Comparisons of the Fatty Acid Content of Cottonseed Oil Used in Glass and Iron Pans[1]

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Abstract

A half of each of 20 chickens was fried in cottonseed oil in an iron pan and the opposite halves were fried in cottonseed oil in a glass ceramic pan. Oil was reused with replenishing additions of fresh oil until ten chicken halves had been fried. In a separate experiment oil was heated intermittently in glass or in iron pans until it had been heated for a total of 47½ hours. The linoleic acid content of the oil (determined chromatographically) decreased significantly with heating or frying. Oil aliquots from the iron pans were not statistically different from aliquots (treated alike) taken from the glass pans.

Introduction

Oxidation occurs in edible fats forming free radicals which further react with atmospheric oxygen. A hydroperoxide group is formed on the methylene group adjacent to a double bond (1–4). Subsequent oxidative degradation occurs more rapidly in a polyunsaturated fat (5). The extent of the degradation is dependent on many factors. Three of these factors are: heat exposure—temperature and time (6); the presence of metallic ions such as iron (7,8); and whether the oil is simply heated or used for frying (9).

Since metals catalyze oxidative reactions of fats, the effects of heating and using cottonseed oil to fry chicken in iron and in glass skillets were studied. The degradation of linoleic acid was of special interest as it is the only polyunsaturated fatty acid that occurs in cottonseed oil in measurable quantities.

Procedure

Cottonseed oil was purchased at a local market in sufficient quantities to insure a common mixture for the entire frying series. Portions of 950 g each were used in both iron and glass ceramic pans. The surface area of the pans was approximately 500 sq cm. Chickens from the same lot were obtained from the Poultry Department of the Mississippi Agricultural Experiment Station. Each chicken was halved, cut into the usual frying pieces, and floured and salted lightly by shaking each half in a paper bag containing one half cup of flour and one half teaspoon of salt. Halves of each of 10 chickens were fried in an iron pan and the opposite halves were fried in a corresponding glass ceramic pan during five consecutive frying periods. Each of these periods consisted of 90 min during which the fat was held at a temperature of 185 ± 5C except when chicken was being fried. The introduction of chicken into the oil caused a drop in temperature but the temperature was not allowed to exceed 190C during frying. During each period, halves of two chickens were fried for 24 min each. After removal from the range, adequate aliquots were taken and the remaining fat from each frying pan was poured into a glass beaker, cooled almost to room temperature, and stored overnight at 9C. Unheated fat was added to each pan at the beginning of each frying period to maintain 950 g. Approximately 100 g were added each time to replace the oil absorbed in the chicken and that removed for sampling. At the end of each frying period the fried chicken and samples of frying fat were stored under nitrogen at −20C until analyzed.

The experiment included two replications, and the four pans used (two glass, two iron) were scoured with steel wool and cleanser after each frying period. An oxidized oil film, that is not removed by ordinary methods of scouring, may be formed on the skillet surface. Then this film would lower the effect of the iron (10).

Cooked chicken samples were thawed and all meat and skin was cut from the bones. The meat and skin were ground with an electric grinder, once through a coarse cutter plate and twice through a fine cutter plate. The ground material was thoroughly mixed after each grinding. The ground chicken was dried in a forced draft oven for 6 hr at 100C, after which the fat was extracted in a Soxhlet extraction apparatus (11). These extracted oils and oil samples that were taken from the skillets were converted to methyl esters using acid-catalized methyl esterification and assayed chromatographically by procedures reported previously (12).

Portions of 950 g of fresh cottonseed oil were placed in two iron and two glass ceramic pans. The temperature of the oil was brought to 185 ± 5C and maintained for 90-min periods until the fat had been heated for the same total time (7½ hr) as the fat in the experiment where chicken was fried. Then the fats were heated to 185 ± 5C for 8-hr periods until they had been heated for a total time of 47½ hr. Fats

TABLE I
Comparison of the Fatty Acid Content of Cottonseed Oils Given Different Treatments

Treatment of fats and skillets	Individual fatty acids as percent of total fatty acids					
	Myristic	Palmitic	Palmitoleic	Stearic	Oleic	Linoleic
Unheated	0.7	20.8	0.6	3.0	17.4	56.9A[a]
After 1st frying period[b]						
Iron	0.9	21.9	1.0	3.0	16.6	56.1 AB
Glass	1.0	22.8	1.1	2.6	16.6	55.3 ABC
After 2nd frying period						
Iron	1.0	23.0	0.9	2.9	17.2	54.2 ABC
Glass	0.9	23.1	1.1	2.7	16.8	54.7 ABC
After 3rd frying period						
Iron	1.1	23.3	0.6	3.2	17.4	53.9 ABC
Glass	0.9	22.7	1.4	3.1	17.1	54.1 ABC
After 4th frying period						
Iron	0.8	24.5	0.4	2.8	18.1	53.0 BC
Glass	0.9	23.6	1.2	3.3	18.0	52.5 C
After 5th frying period						
Iron	1.0	23.0	1.0	3.6	18.1	52.3 C
Glass	0.9	24.1	0.8	3.8	17.2	52.6 C

[a] Values not followed by the same letter differ at the 1% level of probability from other values in the same column.
[b] Each frying period consisted of 90 min during which time the fat was held at a temperature of 185 ± 5C except during the 48 min when two chicken halves were being fried.

[1] Journal Paper No. 1277, Mississippi Agricultural Experiment Station.

TABLE II
Percentages of Fat and of Linoleic Acid in Chicken Fried in Iron and Glass Pans

Frying sequence	Percentage of Fat in Fried Chicken					Percentage of Linoleic Acid[a] in Chicken Fatty Acids				
	Replication 1[b]		Replication 2		Average	Replication 1		Replication 2		Average
	Iron	Glass	Iron	Glass		Iron	Glass	Iron	Glass	
Chicken 1	16.9	17.2	16.3	12.9	15.8	49.3	50.2	49.1	47.1	48.9
Chicken 2	16.9	16.7	13.2	12.1	14.7	41.5	44.6	48.6	46.0	45.2
Chicken 3	18.2	16.0	14.9	15.1	16.0	45.3	44.1	47.3	46.9	45.9
Chicken 4	18.8	17.4	15.7	13.8	16.4	46.4	42.8	41.3	44.1	43.6
Chicken 5	14.9	16.7	17.2	15.3	16.0	44.3	42.4	46.6	47.3	45.1
Chicken 6	14.1	15.8	15.2	14.1	14.8	46.5	46.9	43.7	42.4	44.9
Chicken 7	12.6	10.7	15.8	15.6	13.7	43.8	42.0	44.0	47.6	44.3
Chicken 8	17.3	15.9	13.2	14.8	15.3	45.9	41.2	41.8	38.6	41.9
Chicken 9	17.4	16.7	15.6	15.1	16.2	39.6	42.3	47.1	47.0	44.0
Chicken 10	12.0	11.3	12.8	11.8	12.0	43.2	43.5	45.1	42.9	43.6
Average	15.9	15.4	15.0	14.1	15.1	44.6	44.0	45.4	45.0	44.7

[a] Percent of total fatty acids.
[b] Half of a chicken was fried in the glass pan; the other half of the same chicken in the iron pan. Thus, replication 2 represents a different set of birds.

were cooled and stored in glass beakers as described previously. No replenishing fat was added in this experiment.

Results and Discussion

Fatty acid assays of the cottonseed oil, before and after the chicken was fried in it, are summarized in Table I. Analysis of variance (13) and testing the means by Duncan's Multiple Range test (14) showed a highly significant decrease in linoleic acid with length of frying, but no difference in the fatty acid composition of the oil from the iron and glass pans. There was no difference in the replications.

Since linoleic acid is the only essential fatty acid and the only polyunsaturated fatty acid that occurred in measurable quantities, the percentage of total fatty acids represented by linoleic in the fats extracted from the fried chicken are given in Table II. Statistical analysis of these data showed no significant difference in the linoleic acid content of the chicken whether iron or glass pans were used. Examination of Table I shows a slight trend toward lower values as the lengths of time the fat was used increased, but the differences were not statistically significant. There was, however, a significant difference in the linoleic acid in replications, which indicated a difference in the type or amount of fat in the raw chickens.

The amount of fat extracted from the fried chicken is also given in Table II. These data were calculated as percentage of meat and skin. Since there is very probably some interchange of fat (fat from chicken diffusing into oil and oil being absorbed by chicken), the percentage of fat in the chicken was correlated with the linoleic acid content of the fat extracted from the chicken, and also with the linoleic acid content of the oil in which the chicken had been fried. Neither of these correlation coefficients (0.1347 and 0.2446, respectively) were statistically significant.

The decrease of linoleic acid during the relatively short frying time was rather low. This was expected particularly since fresh oil was added periodically. The effect of certain components in the chicken such as heme compounds or amino acids can not be ignored. The use of the same time and method in drying the chicken and extracting the fat would render comparable fats but not necessarily the exact fat that the freshly fried chicken contained since some degradation would take place during grinding and drying.

The results of heating of cottonseed oil without frying for a period of 47½ hr (first in 90-min frying periods, later in 8-hr frying periods) are presented as confirming evidence that iron skillets do not catalyze the degradation of cottonseed oil when compared to glass skillets. The linoleic acid content of the cottonseed oil heated ten different times for a total of 47½ hr is presented in Table III. An analysis of variance (13) and testing with Duncan's Multiple Range Test (14) showed highly significant decreases due to times but no difference due to pans or interaction of time on pans. Close examination of the data shows a slight tendency for the linoleic acid content of fat from the glass pans to be higher after 31½ hr. This is past the time that using the fat for frying would have been feasible and was not statistically significant.

TABLE III
Percentage Linoleic Acid in Cottonseed Oil Heated in Iron and Glass Pans

Heating time		Iron	Glass
Hours:	0	56.9[b] A[c]	56.9 A
	1½	55.2 A	54.6 B
	3	52.7 B	52.9 B
	4½	52.9 B	53.0 B
	6	52.3 B	51.8 BC
	7½	50.4 C	50.4 C
	15½	45.2 D	45.0 D
	23½	41.4 E	41.0 E
	31½	36.2 F	37.6 E
	39½	34.8 F	35.4 G
	47½	31.8 G	32.0 F
Average		45.3	45.4

[a] Percentage of total fatty acids.
[b] Each value represents an average of four determinations.
[c] Values not followed by the same letter differ at the 1% level of probability from other values in the same column.

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[Received March 14, 1966]