was heated to 180°C. and kept at that temperature for 10 minutes. Then it decreased to a negligible value after 40 minutes of heating, indicating that at this high temperature peroxides were decomposed as fast as they were formed.

No maximum peroxide value was observed while heating the corn oil. Peroxides increased to a small constant value after 40 minutes of heating and remained constant as the heating was continued. A higher value was developed during standing over night, which again decreased to the same equilibrium value after another 30 minutes of heating.

Changes in fatty acid composition of lard during the 50 minutes of heating were too small to be measured accurately by the present method except that the percentage of conjugated diene showed a small but definite increase.

Increases in the values of conjugated dienes of corn oil, which was heated for a longer period, were significant. Total unsaturation, as measured by iodine number, showed a gradual decrease with heating, which in turn resulted in an increase in the calculated value of saturated fatty acids.

Among the unsaturated acids changes in oleic were small, linoleic definitely decreased, and linolenic decreased slightly at first and then increased to a value higher than the original.

Since it is known that the apparent value of polyunsaturated fatty acids decreases with oxidation of that acid but increases (not quantitatively) with oxidation of the acids with one less double bond, the increased value of linolenic and decreased value of linoleic of corn oil can probably be explained by slight oxidation of the large amount of linoleic acid present.

Only traces of tetraenoic acid can be detected in heated corn oil after four hours of heating; therefore the oxidation of linolenic acid is probably not great.

Summary

Effect of cooking on the fatty acid composition of the extracted fat of baked products, butterscotch, frying fat, and stewed soybeans was studied. Except for the frying fat, no significant loss of essential fatty acid was observed among all the samples. Slight losses of linoleic acid occurred when vegetable oil had been used for deep fat frying for several hours.

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TABLE II

Effect of Deep Fat Frying on the Fatty Acid Composition of Lard and Corn Oil

Sample analyzed	Time of heating (min.)	Peroxide value	Iodine number (Wijs)	% Fatty acids in total triglycerides						
				Conjugated diene	Conjugated triene	Saturated	Oleic	Linoleic	Linolenic	Arachidonic
Lard	0	0.0	65.57	0.19	0.0	36.4	46.7	11.3	0.58	0.36
	10	9.6	65.25	0.23	0.0	36.4	47.1	10.9	0.59	0.33
	20	7.2	64.75	0.23	0.0	37.2	46.2	11.0	0.64	0.34
	30	3.2	64.70	0.25	0.0	37.4	45.7	11.3	0.68	0.32
	40	Trace	64.85	0.25	0.0	37.0	46.5	11.0	0.58	0.34
	50	Trace	65.20	0.25	0.0	36.8	46.6	11.0	0.54	0.35
Corn oil	0	0.0	126.1	0.34	0.09	12.5	27.1	55.0	0.47	Trace
	120	6.8	124.2	0.58	0.10	13.5	26.6	54.3	0.42	Trace
	180	7.2	123.3	0.80	0.09	14.0	27.4	52.8	0.46	Trace
	240	7.6	122.1	0.94	0.08	14.7	27.1	52.2	0.52	Trace