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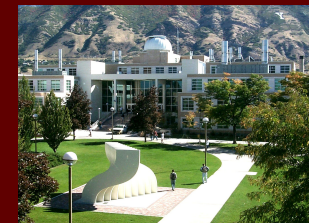
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# Effects of long-term storage on quality of retail-packaged pinto beans

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## Abstract

There is interest in storing low-moisture foods for long periods of time for uses such as personal preparedness, disaster relief efforts and space travel. Pinto beans in restaurant-sized No. 10 cans are available in the retail market, but work is needed to determine the effects of long-term storage on quality. The objective of this research was to investigate the quality of retail-packaged pinto beans held at ambient temperatures up to 32 years.

Fifteen samples of pinto beans packaged in No. 10 cans, which were treated to remove oxygen, were obtained from donors. Samples ranged from <1 to 32 years in age. Prior to cooking, pinto bean samples were soaked in water containing varying levels of baking soda to standardize textural attributes.

Can headspace oxygen ranged from 2.1 to 20.7%. Can seams from cans 11-1, 11-2, 12, 13, and 30 received a rating of poor. All other cans received ratings of satisfactory or good. Water activity ranged from 0.30 to 0.61. L\*a\*b\* color values ranged from 40.36 to 59.06, 6.28 to 14.60 and 15.82 to 22.16, respectively. A 58-member consumer panel evaluated prepared pinto beans for appearance, aroma, texture, flavor, and overall acceptability using a 9-point hedonic scale. Hedonic scores for overall acceptability of pinto beans varied from 3.7 to 6.3. Scores for flavor and overall acceptability, and the percentage of panelists who would eat pinto beans as part of a regular diet or in an emergency situation, decreased slightly with age (p<0.05). However, all samples that had been stored up to 30 years had greater than 80% acceptance for emergency use. Protein digestibility values ranged from 19.3 to 29.5%, but did not significantly decrease with age.

Results indicate that though pinto beans experience a loss of sensory quality during storage, they retain total protein quality and a high percentage of consumer acceptance over long periods of time and should be considered acceptable for use in long-term food storage efforts.

## Introduction

There is interest in storing low-moisture foods for long periods of time for uses such as personal preparedness, disaster relief efforts and space travel. Pinto beans in restaurant-sized No. 10 cans are available in the retail market, but work is needed to determine the effects of long-term storage on quality. Most storage studies have monitored pinto bean quality for one year or less (Sievwright and Shipe 1986, Hoppner and Lampi 1993). A few authors have studied pinto beans stored for more than one year (Martin-Cabrejas and others 1997, Hentges and others 1991). Some studies have also investigated the effects of different soaking and cooking methods (Prodanov and others 2004, Jyothi and Sumathi 1995). Authors agreed that these methods have a dramatic effect on the usability of pinto beans. The objective of this research was to investigate the sensory and nutritional quality of retail-packaged pinto beans held at ambient temperatures up to 32 years.

## Methodology

### Samples

Fifteen samples (and duplicates from the same lot of samples aged 5, 11, 14, and 25 years) of pinto beans packaged in No. 10 cans were obtained from donors. The cans had been stored in private residences at ambient temperature (approximately 13-27°C) and ranged in age from 2 to 32 years. Sample numbers of the same age, but different brands, were designated with the letters a and b. Control samples (<1 year of age) of pinto beans from the 2004 crop year packaged in No. 10 cans were obtained from a commercial vendor.

### Headspace Oxygen, Can Seam, Water Activity and Color

Can headspace oxygen was measured using the 3500-Series Headspace Oxygen Analyzer (Illinois Instruments, Inc., Johnsburg, IL). Can seams were evaluated for thickness, body hook, cover hook, width, and overlap using Seammate System software (Onevision Corporation, Westerville, OH). An overall seam rating and a tightness percentage were determined by an experienced evaluator. Water activity was measured using the chilled mirror technique with an Aqualab CX-2 water activity meter (Decagon Devices, Inc., Pullman, WA). The color of uncooked samples was measured with a Hunterlab Colorflex Spectrophotometer (Hunter Associates Laboratory, Reston, Va., U.S.A.) using the CIE L\*, a\*, and b\* system.

### Sensory Evaluation

A 58-member consumer taste panel evaluated the sensory quality of the pinto beans. Samples were prepared by soaking 400 grams of pinto beans in water with baking soda (4.57 g NaHCO<sub>3</sub> per liter of water) which was added to standardize the textural qualities of the beans. Due to an extended time of cooking found in preliminary testing, four samples (25-b, 29, 30, and 32) were soaked in 13.70 g NaHCO<sub>3</sub> per liter of water. Research has shown that baking soda in soak water does not significantly affect sensory attributes (León and others 1992). The pinto beans were cooked in distilled water using open metal pots and transferred to steam tables where they were held at 70±5°C. The panelists evaluated the prepared beans for appearance, aroma, texture, flavor and overall acceptability using a 9-point hedonic scale. Acceptance was determined by asking panelists if they would eat the sample as part of their regular diet and if they would eat it in an emergency situation.

### Protein Digestibility

In vitro protein digestibility was evaluated following the enzymatic technique of Njintang and others (2001) with pepsin utilized as the protease. Readings were taken after 150 minutes of digestion. This method incorporates the method of Lowry and others (1951) to measure the protein digested. Total protein was measured using a FP-2000 Carbon, Nitrogen, Sulfur Determinator (Leco Corp., St. Joseph, MI).

### Data Analysis

Data was analyzed for significance at a =0.05 using Statistical Analysis System software (SAS Institute, Cary, NC). Analysis of variance (PROC GLM) was used to analyze color and nutrition data. Sensory data was analyzed using a mixed model repeated measures analysis of variance (PROC MIXED). Both models used the Tukey-Kramer procedure to determine significant differences among means. Regression analysis (PROC GLM) was performed to determine which variables (sensory attributes and protein) significantly correlated with age, water activity, and headspace oxygen.

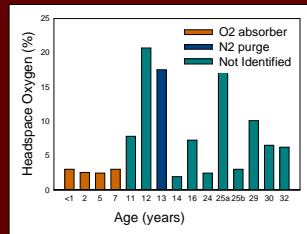


Figure 1. Headspace oxygen levels in cans of pinto beans stored for up to 32 years.

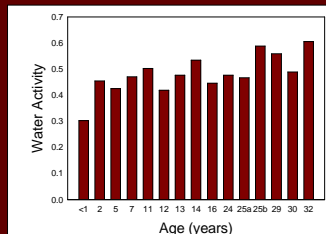


Figure 2. Water activity of pinto beans stored for up to 32 years.

Table 2. Mean Hedonic Scores of Pinto Beans. (n=116)

Age	Appearance	Aroma	Flavor	Texture	Overall Acceptability
<1	5.02 <sup>de</sup>	5.84 <sup>b</sup>	6.05 <sup>ab</sup>	6.30 <sup>a</sup>	6.08 <sup>ab</sup>
2	5.73 <sup>ab</sup>	6.07 <sup>ab</sup>	6.00 <sup>ab</sup>	5.74 <sup>bcd</sup>	5.84 <sup>bcd</sup>
5	5.48 <sup>cd</sup>	6.07 <sup>ab</sup>	5.71 <sup>bc</sup>	5.98 <sup>abc</sup>	5.75 <sup>bcd</sup>
7	5.36 <sup>bde</sup>	5.93 <sup>ab</sup>	6.23 <sup>a</sup>	6.34 <sup>a</sup>	6.23 <sup>a</sup>
11	5.82 <sup>ab</sup>	6.04 <sup>ab</sup>	5.93 <sup>ab</sup>	6.18 <sup>ab</sup>	6.05 <sup>ab</sup>
12	5.88 <sup>ab</sup>	5.83 <sup>b</sup>	6.22 <sup>a</sup>	6.35 <sup>a</sup>	6.26 <sup>a</sup>
13	5.55 <sup>abc</sup>	6.12 <sup>ab</sup>	5.88 <sup>abc</sup>	5.97 <sup>abc</sup>	5.86 <sup>abcd</sup>
14	5.92 <sup>a</sup>	6.20 <sup>a</sup>	5.93 <sup>ab</sup>	6.07 <sup>ab</sup>	5.88 <sup>abc</sup>
16	5.90 <sup>ab</sup>	6.12 <sup>ab</sup>	6.08 <sup>ab</sup>	5.96 <sup>abc</sup>	6.00 <sup>ab</sup>
24	5.69 <sup>ab</sup>	5.94 <sup>ab</sup>	6.19 <sup>a</sup>	6.23 <sup>ab</sup>	6.23 <sup>a</sup>
25-a	5.43 <sup>bc</sup>	5.72 <sup>b</sup>	5.05 <sup>d</sup>	4.96 <sup>e</sup>	4.94 <sup>e</sup>
25-b	5.73 <sup>bcd</sup>	5.80 <sup>b</sup>	5.43 <sup>d</sup>	5.54 <sup>d</sup>	5.38 <sup>de</sup>
29	5.06 <sup>de</sup>	5.93 <sup>ab</sup>	5.70 <sup>cd</sup>	5.20 <sup>de</sup>	5.43 <sup>cd</sup>
30	5.85 <sup>ab</sup>	6.02 <sup>ab</sup>	5.87 <sup>abc</sup>	5.71 <sup>bcd</sup>	5.76 <sup>abcd</sup>
32	4.84 <sup>e</sup>	5.11 <sup>c</sup>	3.78 <sup>e</sup>	4.13 <sup>f</sup>	3.69 <sup>f</sup>

Common superscripts in the same column indicate no significant difference.



Figure 3. Visual appearance of pinto beans prepared for sensory evaluation. Extra baking soda was added to samples 25b, 29, 30, and 32. Hyphenated samples represent duplicates.

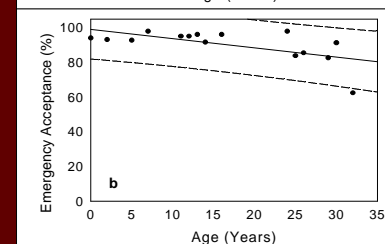
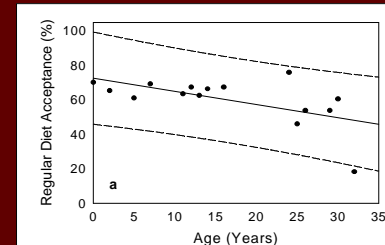


Figure 4. Percentage of panelists that would eat pinto beans stored up to 32 years as part of a regular diet (a) and in emergency situations (b). Dashed line represents 95% prediction interval. (n=116)

Table 1. CIE L\*a\*b\* color values for uncooked pinto beans stored up to 32 years. (n=3)

Age (years)	L*	a*	b*
<1	50.83	8.67	16.21
2	48.88	11.06	20.35
5	56.75	7.83	16.49
7	56.57	6.38	15.82
11	54.03	9.01	18.09
12	47.57	10.63	16.67
13	55.04	7.27	16.67
14	40.54	13.75	19.18
16	52.29	9.91	21.18
24	53.25	8.57	18.66
25-a	44.00	12.43	19.39
25-b	50.79	11.63	22.16
29	52.74	10.14	21.44
30	41.66	11.96	17.45
32	40.36	14.60	20.84

## Results and Discussion

### Headspace Oxygen, Can Seams, and Water Activity

Headspace oxygen exhibited extreme variation, ranging from 2.09 to 20.7% (Figure 1). All cans received ratings of satisfactory or good, except for cans 11-1, 11-2, 12, 13, and 30 which received ratings of poor. The high oxygen levels can be attributed to poor can seam quality or lack of proper oxygen removal.

Water activity ranged from 0.30 to 0.61 (Figure 2). The literature value of percent moisture for pinto beans is 11-14% (Roberts and others 2002) which corresponds to a range in water activity of approximately 0.54 to 0.67 (Iglesias and Chirife 1982). Water activity significantly increased with age which is probably due to differences in processing techniques or bean variety.

### Color

Hunter L\* values ranged from 40.36 to 59.06 (Table 1). Hunter a\* values ranged from 6.28 to 14.60. Hunter b\* values ranged from 15.82 to 22.16. Both a\* and b\* values increased significantly with sample age signifying a more intense red and yellow color. L\* values did not show any significant correlation with age.

### Sensory

As shown in Table 2, ranges for hedonic score means were: 4.84-5.92 for appearance, 5.11-6.12 for aroma, 3.78-6.23 for flavor, 4.13-6.35 for texture, and 3.69-6.26 for overall acceptability. The sensory attributes that significantly decreased in quality over time were flavor, texture and overall acceptability. Figure 3 is a photograph of the cooked samples giving an indication of their visual appearance.

There was significant correlation between water activity and texture, flavor and overall acceptability. There was no significant correlation between the headspace oxygen and the sensory quality of beans.

Acceptance as part of a regular diet ranged from 18.3 to 76.0%, and acceptance for emergency use ranged from 62.5 to 98.1% (Figure 4). For both regular diet and emergency use, percent acceptance declined significantly with increasing sample age.

### Protein Digestibility

In vitro protein digestibility results ranged from 19.25 to 29.52% and did not significantly change with age (Table 3). In contrast, some research reports a decrease in protein digestibility of beans stored over a short period of time (Sievwright and Shipe 1986).

## Conclusions

There was a loss of some aspects of quality in pinto beans stored in restaurant-sized No. 10 cans in residential storage throughout the time period studied. However, even after 30 years of storage all samples were considered acceptable for use in an emergency situation by at least eighty percent of consumer panelists. Also, protein digestibility was found to remain stable over time. Pinto beans can be an important part of a long-term food storage plan because of their sensory stability when properly packaged and stored.

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