Quality of Frozen Peas and Peaches Subjected to Elevated Temperatures During Simulated Retail and Consumer Handling

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The quality of frozen peas and peach slices exposed to 21°C (70°F) for several minutes or 2 hours and to 27°C (80°F) for 20 or 60 minutes was determined by panel ratings and shear force and color difference measurements.

INTRODUCTION

For retention of optimum quality, frozen foods should be held at -18°C (0°F) or below throughout all phases of distribution (1). Time of any unavoidable exposure to temperatures above -18°C should be kept at a minimum and foods should be protected against thawing. Frozen foods are most often exposed to high temperatures during transfer from one area to another. Two occasions when frozen foods may be mishandled are: (1) at the retail store during transfer of packages from shipping containers to the freezer display cases, and (2) between the time consumers select frozen food and ultimately place it in their home freezers (2).

It has been recommended that retailers: (1) sort incoming frozen foods (whether unitized or nonunitized loads) into two groups--those needed now and later; (2) have experienced people price mark products in the backroom and move the products on stocking carts to the display area or temporary frozen storage; (3) do not move unit loads (pallet or mobile cart loads) to the display area for display case stocking; and (4) do not remove more than 10 to 12 cases of frozen food from storage at one time (3)(4). However, mishandling of frozen foods is not uncommon at retail stores and frozen foods may be left out of cold storage for hours (2).

It has also been recommended that consumers: (1) select frozen food purchases last when shopping to shorten the time the food is unrefrigerated, (2) protect food during transport home by having it placed in insulated or double-walled heavy paper bags, and (3) proceed promptly home and place the food in the freezer immediately (5). However, mishandling is not uncommon among some shoppers and frozen food may be exposed to temperatures that could permit thawing (2).

At the request of the Food Distribution Research Laboratory, Agricultural Marketing Research Institute, the Consumer Use of Foods Laboratory of the Consumer and Food Economics Institute, measured the effect of elevated temperatures during retail and consumer handling on the quality of frozen peas and peach slices.

METHODOLOGY

Handling Practices

Commercially frozen sweet peas, packaged in 10-ounce cartons, and frozen

sliced peaches in syrup, packaged in 16-ounce rapid thaw pouches,[2] were exposed to specified temperatures for different times in order to simulate handling practices in retail stores and by consumers. An incubator set to the temperature desired for the treatment was used to control conditions during simulated handling. Products were stored in a freezer with the control set so the temperature did not exceed -18°C. The simulated handling practices were as follows:

1. Proper handling by store: Containers of frozen foods were kept in the freezer except for the time required to remove individual packages from the containers and return them to the freezer. (Simulates no delay between the removal of containers from freezer storage and placement of packages in freezer display case.)

2. Improper handling by store: Containers were removed from the freezer and held for 2 hours at 21°C (70°F). Then the packages were removed from the containers and returned to the freezer. (Simulates delay between removal of containers from freezer storage and placement of packages in freezer display case.)

3. Proper handling by consumer: Packages that had been handled properly or improperly in the simulated store treatments were removed from freezer storage, placed in double-walled heavy paper bags (four packages per bag) and left for 20 minutes at 27°C (80°F). The packages were then removed from the bags and returned to the freezer. (Simulates minimal delay between store purchase and home storage and proper protection of frozen foods during transport.)

4. Improper handling by consumer: Packages that had been handled properly or improperly in the simulated store treatments were removed from freezer storage, left for 1 hour at 27°C (80°F) in single layers with at least 1 inch of space around each package, and then returned to the freezer. (Simulates delay between purchase and home freezer storage and the practice of leaving frozen food unprotected at relatively high temperatures.)

Six packages each of peas and peaches from each of three replications (lots) were randomly assigned to one of the following combinations of simulated store and consumer handling practices:

Treatment I: Proper store handling - proper consumer handling
Treatment II: Proper store handling - improper consumer handling
Treatment III: Improper store handling - proper consumer handling
Treatment IV: Improper store handling - improper consumer handling
Treatment V (Control): Proper store handling - no consumer handling

Two additional packages were assigned to Treatments I and II and four additional packages to Treatments III and IV for the purpose of monitoring the temperature of the food during improper store handling and proper or improper consumer handling. Extra packages were used to fill the containers for improper store handling.

Containers of peas and peaches were subjected to proper (Treatments I and II) and improper (Treatments III and IV) store handling the same day that they were obtained. Packages of peas and peaches assigned to the control treatment were handled the same as those for proper store handling. The temperature of products during the control and proper store handling treatments was not determined since to do so would have resulted in an undesirable delay in returning the individual packages to the freezer.

The temperature of peas in four randomly placed packages in one container and of peach slices in two randomly placed packages in each of two containers was monitored with a recording potentiometer from the start of the improper store handling treatment until the temperature had equalized with that of the freezer after the food was returned to freezer storage. Thermocouples were inserted into the center of randomly selected peas or peaches. The packages from all the treatments were stacked in the freezer with no space between the columns, simulating the close manner in which packages are stacked in store freezer display cases.

After 3 days of freezer storage, packages of peas and peaches for all treatments except the control were removed from the freezer and held for specified times at 27°C (80°F) to simulate proper (Treatments I and III) and improper (Treatments II and IV) handling procedures by the consumer, and then returned to the freezer. The temperature of the food was monitored in two randomly placed packages for each treatment while in the incubator and upon return to the freezer until the temperature of the food had equalized with that of the freezer. Packages of peas and peaches that were handled improperly during transport by the consumer were placed on the freezer shelves in single layers with at least 1 inch of space between the packages while those that were handled properly by the consumer were stacked four-high with no space between the stacks, thus, simulating the way the homemaker might place partially thawed or hard frozen packages, respectively, of recently purchased frozen food in the home freezer. Once the temperature of the packages had equalized with the freezer temperature, the packages from all treatments were stacked together with no space between the columns.

After simulated handling treatments by the consumer, peas were stored at -18°C (0°F) for 5 days and peaches for 6 days before samples were removed for quality evaluation. Samples were also evaluated after 4 weeks of freezer storage.

Subjective and Objective Quality Measurements

For subjective measurements, a trained panel evaluated palatability--color, shape, texture, and flavor--of drained cooked peas and thawed peach slices. For objective measurements, shear force values and color difference readings (using an Allo-Kramer shear press and a Hunter Color Difference Meter, respectively) were determined for thawed and cooked peas and thawed peach slices.[3]

Statistical Design

The design of the experiment was a randomized complete block (6) with three replications. Panel scores for cooked peas and thawed peaches were treated by analysis of variance for differences between treatments, storage times, lots (replications), and judges. Shear force and color difference values for thawed uncooked and cooked peas and thawed peaches were also analyzed by analysis of variance. A Chi-square distribution was used to analyze differences (significant at $P<0.05$ level) in the detection of off-flavor among treatments; a binominal distribution was used to analyze differences (significant at $P<0.05$ level) between storage times. Correlations were calculated between shear force values for cooked peas or thawed peaches and panel judgments for texture and between color difference values for cooked peas or thawed peaches and panel judgments for color. Where applicable, multiple comparisons (7) were conducted for treatment differences.

RESULTS AND DISCUSSION

Temperature Changes During Handling

The warehouse storage temperatures were -13° to -11°C (8° to 12°F) at the time the products were obtained (warehouse storage temperatures of -18°C or 0°F would have been preferred). The temperature of the containers ranged from -12° to -4°C (10° to 25°F) at the warehouse and remained unchanged during transport to the laboratory.

After simulated improper store handling (21°C or 70°F for 2 hours) the temperature in the monitored packages ranged from -6° to -2°C (21° to 29°F) for peas and -9° to -6°C (16° to 22°F) for peaches. After simulated proper consumer handling (20 minutes at 27°C or 80°F in protective bags), the temperature ranged from -12° to -4°C (10° to 24°F) for peas and -14° to -8°C (6° to 17°F) for peaches. After simulated improper consumer handling (60 minutes at 27°C or 80°F) the temperature ranged from -4° to 1°C (24° to 34°F) for peas and -6° to -2°C (21° to 29°F) for peaches. The packages were pliable but no drip was evident.

When the packages were returned to the freezer after treatment, time varied considerably for equilibration of temperature of the monitored packages with the freezer. This variation was probably due in part to variations in the temperatures of the packages when returned to the freezer, and to the position of the package in the freezer--whether next to the freezer coils, at the top of a stack, or surrounded by other packages that would act as insulators.

Quality Measurements

Data for treatment effects on panel ratings, shear force, and color difference are presented in Table 1. Differences due to interactions, lot, and storage effects are discussed, but the data are not shown.

None of the simulated store and consumer handling treatments significantly ($P<0.05$) affected any of the palatability ratings for either peas or peaches (Table 1). Differences were not significant ($P<0.05$) in the detection of off-flavors in the peas and peaches subjected to the various treatments. However, objective measurements showed some significant differences ($P<0.05$) in texture and color.

Some differences in shear force for cooked peas were significant ($P<0.01$) for treatment, lot, and interaction between treatment and lot. As indicated in Table 1, peas subjected to improper handling by the store (Treatments III and IV) were significantly less resistant ($P<0.05$) to shear than those that were handled properly by the store but improperly by the consumer (Treatment II). Generally, shear force of peas was lowest for lot 1 and highest for lot 2. Panel ratings for texture of peas differed significantly ($P<0.01$) between lots.

Shear force values of thawed peas were not affected by treatment but showed significant differences for storage ($P<0.01$), lot ($P<0.01$), and treatment-lot interaction ($P<0.05$). Peas stored for 5 days were less resistant to shear than those stored 4 weeks.

Some significant differences ($P<0.01$) were observed in shear force values for peaches due to the effects of simulated handling conditions, lot, and treatment-lot interaction. Data in Table 1 show that shear force was significantly lower ($P<0.05$) for peaches handled improperly in both store and consumer phase (Treatment IV) than for peaches handled properly in the store and improperly in

Table 1. Mean panel ratings, shear force values, and color values for frozen peas and peach slices subjected to simulated store and consumer handling practices.[1]

Simulated Handling Treatment[2]	Palatability Rating[3]				Shear Force[4]	Color Values[5]		
	Color[6]	Shape[7]	Texture[8]	Flavor[9]		L	a_L	b_L
					Kg			
Uncooked peas								
I	-	-	-	-	208	42.1	-18.4	23.0^{a}
II	-	-	-	-	215	41.5	-18.1	22.6^{ab}
III	-	-	-	-	215	41.6	-18.4	22.7^{ab}
IV	-	-	-	-	215	41.0	-18.3	22.3^{b}
V	-	-	-	-	215	41.4	-18.3	22.6^{ab}
Cooked peas								
I	4.0	6.1	5.5	3.8	110^{ab}	42.5^{a}	-14.6	22.6
II	3.9	6.4	5.9	3.9	113^{a}	42.1^{ab}	-14.6	22.5
III	3.8	6.4	5.7	3.6	108^{b}	41.4^{ab}	-14.5	22.1
IV	4.0	6.6	5.2	3.7	108^{b}	41.2^{b}	-14.5	22.0
V	3.8	6.2	5.6	3.6	112^{ab}	41.9^{ab}	-14.5	22.4
Thawed peaches								
I	4.3	4.1	4.4	3.4	26^{ab}	50.1	14.5	28.7
II	4.2	3.7	4.4	3.2	29^{b}	48.8	15.5	28.4
III	4.5	4.2	4.8	3.3	27^{ab}	48.9	15.5	28.0
IV	4.2	3.7	4.1	3.4	21^{a}	48.2	16.6	28.1
V	4.3	4.0	4.4	3.2	30^{b}	49.5	15.7	28.6

[1] ab - Means in the same column with different letters are significantly different at the 5% level.
[2] Treatment I: Proper store handling - Proper consumer handling; Treatment II: Proper store handling - Improper consumer handling; Treatment II: Improper store handling - Proper consumer handling; Treatment IV: Improper store handling - Improper consumer handling; Treatment V: Control.
[3] Means of 6 panel members, 3 replications, and 2 storage times for a total of 36 ratings.
[4] Means of 3 replications, 2 storage periods, and 2 readings for each 100 gram sample for a total of 12 determinations.
[5] Means of 3 replications and 2 storage periods for a total of 6 determinations.
[6] A rating of 5 for peas and peaches was natural, bright color; a rating of 1 for peas was dull or pale color and for peaches, very brown color.
[7] A rating of 9 for peas was shriveled; a rating of 5 for peaches was firm slices with smooth edges, distinct shape; a rating of 1 for peas was mushy, many broken skins, and for peaches, very limp, indistinct shape.
[8] A rating of 9 for peas was very hard or very tough, very dry and for peaches, very hard or very tough; a rating of 1 for peas was mushy, very wet and for peaches very soft, mushy.
[9] A rating of 5 for peas and peaches was very full, natural flavor; a rating of 1 for peas and peaches was weak or lacking flavor.

the consumer phase (Treatment II) or the control (Treatment V).

Generally, shear force values of peaches were lowest for lot 1 and highest for lot 3. Significant differences in panel ratings for texture of peaches due to lot ($P<0.01$) and lot-treatment interaction ($P<0.05$) were also observed.

For cooked peas the correlation coefficient was +0.63 ($P<0.01$) for the relation between shear force and panel scores for texture. For peaches the corresponding coefficient was +0.46 ($P<0.01$).

Some differences between the b_L (yellow-blue) color values due to simulated handling treatments were significant ($P<0.05$) for uncooked peas and the L (lightness) values for cooked peas (Table 1). Uncooked peas that were handled improperly by both the store and consumer (Treatment IV) were significantly less blue than those that were handled properly by both the store and consumer (Treatment I). Similarly, the lightness values for cooked peas were significantly lower for Treatment IV than Treatment I. Significant differences ($P<0.01$) due to lots were also observed for all color values for both raw and cooked samples of peas.

No significant changes in color as indicated by panel ratings and color difference measurements for the peach slices could be attributed to simulated handling conditions or time of storage. Significant differences ($P<0.05$) due to lots were noted among the lightness values for samples of thawed peaches. Panel color scores did not correlate significantly with any of the Hunter color values for cooked peas and thawed peach slices.

Although peaches within each replication were from the same processing codes, we noted much variability in the apparent ripeness, firmness, color, and shape of peach slices among packages. Possible effects of treatments on peas and peaches were not shown consistently, perhaps because of the large differences among judges, lots, and interaction effects.

The small number of samples limited the interpretation of the results, especially if much variability was inherent in the frozen food before treatment. The adverse effects of improper store and/or consumer handling on quality of frozen foods probably could be demonstrated conclusively in tests with large numbers of samples and drastically improper handling treatments.

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APPENDIX

Materials

A store brand of commercially frozen sweet peas, packaged in 10-ounce cartons packed 24 per container, and a national brand of commercially frozen sliced peaches in syrup, packaged in 16-ounce rapid-thaw pouches packed 12 per container, were used for the study. Two shipping containers of peas and four containers of peaches were obtained each week for 3 weeks during June and July 1974, from the warehouse of a grocery chain in the Washington, D.C. area. The products obtained each week comprised a replication (lot). Containers of peas for weeks 1 and 3 were marked with the same processing codes; containers of peaches had the same code within but not between replications.

The containers were placed in insulated chests for transport (about 30 minutes) directly to the laboratory, then immediately transferred to a household freezer set to maintain -18°C (0°F) or below. The temperature of the containers at the warehouse and laboratory was measured with mercury thermometers placed between the packages in each container.

Preparation of Sample for Evaluation

Three packages of peas from each of the five handling treatments were removed from freezer storage. The contents of the packages were mixed together by treatment and evaluated for quality. A 200-gram sample of peas was removed from each treatment sample and thawed at room temperature for objective evaluation of the raw sample. The remaining frozen peas from each treatment sample were cooked in 1 cup boiling water to which ½ teaspoon salt was added. The peas were cooked, covered, for 6 minutes after the water returned to a boil. The peas were immediately drained and samples were served to a trained panel for quality evaluation. A 200-gram sample of drained cooked peas was objectively evaluated.

Three packages of peaches from each of the five handling treatments were removed from freezer storage and thawed in a 4°C (40°F) refrigerator for 30 hours. The temperature of the packages was monitored with thermocouples so the rate of thawing and the temperature of the thawed peaches could be determined. After the peaches had thawed, the syrup was drained from each package and the peaches were mixed together by treatment and samples were served to a trained panel for quality evaluation. The remaining peaches were drained and a 200-gram sample from each treatment was objectively evaluated.

Subjective Quality Measurements

Palatability of the cooked peas and thawed peach slices was measured by six trained panelists.

Shape and texture of peas were rated on nine-point scales with nine as shriveled and very hard, very tough, very dry. A score of five which was considered

optimal for a particular characteristic was plump, spherical, smooth to slightly wrinkled skin and tender yet firm, succulent. A score of one was mushy, many broken skins and mushy, very wet. Color and flavor of peas were rated on five-point scales. A rating of five was natural, bright color, and very full, natural flavor. A rating of one was dull or pale color and weak or lacking flavor.

Texture of peaches was also rated on a nine-point scale with nine as very hard, very tough. A score of five that was considered optimal was firm, tender. A score of one was very soft and mushy. Color, flavor, and shape of peaches were rated on five-point scales. A rating of five was natural, bright color, very full, natural flavor, and firm slices with smooth edges, distinct shape. A rating of one was very brown color, weak, or lacking flavor, and very limp, indistinct shape.

Panelists were also asked to indicate whether or not they detected any off-flavors in any of the samples.

Objective Quality Measurements

An Allo-Kramer shear press with standard cell and 1134 kilogram proving ring was used for objective determination of tenderness of raw and cooked peas and thawed peach slices. Duplicate 100-gram samples per treatment were used for each test. Shear force was calculated as kilograms of force required to shear 100 grams of product.

Reflected color for thawed and cooked peas and thawed peach slices was determined with a Hunter Color Difference Meter. Sheared samples of peas and intact peach slices were used. Color values were measured on three scales: (1) L, which measures lightness; (2) a_L which measures red (+) and green (-); and (3) b_L which measures yellow (+) and blue (-). Four values for each color parameter were obtained on one sample from each treatment. The sample was rotated 90° between each color observation. The average of four observations was considered the color value for the sample. Green and yellow color standards were used for the color measurements of the peas and peaches, respectively. The values for each standard tile were as follows:

	L	a_L	b_L
Green	60.9	-17.0	6.2
Yellow	83.1	- 4.5	26.1

FOOTNOTES

[1]The authors acknowledge the assistance of Brucy Gray in the statistical analysis of the data and of Evelyn Matthews and Marion Jackson for technical assistance.

[2]See appendix for additional information on the frozen products and the procedure for transporting them to the laboratory.

[3]See appendix for additional information on sample preparation and subjective and objective quality evaluations.