Storage Properties of Potato Flakelets

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SUMMARY

The density of potato flakelets makes nitrogen packing economically feasible. Storage tests were therefore conducted to investigate the keeping properties of flakelets under various packaging conditions. Flakelets containing no antioxidant and packed in nitrogen were compared with samples that were: 1) air packed with 23 ppm BHA plus BHT; 2) air packed with 55 ppm BHA; 3) air packed with both 100 ppm and 50 ppm of mixed tocopherols; and 4) air packed with no antioxidant. Nitrogen-packed flakelets were also compared to nitrogen-packed flakes without antioxidant and to conventionally air-packed flakes containing BHA plus BHT. Flakelet samples were packed in cans and stored 9 months at 73°F. Flakelets protected only by nitrogen packing (2.5% oxygen or less in the cans) kept as well as samples containing BHA plus BHT or BHA alone, and were superior to samples with mixed tocopherols. Further, they improved in rank relative to the other samples as each test progressed.

INTRODUCTION

Potato flakelets are a recently developed dense form of dehydrated mashed potatoes made from a fragmented drum-dried sheet of, for example, potato flakes. When reconstituted, they possess good flavor and texture.

Both the flakelet (Claffey *et al.*, 1961; Eskew and Drazga, 1962) and the flake processes (Cording *et al.*, 1954, 1955, 1957, 1959; Anon., 1959) were developed at the Eastern Division of the Agricultural Research Service, in Philadelphia. Experience has shown that potato flakes of about 6% moisture, packed in air and containing 50 ppm BHA plus BHT as antioxidant and 200 ppm sulfite, keep well at room temperature for approximately 6 months.

In the making of flakelets, additional processing steps are required over those needed for flakes. These may entail exposing the moist product to air for periods up to 40 min. This, and the radical difference between flakelets and flakes, indicated the need for storage tests on the former. At the initiation of these tests, in late 1961, the maximum permissible level of BHA plus BHT in potato flakes was 20 ppm. Consequently, this level (within experimental error) was used with flakelets.

Storage and packing conditions. Three lots of Idaho Russet Burbank potatoes were purchased from a local distributor and conditioned for 2–3 weeks at about 65°F prior to processing so that the reducing sugars content was less than 2.5% on the moisture-free basis. Either potato flakes or drum-dried potato sheets were produced, containing either no antioxidants or one of the several antioxidants under study. After each of the products was broken through holes ¼ inch in diameter, the comminuted material was processed to flakelets.

Storage tests were made on three groups of samples packed under various conditions. The first test was initiated in January, the second in June, and the third in July, 1962. The various samples in any one storage test were made from the same batch of potatoes. The product of each flakelet run (corresponding to one packaging condition) was packed in 202 × 214 cans and stored at 73°F. Flakelets packed under three different conditions were compared in Storage Test I. These are shown in Table 1. Tables 2 and 3 respectively tabulate corresponding information for the other two groups of samples composing Storage Tests II and III. Tabulated data correspond to "zero" storage time.

Two of the samples in the third storage test were flakes having a bulk density of about one-third that of flakelets. In order to have a sufficient amount of flakes per can for the reconstitution recipe in a monthly taste test, these samples were packed in 307 × 409 cans. The two flakelet samples in this storage test were also packed in 307 × 409 cans. Neither the flake nor the flakelet cans were full, but the ratio of unfilled can space above the solids to the weight of solids was the same for the two products.

Table 1. Test I storage samples.

	Flakelets; BHA + BHT (Tenox IV)[a]; in air	Flakelets; no antioxidant; in N_2	Flakelets; mixed tocopherols[c]; in air
Bulk density (lb/cu ft)	46.0	47.0	46.5
Weight in sample can (g)	84	84	84
Moisture (%)	5.8	6.0	5.9
Antioxidant level (ppm)	23	0	100[b]

[a] Eastman Chemical Products, Inc.; 20% butylated hydroxyanisole plus 20% butylated hydroxytoluene.
[b] Based on solids fed to drum dryer.
[c] Distillation Products Industries; 340 mg of mixed tocopherols per g of oil.

Table 2. Test II storage samples.

	Flakelets; no antioxidant; in N_2	Flakelets; BHA (Tenox VII)[a]; in air	Flakelets; mixed tocopherols[b]; in air	Flakelets; no antioxidant; in air
Bulk density (lb/cu ft)	49.9	46.5	41.0	49.9
Weight in sample can (g)	82	82	82	82
Moisture (%)	6.5	5.0	6.3	6.5
Antioxidant level (ppm)	0	55	50[c]	0

[a] 28% butylated hydroxyanisole.
[b] Distillation Products Industries; 340 mg of mixed tocopherols per g of oil.
[c] Based on solids fed to drum dryer.

Table 3. Test III storage samples.

	Flakes; no antioxidant; in N_2	Flakelets; no antioxidant; in N_2	Flakes; BHA + BHT (Tenox IV); in air	Flakelets; BHA + BHT; in air
Bulk density (lb/cu ft)	17.0	47.0	17.5	49.0
Weight in sample can (g)	92	150	92	145
Moisture (%)	5.8	5.8	5.5	6.0
Antioxidant level (ppm)	0	0	29	25

Although the BHA-plus-BHT levels used are based on the potato solids in the samples after canning, the levels of mixed tocopherols are not. In the latter cases no antioxidant assays were made; the levels tabulated reflect only the actual amounts of tocopherols added to the mashed potatoes prior to drum drying. The procedure used for determining the levels of BHA plus BHT (Tenox IV; no endorsement implied) or BHA alone (Tenox VII) was the same as that developed for potato flakes (Filipic and Ogg, 1960).

For samples packed in nitrogen, individual cans were tested for oxygen level before their reconstituted contents were submitted to the taste panel. In all cases, levels in the headspaces were below about 2.5%. Moisture contents of the various in-process and finished products, as tested using a Brabender moisture tester, Type FRA, all fell within the range of 5.0–6.5%. As determined from previous data, variations within this range should not affect storage stability appreciably (Strolle, 1964).

Preparation of storage samples. In making the dehydrated product for storage samples the initial processing steps were the same as those used for potato flakes up to the point of mashing the cooked potatoes (Cording *et al.*, 1957, 1959; Drazga and Eskew, 1962). Antioxidant (when used) was dispersed in the glycerol monostearate emulsion prior to its addition to the mash. Sulfite and citric acid solutions were also incorporated at this stage. The procedures used in processing the drum-dried mashed potatoes to the finished flakelets were similar to those discussed in earlier publications (Drazga and Eskew, 1962).

Taste tests and sample scoring. Samples from each storage test were periodically reconstituted to mashed potatoes and were evaluated by a taste panel of 17–25 persons. This panel was selected from among a larger group on the basis of their consistency and their superior ability to recognize off-flavors characteristic of stored dehydrated mashed potatoes. In making a taste test, panel members were asked to list the several samples in the numerical order of increasing amount of off-flavor present. The sample with the least off-flavor was assigned a rank of 1, the sample with the next higher amount a rank of 2, and so on, so that a sample in Storage Test I received a rank of 1, 2, or 3 and each of the four samples in either Test II or Test III received any one of a possible four ranks. Taste tests were conducted on each group of samples monthly.

At the conclusion of a storage test (in each case, 9 months), a statistical regression analysis of the replicated data was performed. The ranking scores, y, given a sample by the 17–25 panel members in a particular month were treated as replicates and correlated to storage time, x. By means of a linear regression of y to x on each sample over the 9 months, a straight line was calculated that best represented that correlation (Brownlee, 1960; Volk, 1958) assuming the general linear form $y = a + bx$, where b represents the slope of the derived regression line. Since the number of panel members engaged in a taste test were not constant from month to month, each x-value was weighed according to the number of replicates associated with it.

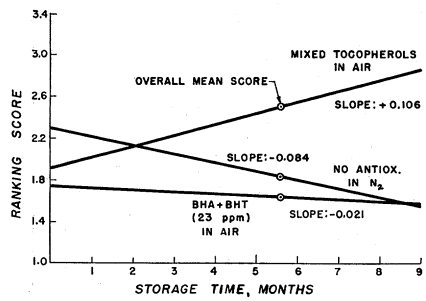

Fig. 1. Storage test I correlation lines.

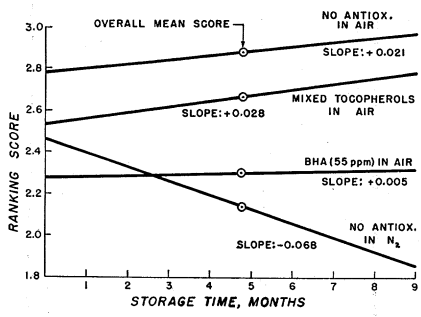

Fig. 2. Storage test II correlation lines.

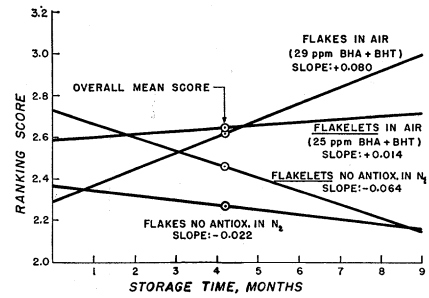

Fig. 3. Storage test III correlation lines.

The derived regression line of the ranking score-to-storage time correlation for each sample in Storage Test I is shown in Fig. 1. Those for Storage Test II and III are shown in Figs. 2 and 3. For the sake of clarity, the groups of replicates corresponding to monthly taste tests on a sample are not plotted in the figures.

The assumption of linearity of the correlation for each sample was tested statistically and proved valid in adequately representing the data in every case. Further, the degree of certainty with which each correlation or re-

Table 4. Results of regression analysis on ranking scores.

	Certainty of correlation	Over-all mean rank score	Slope of correlation line	Significant differences: Between any two means	Significant differences: Between any two slopes
Storage test I (all flakelets)					
Tenox IV (23 ppm) air pack	under 90%	1.628	−0.021	A	A
No antioxidant, N_2 pack	over 99%	1.872	−0.084	A	A
Tocoph. (100 ppm), air pack	over 99%	2.500	+0.106	B	B
Storage test II (all flakelets)					
No antioxidant, N_2 pack	over 95%	2.138	−0.068	A	A
Tenox VII (55 ppm), air pack	under 90%	2.300	+0.005	A	A
Tocoph. (50 ppm), air pack	under 95%	2.665	+0.028	B	A
No antioxidant, air pack	under 90%	2.879	+0.021	B	A
Storage test III					
Flakes, no antioxidant, N_2	under 95%	2.270	−0.022	A	A
Flakelets, no antioxidant, N_2	over 95%	2.459	−0.064	AB	A
Flakes, Tenox IV (29 ppm), air	over 95%	2.620	+0.080	B	B
Flakelets, Tenox IV (25 ppm), air	under 95%	2.642	+0.014	B	AB

gression line represents the correlation for each sample over the entire storage period was calculated. This is tabulated for each sample under "certainty of correlation" in Table 4. Significant differences between the slopes of any two correlation lines within each Storage Test are also tabulated.

RESULTS AND DISCUSSION

In Storage Test I, flakelets protected simply by nitrogen packing were compared to two air-pack samples, one containing initially 23 ppm Tenox IV, the other 100 ppm added tocopherols. The mean rank scores of the samples are shown in Table 4. For each sample these mean scores were obtained by averaging all of the scores given the sample over the 9 months of the test. A *t*-test was used to determine whether the difference between any two mean scores was statistically significant at the 95% confidence level. Samples within each test having capital letters in common on Table 4 are not significantly different.

Samples containing mixed tocopherols were significantly inferior to the others at the 99.9% confidence level. The nitrogen-packed product stored about as well as the conventionally air-packed samples containing Tenox IV. However, comparing over-all mean scores does not reveal how fast any one sample changes in rank with respect to its companions as the test progresses. This is shown by Fig. 1, where changes in ranking score are traced for each sample during storage.

A correlation line having a negative slope indicates that the sample is improving in rank, month by month, relative to the other two samples. This is conspicuous with the nitrogen-packed no-antioxidant flakelets, which suggests that the antioxidant gradually loses its effectiveness and the nitrogen pack deteriorates at a lower rate. If the storage test had been continued, the nitrogen-packed sample may ultimately have scored better than the air-packed sample with BHA plus BHT.

About halfway through Test I it was quite evident that the air-packed flakelet samples containing mixed tocopherols had by far the least storage stability. Also, the level of tocopherols used contributed an objectionable off-flavor. Although strongest at the beginning of the test, it was detectable in subsequent monthly samples. Because of this, a second storage test was conducted. It consisted of flakelets packed under four different conditions. Samples containing no antioxidant were again tested, but under initial conditions of air packaging as well as nitrogen packaging. Two others containing antioxidant and packed in air were also included in the test. One contained Tenox VII (BHA alone), and one contained about half the amount of added mixed tocopherols that the similarly made sample had in the first test.

As might be anticipated the no-antioxidant air-pack sample was significantly inferior to (95% confidence level) the nitrogen pack and to the sample with Tenox VII. Also, the mixed-tocopherols sample proved poorer than either of the latter two. There was no difference between the no-antioxidant nitrogen-packed sample and the sample containing BHA.

Again, the comparative rates of change of the ranking scores should be considered. The positive slopes of the correlation lines for both the air pack with no antioxidant and the mixed-tocopherol pack (Fig. 2) indicate a steady decline in storage stability. Little relative change in score occurred with the BHA sample, so the correlation line is nearly flat. Once more, the nitrogen-packed sample without antioxidant scored progressively better than the others. However, it was not significantly different from any of the other samples in this respect at the 95% level. It can be concluded, however, that it held up at least as well as the antioxidant packs.

The third storage test differed from the other two in that flakes and the flakelets made from them were compared. Each was packed in nitrogen without an antioxidant, as well as in air with BHA plus BHT. Because of the losses of BHA and BHT during processing it was impractical to obtain identical amounts in the finished products. The flakelets contained 25 ppm and the flakes 29. For the purposes of this test this difference was considered unimportant.

The mean rank scores for this third group of samples are also tabulated, as are significant differences between any two means and any two correlation-line slopes. It is apparent that flakes and flakelets have nearly the same keeping properties when similarly packed. Flakelets that are nitrogen-packed with no antioxidant, in addition, keep as well as either product packed in air and protected by the antioxidant. On the other hand, flakes that are nitrogen-packed with no antioxidant keep better than either of the latter products. But both the flakes and the flakelets nitrogen-packed without Tenox IV scored increasingly better than flakes containing Tenox IV and packed in air, as the test progressed.

Table 5. Consumer acceptance test of potato flakelets.

Sample	Acceptability	Significant difference[a]
Flakelets, Tenox IV, N_2 pack	88%	A
Flakelets, no antioxidant, N_2 pack	82%	A
Flakelets, Tenox IV, air pack	63%	B

[a] Samples that have letters in common are not significantly different according to the Chi-Square test.

These results again tend to suggest that nitrogen packing of flakelets having no added antioxidant is at least as good as packing them in air when they do contain antioxidants. Indeed, their keeping properties may be better when protected only by a nitrogen pack.

Consumer acceptance. All of the foregoing data discussed above have to do with the relative keeping properties of each of the samples tested. Not much information is yielded by the three storage tests about the character and intensity of off flavors developed in any single sample pack during storage. To answer better the question of what effect such off flavors might have on consumer acceptance, an additional test was made.

Three samples of reconstituted mashed potatoes were served to 90 people at the Eastern Regional Research Laboratory. Individuals in this group were randomly chosen except that members of the trained taste panel were excluded. The three samples were flakelets made in excess of the requirements of Storage Test I. All had been stored for 11 months at 70°F. One contained no antioxidant and was packed in nitrogen. A second was flakelets containing 23 ppm of BHA plus BHT, packed in air. The third was the same as the second except it was nitrogen-packed. Each mash sample was served singly to each taster, who was asked if he or she judged the sample to be acceptable as a dehydrated mashed potato product. The results are summarized in Table 5.

Statistical analysis of the data by a chi-square test shows no significant difference between acceptabilities of the Tenox IV N_2 pack, and the no-antioxidant N_2 pack. The last sample listed was significantly inferior to the other two. These results add support to the conclusions drawn from the correlations presented in the figures.

Two things should be remembered in judging the significance of these tests.

1) Most, if not all, of the dehydrated mashed potatoes made in this country do contain antioxidants. The protective value of antioxidants during processing and storage of food is well recognized by competent authorities. However, their use is being scrutinized more closely by regulatory agencies and by the public.

2) Cost estimates indicate that flakelets made without antioxidant and packaged in No. 10 cans can be produced at about 1¢ per lb cheaper than flakelets packaged in air with an antioxidant (Claffey *et al.*, 1961). The lower cost stems from the higher density of flakelets.

It is thus apparent that nitrogen-packed flakelets (previously shown to be of high quality) are a product capable of economical manufacture, possessing a long storage life and well suited to military, institutional, and export use.

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The work of Mr. E. S. Della Monica, Engineering and Development Laboratory chemist at the Eastern Division, and of his assistants in making the many oxygen and moisture determinations and in adapting the BHA and BHT analysis to potato flakelets is appreciatively recognized.