THE EFFECT OF CRUDE COTTONSEED OIL AND VITAMIN E ON THE ABSORPTION OF FATTY ACIDS FROM THE GASTROENTESTINAL TRACT OF THE LAYING HEN

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ABSTRACT

THE EFFECT OF CRUDE COTTONSEED OIL AND VITAMIN E ON THE ABSORPTION OF FATTY ACIDS FROM THE GASTROENTESTINAL TRACT OF THE LAYING HEN

by Stephen W. Baum

Addition of crude cottonseed oil to a hen's ration caused cold storage eggs to develop pink whites and salmon colored yolks. The stearic acid to oleic acid ratio of these "cottonseed" eggs was higher than that of normal eggs. The change in the stearic acid to oleic acid ratio could have been caused by changes in the selective deposition of fatty acids in the egg, prevention of dehydrogenation of stearic acid to oleic acid in the liver, changes in the selective absorption of fatty acids through the intestine, or a combination of these.

Evans _et al_. (1962), also confirmed in this thesis, have shown that plasma, livers, and ovaries from hens fed rations containing crude cottonseed oil contained more stearic acid and less oleic acid than similar tissues from hens fed the basal ration only. The ovary contained a smaller percentage of stearic acid than the other tissues. As the percentage of these fatty acids in the total fatty acids of the livers, plasma, and ovaries changed in a like

manner and did not change by the greatest amount in the ovary, the "active" factor in crude cottonseed oil is not only causing changes in the selective deposition of stearic acid and oleic acid in eggs.

Laying hens were fed a basal ration, the basal ration plus 3% crude cottonseed oil, the basal ration plus dl-α-tocopheryl acetate, or the basal ration plus crude cottonseed oil and dl-α-tocopheryl acetate. The hens were sacrificed, intestines removed and divided into three equal lengths, the contents removed, and the relative concentrations of fatty acids in the intestinal contents measured. Absorption was followed by measuring the disappearance of fatty acids from the intestinal contents.

Ovaries, livers, and plasma from hens fed the supplemented rations contained more stearic acid and less oleic acid than those from hens fed the basal ration. Fatty acid distribution in tissues from hens fed the basal ration plus crude cottonseed oil and hens fed the basal ration only usually differed more from each other than that from hens on the other rations.

More stearic acid and less oleic acid was generally absorbed from the intestines of hens fed crude cottonseed oil containing rations than were absorbed by hens fed the basal ration.

The relative stearic acid and oleic acid absorption agreed with the relative amounts of these acids found in the plasma, livers, and ovaries.

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When laying hens were fed a ration containing dl-α-tocopheryl acetate, there was a rise in the stearic acid to oleic acid ratio of their plasma, livers, and ovaries over the ratio found in similar tissues from hens fed the basal ration. Hens fed the basal plus crude cottonseed oil and dl-α-tocopheryl acetate had a higher stearic acid to oleic acid ratio in their tissues than that from hens fed the basal ration plus dl-α-tocopheryl acetate.

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INTRODUCTION

The discoloration of egg yolks from hens fed ground cottonseed was first reported by Roberts and Rice (1891). A black, brown, or olive color developed in the yolks during cold storage (New Mexico, 1927). Schaible, Moore, and Moore (1934) showed that gossypol, a yellow toxic pigment in cottonseed, gave rise to the olive color. Ferric iron from the yolk proteins formed an olive colored complex with gossypol (Swensen _et al_., 1942).

Sherwood (1928, 1931) observed salmon colored yolks and pink egg whites in cold storage eggs. He showed that the substance causing the discoloration was in crude cottonseed oil and partially refined cottonseed oil, but not in extracted cottonseed meal, soapstock, or highly refined cottonseed oil. Upp (1932) showed that there were no bacteria or molds in the discolored eggs.

Almquist and Lorenz (1932) observed that when pink egg whites were fractionated with ammonium sulfate, a pink colored substance showed up in the albumin fraction. These same researchers showed that coagulation of the egg proteins caused this color to disappear. Sherwood (1931) observed that the water content of the salmon yolks increased over that of normal yolks while the percentage of protein remained constant. He concluded that albuminous material was probably traveling from the white to the yolk. Schaible *et al.* (1946a) confirmed the previous observation. They showed that eggs frozen in the shell or separated yolks and egg whites from hens fed crude cottonseed oil did not discolor on cold storage. They concluded that something was traveling from the yolk into the white and *vice versa*. They showed (1946b, 1946c) that conalbumin from egg white combined with the ferric iron from the yolk to form a complex. The salmon color is produced by the blending of the pink color of the ferric-conalbumin complex with the normal yellow pigments of the yolk. They, also, showed (1946a) in contrast to the observations of Sipe (1931), that pink egg white developed in eggs from hens fed non-cottonseed rations when in cold storage for a period of twenty to forty-two months. This is five to ten times longer than is necessary to develop the same color in eggs from hens having crude cottonseed oil in their rations. Schaible *et al.* (1946c) believed that there was something in crude cottonseed oil that caused the weakening of the vitelline membrane.

The Halphen test (A.O.A.C., 1955) is an empirical color reaction used to identify cottonseed oil in the presence of other oils. It is carried out by heating a sample of oil with isoamyl or amyl alcohol and a solution of sulfur in carbon disulfide. A red color indicates a positive result. Lorenz (1939) isolated a fraction from crude cottonseed oil that gave a positive Halphen test and caused eggs from hens fed it to develop pink whites and salmon colored yolks on storage. No other type of egg discoloration was noted. Dijkstra and Duin (1955) reported that *Sterculia foetida* seed oil gave a positive Halphen test. Nunn (1952) and Faure (1956) proved that the material in *S. foetida* seed oil that gave the positive Halphen test was a cyclopropene fatty acid, sterculic acid, with a structure $CH_3(CH_2)_7-\underset{CH_2}{C{=}C}-(CH_2)_7COOH$. MacFarlane *et al.* (1957) discovered a Halphen positive cyclopropene fatty acid from *Malva parviflora*, mavalic acid. They showed that its structure was $CH_3(CH_2)_7-\underset{CH_2}{C{=}C}-(CH_2)_6COOH$. Masson *et al.* (1957) reported that when sterculic acid was fed to hens it caused pink whites and salmon colored yolks of eggs kept in cold storage for at least one month. According to Shenstone and Vickery (1959) about one-quarter of the ingested cyclopropene fatty acids was deposited in the egg yolk. They found that cyclopropane fatty acids did not give positive Halphen reactions and when fed to hens did not cause pink whites and salmon colored yolks in eggs on cold storage. They, also, observed that cyclopropene fatty acids caused some egg white proteins to diffuse into the yolk. Shenstone and Vickery (1961) later found that crude cottonseed oil contained 0.7% - 1.5% malvalic acid and 0.3% - 0.5% sterculic acid. Shenstone and Vickery (1956) reported that cyclopropene fatty acid soaps have strong surface action properties that might weaken the vitelline membrane.

Rinehart *et al.* (1959) and Masson (1959) observed that sterculic acid slowly polymerized at room temperature and the polymers formed underwent no reaction with the Halphen reagent. Evans *et al.* (1960) showed that crude cottonseed oil that had been heated to 200°C gave a negative Halphen reaction, but still produced pink whites and salmon colored yolks in cold storage eggs. Evans *et al.* (1960) said that this showed that either cyclopropene polymerization products or something unrelated to cyclopropenes could be the "active" factor(s) in crude cottonseed oil that produces pink whites.

Ellis *et al.* (1931) reported that feeding crude cottonseed oil to hogs caused the stearic acid and linoleic acid of their backfat to increase at the expense of the palmitic and oleic acids. Evans *et al.* (1961) observed that stored eggs produced by hens fed crude cottonseed oil or *Sterculia foetida* seed oil in their ration contained more stearic acid and less oleic acid than stored eggs produced by hens fed the basal ration. The stearic acid to oleic acid ratio was 1:4 or 1:3 in normal eggs and 1:1 or 1:1.5 in eggs with pink whites and salmon colored yolks. This change in the stearic acid to oleic acid ratio could be caused by the "active" fraction in crude cottonseed oil causing a change in the selective deposition of fatty acids (by the ovary) in the egg, changing the pattern of biosynthesis of fatty acids in the liver, changing the selective absorption of fatty acids through the intestine, or by any combination of these.

When Evans *et al.* (1962) fed crude cottonseed oil or *S. foetida* seed oil in the rations of hens it caused an increase in the stearic acid to oleic acid ratios in the livers, ovaries, and plasma as compared with the ratios found in similar tissues from hens fed the basal ration. They showed that the ovaries had a lower stearic acid to oleic acid ratio than the plasma or livers from hens on the same ration. One would have expected the reverse of this data if crude cottonseed oil acted by changing the selective deposition of fatty acids (by the ovary) into the egg.

Mice and rats can dehydrogenate stearic acid to oleic acid (Schoenheimer and Rittenberg, 1936; and Bernhard *et al.*, 1959), Evans *et al.* (1963) have theorized and experimented on how crude cottonseed oil could change the fatty acid metabolism of hen's liver. Stearic acid might be formed from acetate (which comes from carbohydrate catabolism) and then be dehydrogenated to oleic acid. If this dehydrogenation is prevented by the crude cottonseed oil "active" factor, addition of large amounts of fats to a crude cottonseed oil containing ration should prevent more stearic acid from being laid down in eggs from hens fed this ration than in those eggs from hens fed the basal ration. Rations with 10% crude cottonseed oil or 2.5% crude cottonseed oil plus 7.5% corn oil caused eggs to be formed with large amounts of stearic acid (19% as compared to 9%

from basal and 11% from 10% corn oil rations). If linoleic acid is metabolized to acetate and then built up into stearic acid which is prevented from being dehydrogenated to oleic acid by crude cottonseed oil, feeding high levels of oleic acid and low levels of linoleic acid should cause normal amounts of oleic acid and stearic acid to be deposited in eggs. Eggs from hens fed 0.5% _S. foetida_ seeds plus 10% olive oil in their rations contained less oleic acid (33% as compared to 48%) than eggs from hens fed 10% olive oil in their rations. Eggs from hens fed olive oil had more oleic acid than eggs from hens on the basal ration (48% as compared to 39%). Linoleic acid might be hydrogenated by the hen or by microorganisms in the gastro-entestinal tract to oleic acid or stearic acid, and the equilibrium between stearic acid and oleic acid unbalanced by the "active" fraction in crude cottonseed oil. The author has never heard of this happening in the non-ruminant or of being tested for in fowl. Linoleic acid is not synthesized _de novo_ by the laying hen (Murty _et al_., 1960). When dietary linoleic acid was increased by feeding safflower oil in the hen's ration, the oleic content of the eggs was reduced and the linoleic acid content increased as compared with eggs from hens fed a basal ration (Choudhury and Reiser, 1959). This decline in oleic acid was not to as low a level as when only crude cottonseed oil was added to a basal ration (Evans _et al_., 1961).

Neither vitamin A, carotene, nor ferric chloride caused a decrease in the number of pink whites and salmon colored yolks in eggs from hens fed crude cottonseed oil in their rations (Evans et al.,1957). Lauryl peroxide plus heat destroyed 87% of the total tocopherols in refined cottonseed oils (Machlin, 1961). There was 7 mg. of a peroxide-resistant non-tocopherol compound in refined cottonseed oil which reacted with the Emery-Engel reagent used in vitamin E analysis (Machlin, 1961). Refined cottonseed oil had the most d-α-tocopherol per gram of unsaturated fatty acid of any vegetable oil tested by Herting and Drury (1963). They reported that crude cottonseed oil had two-thirds as much d-α-tocopherol per gram of unsaturated fatty acid as refined cottonseed oil (0.23 mg. of d-α-tocopherol per gram of unsaturated fatty acid in crude cottonseed oil).

It is most probable that crude cottonseed oil prevents the dehydrogenation of stearic acid to oleic acid in the liver. The effect of crude cottonseed oil on the absorption of fatty acids from intestinal contents has not been investigated. The emphasis of this thesis will be changed in the selective intestinal absorption of stearic, oleic, and linoleic acids caused by crude cottonseed oil.

It is well known that vitamin E and tocopherols protect unsaturated fatty acids. dl- -tocopheryl acetate was added to rations of hens fed the basal ration or the basal ration plus 3% crude cottonseed oil in order to determine if it would change the effects of the "active" fraction of crude cottonseed oil on the stearic acid to oleic acid ratio in fatty acids of the plasma, ovary, and liver or on intestinal absorption by the laying hen.

EXPERIMENTAL

Organization

Two groups of four Single Comb White Leghorn hens per group were kept in individual laying cages and fed a basal ration with the following percentage composition: ground corn, 34.5; ground oats, 20.0; wheat bran, 15.0; flour middlings, 10.0; dehydrated alfalfa (15% protein), 3.0; dried milk, 2.0; menhaden fish meal (60% protein), 2.5; soybean oil meal (44% protein), 2.5; ground oyster shell flour, 5.0; steamed bone meal, 1.5; salt, 0.6; and fish oil (3,000 units of vitamin A and 400 ICU of vitamin D_3), 0.4. This ration contained 4.1% of ether extractable material. In Experiment Ia one group of hens was fed the basal ration only. The second group was fed the basal ration plus 3.0% crude cottonseed oil added at the expense of an equal weight of basal ration. Each group of hens was fed 3,000 grams of ration during the experiment. Experiment Ib, a repeat of Experiment Ia, was started two weeks after the start of Experiment Ia. During the one week between the running of Experiments Ia and Ib, Experiment IIa was conducted. Experiment IIa was a repeat of Experiments Ia, with the exceptions that 0.48 grams of dl-α-tocopheryl acetate was added to the basal ration and 8.91 grams of d-α-tocopheryl acetate on corn meal was added to the ration containing crude cottonseed oil. Experiment IIb was started two weeks after the start of Experiment IIa. Experiment IIb was a repeat of Experiment IIa, with the exception that both rations contained 0.67 grams of dl-α-tocopheryl acetate. The hens were on experiment for 72 hours, at the end of which time they were sacrificed. (All experiments were of the same duration.)

Collection of Samples

The following samples were collected; blood, liver, ovary, and content of the gastrointestinal tract (crop, gizzard, and intestine divided into three sections of equal length). Blood was collected in citrate, and the plasma was separated from the cells by centrifugation. All tissues were analyzed on an individual basis. Liver and ovary samples were homogenized in a Waring Blender. Livers, ovaries, and gastroentestinal contents were shell frozen andlyophilized, and the dried samples were stored at -15°F until analyzed. Blood plasma was frozen at -60°C until analyzed.

Extraction and Methylation

The results of the fatty acid analyses were pooled according to the ration of the hens that the samples were taken from and the type of material taken (plasma, liver, and ovary; or contents of crop, gizzard, 1st third of intestine, 2nd third of intestine, or 3rd third of intestine). All livers, ovaries, and plasma samples were analyzed. The gastrointestinal contents of one hen from each of the eight groups were analyzed.

The samples, except for the plasma, were extracted three times each by shaking with 50 ml. portions of chloroform-methanol (1:1) at room temperature for 30 minutes each time. The extracts were evaporated to dryness under nitrogen, and the oil (residue) was saponified by mixing with 10 ml. of ethanol containing 1.5 grams of potassium hydroxide and allowing to stand over night at room temperature. The soaps were dissolved in 25 ml. of water and sulfuric acid to convert them to the free fatty acids. Fatty acids were extracted with peroxide-free ether and made to a volume of 100 ml. Three ml. aliquots of fatty acids were converted to the the methyl esters with diazomethane. The solutions were evaporated under nitrogen and the residues dissolved in benzene.

Plasma fatty acid methyl esters were prepared by the procedure of Michaels (1958). One ml. of plasma was added to 25 ml. of ethanol-acetone (1:1) mixture. After bringing to a boil, the mixture was filtered through Watman #40 paper, the precipitate washed with solvent, and the filtrate evaporated to dryness under nitrogen. The residue was taken up in 10 ml. of 1% sulfuric acid in methanol and refluxed one hour in a test tube capped with a marble.

This mixture was then evaporated to about 1 ml. under nitrogen and diluted with 4 ml. of distilled water. The water suspension was extracted twice with 10 ml. portions of petroleum ether (30° - 60°C). The petroleum ether was evaporated under nitrogen and the residue was dissolved in 100 microliters of benzene.

Gas-liquid Chromatography

Fatty acid methyl esters were separated in a six foot by 1/4 inch (inside diameter) glass column that was filled with diethylene glycol succinate (20%) on Anakrom ABS[1], 110-120 mesh. A Barber-Colman Model Series 5000 gas-liquid chromatographic machine was used. Nitrogen gas flowed at a rate of 90 ml. per minute at a pressure of 25 pounds per square inch through the glass column (which was kept at a temperature of 182°C). The effluent peaks were detected with a flame ionization detector (compressed air at 40 pounds per square inch and hydrogen gas at 19 pounds per square inch) that was kept at 210°C in an insulated bath. Fatty acid methyl esters were vaporized by an injector port heater that was kept at 300°C. A Barber-Colman single point dual range 8000 series recorder set at 5-mv. with a chart speed of 1/3 of an inch per minute was used. The area of each peak was determined by triangulation.

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[1]Tradename of Analytical Engineering Laboratory Inc. acid and base washed diatomaciatious earth that has been coated with silicone,

RESULTS

Crude Cottonseed Oil

The total fatty acids of a ration containing 3% crude cottonseed oil had 4 and 6 percentage points more of palmitic acid and linoleic acid, respectively, and 1, 4, and 2 percentage points less of stearic acid, oleic acid, and linolenic acid, respectively, than the total fatty acids from the basal ration (Table 1).

The percentage of stearic acid in the total fatty acids from ovaries, livers, and plasma of hens increased when crude cottonseed oil was added to the basal ration (Table 2). There was more palmitic acid (3 percentage points), more stearic acid (6 percentage points), more linoleic acid (3 percentage points), and less oleic acid (8 percentage points) in the total fatty acids of plasma from hens on the basal plus crude cottonseed oil ration than in those from hens fed the basal ration only (Table 2). There was more stearic acid (6 percentage points in liver and 5 percentage points in ovary), more linoleic acid (4 percentage points in both), and less oleic acid (10 percentage points in both) in the total fatty acids in livers and ovaries from hens fed the basal ration plus crude cottonseed oil than in those from hens fed the basal ration (Tables 3 and 4). The fatty acids in yolks from hens fed the basal plus crude cottonseed oil ration were within one percentage point of their corresponding fatty acid in yolks from hens fed the basal ration (Table 5). The crude cottonseed oil containing ration (CSO) caused the percentages of some minor fatty acids in some of the tissues to change from the levels in hens fed the basal ration: myristic acid changed only in the plasma (1.2% in basal fed hens and 0.6% in CSO fed hens); palmitoleic acid decreased by half in the ration, half in plasma, half in livers, and one-third in yolks, and more than doubled in ovaries; heptadecanoic acid doubled in plasma and livers; and arachidonic acid increased in the ovaries (2.0% in basal fed hens to 3.2% in CSO fed hens) and decreased in plasma (2.6% in basal fed hens to 1.6% in CSO fed hens) (Tables 2,3,4, and 5).

The crude cottonseed oil containing ration caused some drastic changes in the percentages of some fatty acids in the intestinal contents as compared with the corresponding fatty acids in the contents of similar sections of intestines from hens fed the basal ration (Tables 7 and 8; and figures 1,2, and 3). The addition of crude cottonseed oil to the basal ration caused the percentage of palmitic acid to increase in the 3rd third of the intestine, decrease in the 2nd third of the intestine, and possibly decrease in the 1st third of the intestine (taking into consideration the differences in the percentage of palmitic acid in the two rations). Crude cottonseed oil caused the percentage of stearic acid in the 3rd third of the intestine to increase, in the 1st third of the intestine to decrease slightly, and in the 2nd third of the intestine to decrease greatly as compared to the contents of similar sections of intestines from hens fed the basal ration. Taking in considering the difference in the percentage of oleic acid in the total fatty acids of the ration, the addition of crude cottonseed oil to the basal ration caused the percentage of oleic acid to increase slightly in the 3rd third of the intestine, increase greatly in the 2nd third of the intestine, and to decrease in the 1st third of the intestine. The crude cottonseed oil containing ration caused the percentage of linoleic acid in the total fatty acids to increase in the 1st third of the intestine, increase in the 2nd third of the intestine, and decrease slightly in the 3rd third of the intestine (taking in consideration the difference in the percentage of linoleic acid in the total fatty acids of the two rations) as compared to the percentages present in the intestines of hens fed the basal ration. The percentages of some minor fatty acids in the total fatty acids of the intestinal contents changed when hens fed the crude cottonseed oil containing ration were compared with hens fed the basal ration: myristoleic acid decreased in the 3rd third of the intestine; palmitoleic acid increased greatly in the 1st and 2nd thirds, as compared to the increase in the 3rd third; arachidic

Table 1. Fatty acid Composition of the Total Fatty Acids in the rations (Percent of total fatty acids).

	Experiment I		Experiment II dl- -tocopheryl acetate	
Fatty acid	Basal	Cottonseed	Basal	Cottonseed
Myristic	0.8	0.8	0.8	0.8
Myristoleic	0.3	0.1	0.2	0.2
Palmitic	15.6	19.4	13.1	13.5
Palmitoleic	1.8	1.0	0.4	2.0
Heptadecanoic	0.1	0.1	0.0	0.0
Stearic	4.3	3.4	3.0	3.5
Oleic	27.8	23.4	25.0	22.6
Linoleic	40.8	46.8	42.0	45.0
Arachidic	0.2	0.2	0.0	0.0
Linolenic	4.3	2.4	4.0	2.8
Arachidonic	0.4	0.4	0.7	0.4
Lignoceric	0.2	0.4	0.8	0.6
Hydroxystearic	0.0	0.4	0.6	0.4
Ricinoleic	0.3	0.2	0.6	0.0

Table 2. Fatty acid composition of the total fatty acids in the blood plasma from hens fed various rations (Percent of total fatty acids).

	Experiment I		Experiment II dl- -tocopheryl acetate	
	Basal	Cottonseed oil	Basal	Cottonseed oil
Myristic	1.2	0.6	0.7	0.4
Myristoleic	0.2	0.2	0.7	0.4
Palmitic	25.8	23.9	25.4	23.9
Palmitoleic	2.0	1.0	1.8	0.9
Heptadecanoic	0.6	1.0	0.9	0.6
Stearic	15.7	22.0	20.2	19.8
Oleic	33.5	25.4	29.8	25.4
Linoleic	13.0	16.1	14.2	16.2
Arachidic	1.1	1.0	0.3	0.8
Linolenic	2.3	2.2	1.5	1.5
Arachidonic	2.6	1.6	1.9	1.7

Table 3. Fatty acid composition of the total fatty acids in the livers from hens fed various rations (Percent of total fatty acids).

	Experiment I		Experiment II dl- -tocopheryl acetate	
	Basal	Cottonseed oil	Basal	Cottonseed oil
Myristic	0.4	0.4	0.4	0.5
Myristoleic	0.2	0.2	0.2	0.2
Palmitic	20.2	20.0	21.4	21.7
Palmitoleic	2.0	0.7	1.4	1.0
Heptadecanoic	0.2	0.4	0.4	0.2
Stearic	13.4	19.6	18.5	19.5
Oleic	35.4	25.6	29.2	27.8
Linoleic	15.9	19.6	18.0	18.3
Arachidic	0.2	0.2	0.2	0.2
Linolenic	0.9	0.8	0.8	0.8
Arachidonic	4.8	4.3	4.2	3.4
Lignoceric	0.2	0.3	0.1	0.2
Hydroxystearic	2.7	2.7	2.3	2.0
Ricinoleic	0.6	0.7	0.1	0.3

Table 4. Fatty acid composition of the total fatty acids in the ovaries from hens fed various rations (Percent of total fatty acids).

	Experiment I		Experiment II dl- -tocopheryl acetate	
Fatty acid	Basal	Cottonseed oil	Basal	Cottonseed oil
Myristic	0.4	0.4	0.4	0.4
Myristoleic	0.2	0.1	0.2	0.2
Palmitic	21.5	21.0	21.1	22.1
Palmitoleic	0.4	1.0	1.0	0.7
Heptadecanoic	0.0	0.1	0.0	0.1
Stearic	10.8	15.6	12.2	16.0
Oleic	42.1	32.4	37.8	33.2
Linoleic	17.2	21.2	19.0	18.4
Arachidic	0.2	0.2	0.4	0.1
Linolenic	1.2	1.0	1.2	0.8
Arachidonic	2.0	3.2	2.4	2.2
Lignoceric	0.1	0.1	0.1	0.2
Hydroxystearic	1.9	1.8	1.6	1.2
Ricinoleic	0.2	0.1	0.1	0.2

Table 5. Fatty acid composition of the total fatty acids in egg yolks from hens fed various rations. (Percent of total fatty acids).

	Experiment I		Experiment II dl- -tocopheryl acetate	
Fatty acid	Basal	Cottonseed oil	Basal	Cottonseed oil
Myristic	0.4	0.4	0.4	0.4
Myristoleic	0.2	0.2	0.2	0.2
Palmitic	20.4	21.4	20.6	21.0
Palmitoleic	1.3	1.2	3.4	1.4
Heptadecanoic	0.0	0.0	0.0	0.0
Stearic	9.9	10.8	9.8	13.4
Oleic	41.2	41.8	40.0	40.8
Linoleic	18.2	17.2	18.8	16.5
Arachidic	0.0	0.4	0.0	0.0
Linolenic	1.5	1.2	1.2	1.2
Arachidonic	2.4	2.3	2.3	2.1
Lignoceric	0.0	0.1	0.1	0.0
Hydroxystearic	1.8	1.9	1.9	1.6
Ricinoleic	0.4	0.1	0.1	0.0

Table 6. Distribution of C_{18} Fatty Acids (Percent of total fatty acids).

	Stearic Acid				Oleic Acid			
	B	CSO	B+E	CSO+E	B	CSO	B+E	CSO+E
Ovary	10.8	15.6	12.2	16.0	42.1	32.4	37.8	33.2
Liver	13.4	19.6	18.5	19.5	35.4	25.6	29.2	27.8
Blood	15.7	22.0	20.2	19.8	33.5	25.4	29.8	25.4
Ration	4.3	3.4	3.0	3.5	27.8	23.4	25.0	22.6
Crop Contents	5.7	5.2	4.8	3.3	26.5	23.8	25.2	23.2
Gizzard Contents	5.7	3.9	3.8	3.4	23.9	25.8	24.9	25.4
Intestine 1 Contents	23.9	18.1	18.6	14.0	19.1	13.6	16.7	12.4
Intestine 2 Contents	23.1	13.2	16.2	11.4	14.6	26.3	13.8	14.2
Intestine 3 Contents	12.6	14.7	12.3	12.8	19.1	19.9	21.8	20.9
Feces	9.0	9.4	7.6	5.8	22.4	15.7	19.8	20.6

	Linoleic Acid				Linolenic Acid			
	B	CSO	B+E	CSO+E	B	CSO	B+E	CSO+E
Ovary	17.2	21.2	19.0	18.4	1.2	1.0	1.2	0.8
Liver	15.9	19.6	18.0	13.8	0.9	0.8	0.8	0.8
Blood	13.0	16.1	14.2	16.2	2.8	2.2	1.5	1.5
Ration	40.8	46.8	42.0	45.0	4.3	2.4	4.0	2.8
Crop Contents	30.6	34.7	33.6	36.7	3.2	1.8	3.4	2.1
Gizzard Contents	34.8	41.8	38.0	34.0	2.8	2.6	2.4	2.5
Intestine 1 Contents	21.0	38.1	39.4	35.8	0.7	1.0	1.4	1.8
Intestine 2 Contents	20.6	31.8	32.6	30.4	1.6	1.9	1.5	1.6
Intestine 3 Contents	29.2	29.4	35.8	21.6	2.2	1.1	2.0	1.9
Feces	19.4	14.6	20.1	27.6	2.4	1.6	2.0	3.1

B = Basal
CSO = Basal + 3% crude cottonseed oil
B+E = Basal + dl-α-tocopheryl acetate.
CSO+E = Basal + 3% Crude cottonseed oil + dl-α-tocopheryl acetate.

Fig. 1. The percentage of stearic acid in the total fatty acids in the intestinal contents and some tissues.

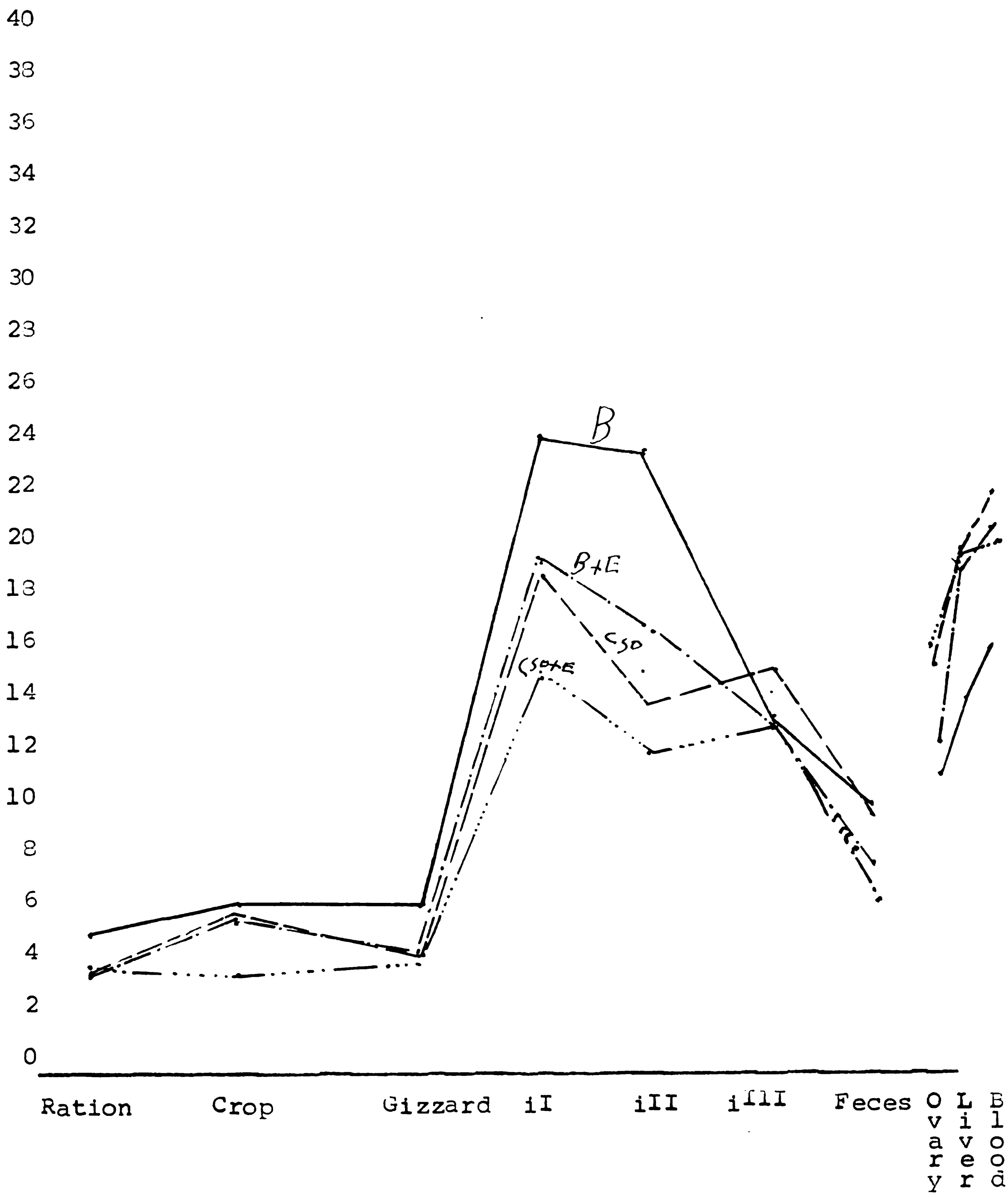

Fig. 2. The percentage of oleic acid in the total fatty acids in the intestinal contents and some tissues.

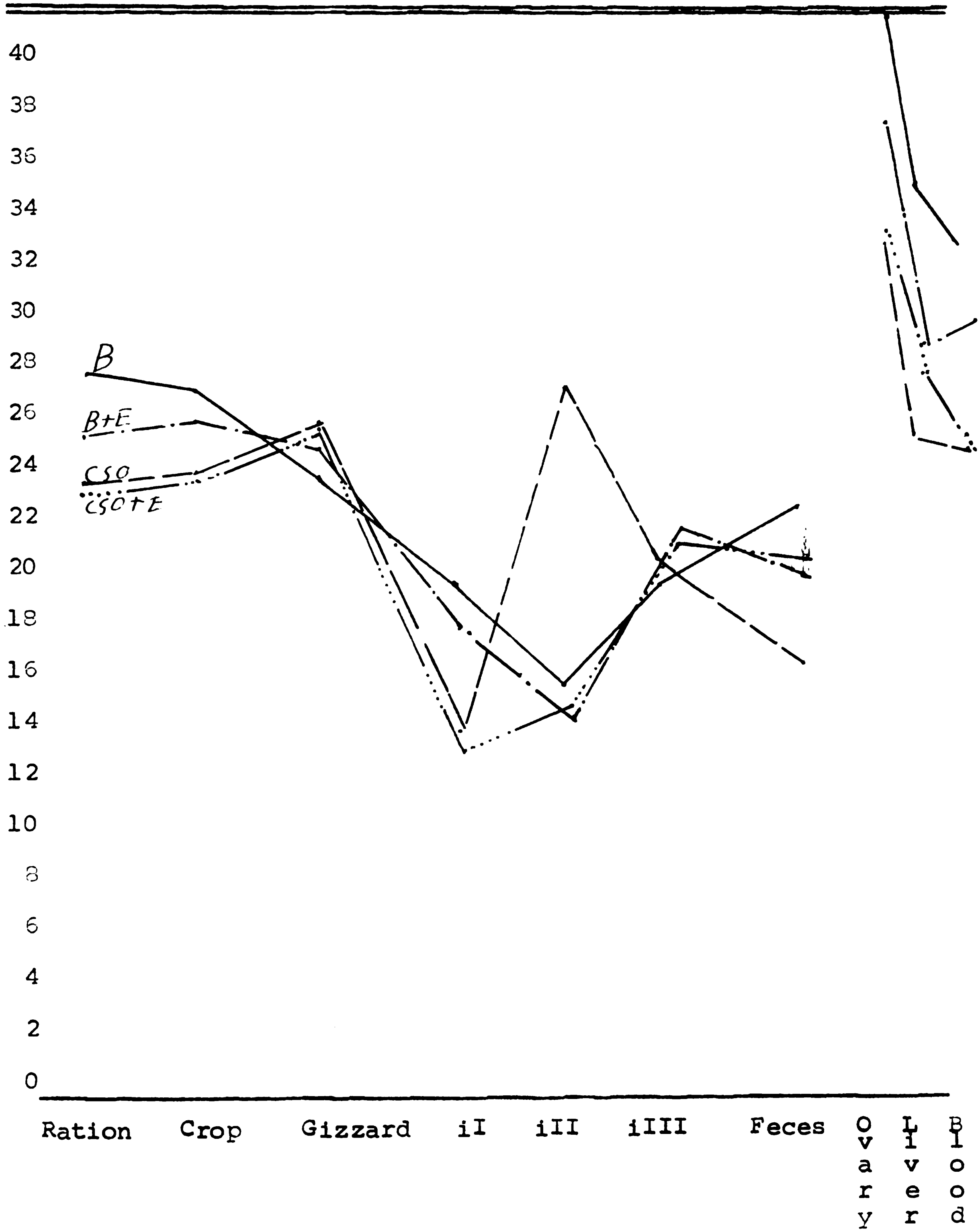

Fig. 3. The percentage of linoleic acid in the total fatty acids in the intestinal contents and some tissues.

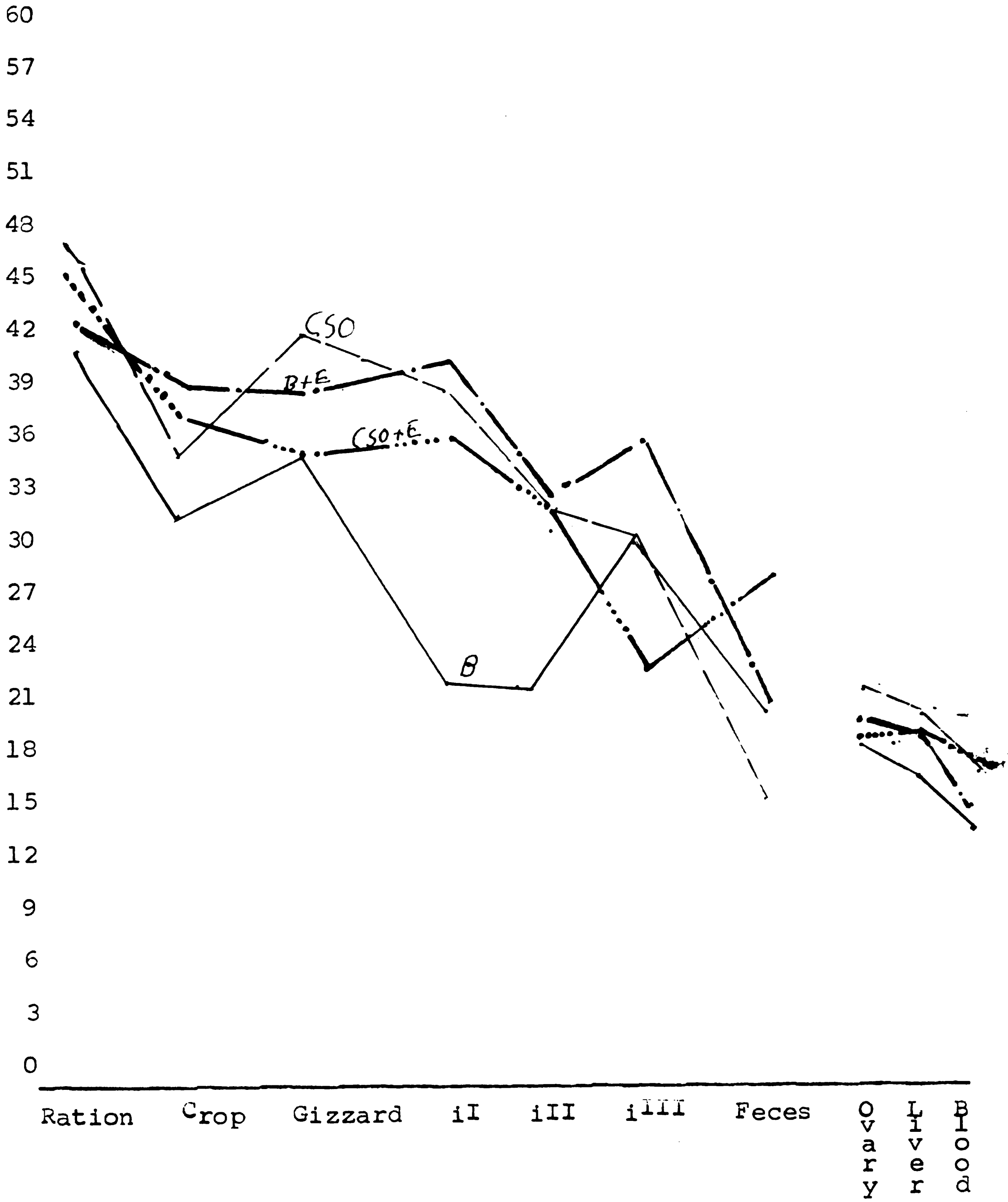

Table 7. Fatty acid composition in the contents of the gastrointestinal tract and selected tissues from hens fed the basal ration only. (Percent of total fatty acids).

Experiment I

Fatty acid	Ration	Crop	Gizzard	Intestine 1	Intestine 2	Intestine 3	Feces	Plasma	Liver	Ovary
Myristic	0.8	1.7	0.7	0.3	0.8	1.0	0.8	0.6	0.3	0.4
Myristoleic	0.3	0.2	0.2	0.1	0.4	1.0	0.2	0.2	0.2	0.2
Palmitic	15.6	20.0	16.4	19.5	22.8	13.3	26.2	26.8	19.4	20.6
Palmitoleic	1.8	1.8	1.0	0.1	0.4	0.9	1.8	1.2	1.4	1.4
Heptadecanoic	0.1	0.0	0.4	0.1	1.0	0.6	0.4	0.6	0.3	0.0
Stearic	4.3	5.7	5.7	23.9	23.1	12.6	9.0	15.4	14.6	10.0
Oleic	27.8	26.5	23.9	19.1	14.6	19.1	22.4	30.6	30.1	40.6
Linoleic	40.8	30.6	34.8	21.0	20.6	29.2	19.4	17.0	16.2	18.6
Arachidic	0.2	0.5	0.8	0.0	0.8	1.6	1.4	0.6	0.2	0.2
Linolenic	4.3	3.2	2.8	0.7	1.6	2.2	2.4	2.5	0.8	1.1
Arachidonic	0.4	0.6	0.4	1.3	0.8	2.0	1.4	4.2	7.5	2.4
Lignoceric	0.2	1.0	1.8	1.1	1.8	1.0	0.7		0.2	0.0
Hydroxystearic	0.0	0.8	0.6	2.0	0.2	1.0	1.1		3.5	2.2
Ricinoleic	0.3	1.3	2.4	6.2	1.8	3.8	2.2		0.8	0.0

Table 8. Fatty acid composition in the contents of the gastrointestinal tract and selected tissues from hens fed a ration containing 3% crude cottonseed oil. (Percent of total fatty acids).

	Experiment I									
				Intestine						
Fatty acid	Ration	Crop	Gizzard	1	2	3	Feces	Plasma	Liver	Ovary
Myristic	0.8	1.6	0.6	0.3	0.5	0.7	2.7	0.6	0.4	0.3
Myristoleic	0.1	0.2	0.2	0.1	0.2	0.2	0.6	0.2	0.1	0.1
Palmitic	19.4	23.0	18.2	20.0	17.5	17.0	32.6	28.5	20.0	20.8
Palmitoleic	1.0	1.3	1.3	0.5	1.6	1.2	1.0	0.6	1.2	1.3
Heptadecanoic	0.1	0.3	0.1	0.3	0.2	0.7	0.5	1.6	0.5	0.4
Stearic	3.4	5.2	3.9	18.1	13.2	14.7	9.4	21.8	16.4	17.4
Oleic	23.4	23.8	25.8	13.6	26.3	19.9	15.7	25.6	25.8	30.6
Linoleic	46.8	34.7	41.8	38.1	31.8	29.4	14.6	17.5	21.6	23.0
Arachidic	0.2	0.8	0.0	0.6	0.4	0.4	1.4	0.2	0.3	0.2
Linolenic	2.4	1.8	2.6	1.0	1.9	1.1	1.6	1.6	0.9	1.1
Arachidonic	0.4	0.4	0.4	2.8	1.7	2.3	0.6	1.4	5.2	2.7
Lignoceric	0.4	0.4	0.5	0.4	0.2	0.6	1.9		0.2	0.2
Hydroxystearic	0.4	0.3	0.7		0.1	1.2	1.2		2.8	0.8
Ricinoleic	0.2	0.0	0.5		0.1	1.0	5.4		0.0	0.0

Table 9. Fatty acid composition in the contents of the gastrointestinal tract and selected tissues from hens fed a ration containing dl-α-tocopheryl acetate. (Percent of total fatty acids).

	Experiment II									
				Intestine						
Fatty acid	Ration	Crop	Gizzard	1	2	3	Feces	Plasma	Liver	Ovary
Myristic	0.8	0.8	1.0	0.8	0.6	0.8	1.9	1.0	0.4	0.4
Myristoleic	0.2	0.2	0.2	0.2	0.3	0.4	0.5	0.8	0.2	0.2
Palmitic	13.1	17.6	18.0	13.6	19.8	17.9	21.3	26.7	20.7	21.3
Palmitoleic	0.4	1.5	1.2	0.8	0.4	0.9	2.2	1.2	1.3	1.2
Heptadecanoic	0.0	0.0	0.1	0.5	0.6	0.6	0.8	1.0	0.2	0.0
Stearic	3.0	4.8	3.8	13.6	16.2	12.3	7.6	21.4	17.0	10.4
Oleic	25.0	25.2	24.9	16.7	13.8	21.8	19.8	24.8	26.2	38.4
Linoleic	42.0	38.6	38.0	39.4	32.6	35.8	20.1	11.1	20.0	18.8
Arachidic	0.0	0.2	0.4	0.1	0.5	1.3	1.9	0.4	0.1	0.2
Linolenic	4.0	3.4	2.4	1.4	1.5	2.0	2.0	0.6	0.7	1.2
Arachidonic	0.7	0.4	0.4	1.6	1.6	2.6	1.2	1.5	6.3	2.9
Lignoceric	0.8	0.8	0.7	0.6	0.4	0.6	0.4	0.2	0.2	0.0
Hydroxystearic	0.6	0.2	0.8	1.1	1.2	1.2	1.6	1.3	2.8	0.4
Ricinoleic	0.6	0.8	1.2	0.6	2.8	0.6	2.3	3.9	0.0	0.4

Table 10. Fatty acid composition in the contents of the gastrointestinal tract and selected tissues from hens fed a ration containing 3% crude cottonseed oil and dl-α-tocopheryl acetate. (Percent of total fatty acids).

	Experiment II									
				Intestine						
Fatty acid	Ration	Crop	Gizzard	1	2	3	Feces	Plasma	Liver	Ovary
Myristic	0.8	1.0	1.0	0.4	0.3	0.9	0.4	0.6	0.4	0.4
Myristoleic	0.2	0.2	0.2	0.1	0.2	0.3	0.2	0.3	0.1	0.1
Palmitic	18.5	22.1	18.9	20.2	17.7	21.1	16.5	23.4	22.2	24.0
Palmitoleic	2.0	1.4	1.4	0.6	0.8	1.5	0.9	1.0	1.3	0.4
Heptadecanoic	0.0	0.2	0.2	0.4	0.7	0.0	0.6	0.6	0.4	0.0
Stearic	3.5	3.3	3.4	14.0	11.4	12.8	5.8	18.4	19.2	16.8
Oleic	22.6	23.2	25.4	12.4	14.2	20.9	20.6	23.0	23.7	32.4
Linoleic	45.0	36.7	24.0	35.8	30.4	21.6	27.6	11.8	18.5	18.1
Arachidic	0.0	0.9	0.4	0.0	0.0	0.0	0.6	0.2	0.2	0.1
Linolenic	2.8	2.1	2.5	1.8	1.6	1.9	3.1	1.4	1.0	1.0
Arachidonic	0.4	0.3	0.4	1.9	1.6	1.0	1.1	2.4	2.6	2.0
Lignoceric	0.6	0.7	0.9	0.6	1.6	1.4	1.5	0.1	0.2	0.1
Hydroxystearic	0.4	0.9	0.8	2.2	1.3	2.0	3.0	1.2	1.4	0.6
Ricinoleic	0.0	0.6	1.2	3.3	8.0	6.1	2.3	2.2	0.5	0.1

acid decreased in the 3rd third; linolenic acid probably decreased in the 3rd third; arachidonic acid increased in the 1st and 2nd thirds; lignoceric acid decreased throughout; unknown fatty acid number 16 decreased in the 2nd third; and ricinoleic acid decreased greatly in the 2nd and 3rd thirds, and possibly in the 1st third.

dl-α-Tocopheryl Acetate

The basal ration plus dl-α-tocopheryl acetate had more palmitic acid, slightly more linoleic acid, less oleic acid, less stearic acid, more lignoceric acid, more hydroxystearic acid, more ricinoleic acid, and less palmitoleic acid than the basal ration (Table 1). The ration containing crude cottonseed oil and dl-α-tocopheryl acetate had less palmitic acid, more palmitoleic acid, slightly less oleic acid, and less linoleic acid than the cottonseed oil ration. The ration containing crude cottonseed oil and dl-α-tocopheryl acetate had less linolenic acid, more palmitoleic acid, less oleic acid, and more linoleic acid than the ration containing only dl-α-tocopheryl acetate.

There was more stearic acid (4 percentage points), more linoleic acid (1.2 percentage points), and less oleic acid (4 percentage points) in the total fatty acids of plasma from hens fed dl-α-tocopheryl acetate than in those of plasma from hens fed the basal ration only (Table 2). There was less stearic acid (2 percentage points) in plasma from hens fed a ration containing crude cottonseed oil and dl- -tocopheryl acetate than in plasma from hens fed the basal ration plus crude cottonseed oil. Of the two dl- -tocopheryl acetate containing rations, the ration that also contained crude cottonseed oil caused the fatty acids of the plasma to contain more palmitic acid, more linoleic acid, and less oleic acid than the plasma fatty acids of hens fed the ration supplemented with dl- -tocopheryl acetate only.

There was more stearic acid (5 percentage points), more linoleic acid (2 percentage points), and less oleic acid (6 percentage points) in the total fatty acids of livers from hens fed the basal ration plus dl- -tocopheryl acetate than in those of livers from hens fed the basal ration. (Table 3). There was more oleic acid (2 percentage points) in livers from hens fed a ration containing crude cottonseed oil and dl- -tocopheryl acetate than in livers of hens fed the basal ration plus crude cottonseed oil. There was slightly more stearic acid and slightly less oleic acid in livers from hens fed a ration containing crude cottonseed oil and dl- -tocopheryl acetate than in those from hens fed the basal ration plus dl- -tocopheryl acetate.

There was more stearic acid (1 percentage point), more linoleic acid (2 percentage points), and less oleic acid (4 percentage points) in the total fatty acids of ovaries from hens fed the basal ration than the other rations (Table 4). There was slightly more palmitic acid and less linoleic acid in ovaries from hens fed the basal ration plus crude cottonseed oil and dl-α-tocopheryl acetate than in those from hens fed a ration containing crude cottonseed oil. There was more stearic acid, slightly more palmitic acid, and less oleic acid in ovaries from hens fed a ration containing crude cottonseed oil and dl-α-tocopheryl acetate than in those from hens fed the basal ration plus dl-α-tocopheryl acetate.

There was more palmitoleic acid and less oleic acid in the total fatty acids of egg yolks from hens fed the basal ration plus dl-α-tocopheryl acetate than those from hens fed the basal ration (Table 5). There was more stearic acid (2.6 percentage points) and less oleic acid (1 percentage point) in the total fatty acids of egg yolks from hens fed crude cottonseed oil and dl-α-tocopheryl acetate in their ration than in those of egg yolks from hens fed the basal ration plus crude cottonseed oil. There was more stearic acid and less linoleic acid in egg yolks from hens fed crude cottonseed oil and dl-α-tocopheryl acetate than in those from hens fed the basal ration plus dl-α-tocopheryl acetate.

The addition of dl-α-tocopheryl acetate to the basal ration caused changes in the percentages of some fatty acids of the intestinal contents (Tables 7 and 9; and figures 1, 2, and 3). dl-α-tocopheryl acetate caused the percentages in the total fatty acids of palmitic acid to decrease in the 1st and 2nd thirds of the intestines, of stearic acid to decrease in the 1st and 2nd thirds of the intestine, of linoleic acid to increase throughout the intestine, of myristoleic acid to decrease in the 3rd third of the intestine, of linolenic acid to increase in the 1st third of the intestine, of palmitoleic acid to increase in the 1st third of the intestine, of lignoceric acid to decrease throughout the intestine, of arachidonic acid to increase in the 2nd third of the intestine, and of ricinoleic acid to decrease in the 1st and 3rd thirds and to increase in the 2nd third of the intestine.

The addition of dl-α-tocopheryl acetate to a ration containing crude cottonseed oil caused changes in the percentages of some fatty acids of the intestinal contents (Tables 8 and 10; and figure 1,2, and 3). The addition of dl-α-tocopheryl acetate to the crude cottonseed oil containing ration caused the percentage of palmitic acid to increase in the 3rd third of the intestine, of stearic acid to decrease throughout the intestine, of oleic acid to decrease in the 2nd third of the intestine, of linoleic acid to decrease in the 1st and 3rd thirds of the intestine, of palmitoleic acid to decrease in the 2nd third of the intestine, of arachidic acid to decrease throughout the intestine, of linolenic acid to increase in the 1st and 3rd thirds and possibly to decrease in the 2nd third of the intestine, of arachidonic acid to decrease in the 1st and 3rd thirds of the intestine, of lignoceric acid to increase in the 2nd and 3rd thirds of the intestine, and of hydroxystearic acid and ricinoleic acid to increase throughout the intestine.

The addition of crude cottonseed oil to a basal ration plus dl-α-tocopheryl acetate caused changes in the percentages of some fatty acids in the total fatty acids of the intestinal contents (Tables 9 and 10; and figures 1,2, and 3). The addition of crude cottonseed oil to the dl-α-tocopheryl acetate containing ration caused the percentage of palmitic acid to increase in the 1st and 3rd thirds and to decrease in the 2nd third of the intestine, of stearic acid to decrease in the 1st and 2nd thirds of the intestine, of oleic acid to decrease in the 1st third of the intestine, of linoleic acid to decrease throughout the intestine, of myristic acid to decrease in the 1st and 2nd thirds of the intestine, of palmitoleic acid to increase in the 3rd third, of arachidic acid to decrease throughout (particularly in the 3rd third) of the intestine, of lignoceric acid to increase in the 2nd and 3rd thirds of the intestine, and of hydroxystearic acid and ricinoleic acid to increase throughout the intestine.

The fatty acid distribution in tissues from hens fed rations containing crude cottonseed oil or dl-α-tocopheryl acetate were very similar (Tables 2,3,4, and 5). The addition of dl-α-tocopheryl acetate to a basal ration caused a change in the fatty acid distribution of the tissues of the hens that ate it to a position between that of hens fed the basal ration plus crude cottonseed oil and of hens fed a basal ration only. (The percentage of oleic acid in total fatty acids when basal ration plus dl-α-tocopheryl acetate was fed, was midway between the percent of this fatty acid in the two rations that did not contain dl- -tocopheryl acetate.

Minor Peaks

Many of the minor fatty acids could not be identified as they did not correspond to any standards that could be bought commercially. Some of the peaks that appeared in the same place as the fatty acid standards are 16-methylheptadecanoic (iso-stearic) acid, rincinoleic acid, 12-hydroxystearic acid, heptadecanoic acid, and pentadecanoic acid (14-methylpentadecanoic acid appeared at about the same place). (See appendices). Wheeler et al. (1959) found heptadecanoic acid in yolks of eggs from hens fed 10% cottonseed oil in their rations. Time did not allow for the identification of more minor peaks.

DISCUSSION

Fatty acid absorption

There have been a few studies on the sites of fat and fatty acid absorption through the intestine. Renner (1965) observed that the fat of tallow, lard, and soybean oil was mostly absorbed from the third-fifth of the intestine of four week old chicks, while almost all of the remaining fat was absorbed in the fourth-fifth of the intestine. She did not test for absorbability through the duodenum, as its contents were a thin paste. Benson (1956) reported that olive oil was preferentially absorbed from the third quarter of the small intestine of the rat. Cottonseed oil fatty acids in the form of triglycerides was "efficiently absorbed" (60%) in the proximal intestine of the dog (Knoebel, 1962). Renner and Hill (1961) reported that, in hens, as the chainlength of saturated fatty acids increased, their absorbability decreased; while unsaturated fatty acids were readily absorbed: myristic, 29%; palmitic, 12%; stearic, 4%; and oleic, 94%. In the experiments that I conducted, stearic acid was not as well absorbed as the other C_{18} fatty acids (Table 6). Noyan *et al*. (1964) reported that about 92% of the labeled palmitic acid fed to chickens was absorbed from the duodenum. They observed that the palmitate was released by the intestinal mucosa into the blood as triglycerides of very low density lipoproteins.

From tables 7,8,9 and 10 the sites of absorption of the major fatty acids were determined by the decrease in the percentage of each fatty acid in the total fatty acids of the intestinal contents. Stearic acid was absorbed through the 3rd third and the 2nd plus the 3rd thirds of the intestine when the basal ration and the ration containing crude cottonseed oil, respectively, were fed. Some oleic acid was absorbed in the 1st third of the intestine, but was mostly absorbed in the 2nd third of the intestine unless crude cottonseed oil was included in the ration (absorption from the 2nd third then dropped drastically). Linoleic acid was absorbed from the 1st and 2nd thirds of the intestine when the basal ration was fed and the 2nd and 3rd thirds of the intestine when the basal ration plus crude cottonseed oil was fed. Crude cottonseed oil containing rations increased slightly the absorption of palmitic acid through the 1st and 2nd thirds of the intestine, while it halved the absorption of palmitic acid from the 3rd third of the intestine (Comparison with the results of feeding the basal ration) (Tables 7 and 8).

Crude cottonseed oil could have expanded the total area of absorption of stearic acid by increasing the absorption of stearic acid by the 2nd third of the intestine. Young and Garnett (1963) observed that stearic acid is absorbed to a much higher degree in the chick when oleic acid is added to the ration. The crude cottonseed oil plus basal ration decreased the absorption of oleic acid from the 2nd third of the intestine by 80% (Table 6). It is possible that the "active" factor in crude cottonseed oil prevents oleic acid from being absorbed from the 2nd third of the hen's intestine, this in turn allowing more stearic acid to be absorbed there.

Fatty acids in tissues

According to table 11 my data compares favorably with the data of Evans *et al.* (1962) with respect to the fatty acid composition of plasma and livers from hens on the basal rations and the basal plus 3% crude cottonseed oil ration. The changes between the fatty acid composition of ovaries from hens fed the basal plus crude cotton seed oil ration and the basal ration only is about half as much in the hens on my Experiment I as on their experiment. Their hens were on experimental rations for six weeks before being sacrificed, while my hens were on experimental rations for three days. The fatty acid composition of the plasma and livers seem to come to equilibrium at least within three days, while the fatty acid equilibrium of the ovaries takes longer to establish. The eggs, laid the second day of my experiments, had the same fatty acid composition irrespective of ration (Table 5). This was expected, as these eggs were in the oviduct for the entire duration of the experiment. I do not know why our data on the myristic acid composition of the rations and plasma disagree.

Table 11. The effect of the duration of feeding crude cottonseed oil on the fatty acid distribution in plasma, liver, and ovary. (Percent of total fatty acids).

Fatty acid	Ration		Plasma		Liver		Ovary	
	B	CSO	B	CSO	B	CSO	B	CSO
Myristic	0.8	0.8	1.2	0.6	0.4	0.4	0.4	0.4
	*1.7	1.5	0.1	0.2	0.5	0.6	0.5	0.5
Palmitic	15.6	19.4	25.3	28.9	20.2	20.0	21.5	21.0
	*16.6	20.9	31.3	33.2	23.4	26.5	25.7	28.5
Palmitoleic	1.8	1.0	2.0	1.0	2.0	0.7	0.4	1.0
	*2.7	2.1	2.9	2.3	3.1	2.3	3.6	1.8
Stearic	4.3	3.4	15.7	22.0	13.4	14.6	10.8	15.6
	*3.2	2.9	17.5	22.0	14.0	22.2	10.4	21.4
Oleic	27.8	23.4	33.5	25.4	35.4	25.6	42.1	32.4
	*27.4	23.4	34.5	24.3	36.2	27.7	42.4	26.6
Linoleic	40.3	46.8	13.0	16.1	15.9	19.6	17.2	21.2
	*45.1	47.3	13.7	18.1	22.9	20.8	17.1	21.2

*row of data from Evans _et al_.,(1962).

My data will be lower than Evans _et al_., (1962) as I have based my numbers on more fatty acids.

B = basal ration
CSO = 3% crude cottonseed oil ration.

<u>dl-α-tocopheryl acetate</u>

The amount of dl-α-tocopheryl acetate used (0.667 grams in 3,000 grams of rations) is the same, 0.022%, as that reported by Machlin <u>et</u> <u>al</u>. (1962) to be sufficient to keep hatchability, fertility, and production of eggs at normal levels when hens were fed high linoleic acid rations (about 70% of the total fatty acids). The rations I fed to my hens had a linoleic content of 40% - 43% of the total fatty acids. The dl-α-tocopheryl acetate level fed should have insured that there was a surplus of vitamin E precursor. The surplus dl-α-tocopheryl acetate was sufficient to change the fatty acid absorption from the laying hen's intestine.

dl-α-tocopheryl acetate had little effect on the site of absorption of stearic acid but it seemed to partially counteract the effect of crude cottonseed oil on the absorption of oleic acid from the intestine. It lowered the percentage of oleic acid in the total fatty acids of the contents in the 2nd third of the intestine (showing increased absorption) and increased slightly the percentage of oleic acid in the total fatty acids of the liver (Table 6 and figure 2). dl-α-tocopheryl acetate changed the site of absorption of palmitic acid and linoleic acid from the 1st and 2nd thirds (much absorbed from the basal ration here) to only the 2nd third of the intestine. If crude cottonseed oil was in the ration, whether or not dl-α-tocopheryl acetate was present, palmitic acid and linoleic acid was absorbed in the

2nd and 3rd thirds of the intestine (Tables 6,8, and 10; and figure 3).

SUMMARY

Fatty acids from ovaries, livers, and plasma from hens fed the basal ration contained less stearic acid, less linoleic acid, and more oleic acid than the fatty acids of similar tissues from hens fed the other rations. Tissues from hens fed the basal ration plus crude cottonseed oil had the largest stearic acid to oleic acid ratio and tissues from hens on the basal ration only had the smallest stearic acid to oleic acid ratio of hens on the four experimental rations.

Generally more stearic acid, less linoleic acid, and less oleic acid was absorbed from the intestines of hens fed the basal plus 3% crude cottonseed oil ration than from the intestines of hens fed the basal ration.

The relative absorption of stearic acid and oleic acid corresponded with the relative amounts of these fatty acids found in the plasma, livers, and ovaries. This does not seem to hold true in the case of linoleic acid. In those hens where the percentage of stearic acid in the total fatty acids of the intestinal contents was high, the percentage of stearic acid in the total fatty acids of the plasma, livers, and ovaries was lowest.

dl-α-tocopheryl acetate seemed to have the same type of effect on the absorption of stearic acid and oleic acid and their presence in the plasma, liver, and ovary as the "active" factor in crude cottonseed oil. Varying the amount of α-tocopheryl acetate from 0.43 grams to 0.67 grams or 3.91 grams to 0.67 grams, or using the d form instead of the dl form did not change the results between parts a and b of Experiment II.

It would be advantageous to feed α-tocopheryl acetate to hens in large doses for several weeks, collect the hens' eggs and put them into cold storage for nine months, and discover whether this produces pink whites and salmon colored yolks.

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Appendix 1. Fatty acid composition of the total fatty acids in the rations. (Percent of total fatty acids).

	Experiment I		Experiment II dl- -tocopheryl acetate	
	Basal	Cottonseed oil	Basal	Cottonseed oil
Decanoic	0.0	0.0	0.0	0.0
Lauric	0.0	0.0	0.1	0.1
1	0.1	0.0	0.1	0.0
2	0.0	0.0	0.0	0.0
Myristic	0.8	0.8	0.8	0.8
3	0.0	0.0	0.0	0.0
Myristoleic	0.3	0.1	0.2	0.2
Pentadecanoic	0.1	0.0	0.1	0.2
Palmitic	15.6	19.4	18.1	18.5
Palmitoleic	1.8	1.0	0.4	2.0
Heptadecanoic	0.1	0.1	0.0	0.0
iso-Stearic	0.0	0.0	0.0	0.0
4	0.1	0.1	0.1	0.1
Stearic	4.3	3.4	3.0	3.5
Oleic	27.8	23.4	25.0	22.6
Nonodecanoic	0.0	0.0	0.0	0.0
Linoleic	40.8	46.8	42.0	45.0
5	0.0	0.0	0.0	0.0
Arachidic	0.2	0.2	0.0	0.0
Linolenic	4.3	2.4	4.0	2.8
6	0.0	0.0	0.0	0.0
7	0.2	0.0	0.6	0.6
8	0.1	0.2	0.0	0.6
Behenic	0.0	0.0	0.0	0.0
9	0.2	0.2	0.3	0.9
10	0.1	0.0	0.0	0.0
11	0.0	0.0	0.0	0.0
Arachidonic	0.4	0.4	0.7	0.4
Erucic	0.2	0.0	0.0	0.0
12	0.1	0.0	0.3	0.1
13	0.9	0.2	0.3	0.6
Lignoceric	0.2	0.4	0.3	0.6
14	0.0	0.0	0.6	0.0
15	0.0	0.0	0.2	0.0
16	0.2	0.2	0.2	0.1
17	0.0	0.0	0.0	0.0
18	0.4	0.0	0.1	0.1
19	0.2	0.2	0.0	0.0
20	0.1	0.0	0.1	0.1
21	0.1	0.1	0.0	0.0
Hydroxystearic	0.0	0.4	0.6	0.4
Ricinoleic	0.3	0.2	0.6	0.0
22	0.2	0.0	0.2	0.1

Appendix 2. Fatty acid composition of the total fatty acids in the blood plasma from hens fed various rations (Percent of total fatty acids.

	Experiment		Experiment II dl- -tocopheryl acetate	
Fatty acid	Basal	Cottonseed oil	Basal	Cottonseed oil
Decanoic	0.0	0.0	0.0	0.0
Lauric	0.4	0.1	0.2	0.2
1	1.0	0.2	0.2	0.2
2	0.0	0.0	0.2	0.2
Myristic	1.2	0.6	0.7	0.4
3	0.0	0.0	0.2	0.2
Myristoleic	0.2	0.2	0.7	0.4
Pentadecanoic	0.6	0.4	0.6	0.1
Palmitic	25.3	28.9	25.4	28.9
Palmitoleic	2.0	1.0	1.8	0.9
Heptadecanoic	0.6	1.0	0.9	0.6
iso-Stearic	0.0	0.0	0.0	0.0
4	0.0	0.0	0.1	0.1
Stearic	15.7	22.0	20.2	19.8
Oleic	33.5	25.4	29.8	25.4
Nonodecanoic	0.0	0.0	0.0	0.0
Linoleic	13.0	16.1	14.2	16.2
5	0.0	0.0	0.1	0.2
Arachidic	1.1	1.0	0.8	0.8
Linolenic	2.8	2.2	1.5	1.5
6	0.0	0.0	0.1	0.1
7	0.0	0.0	0.5	0.5
8	0.0	0.0	0.4	0.9
Behenic	0.0	0.0	0.2	0.4
9	0.0	0.0	0.2	0.9
10	0.0	0.0	0.2	0.6
11	0.0	0.0	0.0	0.0
Arachidonic	2.6	1.6	1.8	1.7

Appendix 3. Fatty acid composition of the total fatty acids in the livers from hens fed various rations. (Percent of total fatty acids.)

Fatty acid	Experiment I: Basal	Experiment I: Cottonseed oil	Experiment II dl- -tocopheryl acetate: Basal	Experiment II dl- -tocopheryl acetate: Cottonseed oil
Decanoic	0.0	0.0	0.0	0.0
Lauric	0.0	0.0	0.0	0.0
1	0.0	0.0	0.0	0.0
2	0.0	0.0	0.0	0.0
Myristic	0.4	0.4	0.4	0.5
3	0.0	0.0	0.0	0.0
Myristoleic	0.2	0.2	0.2	0.2
Pentadecanoic	0.2	0.2	0.2	0.2
Palmitic	20.2	20.0	21.4	21.7
Palmitoleic	2.0	0.7	1.4	1.0
Heptadecanoic	0.2	0.4	0.4	0.2
iso-Stearic	0.0	0.2	0.2	0.2
4	0.1	0.1	0.1	0.1
Stearic	13.4	19.6	18.5	19.5
Oleic	35.4	25.6	29.2	27.8
Nonodecanoic	0.0	0.0	0.0	0.0
Linoleic	15.9	19.6	13.0	13.8
5	0.0	0.0	0.0	0.0
Arachidic	0.2	0.2	0.2	0.2
Linolenic	0.9	0.8	0.8	0.8
6	0.0	0.0	0.0	0.1
7	0.1	0.0	0.0	0.3
8	0.2	0.5	0.4	0.4
Behenic	0.0	0.0	0.0	0.0
9	0.2	0.2	0.2	0.2
10	0.4	0.6	0.6	0.6
11	0.0	0.0	0.0	0.0
Arachidonic	4.8	4.8	4.2	3.4
Erucic	0.0	0.0	0.0	0.0
12	0.0	0.0	0.0	0.0
13	0.2	0.2	0.1	0.1
Lignoceric	0.2	0.3	0.1	0.2
14	0.0	0.0	0.0	0.0
15	0.0	0.0	0.1	0.0
16	0.4	0.8	0.4	0.4
17	0.0	0.0	0.0	0.0
18	0.4	0.9	0.5	0.6
19	0.1	0.0	0.0	0.0
20	0.2	0.2	0.2	0.2
21	0.0	0.1	0.0	0.1
Hydroxystearic	2.7	2.7	2.3	2.0
Ricinoleic	0.6	0.7	0.1	0.3
22	0.1	0.1	0.0	0.0

Appendix 4. Fatty acid composition of the total fatty acids in the ovaries from hens fed various rations (Percent of fatty acids).

	Experiment I		Experiment II dl- -tocopheryl acetate	
Fatty acids	Basal	Cottonseed oil	Basal	Cottonseed oil
Decanoic	0.0	0.0	0.0	0.0
Lauric	0.0	0.0	0.0	0.0
1	0.0	0.0	0.0	0.0
2	0.0	0.0	0.0	0.0
Myristic	0.4	0.4	0.4	0.4
3	0.0	0.0	0.0	0.0
Myristoleic	0.2	0.1	0.2	0.2
Pentadecanoic	0.1	0.1	0.1	0.1
Palmitic	21.5	21.0	21.1	22.1
Palmitoleic	0.4	1.0	1.0	0.7
Heptadecanoic	0.0	0.1	0.0	0.1
iso-Stearic	0.0	0.0	0.0	0.0
4	0.1	0.1	0.1	0.1
Stearic	10.8	15.6	12.2	16.0
Oleic	42.1	32.4	37.8	33.2
Nonodecanoic	0.0	0.0	0.0	0.0
Linoleic	17.2	21.2	19.0	18.4
5	0.0	0.0	0.0	0.0
Arachidic	0.2	0.2	0.4	0.1
Linolenic	1.2	1.0	1.2	0.8
6	0.0	0.0	0.0	0.0
7	0.0	0.0	0.0	0.0
8	0.2	0.4	0.4	0.5
Behenic	0.0	0.0	0.0	0.0
9	0.1	0.1	0.1	0.2
10	0.4	0.5	0.4	0.4
11	0.0	0.0	0.0	0.0
Arachidonic	2.0	3.2	2.4	2.2
Erucic	0.5	0.0	0.0	0.0
12	0.0	0.0	0.0	0.0
13	0.1	0.4	0.8	1.8
Lignoceric	0.1	0.1	0.1	0.2
14	0.0	0.0	0.0	0.0
15	0.0	0.0	0.0	0.0
16	0.3	0.3	0.2	0.2
17	0.0	0.0	0.0	0.0
18	0.4	0.3	0.3	0.3
19	0.0	0.0	0.0	0.0
20	0.3	0.2	0.3	0.2
21	0.0	0.0	0.0	0.0
Hydroxystearic	1.9	1.8	1.6	1.2
Ricinoleic	0.2	0.1	0.1	0.2
22	0.0	0.0	0.0	0.0

Appendix 5. Fatty acid composition of the total fatty acids in egg yolks from hens fed various rations (Percent of total fatty acids).

	Experiment I		Experiment II dl- -tocopheryl acetate	
Fatty acid	Basal	Cottonseed oil	Basal	Cottonseed oil
Decanoic	0.0	0.0	0.0	0.0
Lauric	0.0	0.0	0.0	0.0
1	0.0	0.0	0.0	0.0
2	0.0	0.0	0.0	0.0
Myristic	0.4	0.4	0.4	0.4
3	0.0	0.0	0.0	0.0
Myritoleic	0.2	0.2	0.2	0.2
Pentadecanoic	0.0	0.0	0.1	0.0
Palmitic	20.4	21.4	20.6	21.0
Palmitoleic	1.8	1.2	3.4	1.4
Heptadecanoic	0.0	0.0	0.0	0.0
iso-Stearic	0.0	0.0	0.0	0.0
4	0.0	0.0	0.0	0.0
Stearic	9.9	10.8	9.8	13.4
Oleic	41.2	41.8	40.0	40.8
Nonodecanoic	0.0	0.0	0.0	0.0
Linoleic	18.2	17.2	18.8	16.5
5	0.0	0.0	0.0	0.0
Arachidic	0.0	0.4	0.0	0.0
Linolenic	1.1	1.1	1.3	0.7
6	0.0	0.0	0.0	0.0
7	0.2	0.2	0.2	0.2
8	0.0	0.0	0.0	0.0
Behenic	0.0	0.0	0.0	0.0
9	0.0	0.0	0.0	0.1
10	0.2	0.2	0.2	0.2
11	0.0	0.0	0.0	0.0
Arachidonic	2.4	2.3	2.3	2.1
Erucic	0.0	0.0	0.0	0.0
12	0.0	0.0	0.0	0.0
13	0.2	0.2	0.1	0.1
Lignoceric	0.0	0.1	0.1	0.0
14	0.0	0.0	0.0	0.0
15	0.0	0.0	0.0	0.0
16	0.3	0.2	0.2	0.2
17	0.0	0.0	0.0	0.0
18	0.3	0.3	0.2	0.2
19	0.0	0.0	0.0	0.0
20	0.4	0.4	0.2	0.3
21	0.0	0.0	0.0	0.0
Hydroxystearic	1.3	1.9	1.9	1.6
Ricinoleic	0.4	0.1	0.1	0.0
22	0.0	0.0	0.0	0.0

Appendix 6. Fatty acid composition in the contents of the gastrointestinal tract and selected tissues from hens on the basal ration only. (Percent of total fatty acids).

				Experiment I						
				Intestine						
Fatty acid	Ration	Crop	Gizzard	1	2	3	Feces	Plasma	Liver	Ovary
Decanoic	0.0	0.0	0.0	0.0	0.1	0.2	0.0	0.0	0.0	0.0
Lauric	0.0	0.3	0.2	0.0	0.1	0.5	0.0	0.2	0.0	0.0
1	0.1	0.0	0.1	0.0	0.0	0.1	0.0	0.3	0.0	0.0
2	0.0	0.0	0.1	0.0	0.2	0.1	0.1	0.0	0.0	0.0
Myristic	0.8	1.7	0.7	0.3	0.8	1.0	0.8	0.6	0.3	0.4
3	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0
Myristoleic	0.3	0.2	0.2	0.1	0.4	0.4	0.2	0.2	0.2	0.2
Pentadecanoic	0.1	0.0	0.0	0.1	0.4	0.4	0.2	0.2	0.2	0.2
Palmitic	15.6	20.0	16.4	19.5	22.8	13.3	26.2	26.8	19.4	20.6
Palmioleic	1.8	1.8	1.0	0.1	0.4	0.9	1.8	1.2	1.4	1.4
Heptadecanoic	0.1	0.0	0.4	0.1	1.0	0.6	0.4	0.6	0.3	0.0
iso-Stearic	0.0	0.0	0.1	0.0	1.1	0.5	2.0	0.0	0.2	0.0
4	0.1	0.2	0.2	0.0				0.0	0.1	0.1
Stearic	4.3	5.7	5.7	23.9	23.1	12.6	9.0	15.4	14.6	10.0
Oleic	27.8	26.5	23.9	19.1	14.6	19.1	22.4	30.6	30.1	40.6
Nonodecanoic	0.0	0.0	0.0	0.0	0.6	0.6	0.3	0.0	0.0	0.0
Linoleic	40.8	30.6	34.8	21.0	20.6	29.2	19.4	17.0	16.2	13.6
5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Arachedic	0.2	0.5	0.8	0.0	0.8	1.6	1.4	0.6	0.2	0.2
Linolenic	4.3	3.2	2.8	0.7	1.6	2.2	2.4	2.5	0.8	1.1
6	0.0	0.0	1.0	0.1	0.8	1.0	0.0	0.0	0.0	0.0
7	0.2	1.1	0.4	0.2	0.5	0.6	0.2	0.0	0.4	0.1
8	0.1	0.1	0.4	0.0	0.2	0.2	0.2	0.0	0.4	0.1
Behenic	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0
9	0.2	0.4	0.2	0.1	0.1	0.1	0.6	0.0	0.4	0.2
10	0.1	0.0	0.6	0.1	0.2	0.4	0.5	0.0	0.6	0.2
11	0.0	0.0	0.1	0.0	0.0	0.2	0.0	0.0	0.0	0.0

Appendix 6 Continued ....

Fatty acid	Ration	Crop	Gizzard	Intestine 1	Intestine 2	Intestine 3	Feces	Plasma	Liver	Ovary
Arachidonic	0.4	0.6	0.4	1.3	0.8	2.0	1.4	4.2	7.5	2.4
Erucic	0.2	0.1	0.0	0.4	0.1	0.1	0.4		0.0	0.1
12	0.1	0.0	0.2	0.2	0.0	0.0	0.1		0.0	0.0
13	0.9	0.6	0.4	0.3	1.4	0.6	0.7		0.2	0.0
Lignoceric	0.2	1.0	1.8	1.1	1.8	1.0	0.7		0.2	0.0
14	0.0	0.0	0.6	0.2	0.8	1.3	0.0		0.0	0.0
15	0.0	0.0	0.4	0.1	0.0	0.1	0.1		0.0	0.0
16	0.2	1.6	0.3	0.8	1.9	0.6	1.7		0.6	0.4
17	0.0	0.0	0.0	0.0	0.0	0.0	0.0		0.0	0.0
18	0.4	0.2	0.2	0.1	1.0	0.4	1.2		0.6	0.4
19	0.2	0.2	0.2	0.0	0.0	0.2	1.0		0.0	0.0
20	0.1	0.0	0.0	0.0	0.1	0.4	0.9		0.4	0.4
21	0.1	0.2	1.0	1.1	0.2	0.6	0.0		0.1	0.0
Hydroxystearic	0.0	0.8	0.6	2.0	0.2	1.0	1.1		3.5	2.2
Ricinoleic	0.3	1.3	2.4	6.2	1.8	3.8	2.2		0.8	0.0
22	0.2	0.6	1.0	1.0	0.2	0.8	0.8		0.5	0.0

Appendix 7. Fatty acid composition in the contents of the gastrointestinal tract and selected tissues from hens fed a basal ration plus 3% crude cottonseed oil (Percent of total fatty acids).

				Experiment I						
					Intestine					
Fatty acid	Ration	Crop	Gizzard	1	2	3	Feces	Plasma	Liver	Ovary
Decanoic	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Lauric	0.0	0.0	0.0	0.0	0.1	0.2	0.5	0.0	0.0	0.0
1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0
2	0.0	0.2	0.0	0.0	0.0	0.2	0.6	0.0	0.0	0.0
Myristic	0.8	1.6	0.6	0.3	0.5	0.7	2.7	0.6	0.4	0.3
3	0.0	0.2	0.1	0.1	0.0	0.1	1.4	0.0	0.1	0.0
Myristoleic	0.1	0.2	0.2	0.1	0.2	0.2	0.6	0.2	0.1	0.1
Pentadecanoic	0.0	0.1	0.0	0.2	0.1	0.1	0.2	0.3	0.2	0.1
Palmitic	19.4	23.0	18.2	20.0	17.5	17.0	32.6	28.5	20.0	20.8
Palmitoleic	1.0	1.3	1.3	0.5	1.6	1.2	1.0	0.6	1.2	1.3
Heptadecanoic	0.1	0.3	0.1	0.3	0.2	0.7	0.5	1.6	0.5	0.4
iso-Stearic	0.0	0.0	0.0	0.5	0.2	1.7	0.6	0.0	0.1	0.0
4	0.1	0.1	0.0	0.0	0.1			0.0	0.1	0.0
Stearic	3.4	5.2	3.9	18.1	13.2	14.7	9.4	21.8	16.4	17.4
Oleic	23.4	23.8	25.8	13.6	26.3	19.9	15.7	25.6	25.8	30.6
Nonodecanoic	0.0	0.0	0.0	0.2	0.2	0.8	0.4	0.0	0.0	0.0
Linoleic	46.8	34.7	41.8	38.1	31.8	29.4	14.6	17.5	21.6	23.0
5	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Arachidic	0.2	0.8	0.0	0.6	0.4	0.4	1.4	0.2	0.3	0.2
Linolenic	2.4	1.8	2.6	1.0	1.9	1.1	1.6	1.6	0.9	1.1
6	0.0	1.3	0.2	0.0	0.1	0.6	1.8	0.0	0.1	0.0
7	0.0	0.2	0.2	0.0	0.2	0.2	0.6	0.0	0.2	0.2
8	0.2	0.0	0.2	0.3	0.2	0.2	0.1	0.0	0.3	0.2
Behenic	0.0	0.1	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0
9	0.2	0.1	0.2	0.2	0.2	0.2	0.1	0.0	0.2	0.1
10	0.0	0.1	0.4	0.2	0.2	0.3	0.6	0.0	0.6	0.4
11	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Arachidonic	0.4	0.4	0.4	2.8	1.7	2.3	0.6	1.4	5.2	2.7

Appendix 7. Continued ....

Fatty acid	Ration	Crop	Gizzard	Intestine 1	Intestine 2	Intestine 3	Feces	Plasma	Liver	Ovary
Erucic	0.0	0.0	0.2	0.1	0.4	0.2	0.2		0.1	0.0
12	0.0	0.1	0.0	0.0	0.0	0.2	0.0		0.0	0.0
13	0.2	0.2	0.4	0.4	0.4	0.7	1.4		0.1	0.0
Lignoceric	0.4	0.4	0.5	0.4	0.2	0.6	1.9		0.2	0.2
14	0.0	0.4	0.2	0.4	0.2	0.4	0.0		0.0	0.0
15	0.0	0.1	0.0	0.0	0.0	0.6	0.0		0.0	0.0
16	0.2	0.6	0.2	0.5	0.2	0.7	2.0		0.8	0.3
17	0.0	0.0	0.0	0.0	0.0	0.2	0.0		0.0	0.0
18	0.0	0.4	0.2	0.2	0.2	0.4	1.0		1.2	0.2
19	0.2	0.4	0.0	0.1	0.0	0.2	1.2		0.1	0.0
20	0.0	0.2	0.2		0.0	0.2	0.8		0.2	0.1
21	0.1	0.0	0.2		1.3	0.2	0.0		0.1	0.0
Hydroxystearic	0.4	0.3	0.7		0.1	1.2	1.2		2.8	0.8
Ricinoleic	0.2	0.0	0.5		0.1	1.0	5.4		0.0	0.0
22	0.0	1.6	0.1		0.1	0.7	2.1		0.1	0.0

Appendix 8. Fatty acid composition in the contents of the gastrointestinal tract and selected tissues from hens fed basal ration plus dl-α-tocopharyl acetate (Percent of total fatty acids).

				Experiment II Intestine						
Fatty acid	Ration	Crop	Gizzard	1	2	3	Feces	Plasma	Liver	Ovary
Decanoic	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Lauric	0.1	0.2	0.3	0.0	0.1	0.0	0.4	0.2	0.0	0.0
1	0.1	0.1	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0
2	0.0	0.1	0.1	0.0	0.2	0.0	0.1	0.0	0.0	0.0
Myristic	0.3	0.8	1.0	0.8	0.6	0.8	1.9	1.0	0.4	0.4
3	0.0	0.0	0.0	0.0	0.1	0.5	2.0	0.4	0.0	0.0
Myristoleic	0.2	0.2	0.2	0.2	0.3	0.4	0.5	0.8	0.2	0.2
Pentadecanoic	0.1	0.2	0.0	0.2	0.4	0.2	0.6	0.3	0.2	0.1
Palmitic	18.1	17.6	18.0	13.6	19.8	17.9	21.3	26.7	20.7	21.3
Palmitoleic	0.4	1.5	1.2	0.8	0.4	0.9	2.2	1.2	1.3	1.2
Heptadecanoic	0.0	0.0	0.1	0.5	0.6	0.6	0.8	1.0	0.2	0.0
iso-Stearic	0.0	0.1	0.0	0.1	0.5	0.8	0.4	0.0	0.2	0.0
4	0.1	0.2	0.1		0.1			0.0	0.2	0.1
Stearic	3.0	4.8	3.8	18.6	16.2	12.3	7.6	21.4	17.0	10.4
Oleic	25.0	25.2	24.9	16.7	13.8	21.8	19.8	24.8	26.2	38.4
Nonodecanoic	0.0	0.4	0.0	0.2	0.3	0.6	0.6	0.0	0.0	0.0
Linoleic	42.0	38.6	33.0	39.4	32.6	35.3	20.1	11.1	20.0	18.8
5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0
Arachidic	0.0	0.2	0.4	0.1	0.5	1.3	1.9	0.4	0.1	0.2
Lenolenic	4.0	3.4	2.4	1.4	1.5	2.0	2.0	0.6	0.7	1.2
6	0.0	0.1	1.2	0.0	1.1	0.0	2.0	0.1	0.0	0.0
7	0.6	0.4	0.4	0.2	0.2	0.2	0.5	0.5	0.1	0.1
8	0.0	0.2	0.2	0.2	0.2	0.4	0.6	0.4	0.4	0.2
Behenic	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.3	0.6	0.0
9	0.3	0.1	0.3	0.2	0.2	0.2	0.6	0.4	0.2	0.0
10	0.0	0.2	0.0	0.1	0.2	0.1	0.6	0.2	0.8	0.4
11	0.0	0.0	0.3	0.1	0.2	0.2	0.9	0.0	0.0	0.0

Appendix 3. Continued ....

Fatty acid	Ration	Crop	Gizzard	Intestine 1	Intestine 2	Intestine 3	Feces	Plasma	Liver	Ovary
Arachidonic	0.7	0.4	0.0	1.6	1.6	2.6	1.2	1.5	6.3	2.9
Erucic	0.0	0.1	0.0	0.0	0.0	0.1	0.2	0.2	0.0	0.0
12	0.3	0.0	0.0	0.2	0.0	0.1	0.3	0.0	0.0	0.0
13	0.3	0.4	0.4	0.8	0.8	0.6	1.1	0.2	0.1	2.8
Lignoceric	0.8	0.8	0.7	0.6	0.4	0.6	0.4	0.2	0.2	0.0
14	0.6	0.2	0.6	0.0	0.4	0.2	0.4	0.2	0.0	0.0
15	0.2	0.4	0.2	0.1	0.2	0.0	0.0	0.0	0.0	0.0
16	0.2	0.8	0.4	0.2	0.5	0.4	1.1	0.2	0.8	0.1
17	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0
18	0.1	0.2	0.4	0.2	0.2	0.4	1.0	0.2	0.8	0.1
19	0.0	0.0	0.3	0.1	0.6	0.0	0.0	0.1	0.0	0.0
20	0.1	0.5	0.3	0.2	0.3	0.2	0.6	0.2	0.2	0.1
21	0.0	0.0	0.3	0.1	0.6	0.0	0.0	0.1	0.0	0.0
Hydroxystearic	0.6	0.2	0.8	1.1	1.2	1.2	1.6	1.3	2.8	0.4
Ricinoleic	0.6	0.8	1.2	0.6	2.8	0.6	2.3	3.9	0.0	0.4
22	0.2	0.2	0.1	0.2	0.6	0.1	1.8	0.0	0.0	0.1

Appendix 9. Fatty acid composition in the contents of the gastrointestinal tract and selected tissues from hen fed basal ration plus 3% crude cottonseed oil and dl-α-tocopheryl acetate (Percent of total fatty acids).

	Experiment II									
				Intestine						
Fatty acid	Ration	Crop	Gizzard	1	2	3	Feces	Plasma	Liver	Ovary
Decanoic	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Lauric	0.1	0.0	0.2	0.0	0.0	0.0	0.1	0.2	0.0	0.0
1	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.2	0.0	0.0
2	0.0	0.2	0.1	0.0	0.0	0.0	0.1	0.2	0.0	0.0
Myristic	0.8	1.0	1.0	0.4	0.3	0.9	0.4	0.6	0.4	0.4
3	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.2	0.0	0.0
Myristoleic	0.2	0.2	0.2	0.1	0.3	0.2	0.2	0.3	0.1	0.1
Pentadecanoic	0.2	0.1	0.0	0.1	0.1	0.2	0.3	0.1	0.1	0.1
Palmitic	18.5	22.1	18.9	20.2	17.7	21.1	16.5	23.4	22.2	24.0
Palmitoleic	2.0	1.4	1.4	0.6	0.8	1.5	0.9	1.0	1.3	0.4
Heptadecanoic	0.0	0.2	0.2	0.4	0.7	0.0	0.6	0.6	0.4	0.0
iso-Stearic	0.0	0.8	0.0	0.2	0.4	1.0	0.2	0.0	0.2	0.1
4	0.0		0.2	0.2	0.6	0.0	0.1	0.0	0.1	0.1
Stearic	3.5	3.3	3.4	14.0	11.4	12.8	5.8	18.4	19.2	16.8
Oleic	22.6	23.2	25.4	12.4	14.2	20.9	20.6	23.0	28.7	32.4
Nonodecanoic	0.0	0.0	0.2	1.0	0.5	0.0	0.2	0.0	0.0	0.0
Linoleic	45.0	36.7	34.0	35.8	30.4	21.6	27.6	11.8	18.5	18.1
5	0.0	0.0	0.0	0.0	0.4	0.0	0.4	0.5	0.1	0.0
Arachidic	0.0	0.9	0.4	0.0	0.0	0.6	0.2	0.2	0.1	0.1
Linolenic	2.8	2.1	2.5	1.8	1.6	1.9	3.1	1.4	1.0	1.0
6	0.0	0.5	1.2	0.0	0.2	0.0	1.2	0.0	0.1	0.0
7	0.6	0.2	0.4	0.2	0.3	1.7	0.8	0.4	0.0	0.3
8	0.6	0.1	0.2	0.0	0.3	0.0	1.2	0.4	0.0	0.3
Behenic	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.3	0.0	0.0
9	0.9	0.0	0.2	0.1	0.4	0.8	0.8	0.4	0.3	0.2
10	0.0	0.0	0.2	0.1	0.4	0.4	0.6	0.3	0.3	0.5
11	0.0	0.0	0.1	0.0	0.2	0.0	0.7	0.0	0.0	0.0

Appendix 9. Continued ....

Fatty acid	Ration	Crop	Gizzard	Intestine 1	Intestine 2	Intestine 3	Feces	Plasma	Liver	Ovary
Arachidonic	0.4	0.3	0.4	1.9	1.6	1.0	1.1	2.4	2.6	2.0
Erucic	0.0	0.3	0.1	0.1	0.3	0.1	1.1	0.0	0.1	0.0
12	0.1	0.0	0.0	0.0	0.2	1.2	0.0	0.0	0.0	0.0
13	0.6	0.3	0.2	0.8	0.1	1.7	1.9	1.0	0.2	2.2
Lignoceric	0.6	0.7	0.9	0.6	1.6	1.4	1.5	0.1	0.2	0.1
14	0.0	0.6	1.8	0.0	1.0	0.0	0.0	0.1	0.2	0.0
15	0.0	0.0	0.0	0.0	0.2	0.1	0.1	0.1	0.0	0.0
16	0.1	1.2	0.8	0.6	0.4	0.3	1.3	0.6	0.3	0.2
17	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0
18	0.1	0.3	0.3	0.4	0.1	0.1	0.4	0.6	0.6	0.3
19	0.0	0.5	0.3	0.1	0.1	0.0	0.5	1.4	0.0	0.0
20	0.1	0.5	0.2	0.2	1.0	0.2	0.6	0.4	0.3	0.0
21	0.0	0.0	0.4	0.4	1.7	0.2	0.6	1.2	0.2	0.2
Hydroxystearic	0.4	0.9	0.8	2.2	1.8	2.0	3.0	1.2	1.4	0.6
Ricinoleic	0.0	0.6	1.2	3.3	3.0	6.1	2.3	2.2	0.5	0.1
22	0.1	0.7	2.2	0.8	0.2	0.3	1.9	0.2	0.1	0.0