Studies on Rancidity[1]

I—The Influence of Air, Light, and Metals on the Development of Rancidity

By James A. Emery and R. R. Henley

Biochemic Division, Bureau of Animal Industry, Washington, D. C.

The following paper records experiments on the effect of metals on the development of rancidity in fats and oils.

Fats, even when kept in contact with metals, exposed to light and at summer temperatures, did not become rancid provided that air was excluded. However, the development of rancidity was not prevented when fats, alone and in contact with metals, were kept in a Novy jar through which carbon dioxide, presumably air-free, was passed continuously.

Fats stored, with and without contact with metals, in an atmosphere of oxygen developed rancidity at an earlier date, and the development of rancidity progressed more rapidly, than when the same fats were held in an atmosphere of air, all other conditions being the same.

The development of rancidity was hastened when the fats or oils were in contact with metals, provided there was free access of air or oxygen. Some metals, however, acted more energetically than others. The action of the metal was independent of the corrosive action of the fat upon the metal. In other words, metals hastened the production of rancidity in fats even when the metals themselves were not attacked.

Light was necessary for the development of rancidity in fats exposed to air and not in contact with metals, but fats stored in contact with metals developed rancidity even when protected from light. In other words, light in the absence of metals appeared to exert the same effect as was exerted by metals in the absence of light.

In one test it was indicated that the direct part taken by moisture in the development of rancidity, at least in comparison with the other factors discussed, is negligible.

It may be concluded that air; oxygen, alone or in combination; light; and metals are among the factors which influence the development of rancidity in fats and oils.

During an investigation of the action of fats and oils upon metals[2] it was noted by one of us that rancidity developed more rapidly when these glycerides were held in metallic containers or in contact with metals than when they were held in glass vessels. Since a search of the literature did not disclose any similar observation by others, the experimental work presented in this paper was conducted.

The detection of rancidity through the sense of smell or of taste, especially in the incipient stage, is not to be relied upon, and therefore in all of the work the Kreis test, which is most sensitive to the chemical changes that finally express themselves in the form of rancidity, was applied at the time the odor was noted. In this test 2 cc. of the fat or oil under examination are dissolved in 2 cc. of a 1 per cent solution of phloroglucinol in ether, 2 cc. of commercial hydrochloric acid are added, and the whole is well shaken, the appearance of any color being noted. Rancid fats cause the development of a more or less pronounced pink shade, the degree of change in the fat being indicated by the depth of color produced. No color is given by freshly prepared fats.

Inasmuch as rancidity was recognized as being due to chemical changes in the fats, the various factors which, during the progress of the investigation, appeared to have an influence either in promoting or retarding its production, were noted, with the view of later determining the part played by each in the phenomena produced.

Effect of Metals and Light in Production of Rancidity in Fats Exposed to Air

Series I—The fat used in all of the experiments was rendered in the laboratory from the leaf fat of a freshly killed hog and in each test 60 g. of fat were employed. With but two exceptions (small cups of tin and galvanized iron) the containers were glass vessels of 150-cc. capacity. The metals used were in sheet form, cut approximately of the same size, and rolled into half cylindrical shapes which, when placed on end in the fat or oil, projected slightly above the surface.

Expt. A—Three glass beakers, one containing lard and lead, one lard and copper, and the third lard alone, covered to exclude dust, were placed on a laboratory table exposed to light.

Expt. B—A beaker containing lard and lead, and one containing lard alone, also covered, were placed in a dark closet situated directly under the table mentioned in Expt. A.

Expt. C—Lard in a galvanized iron cup, lard in a tin-plated cup, and lard in a glass beaker, all containers being of the same diameter and also covered, were placed in the light on the table above referred to.

On the fifth day and at frequent intervals thereafter the odor of each sample was noted and the Kreis test was applied, with the results shown in Table I.

It will be seen that the fats in contact with metals became rancid much more rapidly than those in contact with glass alone. The rancid odor became apparent in lard and lead on the seventh day, in lard and copper on the sixth day, and in lard alone on the twenty-sixth day; a positive Kreis reaction appeared with lard and lead on the sixth day, with lard and copper before the fifth day, and with lard alone on the twenty-third day. In Tests 4 and 5 the lard and lead gave a positive Kreis reaction on the fifth day, and lard alone on the twenty-seventh day. The same relation between the rate of production of rancidity in fats kept in metallic and in glass containers, is maintained in Tests 6, 7, and 8.

In regard to the effect of light, there appeared to be no marked difference in the rate of production of rancidity in fats kept in the dark and those kept in the light; however, the evidence upon this point, in view of the limited number of tests, cannot be regarded as conclusive.

Effect of Light on Production of Rancidity

Series IV—The results obtained in Series I were considered inconclusive, and since some observers[3] have maintained that light is necessary for the production of rancidity, tests were conducted to settle the question more definitely. The samples were placed in blackened light-tight Erlenmeyer flasks, plugged with cotton, and kept under blackened light-tight beakers. The following are the tests conducted:

[1] Received April 27, 1922. Published with permission of the Department of Agriculture.

[2] James A. Emery, "The Use of Metallic Containers for Edible Fats and Oils," U. S. Dept. Agr., Bur. Animal Ind., 26th Annual Report, **1909**.

[3] Ritsert, *Naturw. Wochenschr.*, Berlin, **5** (1890), 331, 354, 364; Reinmann, *Centr. Bakt. Parasitenk.*, *II Abt.*, **6** (1900), 131, 166, 209; Scala, *Chem. Zentr.*, **1896**, 520; Winckel, *Z. Nahr.-Genussm.*, **9** (1905), 90.

TABLE I—EFFECT OF METALS AND LIGHT IN PRODUCTION OF RANCIDITY IN FATS EXPOSED TO AIR

Date 1912 4/10	Light						Darkness				Light					
	1 Lard and Lead (Beaker)		2 Lard and Copper (Beaker)		3 Lard (Beaker)		4 Lard and Lead (Beaker)		5 Lard (Beaker)		6 Lard in Tin Cup		7 Lard in Galv. Iron Cup		8 Lard (Beaker)	
	Odor	Kreis Test	Odor	Kreis Test	Odor	Kreis Test	Odor	Kreis Test	Odor	Kreis Test	Odor	Kreis Test	Odor	Kreis Test	Odor	Kreis Test
4/15	–	–	–	+3	–	–	–	+2	–	–	–	+1	–	–	–	–
4/16	–	+2	+1	+4	–	–	+1	+3	–	–	+1	+3	...	+1	–	–
4/17	+1	+3	+2	+4	–	–	+2	+4	–	–	+1	+4	+1	+2	–	–
4/18	+2	+4	+2	+4	–	–	+2	+4	–	–	+2	+4	+1	+3	–	–
4/20	+2	+4	+3	+5	–	–	+2	+5	–	–	+2	+5	+2	+3	–	–
4/23	+3	+5	+3	+5	–	–	+2	+5	–	–	+3	+5	+2	+4	–	–
4/26	+3	+5	+3	+5	–	–	+3	+5	–	–	+3	+5	+3	+4	–	–
5/1	...	...	...	...	–	–	...	...	–	–	...	...	+3	+5	–	–
5/3	...	...	...	...	–	–	...	...	–	–	...	...	...	...	–	+1
5/7	...	...	...	...	+2	+1	...	...	–	+2	...	...	...	...	–	+2
5/24	...	...	...	...	...	+4	...	...	...	...	...	...	...	...	+2	+3

– = Negative; + = Positive; suffixed numerals used to indicate degree.

This set consisted of two clear 100-cc. flasks, one of which contained 50 cc. of lard, the other 50 cc. of lard in which a sheet of copper had been placed, and of two blackened 100-cc. flasks, one of which contained 50 cc. of lard alone, and the other 50 cc. of lard and a sheet of copper (2 in. by 2 in.).

These flasks were plugged with cotton, and placed upon the table, the blackened flasks being placed under blackened beakers. After 16 days the first observations were made.

	Odor	Kreis Test
Clear Flask:		
Lard	Good	Very faint
Lard + Cu	Rancid	Intense
Blackened Flask:		
Lard	Good	Negative
Lard + Cu	Rancid	Intense

As the lard in the blackened flask showed no evidence of rancidity, while the lard in the clear flask showed faint evidences of rancidity, the flasks were kept upon the table for 40 days longer.

	Odor	Kreis Test
Clear Flask:		
Lard	Rancid	Intense
Lard + Cu	Very rancid	Very intense
Blackened Flask:		
Lard	O. K.	Negative
Lard + Cu	Very rancid	Intense

The outstanding feature of these tests was that the lard alone in the blackened flask showed no rancidity after 56 days, while the lard in the clear flask was strongly rancid at that time, and probably faintly rancid on the sixteenth day. Further, the lard containing copper in the blackened flask was not quite as rancid after 56 days as was the lard and copper in the clear flask; the difference was so very slight, however, that it may be said that little or no difference exists in the rate of production of rancidity in fats exposed and not exposed to light, when these fats are in contact with metals. A larger number of such tests, with observations made at more frequent intervals, would afford more interesting and more conclusive results than were obtained, and would probably yield valuable information regarding the chemistry of rancidity.

Relative Effect of Air, Carbon Dioxide, and Oxygen in Promoting Rancidity

Series II—Ritsert,[3] who studied the effect of air, carbon dioxide, and other gases on fats held in glass containers, found that next to oxygen, carbon dioxide was the most rapidly absorbed. He noted, however, that, although the fats stored in carbon dioxide developed acidity and a flat taste, they did not become rancid.

It is generally believed that the presence of air, or the oxygen of air, is necessary for the production of rancidity. Donath,[4] whose observations have been confirmed by studies (as yet unpublished) made in this laboratory demonstrated that as a rule fatty acids act upon metals only in the presence of oxygen. The following tests were conducted concerning the rate of production of rancidity in fats stored in atmospheres of air, oxygen, and carbon dioxide:

Fifty grams of freshly rendered leaf lard were placed in each of nine 100-cc. beakers. A sheet of copper was placed in each of three of these, a sheet of tin in each of three others, while to the remaining three no metal was added. The metallic sheets were of uniform size (1.5 in. by 1.5 in.). The beakers were then divided into three groups, each of which consisted of one containing lard and copper, one containing lard and tin, and one containing lard alone. One set was placed on the laboratory table under an open bell jar, another was placed in a Novy jar, through which a stream of oxygen was allowed to flow constantly; and the remaining set was placed in a Novy jar, through which carbon dioxide, obtained by the action of sulfuric acid on marble, was continually being passed. Both the carbon dioxide and oxygen were dried by passing through calcium chloride. Results of these tests are shown in Table II.

In an atmosphere of oxygen, both in the presence of a metal and when no metal was in contact with the fat, rancidity developed at an earlier date, and progressed more rapidly, than in samples held in an atmosphere of carbon dioxide or in air. It was also noted that the fats held in carbon dioxide became rancid a trifle more slowly than did those held in air, although this difference is but slight.

Carbon dioxide had been used in this test solely for the purpose of excluding oxygen. The production of rancidity, and its rather rapid development, in the fats stored in an atmosphere of carbon dioxide was not only not anticipated, but was surprising. While it was believed that the oxygen of the air had been replaced by carbon dioxide, in the Novy jar in which the fats were held, the jar had been opened from time to time for the purpose of extracting samples of fat for examination, and an opportunity was thus afforded for the fat to absorb oxygen. To avoid this the test was repeated in the following manner:

Into each of three 50-cc. beakers, all of the same diameter, 30 cc. of freshly rendered leaf fat which had an acidity of 0.22 per cent (calculated as oleic acid) were added. In one beaker, a square of copper and in a second a square of tin was placed. A third beaker contained the lard alone. The squares of metals each measured 2 in. by 2 in. and were thoroughly cleaned and polished before being placed in the fats.

[4] *Dinglers polytech. J.*, **294** (1894), 186.

TABLE II—RELATIVE EFFECT OF AIR, CARBON DIOXIDE, AND OXYGEN IN PROMOTING RANCIDITY

Date 1912 6/20	Air						Oxygen						Carbon Dioxide					
	Lard and Tin		Lard and Copper		Lard		Lard and Tin		Lard and Copper		Lard		Lard and Tin		Lard and Copper		Lard	
	Odor	Kreis Test	Odor	Kreis Test	Odor	Kreis Test	Odor	Kreis Test	Odor	Kreis Test	Odor	Kreis Test	Odor	Kreis Test	Odor	Kreis Test	Odor	Kreis Test
6/28	–	+2	–	+3	–	–	+1	+3	+1	+4	–	–	–	+2	+1	+3	–	–
7/1	+1	+2	+1	+4	–	–	+1	+3	+1	+5	–	–	–	+2	+1	+3	–	–
7/3	+1	+3	+1	+5	–	–	+2	+4	+2	+5	–	+1	–	+2	+2	+4	–	–
7/5	+2	+4	+2	+5	–	+1	+2	+4	+2	+5	–	+1	+1	+3	+2	+4	–	+2
7/10	+2	+5	+2	+5	–	+1	+2	+5	+2	+5	–	+2	+1	+4	+2	+5	–	+2
7/12	+2	+5	+2	+5	–	+1	+2	+5	+2	+5	+1	+2	+2	+4	+2	+5	+1	+3
7/16	+2	+5	+2	+5	–	+2	+2	+5	+2	+5	+1	+3	+2	+5	+2	+5	+1	+3

A second and third set of beakers, identical in all details with the above described, were prepared at the same time.

One set consisting of beakers containing lard, lard with tin, and lard with copper, was placed on the laboratory table, protected from dust but exposed to light and air.

Another set was placed in a Novy jar containing calcium chloride, and through the jar a stream of oxygen, previously dried by passage through calcium chloride, was continuously passed. It was placed on the table beside the first set.

The third set was placed in a second Novy jar, which contained calcium chloride, and through which a stream of carbon dioxide was continuously passed both day and night. The carbon dioxide was generated in a Kipp generator from marble and sulfuric acid, and was washed and dried before entering the jar. The stream of carbon dioxide was interrupted only when it was necessary to recharge the Kipp generator, and on such occasions the jar was closed to prevent access of air. This Novy jar remained unopened from October 14 to November 21. The fats in the first and second sets were tested for rancidity on October 28 and November 8. The results of the Kreis test are shown in Table IIa.

Again those fats held in a Novy jar through which carbon dioxide was passed continuously, developed rancidity. It is true that the complete absence of air, or oxygen, was not proved, but the amount of residual, or adventitious, air or oxygen present must have been, in comparison with the amount of carbon dioxide, extremely small. These experiments certainly indicate that carbon dioxide may promote the production of rancidity. While this observation was considered important and interesting, time did not permit of a more extended investigation.

Table IIa—Relative Effect of Air, Oxygen, and Carbon Dioxide in Promoting Rancidity

Date 1912 10/14	Atmosphere of Air			Atmosphere of Oxygen			Atmosphere of CO_2		
	Lard	Lard and Tin	Lard and Copper	Lard	Lard and Tin	Lard and Copper	Lard	Lard and Tin	Lard and Copper
	Kreis Test								
10/28	–	–	+5	+3	+4	+5	Not tested	Not tested	Not tested
11/8	–	+3	+5	+5	+5	+5	Not tested	Not tested	Not tested
11/21	+2	+4	+5	+5	+5	+5	+1	+4	+5

Effect of Exclusion of Air on Development of Rancidity

Series III—Since the rate of development of rancidity in fats stored in air and carbon dioxide appeared to be practically the same, the method which had been planned of securing exclusion of air by replacing it with carbon dioxide, both with and without contact with metals, was abandoned. Complete exclusion of air was obtained by completely filling the container with the melted fat and then forcing a cork stopper into the flask. The fat which was forced out was removed by washing with ether, and the cork was then sealed with wax. The effect of the presence of moisture on the rate of development of rancidity was included in this test. In detail the tests were as follows:

First Set—A 20-cc. bottle was filled with lard, and a second one with lard in which three bright copper strips were placed. The bottles were corked and sealed.

Second Set—A 20-cc. bottle was filled with lard, and a second one with lard in which three bright copper strips were placed; 0.2 cc. of water was added to each, and they were sealed and well shaken.

Third Set—A 20-cc. bottle was filled with lard and a second one with lard in which three strips of copper were placed; they were allowed to remain open and exposed to the air.

Fourth Set—A 20-cc. bottle was filled with lard and a second one with lard in which three copper strips were placed; 0.2 cc. of water was added to each, after which they were well shaken, and allowed to remain open and exposed to the air.

The lard used in all of the above tests was freshly rendered from leaf fat and contained 0.22 per cent of free fatty acids calculated as oleic acid. After filling, all bottles were placed upon a laboratory table directly below a window facing the east. They remained upon this table from June 13 to October 1, when they were examined.

First Set—Sealed, no moisture.
Lard alone: Odor, good; Kreis test, extremely faint.
Lard and copper: Odor, good; Kreis test, extremely faint.
No change in acidity was found. Copper had not been attacked.

Second Set—Sealed, 1 per cent water.
Lard alone: Odor, good; Kreis test, negative.
Lard and copper: Odor, good; Kreis test, negative.
Copper showed no evidence of having been attacked. The acidity of the lard alone had increased to 0.44 per cent and of the lard with copper to 0.37 per cent, calculated as oleic acid.

Third Set—Open in air. No moisture.
Lard alone: Odor, rancid; Kreis test, intense.
Lard and copper: Odor, rancid; Kreis test, intense.
The lard of the lard and copper was green in color, showing that the copper had been attacked.

Fourth Set—Open in air, 1 per cent water.
Lard alone: Odor, rancid; Kreis test, strong.
Lard and copper: Odor, rancid; Kreis test, intense.
The copper had been attacked, as was evidenced by the green color of the fat.

It is clearly evident from the foregoing tests that oxygen, either free or combined, is an essential in the production of rancidity in fats, whether metals or moisture, or both, be present. Further, direct sunlight and summer temperatures did not cause the production of rancidity in fats which were protected from the access of air. It will also be noted that of the fats in the sealed containers, those in which moisture was present became rancid somewhat more slowly.

Production of Rancidity in Corn Oil and Cottonseed Oil as Affected by Metals

Series V—Corn oil and cottonseed oil do not become rancid as rapidly as animal fats, perhaps on account of the fact that they contain glycerides of the lesser saturated fatty acids. To determine the influence of metals on the production of rancidity in these oils, the following test was conducted:

Cottonseed oil (20-cc. samples) was placed in each of seven 50-cc. glass beakers, and in each of six of these was placed a weighed 0.75-in. square of iron, lead, tin, zinc, copper, and aluminium, respectively. To the remaining beaker no metal was added. They were then allowed to remain for 3 wks. upon a laboratory table exposed to light, when the metals were removed and the loss in weight of each metal, the acidity, and the rancidity of the oil were determined. The results are shown in Table III.

At the same time and under identical conditions, similar tests were conducted with corn oil and lard. In the case of lard, however, changes in acidity were not determined.

The cottonseed oil (iodine value = 105.36; acid value = 0.17) and the corn oil (iodine value = 119.1; acid value = 0.86) were purchased in the open market and represent a good grade of the commercial product.

Rancidity failed to develop in any one of the three samples in which no metal had been placed, although the acidity of both the corn oil and cottonseed oil was slightly diminished. Of the samples of cottonseed oil in contact with metals, those in which iron, lead, and copper had been placed showed, by the Kreis test, marked rancidity, while the one with zinc gave only a slight positive reaction. The samples containing aluminium and tin, when subjected to this test, afforded a blue color, not before noted, but which, nevertheless, was regarded as due to the development of rancidity, or at least to a similar change in the fat. The acidity of all the samples of cotton-

TABLE III—EFFECT OF METALS ON PRODUCTION OF RANCIDITY IN COTTONSEED OIL AND CORN OIL[1]

		Iron			Lead			Copper			Zinc			Aluminium			Tin			Oil or Fat	
Fat or Oil	Original Acidity	Loss Mg.	Acidity	Kreis Test	Loss Mg.	Acidity	Kreis Test	Loss Mg.	Acidity	Kreis Test	Loss Mg.	Acidity	Kreis Test	Loss Mg	Acidity	Kreis Test	Loss Mg.	Acidity	Kreis Test	Acidity	Kreis Test
Cottonseed	0.17	0.0	0.05	+2	68.3	0.62	+4	0.0	0.05	+5	1.4	0.11	+1	0.0	0.05	(Blue)	0.0	0.11	(Blue)	0.11	−
Corn	1.86	0.0	1.86	−	44.0	1.69	+1	3.1	1.18	+4	12.1	1.57	−	0.0	2.25	−	0.1	1.35	+3	1.69	−
Lard	..	0.0	..	+4	63.9	..	+5	0.0	..	+5	0.0	..	+3	0.0	..	+4	0.3	..	+3	..	−

[1] Three-week exposure.

TABLE IV—EFFECT OF COATINGS ON METALS IN PRODUCTION OF RANCIDITY

Date 1912 8/1	Lard (Glass Cup)		Lard (Bakelized Tin Cup)		Lard (Tin Cup)		Lard (Bakelized Galv. Iron Cup)		Lard (Galv. Iron Cup)		Lard and Bakelized Copper (Glass Cup)		Lard and Copper (Glass Cup)	
	Odor	Kreis Test	Odor	Kreis Test	Odor	Kreis Test	Odor	Kreis Test	Odor	Kreis Test	Odor	Kreis Test	Odor	Kreis Test
8/6	−	−	−	−	−	−	−	−	−	+2	−	+2	−	+2
8/8	−	−	−	−	−	−	−	−	−	+2	−	+2	+1	+3
8/10	−	−	−	−	+1	+3	−	−	−	+2	−	+3	+1	+3
8/13	−	−	−	−	+2	+3	−	−	+1	+3	−	+3	+2	+4
8/15	−	−	−	+1	+2	+4	−	−	+2	+3	+1	+4	+3	+4
8/17	−	−	−	+2	+2	+4	−	−	+2	+4	+1	+5	+3	+5
8/20	−	−	−	+3	+2	+4	−	−	+2	+4	+1	+5	+3	+5
8/22	−	−	−	+3	+3	+5	−	−	+3	+5	+2	+5	+3	+5
8/24	−	−	−	+3	+3	+5	−	−	+3	+5	+3	+5	...	...
8/27	−	−	+1	+4	+3	+5	−	+1	+3	+5	([1])	...	...	...
8/29	−	+1	+2	+5	+3	+5	−	+2	+3	+5	...	...	...	...
8/31	−	+2	+2	+5	+3	+5	+1	+3	...	...	...	...	...	...

[1] Contained 1.2 mg. copper per 50 g. fat.

seed oil decreased with the exception of that of the oil in contact with lead. Lead in cottonseed oil lost 68.3 mg. in weight, and zinc 1.4 mg.; the other metals suffered no determinable loss. It appears from this that cottonseed oil in contact with metals develops rancidity more rapidly than cottonseed oil stored in glass alone, even when the metals suffer no apparent loss of weight.

Corn oil was not affected as much by contact with metals as was the cottonseed oil; only those samples in contact with lead, copper, and tin developed rancidity. Lead, copper, and zinc lost appreciably in weight; tin, but slightly, while iron and aluminium showed no loss. The original acidity of the corn oil remained unchanged in contact with iron, while in contact with lead, zinc, tin, and copper, and even in glass alone, decreased acidities resulted. The oil in contact with aluminium, however, increased in acidity. It appears that contact with metals promotes development of rancidity in corn oil. Some metals act more energetically than others, but in no case is corn oil as greatly affected as cottonseed oil under similar conditions.

All of the lard samples in contact with metals developed rancidity even when the metal itself was apparently not attacked, while rancidity did not develop in the lard not in contact with a metal.

It will be further noted that the oils in contact with copper developed rancidity more rapidly than those in contact with other metals; those in contact with tin and aluminium were the least affected.

The Value of Protective Coatings on Metal in Preventing Production of Rancidity

SERIES VI—As metallic containers for fats are by far the most common, having been found by experience to be the most adaptable, and as contact of metals with fats undoubtedly hastens the development of rancidity, an attempt was made to determine the influence of a protective coating of lacquer. The lacquer selected for this purpose was bakelite and was applied in the manner directed by the manufacturer; that is, the thoroughly cleansed metal was painted with the lacquer and, after being dried, was heated while under air pressure.

Copper, tin, and galvanized iron were employed in the test. Portions of lard (100 g.) were placed in a lacquered tin cup, in an untreated tin cup, in a lacquered galvanized iron cup, and in an untreated galvanized iron cup, all cups being of practically the same size. In the test with copper both lacquered and untreated copper strips of the same size and shape were submerged in separate 50-g. portions of lard contained in 100-cc. glass beakers. With 50 g. of the lard in a glass beaker as a check, all of the samples were placed upon a laboratory table exposed to the light, portions being removed from time to time by carefully melting, stirring, and withdrawing small equivalent amounts of the fat. The results of rancidity tests are shown in Table IV.

It will be noted that in each case rancidity developed earlier in the fat exposed to the unlacquered metal. The difference in the time of appearance of rancidity in the fat exposed with the protected and unprotected copper strips is very slight; however, the lard containing the protected copper strip showed at an early date the green color of copper soaps, and on analysis was found to contain 2.4 mg. of copper per 100 g. of fat, showing that the bakelite coating upon the strips was not intact.[5]

The greatest difference in the time of the appearance of rancidity is found in the case of the galvanized iron cups. In the unprotected galvanized iron cup, the lard was faintly rancid by the Kreis test on the sixth day, while the lard in the protected cup did not give a faintly positive Kreis test until between the twenty-seventh and twenty-ninth days; and, as the lard in glass showed a very faint Kreis reaction on the twenty-ninth day, the protective coating on the galvanized iron cup was evidently efficient.

In the tin cups, the lard in the unprotected cup showed a faint Kreis test on the sixth day, and in the protected cup, between the seventeenth and twentieth days.

These tests indicate:

1—The production of rancidity in fats is hastened by contact with metals.

2—A continuous and unbroken coating of lacquer upon a metallic container effectually prevents the effect of the metal in promoting rapid production of rancidity.

[5] Copper strips lacquered with bakelite, immersed in lard, were kept exposed to air for several weeks at an elevated temperature of 70° C. with complete protection of the metal.

The American Relief Administration recently forwarded to Russia a consignment of scientific literature selected by various bureaus of the Department of Agriculture, for the purpose of supplying Russian men of science with the results of American scientific work accomplished since 1914. Since that time very few scientific publications from America have entered Russia. Arrangements were made through the American Committee to Aid Russian Scientists with Scientific Literature.