Rancidity Problems in Baked and Fried Food Products

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THERE is an urgent need for a standard, reliable and readily reproducible method for the measurement of the keeping quality of finished baked or fried products. Such a method should be fairly rapid, yield quantitative results for the entire induction period of the food product, and, if possible, be dependent upon a chemical reaction instead of an individual's organoleptic response.

Incubation tests at elevated temperatures are employed at present and the end point is determined by individuals who, in nearly every case, claim plaudits for their acute sense of smell. As yet there has been little or no attempt to develop a standard incubation method. There are nearly as many ideas concerning the correct value of the incubation temperature as there are laboratories engaged on the problem. To our knowledge, tests are made now at temperatures of 120°F., 140°F., 145°F., 160°F., and in one food laboratory they are made on the window sill at room temperature.

There is also doubt as to the soundness of employing elevated incubation temperatures to determine the keeping quality of products stored at room temperature. One investigator suggested that a one to twenty relationship existed between the keeping time at 145°F. and the keeping time at 75°F. We have been unable to establish proof of this relationship.

Nearly everyone who has attempted to duplicate work reported by other laboratories will agree that the incubation test is inexact and that it is affected by many variables. An interesting experience was encountered a few months ago when an attempt was made to check another laboratory's incubation data on crackers. Commercial crackers which were incubated at 145°F. were reported to have a keeping time varying between 2 and 6 days, a figure much too low considering the keeping time of the original fat used in the crackers. In our laboratory these crackers were found to have a keeping time of 8 to 15 days when incubated at the same temperature. It was not possible to secure duplicate results until after it was noticed that one laboratory "precrisped" the crackers for 6 minutes at 300°F. in an electric oven while the second laboratory used a gas oven for the same purpose. It was then determined that the exposure of the crackers to the combustion gases which were present in the gas oven reduced the incubation time by a factor of thirty to fifty per cent. It was also observed that exposure of the crackers to regular Chicago fuel gas would produce similar results to those obtained in a gas heated oven. The effect of this treatment, however, varied inversely with the original stability of the fat. Little reduction of the incubation time was noticed when fats of extremely long rancidity induction periods were tested.

Much difficulty has been encountered by the inability of some operators to establish a definite "RANCIDITY" end-point. The occurrence of milky odors, spicy flavors, staleness, mustiness, and reverted odors have sometimes been reported as evidence of rancidity. Attempts to be too exact have often resulted in a rather loose conception of the term "rancid". At present there seem to be two schools of thought on the subject; one which reports any off odor as evidence of rancidity, and the other which waits for the development of a *positive* rancid odor independent of the presence of all other odors.

KEEPING QUALITY FACTORS IN FRIED PRODUCTS

There are many factors which influence the keeping quality of fried and baked goods which are beyond the control of the shortening manufacturer. Only a few of the most troublesome ones are considered in the present publication.

Since rancidity seems to be the primary evil of the potato chip business, this industry may be considered to be typical of all producers of fried products requiring long shelf life. A great deal of money is lost annually by potato chip makers because of rancidity. There are many contributing factors to the development of rancidity in potato chips among which may be mentioned (1) the potatoes, (2) frying equipment, (3) packaging, (4) fat turnover, and (5) influence of alkalies.

1. *Potatoes:* There is a dearth of factual information available which is concerned with the influence of the potato on keeping quality. Despite this fact manufacturers report private opinions that occasional lots of potatoes produce chips of extremely poor keeping qualities.

2. *Frying Equipment:* Frying equipment has been given considerable attention during the past few years and many improved frying kettles are now in use. Kettles constructed partly of copper alloys, kettles equipped with heating units of extreme radiation intensity, and kettles of this type combined with various filtering or "fat reclaiming" devices seem to be the worst offenders, but they are nevertheless in fairly wide use. However, credit must be given to those individuals in the frying equipment business who have made and introduced many improvements in this field.

3. *Packaging:* Although it is well known that completely transparent packages contribute to the acuteness of the rancidity problem, their use is considered necessary by the industry.

4. *Fat Turnover in the Frying Kettle:* The most neglected but obviously the most important factor in the food frying industry pertains to the fat turnover or fat replenishment of the kettle. Kettles holding 400 to 1000 pounds of frying fat are sometimes installed for the purpose of reducing labor costs. Often the amount of business done does not justify kettles of such capacity. Regardless of the kettle capacity, however, it is desirable to have a sufficient volume of business to secure a daily or at least two-day fat turnover in the kettle. Without rapid fat turnover it is folly for the producer of fried goods to expend much time, effort or money on other rancidity safeguards since deterioration of fat in the frying kettle is the primary cause of the trouble. The following tabulated data indicates how

little importance may be attached to the selection of the frying fat when the factor of fat turnover is ignored. It should be remembered that these data represent an extreme case of a twenty-day fat turnover. It nevertheless indicates the seriousness of the problem.

KEEPING QUALITY FACTORS IN CRACKERS

There seems to be fewer and fewer problems with respect to rancidity throughout the cracker industry, notwithstanding the fact that the volume of hydrogenated fat being consumed in this product is probably

TABLE I.—EFFECT OF FAT TURNOVER IN THE FRYING KETTLE ON THE PROPERTIES OF THE FAT USED AND ON THE FRIED PRODUCT

	ANALYTICAL RESULTS												INCUBATION RESULTS	
	Hours Fat Heated	% F.F.A.	Smoke Pt. °F.	Active Oxygen Hours	Initial Peroxide Value	Color Y.	Color R.	Melting Point °F.	Softening Point °F.	Refractive Index	Iodine No.	Saponification No.	Hours Fat Heated	Potato Chips Keeping Time-Days Inc. 145°F.
Fat No. 1 (hydrogenated vegetable oil).....	Orig.	0.03	425	118	.....	11	1.0	100	93	39.4	64.6	192.5	6	96
	27	.15	380	4	4.2								30	6
	38	.22	360	3	6.0								38	4
	45	.27	380	2	4.0			Tended to foam after 38 hours					45	6
	70	.41	350	4	5.2								70	3
	91	.79	320	5	3.0								93	4
	113	1.01	340	8	2.2	40	9.4	102	95	42.8	58.0	200	111	5
Fat No. 2 (hydrogenated vegetable oil).....	Orig.	0.02	405	157	3.8	10	0.9	106	98	37.9	57.2	196.7	2	150
	29	.23	380	4	8.0								30	5
	45	.32	370	5	7.0								46	16
	53	.43	350	7	7.8			Tended to foam after 46 hours					54	15
	61	.52	355	7	6.8								65	8
	65	.57	320	6	3.2	35	10.4	105	91	40.8	50.7	199.7	.....	.....
Fat No. 3 (hydrogenated vegetable oil).....	Orig.	0.02	430	112	.....	12	1.1	103	93	39.3	63.8	193.5	0	108
	3	.04	415	107	7.0								2	108
	21	.18	390	4	7.4								21	24
	27	.21	380	5	8.4			Tended to foam after 52 hours					27	6
	52	.36	355	4	6.6								52	5
	61	.46	350	5	7.4								60	6
	69	.53	340	5	7.2	30	7.4	102	97	42.5	57.7	196.8	69	10
Fat No. 4 (hydrogenated vegetable oil).....	Orig.	0.03	405	70	.....	14	1.6	113	107	38.7	59.7	195.3	0	.....
	30	.17	375	2	8.4								30	2
	47	.23	360	3	5.6			Tended to foam after 48 hours					53	3
	54	.31	345	4	6.6								72	4
	70	.41	335	4	6.2	(1″ column)							78	4
	78	.53	320	6	6.2	(25	3.0)	113	105	41.7	53.5	197.7	.....	.....
Fat No. 5 (hydrogenated vegetable oil).....	Orig.	0.02	430	55	1.0	13	1.9	111	104	40.5	71.8	195.1	0	.....
	24	.57	400	5	6.6								24	6
	40	.27	385	3	5.2								48	4
	48	.31	375	4	5.6			Tended to foam after 44 hours					56	14
	56	.47	370	5	8.0								64	4
	64	.49	345	5	6.0	30	4.4	111	104	44.5	62.2	197.6	.....	.....
Fat No. 6 (hydrogenated vegetable oil).....	Orig.	0.06	410	22	.....	15	1.3	107	102	40.7	70.7	193.7	0	.....
	24	.20	385	3	4.6								24	3
	42	.21	375	3	6.2								42	2
	50	.27	370	3	4.0			Tended to foam after 44 hours					58	4
	58	.32	355	5	8.2								66	9
	66	.43	340	5	6.2	65	14.7	105	102	44.1	61.9	194.9	.....	.....
Fat No. 7 (hydrogenated vegetable oil).....	Orig.	0.04	425	88	0.6	13	1.4	104	91	39.7	67.9	194.1	0	83
	7	.06	420	48	5.2								7	57
	24	.17	405	6	5.4								28	6
	47	.30	385	6	6.4			Tended to foam after 49 hours					49	9
	56	.36	375	6	8.8								58	7
	71	.46	390	7	4.8	30	9.2	102	97	42.6	58.8	199.2	71	9
Fat No. 8 (hydrogenated vegetable oil).....	Orig.	0.03	410	56	0.3	20	1.9	118	111	40.9	73.0	195.2	0	47
	6	.06	420	30	8.2								6	39
	26	.13	405	5	7.0								27	7
	49	.21	395	4	6.0			Tended to foam after 51 hours					51	5
	62	.33	355	4	6.0								62	11
	70	.36	340	5	4.4	30	8.5	118	113	43.9	62.0	198.3	70	7
Fat No. 9 (prime steam lard, stabilized)....	Orig.	0.26	370	42	0.4	8	1.0	121	108	40.7	70.6	193.8	2	32
	8	.32	350	6	7.4	0.1 B							9	13
	25	.40	355	2	8.6								25	6
	33	.50	345	2	16.0			Tended to foam after 44 hours					33	5
	45	.56	350	2	5.8								45	3
	64	.60	335	2	7.0								66	3
	73	.67	345	2	15.4	24	7.0	120	105	43.5	62.3	198.0	73	2
Fat No. 10 (prime steam lard, hydrogenated)	Orig.	0.14	390	17	.....	3	0.7	120	108	38.8	60.2	195.4	0	....
	24	.28	360	1	12.4								24	2
	32	.38	370	2	5.4								32	3
	40	.38	350	2	6.6			Tended to foam after 64 hours					40	2
	64	.54	350	4	4.6								64	4
	87	.74	320	5	3.2								88	6
	95	.86	330	5	2.0	50	10.0	118	107	42.3	53.1	.....	.....	.....

5. *Use of Alkalies:* Frying corn chips which contain lime and potato chips which have been washed in sodium carbonate solutions sometimes adds to the fat manufacturer's problems since the alkali tends to cause foaming of the fat which is otherwise quite satisfactory. Such practices are not common but several cases are on record.

smaller than ever before. Lard and oleo oil seem to be the major products used in this field at the present time apparently because better flavor and superior lubricating properties are obtained through their use, although economic advantages may also be a motivating reason.

Enzymatic Activity: It is probable that many keeping quality discrepancies could be explained if more specific

information were available with regard to the presence and influence of oxidase and peroxidase enzymes. Tests made with cracker sponges containing extracts of raw potatoes clearly illustrate this point as may be observed from the data in Table 2.

TABLE II.—EFFECT OF ENZYMES (POTATO EXTRACT) ON THE INCUBATION TIME OF CRACKERS AT 145°F.

Fat Used	Standard Cracker Sponge Days	Cracker Sponge Plus Potato Extract Days
Lard	6	5
Oleo Oil	11	9
Hydrogenated Cottonseed Oil	19	12

It is well known that old, musty flour definitely reduces keeping quality.

Packaging: Although most cracker packages are now lined with grease-proof paper the packaging problem is not wholly solved. Many products are quite often packaged while warm in order to reduce the tendency of the goods to check. Some plants make a practice of packaging their products at temperatures of 120°F. or higher, whenever production schedules exceed the cooling capacity of the plant. This practice invariably results in decreased shelf life.

The packaging of cookies should be included in any discussion dealing with the influence of the package on keeping quality. The large variety of cookie packages combined with an increasing number of small manufacturers who seem to never exhaust their imaginations with respect to package design presents a problem which is becoming serious. Nearly all cookie packages are designed to secure maximum visibility combined with a certain amount of rigidity. This type of package usually consists of a combination of cardboard stripping to provide rigidity and cellophane to provide visibility. The high fat content of the cookies results in a rapid absorption of the fat by the cardboard, often within 24 hours after packing. There seems to be no completely grease-proof board in use because the cut edges offer a blotter-like surface that insures absorption of the fat by the board.

Dutch machine cookies made with 80 pounds of oleo oil per barrel of flour were used to demonstrate the influence of cardboard on keeping quality. The results of the test are recorded in Table 3.

TABLE III.—EFFECT OF VARIOUS PACKAGING MATERIALS ON KEEPING TIME OF DUTCH COOKIES AT 145°F.

Number	Package Material	Keeping time in days
1	Glass jar	14
2	Cellophane bag	14
3	Cellophane on board (No. 1 white patent news back)	5
4	Same as No. 3 (only on Southern Pulp Solid Bleached Sulfate Board)	5
5	Same as No. 3 (white patent No. 1 news back paraffined)	5
6	Board treated with cereal flour	14
7	Single Bleached Sulfate Solid Manila Back (no pulp)	5
8	Grease-proof parchment paper liner	14+

The cardboards used in the cookie packages reported in Table 3 obviously had absorbed small quantities of fat from the cookies. Further tests were made by incubating cardboard strips impregnated with small quantities of fats. Lard, oleo oil, and hydrogenated cottonseed oil were tested. A standard white patent news back board was used. Additional tests were made on other strips taken from the same board but which differed through treatment with dilute alcoholic solutions of citric acid and pyrogallol before impregnation with the fats. The treated boards were heated to 100°C. to secure removal of the alcoholic solvent before impregnation. The results are recorded in Table 4.

TABLE IV.—EFFECT OF CARDBOARD ON THE KEEPING TIME OF FATS AT 145°F.

	Incubation Time at 145°F.		
	Lard	Oleo Oil	Hydrogenated Cotton Oil
Incubation Time of Fats in Glass Jar	7 days	10 days	39 days
2 gm. Fat Impregnated in No. 1 White Patent Newsback Board	5	7	12
Board Treated with Citric Acid Before Impregnating with the Fats	6	13	18
Board Treated with Pyrogallol Before Impregnating with the Fats	28	40	55

Other tests were made using cardboard obtained from a cookie manufacturer. When this board was impregnated with fat, rancidity developed within 24 hours when incubated at 145°F. regardless of type of fat tested. In this connection it might be mentioned that the use of various antioxidants with this board gave even more outstanding results than those reported here.

Attention should also be called to the fact that often supposedly rancid products may be removed from the container, heated to drive off absorbed odors, and then kept for months without any semblance of returned rancidity. These data clearly indicate that the shortening manufacturer needs the assistance of the cookie manufacturers and the package designers in preventing off-flavored products from reaching the consumer.