paratively small concentrations of soap or other alkali might have on the chlorophyll removal capacity of the bleaching earths. The data are incomplete, however, for these considerations and any discussion as to the magnitude of this effect would be speculative at this time.

It appears, nevertheless, that the bleaching power of an earth for chlorophyll can be determined chemically under certain conditions and that the "acidity" of an earth, as defined in this study, is a definite and quantitative criterion for the adsorption. That within certain limits, in this study, the removal of 95% of the original chlorophyll content — the quantity of earth required to obtain a definite degree of chlorophyll reduction can be calculated providing its ion adsorption characteristics and the bleaching capacity for chlorophyll in oil at any concentration are known. Furthermore, it is possible under these conditions to determine the quantity of any earth required to remove a definite amount of chlorophyll from this same oil, by evaluation of the ion adsorption properties.

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Correlation of Keeping Properties of Shortenings With Keeping Quality of Biscuits*

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THE possibility of the development of rancidity in biscuits and crackers is a subject which has received considerable attention over a period of many years. My contact with the industry has covered the past 26 years, and during that time there has been a never ceasing effort to improve the keeping quality of these products.

Improved methods and increased care in selecting and rendering animal fats on the part of the fat producers and new methods of measuring the keeping life of the fat itself have enabled us to have more assurance in marketing the finished products. Improved methods of producing vegetable shortenings have also been introduced by the vegetable oil refiners, and these shortenings have likewise played their part in improving the keeping quality of biscuits and crackers.

A comparison of the keeping life of one particular kind of cracker made with lards of different stability will serve to illustrate the importance of controlling the quality of the shortening to be used.

In Table 1 the first column gives the keeping life of lard as measured by the Swift Stability test. Column 2 gives the keeping life of the crackers as measured on the broken-up crackers held in closed glass bottles at 125° F. Column 1 gives the number of different runs involved in each average figure.

These crackers were made in different bakeries using lards from various suppliers.

The samples made with lards keeping from five to seven hours show inconsistencies, but the general averages, considering the large number of distinct and different samples, show a very definite improvement in the keeping life of the crackers in direct relationship to the keeping life of the lard.

In another test we held sponge crackers at the elevated temperature of 125° F. and duplicate samples were held at room temperatures. These results are given in Table II.

TABLE I

Number of Samples	Keep test of lard, active oxygen	Keep test of sponge crackers, days at 125° F.
13	1 to 3 hours	30
8	3 to 4 hours	43
10	4 to 5 hours	53
6	5 to 6 hours	40
6	6 to 7 hours	48
8	7 to 8 hours	61
11	8 and above	63

TABLE II

Sample No.	Keeping time of crackers	
	Days at 125° F.	Days at room temp.
1	45	189
2	40	160
3	35	160
4	50	140
5	30	110
6	35	148
Average	39	151

These tests were started in the fall and room temperature would average about 70° F. The results indicate that we could expect the crackers to keep about four times as long under ordinary conditions as they would at the elevated temperature. Carrying this ratio back to Table I, we would expect crackers made with a 1- to 3-hour lard to be marketable for a period of something less than four months, and when made with 7- to 8-hour lard for a period of eight months. Naturally we prefer a 7- to 8-hour lard although we do not expect the goods to stay in the stores for these excessive lengths of time.

A further extension of the keeping life may be obtained by the use of suitable antioxidants or stabilizers. As an example, some of the samples reported in Table II were accompanied by other crackers using the same lards with the addition of .15% soy lecithin. These tests are shown in Table III.

Averaging these figures, we find that the addition of the lecithin has nearly doubled the keeping life, at

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TABLE III

Shortening	Keep test of crackers	
	Days at 125° F.	Days at room temp.
Lard	40	160
Lard + .15% lecithin	50	275
Lard	35	160
Lard + .15% lecithin	55	200
Lard	30	110
Lard + .15% lecithin	65	300
Lard	35	148
Lard + .15% lecithin	98	235

the elevated temperature, 67 days compared to 35 days, and under room conditions, 255 days instead of 144 days. For this particular use we attempt to choose a lecithin which will increase the stability of lard as measured on the Swift Stability outfit by 200 to 300%.

The tests shown have been for one type of cracker containing principally flour and shortening. If the quantity of shortening is increased, the keeping life will be shorter, and if there is a smaller amount of shortening, the keeping life will be extended.

The addition of other raw materials in the production of sweet cookies changes the picture. The use of starch for the purpose of softening a flour gives poorer keeping life, possibly because protective materials that may be present in wheat flour are diluted by the starch. The use of molasses, and particularly the use of spices, extends the keeping life. Here are some typical keeping life tests which illustrate this effect:

TABLE IV

Description of variety	Keeping life at 125° F.
	days
Sponge cracker containing 20 lbs. lard per bbl	34
Sweet cookie containing 48 lbs. lard, 75 lbs. sugar, and 24 lbs. invert syrup per bbl	76
Hard sweet product containing 24 lbs. lard, 45 lbs. sugar, 33 lbs. invert syrup, plus 30 lbs. corn starch	8
Molasses cookie containing 33 lbs. lard, 136 lbs. molasses, and ½ oz. oil of nutmeg	120
Molasses cookie containing 28 lbs. lard, 115 lbs. molasses and 3 lbs. of ginger	236

A series of tests, using several materials which have antioxidant properties, may be of interest.

TABLE V

Shortening	Keep test of shortening, hours	Increase in A.O. keep test	Keep test of cookies, days at 125° F.	Increase in keeping life
		per cent		*per cent*
Lard	2.5	.....	24	.....
Lard + .15% lecithin	9.5	280	38	59
Lard + .15% flake lecithin	10.0	300	59	146
Lard + .01% N.D.G.A.	63.0	2420	59	146
Lard + .3% powdered exhausted cloves, after removal of clove oil	12.0	380	61	154

It will be noticed that the increase in keeping life of the crackers is not proportional to the increase in keeping life of the fat itself.

Shortenings other than lard are, of course, used by the biscuit and cracker industry in large volume. The large volume ones are butter, oleo oil, and hydrogenated vegetable shortenings. In a comparison of oleo oil and lard the oleo crackers will keep longer than would be indicated by the stability test on the shortening itself although the crackers may develop a tallowy odor quite distinct from rancidity. This tallowy or reversion odor may also develop when certain vegetable oil shortenings are used.

A direct comparison of the keeping life of crackers made with lard and with various hydrogenated vegetable shortenings is given in Table VI.

TABLE VI

Shortening	Keeping life of sponge crackers, days at 125° F.
Lard	37
Hydrogenated cottonseed oil	82
Hydrogenated corn oil	83
Hydrogenated peanut oil	161

This shows that the crackers made with hydrogenated vegetable shortenings have appreciably longer keeping life.

A combination of one shortening with a different type may also give more improvement in keeping quality than would be expected. For instance, a sweet cookie made with 35 lbs. of lard kept for 8 days at 125° F. and when 31 lbs. of lard and 4 lbs. of hydrogenated vegetable shortening were used, the same piece kept for 13 days.

In Figures I and II we are showing the possible beneficial effect of shortening of one type upon shortenings of a different source. These curves show the keeping life as measured by the Swift Stability Outfit for mixtures of shortenings of various percentages. In Figure I the left side shows the keeping life of 100% palm oil, and, progressing toward the right, various percentages of lard or oleo oil were added until at the right the keeping life is for 100% lard on the top curve or oleo on the lower. In the top curve the mixtures of palm oil and lard all kept much longer than either of the fats by itself. In Figure II we show similar curves of blends of other shortenings. The curve for blends of lard and hydrogenated vegetable shortening is convex, showing improvement of keeping quality above what might be expected. The one for lard and cocoanut oil, on

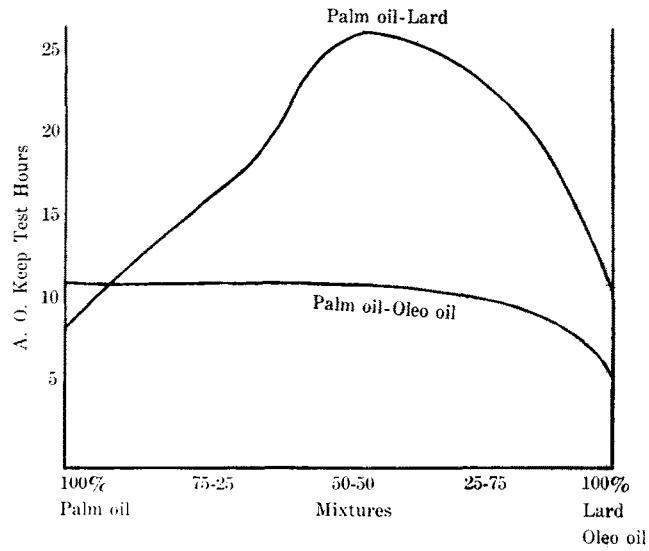

FIG. I.

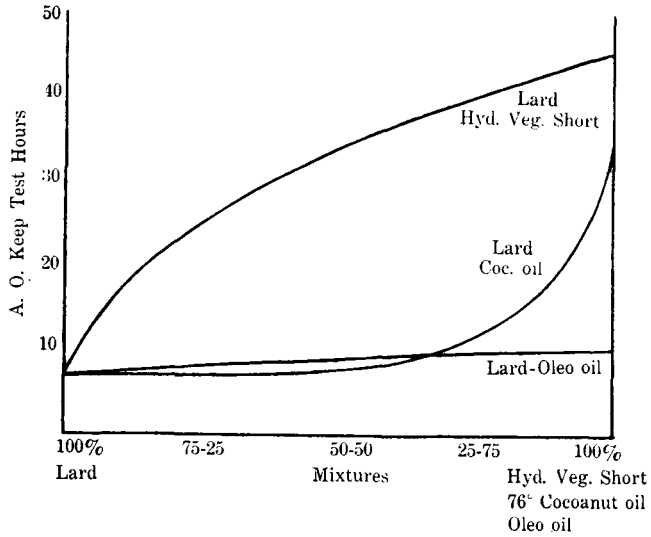

FIG. II.

the contrary, is concave, showing reduction below a straight line relationship while the lard-oleo oil curve might almost be made by averaging the keep tests of the individual shortenings involved.

Additional protection of the baked merchandise may be obtained by control of packaging materials and packaging methods. Packaging in a vacuum tin is very effective in extending the shelf life. We packed a number of different kinds of sweet and sandwich cookies for long-time carry by this means just prior to the war, anticipating a substantial production of goods packed for export trade.

Table VII shows the condition of some of these goods and the peroxide value of fat extracted from them at the end of one year's storage at room temperature. The goods described in the column on the left were merely sealed in the cans under atmospheric pressure. In the column on the right a 29" vacuum was drawn and the cans were sealed.

TABLE VII

Four different varieties sealed with air for one year		Same four varieties sealed under 29" vacuum for one year	
Odor	Peroxide value of fat	Odor	Peroxide value of fat
Stale—not rancid	4.0	Stale—not rancid	1.8
Slightly rancid	14.0	Not rancid	2.8
Rancid	29.0	Questionable	8.0
Rancid	22.0	Not rancid	3.0

In this original test as started, there were 18 different varieties involved. Some of these which were not completed at the end of a year were continued for a total of two years and ten months and were examined at that time as shown in Table VIII.

At the time of Pearl Harbor we were embarked on this packing method and produced 65,000 tins for export to the West Indies during 1942.

A short time before the war, when our tests indicated that hydrogenated vegetable shortenings were keeping for 50 or 60 hours on the Swift Stability outfit, one of the shortening manufacturers asked if we would be interested in a shortening keeping up to 200 hours. We told him that the present life was adequate for our domestic use but that possible future army rations might require something of the sort and the present 100-hour army hydrogenated vegetable

TABLE VIII

Five different varieties sealed with air for 2 years and 10 months		Same five varieties sealed under 29" vacuum for 2 years and 10 months	
Odor	Peroxide value of fat	Odor	Peroxide value of fat
Rancid	20.2	Old butter—not rancid	1.2
Strong rancid	67.2	Not rancid	7.3
Rancid	9.6	Very stale	1.2
Rancid	5.2	Not rancid	1.8
Very rancid	54.8	Not rancid	2.4

shortening has fulfilled a very helpful purpose in ration biscuit.

In searching for ways and means of lengthening the keep life, we have, of course, encountered many things which shorten the life. The presence of traces of copper or iron has a harmful effect on the keeping life. Overbaking has a harmful effect. Packing the merchandise at too high a temperature shortens the life. In types of cookies where the baking pans are greased to prevent sticking, this grease must be chosen with care as it may be the means of starting rancidity. During a shortage of the regular type of raisins we used bleached raisins in a product with the result that goods formerly keeping for 36 days at 125° F. kept for only 5 days.

Packing materials in contact with the goods must be chosen with care. Tight sealing of certain classes of goods in waxed paper where the package cannot "breathe" may cause early rancidity, perhaps because the odors by which rancidity is judged have been confined. The use of non-greaseproof paper with the merchandise containing high percentages of fat may allow the fat to be absorbed by the paper and speed up rancidity. Type C Army Ration Unit B cans is a case in point. At the start of production lumps of sugar wrapped in paper were packed in this can in contact with the biscuit.

Tests showing the effect of this paper on the biscuit are given below, at storage temperature of 125° F., and at room temperature:

TABLE IX

At 125° F.	Sugar wrapped Sugar not wrapped	Rancid in 27 days Not rancid in 210 days
At room temperature	Sugar wrapped Sugar not wrapped	Rancid in 210 days Not rancid in 300 days

The cans which had been set aside for this test were eventually entirely exhausted, and we were unable to follow it beyond the 7 months in the case of 125° storage, and 10 months for the room storage.

In order to overcome this effect we have used a disk of glassine paper packed between the biscuit and any other part of the ration which might have a harmful effect.

We also made keeping tests on regular army rations which were produced in January, 1944, and were held in closed glass jars at room temperature and at 125° F. These are shown in Table X.

TABLE X

Type	Rancidity at 125° F. days	Rancidity at room temp., days
K1A	323	(Sample jar broken)
K2	513	Not rancid at 18 months
K3	Not rancid at 18 months	Not rancid at 18 months
Type C	341	507
Crackers, whole wheat	489	Not rancid at 18 months