# SOME FACTORS AFFECTING RANCIDITY

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Rancidity is probably of more importance in biscuit and cracker manufacture than in bread, cake or pie baking, because of the longer "shelf-life" or period of time before the product is consumed. The problem is a long way from being solved, but much knowledge of importance has been gained in recent years, and the manufacturers of shortenings for our industry have made remarkable improvements, particularly in the last three or four years.

One of the difficulties of carrying out experimental work on the problem is the impossibility of making a soda cracker on a laboratory scale which is at all comparable to those made in the plant, and it is the soda cracker which gives the most trouble with rancidity. Experience in the industry, as well as some unpublished laboratory work by one of the authors of this paper, gives every indication that sugar is a powerful anti-oxidant. The quantity of sugar necessary to show strong anti-oxidant properties is so large that it could never be added solely for that purpose; the stability given by the sugar is incidental to the use of the sugar for its sweetening properties. For this reason, rancidity of cookies such as vanilla wafers, hard sweets and shortbreads is far less common than that of soda crackers.

The problem of rancidity is therefore particularly acute with soda crackers which are almost the only "non-sweet" product of importance in our industry.

Triebold[1], and Triebold and Bailey[2,3], have reported on attempts to correlate the keeping properties, induction periods, and chemical constants of shortenings with the keeping properties of soda crackers made with the same shortenings. The correlation between the induction period of the shortenings and the keeping properties of the crackers was fair, but there were important exceptions difficult of explanation.

The work reported here is not a connected research, but developed from an attempt on our part, in co-operation with the larger packers, to produce a lard with more stability than those made in the usual manner. It was thought that greater stability of the lard would be reflected in the crackers, increasing the resistance of the latter to rancidity.

The flavor and shortening value of lard have made it a desirable and popular shortening for crackers.

### Methods of Testing the Stability of Shortenings and Crackers

The method used for testing the shortenings reported in this survey was the Schaal Test, which is briefly as follows:

A 50 gm. sample of the fat in a glass jar having a glass cover is kept in an electrically heated cabinet held at 145° F. and examined daily for a rancid odor. The samples are kept in the cabinet for 2 or 3 days after rancidity is first noted, in order to make sure that true rancidity has developed. The number of days before the first signs of true rancidity appear is considered the keeping time of the fat.

A similar accelerated test for crackers, and a test which has been used by the Technical Institute for several years, is as follows (Rabak Test):

Eight or ten crackers are heated on a flat pan in a gas oven for 7 minutes at 300° F. The pan of crackers is allowed to stand on the laboratory table for 3 hours. The crackers are then placed, in unbroken condition, if possible (large crackers may have to be broken), into one pint Mason jars, are incubated at 145° F. and the odor noted daily until rancidity develops.

As a result of many hundreds of tests on the various types of shortenings and crackers made with them in cracker plants, we find the keeping times of at least 90% of both crackers and shortenings fall inside the following limits:

Table 1 Factory Crackers

| Type of Shortening | Keeping Time: Shortenings (Days) | Keeping Time: Crackers (Days) |
|---|---|---|
| Lard | 5 to 10 | 2 to 6 |
| Oleo Oil | 5 to 8 | 6 to 15 |
| All-hydrogenated (B. & C. type) | 30 to 120 | 15 to 40 |

Attention is called to the fact that oleo oils themselves keep no longer than lards, but the crackers keep two or three times as long. This will be discussed later.

The following table (2) shows the keeping times of several individual shortenings and the keeping times of crackers made commercially containing the same lot of shortening:

Table 2. Factory Crackers

| | Keeping Time: Shortening (Days) | Keeping Time: Crackers (Days) |
|---|---|---|
| Prime Steam Lard (1792) | 7 | 4 |
| Prime Steam Lard (1775) | 7 | 2 |
| Lard (1508) | 8 | 2 |
| Dry Rendered Lard (1035) | 9 | 7 |
| Prime Steam Lard (2034) | 13 | 5 |
| All-hydrogenated shortening (regular) | 15 | 13 |
| Special Lard (1038) | 24 | 9 |
| Fresh, unrefined corn oil | 24 | rancid when rec'd at lab. |
| All-hydrogenated shortening (regular) | 24 | 15 |
| All hydrogenated shortening (regular) | 24 | 22 |

The results with the special lard No. 1038 and the unrefined corn oil are interesting. Both of these products contained substantial amounts of anti-oxidants. The special lard was unrefined and unbleached, and was rendered in such a way as to preserve the anti-oxidants known to be present in certain portions of fatty tissue in the hog. Yet the crackers containing this lard kept very little longer than those made with dry rendered lard No. 1035 of much inferior keeping properties. An even more striking illustration of the almost complete destruction of a natural anti-oxidant is the result with the corn oil. This oil, freshly pressed from dry-milled corn germ, is high in natural anti-oxidants according to Mattill[4]. The oil itself showed remarkable stability, but the crackers were rancid when received at the laboratory. The all-hydrogenated shortenings in Table 2 were not of the biscuit and cracker type (especially made for high stability). The shortenings themselves kept no better than the special lard or corn oil, but the crackers kept far longer.

As mentioned earlier, we really started this work in an attempt to develop a lard of superior keeping qualities. Several tierces of the special lard No. 1038, mentioned above, were made into crackers in different biscuit and cracker plants. Keeping tests on the lard itself showed that it had keeping properties from 50% to 100% greater than good prime steam lard. The crackers were tested along with the crackers made with the lard used regularly, which was usually a good prime steam lard. The comparative results of these tests are shown in Table. 3.

While there is evidence in some cases that the special lard increased the stability of the crackers, the increase was not great, and of no particular importance practically. In fact, in Plant A, Tests Nos. 1 and 3, the apparent improvement may have been due chiefly to unusually poor regular lard.

We should mention here that we have experimented with two other anti-oxidants used for "stabilizing" lard. One, derived from vegetable sources, acts precisely like the natural anti-oxidants in lard and corn oil in that it substantially increases the stability of lard but is completely lost when the lard is used in crackers. The other, of unknown source, does carry through into the cracker. Even with this anti-oxidant, it is not possible to raise the stability of lard crackers to anything like that obtained with the better all-hydrogenated shortenings.

We do not wish the inference to be drawn from these data that lards of poor stability are satisfactory for crackers. We are convinced that only lards of high quality and good stability should be used in cracker products.

In order to check these results under carefully controlled conditions, a method for making laboratory crackers was worked out. Tests have shown that this method gives good checks on the same shortening used in different batches.

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[1]Triebold, H. O. Rancidity, 1931. Cereal Chemistry 8, 518–532.
[2,3]Triebold and Bailey. Cereal Chemistry 9, p. 50 and p. 91 (1932).
[4]Mattill and Crawford. Ind. and Eng. Chem., April 1930, 22 p. 341–4.

The very small quantity of triacontanic acid found in the oil was probably not in combination with glycerine but as a constituent of a wax which was removed from the palm fruit during the expression of the oil.

**Summary**

The chemical and physical characteristics, as well as the percentages of the fatty acids in Pataúa palm oil, have been determined. The sample of authentic oil studied contained 79.94 per cent of unsaturated acids in which oleic acid predominated, there being only 3.4 per cent of linoleic acid. The saturated acids, which amounted to 14.45 per cent, consisted of a mixture of palmitic and stearic acids along with a very small quantity of triacontanic acid, the source of which was probably the fruit wax dissolved in the oil.

Attention is called again to the similarity of this fine edible oil and olive oil, in appearance, characteristics, and composition, insofar as the proportions of the major fatty acids are concerned.

## U. S. Rubber Promotes Men

H. A. Everlien, sales manager, mechanical goods division, U. S. Rubber Products, Inc., has announced the appointment of H. S. McPherson as manager of mechanical sales in the St. Louis district. Mr. McPherson, who has been with the company for over 15 years, was formerly in charge of mechanical sales in the Boston district. Prior to that he held important posts in the export department in Australia, South America and the Far East. W. G. Mueller, who has enjoyed for more than 25 years an interesting and successful record as a salesman with the company, largely in the Connecticut territory, has been promoted to be manager of mechanical sales, Boston branch of U. S. Rubber Products, Inc.

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Table 3. Factory Crackers

| Plant A | Test No. 1 (Days) | Test No. 2 (Days) | Test No. 3 (Days) | Test No. 4 (Days) |
|---|---|---|---|---|
| Regular lard | 2 | 4 | 2 | 7 |
| Special lard | 4 | 4 | 5 | 9 |
| All-hyd. shortening (B. & C. type) | | | 18 | |
| All-hyd. shortening (B. & C. type) | | | 25 | |
| Plant B | | | | |
| Regular lard | 5 | | | |
| Special lard | 5 | | | |
| Plant C | | | | |
| Regular lard | 3 | | | |
| Special lard | 3 | | | |

### Methods for Making Crackers in the Laboratory

As mentioned above, we have so far been unable to make a laboratory cracker which even remotely approaches the commercial product in texture and appearance. However, it is possible to make a laboratory cracker for keeping test purposes, and by using a control, we probably get better comparative results than is possible in factory tests. A commercial formula is used except for more yeast, as follows:

Sponge

| | |
|---|---|
| Flour | 60 gms. |
| Water | 25 gms. |
| Yeast | ½ gm. |

This is mixed and fermented at 30° C. for 19 hours.

Dough

| | |
|---|---|
| Flour | 40 gms. |
| Shortening | 11 gms. |
| Salt | 1 gm. |
| Soda | ½ gm. |
| Water | 7 gms. |

The soda is dissolved in the water, and the ingredients are thoroughly mixed with the sponge until a smooth dough is obtained. The mixing is best done with the hand, and finished by folding the very stiff dough with both hands about 50 times.

The dough is fermented 5 hours at 30° C. It is rolled to 3/32 inch thickness on a glass plate, without dusting flour, and folded to 3 layers. The triple sheet of dough is turned 90° and cross rolled to 3/32 inch a second time. A third folding and cross rolling completes the rolling operation. Round crackers are then cut out with a thin glass tumbler and dockered with a thin wooden pin. They are baked on clean, flat, ungreased pans at 480° F. until slightly brown. This takes 8 to 9 minutes in our gas oven.

In the following table are given typical data on the keeping tests of various shortenings and laboratory crackers made from them.

Table 4. Laboratory Crackers

| | Days shortening kept | Days laboratory crackers containing same shortening kept |
|---|---|---|
| Prime steam lard No. 3107 | 10 | 13-14 |
| Prime steam lard No. 2311 | 12 | 8 |
| Prime steam lard No. 3413 | 9 | 9 |
| Oleo oil No. 3061 | 7 | 25 |
| Oleo oil No. 3110 | 8 | 22 |
| Oleo oil No. 3066 | 5 | 25 |
| All-hyd. shortening, B. & C. type No. 3106 | 71 | 62 |
| All-hyd. shortening, B. & C. type No. 3020 | 45 | 54 |
| All-hyd. shortening, B. & C. type No. 2039 | 82 | 57 |
| All-hyd. shortening, regular type No. 2048 | 9 | 12 |

Several points are worthy of note in the data shown in Table 4:

1. The laboratory crackers keep much longer than those made in cracker plants. As will be shown later, the absence of metallic contamination in the laboratory crackers partially accounts for this.

2. Again, we find no correlation between stability of shortenings and stability of crackers containing them. Oleo oils themselves show less stability than lards, but the crackers keep much longer. All-hydrogenated shortenings in general have excellent stability, as do the crackers containing them, and the crackers show stability comparable to the stability of the shortenings.

It will be noted that the comparative results of the laboratory crackers from different shortenings are similar to those given by crackers made commercially, as shown in Tables 1, 2 and 3.

### Discussion of Results

The data given prove rather conclusively that the keeping properties of shortenings do not correlate well with the crackers containing them. Triebold, Rudy and Webb[3] showed that a lard may be abused almost to the point of rancidity, but the crackers made with it show the same stability as those made with the original lard. We have shown that certain lards and corn oil, themselves relatively stable, produce crackers of relatively poor stability.

We propose a tentative theory to explain this apparently anomalous situation. We may consider that stability of fats can come from two sources:

1. Anti-oxidants, such as those normally present in unrefined, unbleached lard, and in unrefined corn oil, or "pro-oxidants" formed by abuse of a shortening. Such stability is related to traces of extraneous substances not connected with the composition of the fatty acids.

2. Chemical composition of fatty acids. Tentatively, we may rate the stability of the fatty acids as follows:
the fatty acids in Table 7 on page 220.

In the shortenings themselves, we may have stability affected by both factors, anti-oxidants, and pro-oxidants or fatty acid composition.

When we make crackers, however, we find that, in general (the exception has been noted), stability depends chiefly on the chemical composition of the fatty acids. Anti-oxidants and pro-oxidants may disappear to a great extent during the mixing, fermentation and baking operations. If we apply this theory to the shortenings we have discussed, we find that it explains most of the apparently contradictory results shown earlier.

See Table 8 on page 220.

It might at first glance be thought that the iodine number of a fat should be closely related to the stability in crackers. This is true of normal fats, but by hydrogenation, much glyceride of iso-oleic acid may be produced. This fat has the same iodine number as the glyceride of oleic acid but is far more stable. Thus it is possible to have fats of the same iodine number and quite different stability, a fact well-known to chemists. For the same reason, melting point and stiffness

[3]Triebold, Webb and Rudy, Cereal Chemistry 10, p. 263 (1933).

are not correlated with the stability of fats in crackers where hydrogenation and the presence of the glycerides of iso-oleic acid are concerned.

These facts have been known to and used by manufacturers of the biscuit and cracker all-hydrogenated shortenings for some time. Some biscuit and cracker shortenings are so stable that even when rancidity is detected in the test crackers, the odor is very faint and it takes a week or more before the rancidity can be called definite.

There are factors other than stability of the shortening which affect the stability of crackers. Among these are plant conditions, bacterial infection of doughs, the temperature at which crackers are packed, the type of package, and traces of metallic contamination in doughs. The latter is one of the most powerful in its effect.

**Effect of Traces of Metals on Crackers**

It has long been known that some crackers may become rancid much more quickly than others from the same large dough. In an attempt to explain this, we questioned whether spots of rust from the trough on some of the pieces of dough might cause the ununiform stability. To test this, we made laboratory doughs, fermenting some in glass and others in a rusty trough made from the usual trough metal (steel). The doughs were handled without contact with metal except for the steel trough, were made into crackers, and then tested for stability. The results are shown in Table 5.

Table 5. Laboratory Crackers

| Shortening used | Keeping time of shortening (Days) | In glass — Keeping time of Crackers (Days) | In steel trough — Keeping time of Crackers (Days) |
|---|---|---|---|
| Prime steam lard No. 3107 | 10 | 12 | 5 |
| Prime steam lard | 12 | 8 | 4 |
| Lard containing anti-oxidant | 22 | 18 | 13 |
| Regular all-hyd. | 9 | 12 | 9 |
| B. & C. all-hyd | | 96 | 78 |
| B. & C. all-hyd | 51 | 41 | 40 |
| B. & C. all-hyd | 82 | 57 | 31 |

The data need no comment and check with the results of King, Roschen and Irwin[6], and others on the reduction of the stability of shortenings by traces of metals.

In our early work with laboratory crackers, the sponges and doughs were mixed in a Hobart mixer with a tinned bowl. After fermentation, the doughs were rolled thin and cut with a brass and iron hand cutter built like the cutters used commercially. We soon found that both the mixer and the metal cutter substantially reduced the stability of the crackers. The following data show this. The shortenings used were biscuit and cracker all-hydrogenated shortenings. See Table 6.

Table 6. Laboratory Crackers

| Shortenings | Keeping Time of Crackers — Machine mixed, Metal cutter used (Days) | Hand mixed, Metal cutter used (Days) | Hand mixed, Metal cutter not used (Days) |
|---|---|---|---|
| 2114 | 11 | 17 | 30 |
| 1969 | 33 | 37 | 46 |
| 2111 | 18 | 26 | 42 |
| 2010 | 16 | 16 | 32 |
| 1970 | 16 | 20 | 28 |

Again, the effect on stability of contamination of the doughs by traces of metal is very definite. Whether baking the crackers on steel pans has an effect on the stability is a point we have not investigated. It is the only contact with metal to which our laboratory crackers are subjected at present.

From a practical standpoint, the cracker baker can substantially reduce the metallic contamination from his dough troughs by occasionally lacquering them with a colorless lacquer. This is common practice in some cracker plants at the present time.

**Summary**

1. Data are given showing the relative

[6]King, A. E., Roschen, H. L., and Irwin, W. H., Oil and Soap, Nov. 1933, 10, 204.