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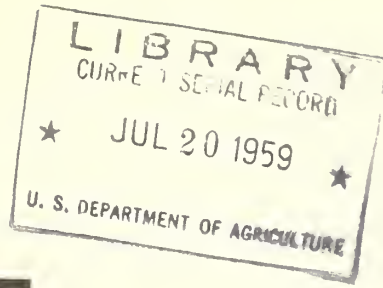
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extending

the

market life

of

PACKAGED SHELLED NUTS

MARKETING RESEARCH REPORT NO. 329

U. S. DEPARTMENT OF AGRICULTURE

AGRICULTURAL MARKETING SERVICE

MARKETING RESEARCH DIVISION

WASHINGTON, D. C.

PREFACE

This report is part of a broad program of continuing research designed to reduce the cost of marketing farm products.

The Diamond Walnut Growers, Inc., generously supplied many of the samples used in this survey. Several brokers collected and forwarded the packaged walnuts to us, and Don Swarthout, Director of Research, Diamond Walnut Growers, Inc., arranged for the collection of a large number of the samples.

The radiation treatments described in this report were made through the cooperation of the Argonne National Laboratory and under contract with the Quartermaster Food and Container Institute.

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June 1959

EXTENDING THE MARKET LIFE OF PACKAGED SHELLED NUTS

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SUMMARY

Shelled walnuts, pecans, filberts, macadamia nuts, and pistachios were packaged in transparent film bags and stored at Pomona, Calif., in 1956 and 1957, under various conditions of light, temperature, and atmosphere. Some of the nuts were treated with antioxidants before packaging. After storage the nuts were examined to find the effects of each of these factors on flavor and color. Also, in 1958 shelled walnuts in film packages were purchased from retail stores throughout the United States and a study was made of the condition of the packages and their contents.

Stored walnuts, pecans, or filberts in transparent film packages became stale and dark in color in 3 or 4 weeks under temperature and light conditions similar to those encountered in marketing, unless protected from light and oxygen or treated with antioxidants.

The shelf life of shelled walnuts, pecans, and filberts was measurably lengthened by storage in nitrogen. Differences in the color and flavor of walnuts and pecans stored in air and of those stored in nitrogen became apparent during the first 4 weeks of storage at 75° F. After 25 weeks those held in nitrogen were still in salable condition, whereas those in air were stale or rancid and dark colored.

Shelled walnuts and pecans which were stored in the light became dark colored and rancid more rapidly than those held in darkness.

Moisture content higher than about 3.5 percent caused an increase in the rate of rancidity development but had no effect on the rate of discoloration.

Antioxidants extended the shelf life of shelled nuts by delaying the onset of rancidity. After 8 or 10 weeks' storage at 70° to 75° F., nuts treated with antioxidants were in good condition, whereas untreated nuts had begun to deteriorate.

Walnuts and pecans subjected to gamma radiation at or above 5×10^4 r. e. p. developed very objectionable odors and flavors. This was evident immediately after treatment and did not become noticeably worse after storage for 30 days at 75° F.

Macadamia nut meats, containing 3.3 percent moisture and packaged in polyvinyl chloride bags, retained excellent quality for more than a year at 32° or 38° F. Those held at 50° were salable but the flavor was not equal to those stored at the lower temperatures.

Pistachio nuts were very stable. Nuts stored at 75° F. in air for 20 months were not rancid. There was no significant difference in quality between those held at 75° and those held in cold storage at either 32° or 38°.

Examination of the shelled walnuts in plastic bags bought in retail stores indicated that many of them reach the consumer in stale or rancid condition. The flavor and odor of walnuts from packages labeled as treated with antioxidants before packaging were much better than those of nuts for which no treatment was indicated.

INTRODUCTION

Transparent plastic film packages are widely used for shelled nuts. They are less costly and lighter in weight than metal cans, but do not provide as much protection as metal from the effects of air, light, moisture, and insects.

Since some kinds of shelled nuts are quite perishable, their shelf life in transparent film packages is usually rather limited unless suitable protective measures are taken. A better knowledge of the factors which contribute to the loss of quality and of the effectiveness of measures which may be taken to minimize these losses should be helpful to those concerned with marketing nuts.

This report gives results of a study of several kinds of nuts that were packaged in film bags and stored under controlled conditions, and a study of film-packed shelled walnuts that were bought in retail stores.

STORAGE TESTS OF PACKAGED NUTS

Materials and Methods

Shelled nuts used for this study included walnuts, pecans, filberts, macadamias, and pistachios. They were obtained at harvest from growers or marketing organizations and were held at 36° F. until used for the test samples. The tests were made at Pomona, Calif., in 1956 and 1957.

Although several films were tested, most of the work was done with packages made of 100-gage, double-wall polyvinyl chloride, which was chosen because of its high transparency, low permeability to oxygen (table 1), and favorable heat-sealing characteristics. The results reported were all obtained with this film unless otherwise indicated.

TABLE 1.--Oxygen permeability of nitrogen-filled bags made of 100-gage, double-wall, heat-sealed polyvinyl chloride

Days after sealing bags	Oxygen content of bags ¹	Days after sealing bags	Oxygen content of bags ¹
	<i>Percent</i> ²		<i>Percent</i> ²
0.....	0.25	24.....	0.40
7.....	.30	108.....	1.80
16.....	.30		

¹ 6- by 6-inch bags were evacuated, filled with nitrogen, and then sealed.

² Each value shown is the average of determinations on 3 bags.

Determinations were made of the shelf life of nuts as influenced by light, oxygen, antioxidants, gamma radiation, moisture, and temperature. The stored nuts were examined at intervals and rated for quality as indicated by their flavor, odor, color, and texture. The scoring was on a scale of 1 to 4 as follows:¹

<u>Rating</u>	<u>Flavor</u>	<u>Color</u>
1.....	Rancid	Very dark brown
2.....	Stale	Dark brown
3.....	Good	Brown
4.....	Excellent	Light brown

¹ This method of scoring differs from that used for commercial grading. In the latter method No. 1 refers to first quality and higher numbers to lower quality.

Several of the published methods on chemical determination of rancidity were investigated but further work is necessary before any decision can be made as to their applicability to nuts.

Effect of Oxygen on Shelf Life of Nuts

The role of oxygen in causing rancidity and other undesirable changes in fats and fatty foods is well known (5, 9, 10, 12).² The rate at which these changes proceed depends on several factors, among which are temperature, the amount of moisture present in the product, and the nature of the fat. As shown in table 2, pecans showed no rancidity when held at 38° F. for 60 weeks, but some flavor deterioration occurred in 10 weeks at 75°.

TABLE 2.--Effect of storage temperature on flavor and color of shelled pecans in polyvinyl chloride bags, after storage for indicated periods, California, 1957

Storage temperature	Flavor rating after indicated storage period ¹			Color rating after indicated storage period ²		
	10 weeks	20 weeks	60 weeks	10 weeks	20 weeks	60 weeks
38° F.....	4.0	4.0	4.0	4.0	4.0	4.0
75° F.....	3.0	2.5	1.0	3.0	3.0	2.0

¹ Flavor ratings: 1, rancid; 2, stale; 3, good; 4, excellent.

² Color ratings: 1, very dark brown; 2, dark brown; 3, brown; 4, light brown.

Nuts packed under vacuum are protected from flavor and color changes caused by oxidation, but when vacuum is applied to a film bag the plastic conforms to the shape of the contents and the package becomes hard and rigid, seriously detracting from its appearance.

Replacement of air in the film packages with nitrogen gave satisfactory results in the prevention of darkening and rancidity and did not present the objectionable features of the vacuum package (table 3). Freshly harvested walnut halves and pieces, pecan halves and pieces, filberts, macadamias, and pistachios were packaged in polyvinyl chloride bags in air or nitrogen and stored in darkness at 75° F. After 4 weeks differences in flavor and color between the walnuts and pecans packed in air and those packed in nitrogen were apparent. At this time the filberts, macadamias, and pistachios were of excellent quality whether held in air or in nitrogen. Macadamia nuts stored in air at 75° F. for 15 weeks became stale and unpalatable but those held in nitrogen retained acceptable flavor and color. The flavor of pistachio nuts held 15 weeks at 75° F. was unchanged. After 25 weeks walnuts stored in air were dark colored and rancid, whereas those in nitrogen still had acceptable color and were not rancid. Similar differences were apparent in the pecans and filberts which had been held in air and those in nitrogen.

The increased shelf life of nuts stored in the absence of oxygen was demonstrated by these data and by the work of many other investigators. However, because of imperfections in sealing technique or the unattractive appearance of the package, nitrogen or vacuum packaging of nuts in plastic bags is little used commercially.

² Underscored numbers in parentheses refer to items in the Literature Cited, p. 14.

TABLE 3.--Effect of nitrogen on the flavor and color of shelled nuts in polyvinyl chloride bags, after storage in darkness at 75° F. for indicated periods, California, 1957

Kind of nuts, percentage of moisture, and atmosphere in bags	Flavor rating after indicated storage period ¹				Color rating after indicated storage period ²			
	4 weeks	9 weeks	15 weeks	25 weeks	4 weeks	9 weeks	15 weeks	25 weeks
Walnuts, 4.2 percent:								
Nitrogen.....	4.0	4.0	3.0	2.5	4.0	4.0	3.0	3.0
Air.....	3.0	3.0	2.0	1.0	3.5	3.0	3.0	1.0
Pecan halves, 2.8 percent:								
Nitrogen.....	4.0	4.0	---	---	4.0	4.0	---	---
Air.....	3.0	3.0	---	---	---	3.0	---	---
Pecan pieces, 3.3 percent:								
Nitrogen.....	---	---	---	3.0	4.0	4.0	---	3.0
Air.....	---	---	---	2.0	3.5	3.0	---	2.0
Filberts, 4.4 percent:								
Nitrogen.....	4.0	---	---	3.0	4.0	---	---	3.0
Air.....	4.0	---	---	1.5	4.0	---	---	2.0
Macadamia nuts, 3.3 percent:								
Nitrogen.....	4.0	---	3.0	---	4.0	---	4.0	---
Air.....	4.0	---	2.0	---	4.0	---	4.0	---
Pistachio nuts, 4.5 percent:								
Nitrogen.....	4.0	---	---	---	4.0	---	---	---
Air.....	4.0	---	4.0	---	4.0	---	4.0	---

¹ Flavor ratings: 1, rancid; 2, stale; 3, good; 4, excellent.

² Color ratings: 1, very dark brown; 2, dark brown; 3, brown; 4, light brown.

Effect of Moisture and Light on Rancidity and Discoloration

Brison in 1945 (1) reported that optimum moisture content for pecan kernels was about 3.5 percent and that relatively slight variations in moisture resulted in inferior texture. At high temperatures nuts with suboptimal moisture became rancid more rapidly than those with optimal moisture, whereas the rate was not affected by moisture somewhat higher than optimum. Rockland (6, 7, 8) reported that shelled walnuts which were either above or below the optimal moisture were subject to more rapid skin discoloration and loss of quality than those which were at the optimum.

Moisture appears to have more influence on the rate of rancidity development than on darkening. This is indicated by the results of an experiment in which two lots of pecans containing 3 and 5 percent moisture, respectively, and two lots of walnuts containing 3 and 6 percent moisture respectively were packaged in clear moistureproof plastic bags and stored as indicated in table 4. No difference was found in the color of either pecans or walnuts at the two moisture levels after storage in darkness for 5 and 13 weeks, respectively. Flavor, however, was adversely affected under these conditions. Nuts with 5 or 6 percent moisture became very rancid, whereas those with 3 percent retained good flavor. Flavor and color retention were much better in nuts with 3 percent moisture content when held at 70° F. in darkness than in light (table 4).

TABLE 4.--Effect of moisture and light on flavor and color of shelled pecans and walnuts in polyvinyl chloride bags, after storage at 70° F. for indicated periods, California, 1956

Kind of nuts and percentage of moisture, stored in light or darkness	Flavor rating after indicated storage period ¹		Color rating after indicated storage period ²	
	5 weeks	13 weeks	5 weeks	13 weeks
<u>Pecans</u>				
3.0 percent:				
Darkness.....	3.0	---	3.5	---
Light.....	1.0	---	2.5	---
5.0 percent:				
Darkness.....	1.5	---	3.5	---
<u>Walnuts</u>				
3.0 percent:				
Darkness.....	---	3.0	---	3.0
Light.....	---	1.5	---	2.0
6.0 percent:				
Darkness.....	---	1.5	---	3.0

¹ Flavor ratings: 1, rancid; 2, stale; 3, good; 4, excellent.

² Color ratings: 1, very dark brown; 2, dark brown; 3, brown; 4, light brown.

In an experiment to determine the effects of various colored bags, pecans and walnuts containing 3 percent moisture were packaged in transparent plastic bags, overwrapped with red, amber, or green cellophane and stored at 70° to 80° F. They were examined after 5 and 15 weeks of continuous exposure to fluorescent light (table 5). The red overwrap prevented darkening but gave little or no protection against the development of rancidity. The other overwraps were of little value, particularly with pecans. The nuts did not appear in their true color when viewed through any of the colored films.

Effectiveness of Antioxidants in Extending Shelf Life of Nuts

The effectiveness of antioxidants in preventing undesirable changes in flavor, odor, and color of nuts and other fatty foods has been studied extensively. Cruess and Armstrong in 1947 (4) reported the results of tests on walnuts with a number of antioxidant materials including nordihydroguaiaretic acid (NDGA). The latter material checked rancidity but imparted a bitter flavor to the product. In 1951 Cecil and Woodroof (3) reported that the use of butylated hydroxyanisole (BHA) in the cooking oil or mixed with the salt used on salted peanuts increased the shelf life of the nuts. In 1951 and 1952 Wells (13, 14) reported on tests with BHA and NDGA on shelled pecans, but the results were not promising because the treated nuts were bitter. In 1955 Rockland (6) reported that antioxidants increased the shelf life of shelled walnuts. The authors tested butylated hydroxytoluene (BHT) as an antioxidant for pecans and walnuts. This antioxidant was applied in solution in amounts of 0.05 percent of the weight of the oil in the nuts.

TABLE 5.--Effect of light on flavor and color of shelled walnuts and pecans in colored cellophane bags, after storage at 70°-80° F. for indicated periods, California, 1956

Kind of nuts, moisture content, and method of protection from light	Flavor rating after indicated storage period ¹		Color rating after indicated storage period ²	
	5 weeks	15 weeks	5 weeks	15 weeks
Walnuts (3.0 percent):				
Clear plastic (control)....	---	1.5	---	2.0
Red cellophane.....	---	1.5	---	3.5
Amber cellophane.....	---	1.0	---	3.0
Green cellophane.....	---	1.0	---	3.0
Darkness.....	---	3.0	---	3.0
Pecans (3.0 percent):				
Clear plastic (control)....	1.0	1.0	2.5	1.0
Red cellophane.....	3.0	1.5	3.5	3.0
Amber cellophane.....	2.0	1.0	3.0	1.0
Green cellophane.....	2.0	1.0	2.5	1.0
Darkness.....	3.0	2.0	3.5	3.5

¹ Flavor ratings: 1, rancid; 2, stale; 3, good; 4, excellent.

² Color ratings: 1, very dark brown; 2, dark brown; 3, brown; 4, light brown.

The treated pecans were divided into two lots, one of which was sealed in clear polyvinyl chloride bags and stored in darkness at 75° F. and the other placed in lightly covered beakers and held in an oven at 145° for an accelerated test. Untreated nuts were held under each of the above conditions for comparison. After 30 weeks' storage at 75°, the treated nuts were in good condition (table 6). There was no odor or flavor of rancidity. Untreated pecans held under the same conditions were extremely rancid.

TABLE 6.--Effect of antioxidants on preservation of flavor in shelled pecans and walnuts in polyvinyl chloride bags, after storage for indicated periods, California, 1957

Kind of nuts, storage temperature, and antioxidant used	Flavor rating after indicated storage period ¹				
	6 weeks	8 weeks	10 weeks	14 weeks	30 weeks
Pecans (75° F.):					
BHT.....	---	4.0	---	4.0	3.0
None.....	---	3.0	---	2.0	1.5
Walnuts (70° F.):					
BHT.....	4.0	4.0	4.0	---	---
None.....	4.0	3.0	2.5	---	---

¹ Flavor ratings: 1, rancid; 2, stale; 3, good; 4, excellent.

Pecans held at 145° F. were examined daily for the detection of rancid odors (table 7). On the fourth day the untreated controls were slightly rancid and on the sixth day they were strongly rancid. At this time both the treated and untreated nuts were much darker in color than similar ones held at room temperature, but the flavor and odor of the treated nuts were good. Although the nuts which had been treated with antioxidant gradually became rancid, they remained edible about twice as long as nontreated ones in this accelerated test.

TABLE 7.--Accelerated storage tests: Effect of antioxidant on preservation of flavor of shelled pecans in polyvinyl chloride bags, after storage at 145° F. for indicated periods, California, 1956

Antioxidant used	Flavor rating after indicated storage period ¹		
	4 days	6 days	12 days
BHT.....	4.0	4.0	2.0
None.....	2.0	1.0	---

¹ Flavor ratings: 1, rancid; 2, stale; 3, good; 4, excellent.

In tests on shelled walnuts which had been treated with BHT, packaged, and held at 70° F., the better maintenance of quality as a result of treatment became apparent after about 8 weeks (table 6).

Effect of Radiation on Nut Meats

Recently much attention has been given to radiation sterilization of foods to lengthen their storage life. It seemed desirable to learn whether irradiation would be helpful in maintaining quality in nut meats. Shelled pecans and walnuts were packaged in polyvinyl chloride bags holding about 4 ounces each, and these bags were then placed in sealed tin cans for irradiation. The radiation dosages used were 5×10^4 , 1×10^5 , 2×10^5 , 3×10^5 , 5×10^5 , and 1×10^6 r. e. p. Three replicates were used for each dosage.

All of the nuts developed very objectionable flavors and odors. The changes were detectable immediately after radiation and did not become noticeably worse on further storage for 30 days at 75° F.

Storage of Macadamia Nuts

Macadamia trees have been used as ornamentals in southern California for a number of years but the commercial production of macadamia nuts is a comparatively new industry in continental United States (2). Few data are available on the storage requirements of these nuts. The present work was undertaken to provide information which could be used by the industry if production increases to a volume which will necessitate storing some of the crop for long periods.

Shelled macadamia nuts of the variety *M. tetraphylla* were obtained from a California grower at the time of harvest. The kernels contained 3.3 percent moisture and 64.7 percent oil. They were divided into several lots, packaged in polyvinyl chloride bags, in either nitrogen or air, and stored at 32°, 38°, 50°, and 75° F. They were examined at intervals over a period of 60 weeks (table 8).

TABLE 8.--Flavor of shelled macadamia nuts in polyvinyl chloride bags filled with nitrogen or with air, after storage at temperatures from 32° to 75° F. for indicated periods, California, 1957

Storage temperature and atmosphere in bags	Flavor rating after indicated storage period ¹			
	4 weeks	16 weeks	27 weeks	60 weeks
75° F:				
Nitrogen.....	4.0	3.0	---	2.0
Air.....	4.0	2.0	1.5	---
50° F:				
Air.....	---	3.0	3.0	3.0
38° F:				
Nitrogen.....	---	4.0	---	---
Air.....	---	4.0	4.0	4.0
32° F:				
Air.....	---	4.0	4.0	4.0

¹ Flavor ratings: 1, rancid; 2, stale; 3, good; 4, excellent.

The nuts held in air at 75° F. for 27 weeks were rancid. Those stored in nitrogen at the same temperature were slightly stale but not rancid after 60 weeks when the test was terminated. Nuts held 60 weeks in air at 50° were acceptable but the flavor was not as fresh as those which had been stored at 32° or 38°. The data indicate that macadamia nuts dried to a moisture content of approximately 3.5 percent and packaged to prevent absorption of moisture can be held in prime condition in air for more than a year at 32° to 38°, and in fairly good condition for the same length of time at 50°.

Storage of Pistachio Nuts

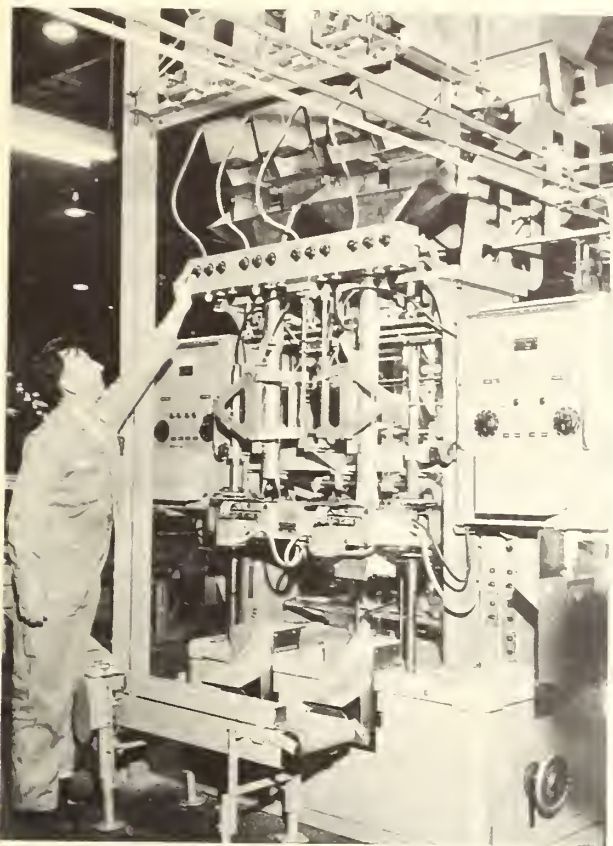
Pistachio nuts used in the United States are largely imported from the Middle East. There is a small commercial production in the Sacramento Valley of California and with the interest reported (11) in larger supplies of these nuts, a modest domestic production could eventually result. There is little information available on storage requirements of these nuts and some tests were conducted to provide data on the subject.

Freshly harvested shelled nuts were obtained from a northern California grower. The nuts contained 4.5 percent moisture and 49.2 percent oil. They were divided into two lots, one of which was packaged in polyvinyl chloride bags in nitrogen and the other lot in similar bags in air. Packages of each lot were stored at 38° and 75° F. and additional packages in air at 32° and 50°. These were examined at intervals over a period of 60 weeks.

These nuts were very stable. Those stored in either air or nitrogen at 75° F. for 60 weeks were not rancid. The quality was good. There was no significant difference in quality between those held at 32° to 38° and those held at 75° for 60 weeks. They were still in good condition after 20 months when the experiment was terminated.

PACKAGED WALNUTS PURCHASED IN RETAIL STORES

Many shelled nuts sold at retail are packaged in transparent film with equipment similar to that shown in figure 1. A typical retail market display of packaged nut meats is shown in figure 2. To obtain information on the quality of film-packed walnuts as they are offered for sale to customers, a large number of film packages of shelled walnuts were purchased from retail stores and a study made of the condition of the packages and their contents.



BN 7612

Figure 1. Fully automatic packaging equipment of type used for shelled nuts.



BN 7613

Figure 2. Retail display of nut meats.

Collection and Examination of Samples

Packages containing 2, 3, or 5 ounces of shelled walnuts were purchased in retail markets located in widely scattered sections of the United States. These were purchased at intervals of 2 or 4 weeks over a period of 7 months and the packages mailed to Pomona, Calif., where the study was made in 1958. More than 500 packages representing 14 different brands were examined during the survey.

The packages were inspected for breaks in the walls or seams and the nuts examined for evidence of insect infestation. Determinations were made of the oxygen content of the package atmosphere. The moisture, flavor, odor, and color of the nuts and the fatty acids of the nut oil also were determined.

Oxygen content of the package atmosphere was determined by puncturing the film with a hypodermic needle and withdrawing a sample of the gas into an oxygen analyzer for direct reading. Moisture was determined by xylene distillation or moisture balance.

Flavor, odor, and color were determined by sensory methods using packaged, cold-stored nuts as a standard. The flavor, odor, and color of the nuts were rated on an arbitrary scale of 1 to 4 as follows:

<u>Rating scale</u>	<u>Flavor</u>	<u>Odor</u>	<u>Color</u>
1	Rancid	Rancid	Dark brown
2	Stale	Stale	Brown
3	Good	Good	Amber
4	Excellent	Excellent	Light amber

Labels on some of the packages declared the use of butylated hydroxyanisole and butylated hydroxytoluene on the walnuts to preserve and maintain quality. Where there was no label declaration concerning the use of preservatives or antioxidants, we assumed none had been used since regulations of the U. S. Food and Drug Administration require that the presence of such additives must be declared on the label of foods entering interstate commerce.

Results and Discussion

About 95 percent of the walnuts from packages labeled as antioxidant treated were rated as having good or excellent flavor and odor. Only 24 to 27 percent of the untreated nuts were classified in these categories (table 9). About 85 percent of the treated nuts and 60 percent of the untreated were classed in the two lightest color ratings.

TABLE 9.--Percentage distribution in ratings of shelled walnuts in film bags purchased in retail stores, by type of treatment, 1958

Treatment and characteristics rated	Rating ¹			
	1	2	3	4
Antioxidant treated:				
Flavor.....	<i>Percent</i> ---	<i>Percent</i> 4.1	<i>Percent</i> 51.0	<i>Percent</i> 44.9
Odor.....	0.2	5.2	50.2	44.4
Color.....	0.2	14.6	52.5	32.7
No treatment:				
Flavor.....	46.1	30.3	11.8	11.8
Odor.....	34.9	37.9	13.6	13.6
Color.....	7.6	31.9	46.9	13.6

¹ Ratings:

- 1 - Flavor and odor rancid, color dark brown.
- 2 - Flavor and odor stale, color brown.
- 3 - Flavor and odor good, color amber.
- 4 - Flavor and odor excellent, color light amber.

Darkening of light-colored nut meats due to oxidation was usually closely related to the development of rancidity. However, some of the extremely rancid, untreated kernels were very light colored. Nuts also may become discolored from weather damage or other causes during growth or harvesting without becoming rancid. Many dark-colored nuts of

otherwise excellent quality were found during the survey. The correlation between darkening and rancidity that was found during the storage tests described in this report was not evident.

Average fatty acid content of the rancid nuts was slightly higher than that of non-rancid ones (table 10). However, because of the wide variation within groups, it is doubtful that the differences are of any significance.

TABLE 10.--Fatty acid and moisture content of shelled walnuts in film bags purchased in retail stores, by flavor rating and type of treatment, 1958

Flavor rating ¹	Antioxidant treated						No treatment					
	Fatty acid			Moisture			Fatty acid			Moisture		
	Max.	Min.	Avg.	Max.	Min.	Avg.	Max.	Min.	Avg.	Max.	Min.	Avg.
	<i>Pct.</i>	<i>Pct.</i>	<i>Pct.</i>	<i>Pct.</i>	<i>Pct.</i>	<i>Pct.</i>	<i>Pct.</i>	<i>Pct.</i>	<i>Pct.</i>	<i>Pct.</i>	<i>Pct.</i>	<i>Pct.</i>
1.....	---	---	---	---	---	---	0.93	0.14	0.33	4.6	3.4	3.9
2.....	0.57	0.23	0.37	3.8	3.2	3.6	1.19	0.13	0.32	5.0	3.3	4.0
3.....	0.51	0.11	0.28	4.2	3.2	3.7	0.68	0.14	0.29	4.6	3.3	3.7
4.....	0.47	0.19	0.24	4.0	3.3	3.6	0.42	0.11	0.20	4.1	3.2	3.7

¹ Ratings:

- 1 - Flavor and odor rancid, color dark brown.
- 2 - Flavor and odor stale, color brown.
- 3 - Flavor and odor good, color amber.
- 4 - Flavor and odor excellent, color light amber.

The average moisture content of the untreated nuts was somewhat higher than that of those which had been treated with antioxidants (table 10). The percentage of moisture found in a number of individual samples of untreated nuts was higher than the 3.5 per cent recommended for best flavor retention, but these were not measurably darker colored or more rancid than untreated nuts with nearly optimum moisture content.

Occasional packages were tested for leaks by immersing them in water, applying slight pressure, and observing whether or not air bubbles appeared. Spot checks from time to time indicated that a high percentage of the packages had small leaks along the seams. With few exceptions the package atmosphere contained the normal atmospheric concentration of oxygen, which provided further evidence that very few of the packages were gas tight.

Insect infestation was found in only one package. The package had a small break in the seal through which the insects could have entered.

LITERATURE CITED

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