Some Notes on the Keeping Quality of Fats In Baked Goods

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IN the past decade accelerated oxidation tests have come into wide use as a means of quickly estimating the stability of edible fats and oils. The normal oxidation of fats may be speeded up in a number of different ways (7). For example, by allowing the fat to react with an atmosphere containing more oxygen than is present in air or by allowing it to react with air at elevated temperatures, by the presence of strong light (2) or of a pro-oxidative substance. In practice, however, most of the accelerative measures have proven to be either inconvenient or difficult to control. Consequently the two methods now in general use, the Swift method (4) and the Schaal test or oven method, depend only upon elevated temperatures and exposure to air to increase the normal rate of oxidation.

Since the Schaal test involves only a simple incubation of the sample in a cabinet controlled to a definite temperature, it is equally applicable to baked goods containing fats. In studies by this method, however, it has been observed by various workers (3, 5, 6) other than the writers, that the keeping quality of baked products does not always correlate well with that of the fat from which they are made. One group of observers (1) which studied the keeping quality of laboratory prepared soda crackers attributed this discrepancy to the fact that some fats contain natural anti-oxidants, which may be inactivated by the baking process. They found that the keeping quality of their crackers generally depended upon the relative saturation of the fatty acids of the oil or fat, without regard to the stability of the latter as such. From this they concluded that, in soda crackers at least, the stability of a fat depends solely upon its composition with respect to the various fatty acids.

Valuable as the accelerated tests are, it is generally recognized that in many cases they should be interpreted with considerable caution. This is particularly true where they are used for intercomparing fats of different kinds, and is even more particularly true where the fats may contain added anti-oxidants. As baked goods by their very nature will always contain a number of substances capable of anti- or pro-oxidative action, it would seem possible that there might be some products which would behave quite differently from soda crackers. There would also seem to be some possibility of *accelerated* tests on the baked goods failing to correlate with storage tests at *ordinary* temperatures. These considerations have led the writers to undertake a further investigation of the problem, the first results of which are reported herewith.

Experimental Details

The following fats were selected for the tests:

(a) Fresh prime steam lard
(b) The same lard plus 0.1% soyabean lecithin
(c) Fresh oleo oil
(d) The same oil plus 0.1% soyabean lecithin
(e) Hydrogenated lard (Iodine Number 60.3)
(f) Hydrogenated vegetable oil (Iodine Number 58.2)

Two simple unleavened doughs were made from each of the fats. One of the doughs was sweetened and one was unsweetened. The formula for the unsweetened dough was as follows:

Fat	31 gms.
Flour	250 gms.
Salt	3 gms.
Water	75 gms.

For the sweetened dough, 50 gms. of sugar were added to the above formula. The doughs were mixed by hand in glass bowls, to avoid metallic contamination, and were rolled out on a glass plate with a glass rolling pin and cut into rounds with a glass cutter. They were baked at 425°F for 14 minutes on glass trays. After cooling for 1 hour, the resulting biscuits were packed in glass jars with loose glass covers and stored at two temperatures, 98°F and 120°F. It was originally planned to use 145°F for the high temperature, as in the Schaal test on the fat, but after it was found that some of the products became rancid within 24 hours at this temperature, the lower temperature was adopted. The keeping quality in each case was recorded as the number of days required for the product to develop distinct organoleptic rancidity.

The keeping quality of each fat was determined by the Swift method at 210°F and by the Schaal method at 145°F.

The complete results of the various tests are in Table I.

TABLE I.

Complete Results of Accelerated Tests on Several Fats and Biscuits Made Therefrom.

	Keeping Quality of Biscuits					
	KQ of Fat		120°F		98°F	
Shortening	Swift Hrs.	Schaal Days	No Sugar Days	Sugar Days	No Sugar Days	Sugar Days
Prime steam lard	8	10	3	11	34	50
Prime steam lard plus 0.1% lecithin	9	11	5	15	37	60
Oleo oil	10	12	5	37	50	320
Oleo oil plus 0.1% lecithin	60	65	7	37	60	300
Hydrogenated lard	22	26	7	22	75	360
Hydrogenated vegetable oil	70	70	16	55	80	360

Effect of Accelerating the Storage Tests

The lower temperature used for incubating the biscuits (98°F) may be regarded as a more or less normal storage temperature. The higher temperature (120°F) is not normal, and the test at this temperature may be considered to be accelerated by heat. As an aid to judging the effect of this acceleration, the relative keeping qualities of the various biscuits at 98°F and 120°F are tabulated in Table II which shows that the effect of raising the temperature from 98°F and 120°F is very marked, but is by no means uniform amongst the various fats and formulas. In test 5b, the biscuits keep 16

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times as long at 98° as at 120°. In test 2b, they keep 4 times as long at the lower temperature. Other tests are intermediate between the two quoted. It is evident that erroneous conclusions will be reached by intercomparing the various fats on the basis of the accelerated tests.

TABLE II.

Comparison of Keeping Qualities at 120°F and 98°F of Biscuits Made from Several Fats (On basis KQ at 120°F = 1, for each fat)

Test No.	Shortening Used	Kind of Dough Made	Keeping Quality at 120°F	Keeping Quality at 98°F
1a	Prime steam lard	Plain	1	11
1b	Prime steam lard	Sweetened	1	5
2a	Prime steam lard plus 0.1% lecithin	Plain	1	7
2b	Prime steam lard plus 0.1% lecithin	Sweetened	1	4
3a	Oleo oil	Plain	1	10
3b	Oleo Oil	Sweetened	1	9
4a	Oleo oil plus 0.1% lecithin	Plain	1	9
4b	Oleo oil plus 0.1% lecithin	Sweetened	1	8
5a	Hydrogenated lard	Plain	1	11
5b	Hydrogenated lard	Sweetened	1	16
6a	Hydrogenated vegetable oil	Plain	1	5
6b	Hydrogenated vegetable oil	Sweetened	1	7

The Effect of Sugar and of Lecithin in the Formula

Sugar, as stated in the literature (1), was found to be a powerful anti-oxidant for most of the fats. The protection factors afforded by the sugar for the different fats are shown in Table III.

TABLE III.

Protection Factors Afforded by Sugar in Biscuits from Different Fats.

	Protection Factor at 120°F	Protection Factor at 98°F
Prime steam lard	4	1.5
Prime steam lard containing 0.1% lecithin	3	1.6
Oleo oil	7	6
Oleo oil containing 0.1% lecithin	5	5
Hydrogenated lard	3	5
Hydrogenated vegetable oil	3	5

In the case of prime steam lard, sugar acted as only a mild anti-oxidant at 98°, yielding protection factors of 1.5 to 1.6. This is, however, not surprising in view of the considerable number of other anti-oxidants which are comparatively impotent in this fat. The accelerated tests are misleading with regard to the effect of sugar on lard shortened products, as protection factors of 3 to 4 are indicated at 120°F.

Lecithin, which is very effective as an anti-oxidant in oleo oil, loses practically all its effect in baking.

Comparison of Different Methods for Evaluating the Fats

Since the storage tests at 98°F may be regarded as an indication of the behaviour of the baked products under normal storage conditions, it is interesting to evaluate the various fats on this basis and compare the results with a similar evaluation on the basis of each of the accelerated tests. As an aid to this comparison, Table IV has been prepared.

TABLE IV.

Relative Stabilities of Different Fats (by the Accelerated Tests) and Biscuits Made with Them at High and Low Temperatures (On basis KQ of least stable product in each case = 1).

Kind of Fat	KQ of Fat (by Schaal test)	Biscuits: Plain 120°F	Plain 98°F	Sweetened 120°F	Sweetened 98°F
Prime steam lard	1.0	1.0	1.0	1.0	1.0
Prime steam lard with lecithin	1.1	1.7	1.1	1.4	1.2
Oleo oil	1.2	1.7	1.5	3.4	6.4
Oleo oil with lecithin	6.5	2.3	1.8	3.4	6.0
Hydrogenated lard	2.6	2.3	2.2	2.0	7.2
Hydrogenated vegetable oil	7.0	5.3	2.4	5.0	7.2

In the case of the unsweetened biscuits, the accelerated tests on the fat alone greatly exaggerate the stability of both the oleo oil and the hydrogenated vegetable oil. As determined by the Schaal method, these two have stabilities about seven times that of lard and about two and one-half times that of hydrogenated lard while actually, in the biscuits, their stabilities are only twice that of lard and about the same as that of hydrogenated lard. In the accelerated biscuit tests the high stability of the lecithin treated oleo oil disappears but the hydrogenated vegetable oil still has an indicated stability about five times that of lard and over two times that of hydrogenated lard. That this is misleading is evident from the results of the tests at the lower temperatures.

In the sweetened products the results are also misleading. The tests on the fats alone fail to predict the great inferiority of lard in comparison with oleo oil and hydrogenated lard. As in the case of the unsweetened products, the accelerated tests on both the fats and the baked goods fail to show the virtually equal stability of the hydrogenated lard and the hydrogenated vegetable oil. Probably the most important feature of the tests is the fact that either class of *baked goods* keeps equally as well at normal storage temperatures, whether made with hydrogenated lard or hydrogenated vegetable oil, whereas the accelerated tests on the fat alone indicate that the hydrogenated lard has only about one-third the keeping quality of the hydrogenated vegetable oil. It will be noted in Table IV that sweetened baked goods made with oleo oil keep almost as well as that made with hydrogenated lard or hydrogenated vegetable oil, even though accelerated tests on the fats alone indicate it to be much inferior.

On the basis of the present tests it can only be concluded that the actual shelf life of baked products made with various fats cannot be truly predicted by tests accelerated by heat, whether applied to the fat alone or to the baked products. It is realized that the simplified formulas used in these tests do not include certain ingredients such as eggs, milk, flavoring materials, leavening, and the like which will be found in commercial products, but it seems unlikely that the addition of such ingredients would serve to bring back into line the very discordant results obtained by using the simple formulas, except perhaps in some isolated cases.

Summary

1. Six fats have been tested for their stability in baked goods, both under normal and accelerated conditions.

2. Accelerated tests on the fats alone or on biscuits baked with them have not been found satisfactory for evaluating the stability of the fats.

3. The accelerated tests have been found particularly inadequate to properly evaluate the stability of hydrogenated lard in baked products.

4. It is concluded that the practice of evaluating fats for baking purposes by accelerated tests is not indicative of their true stability.

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