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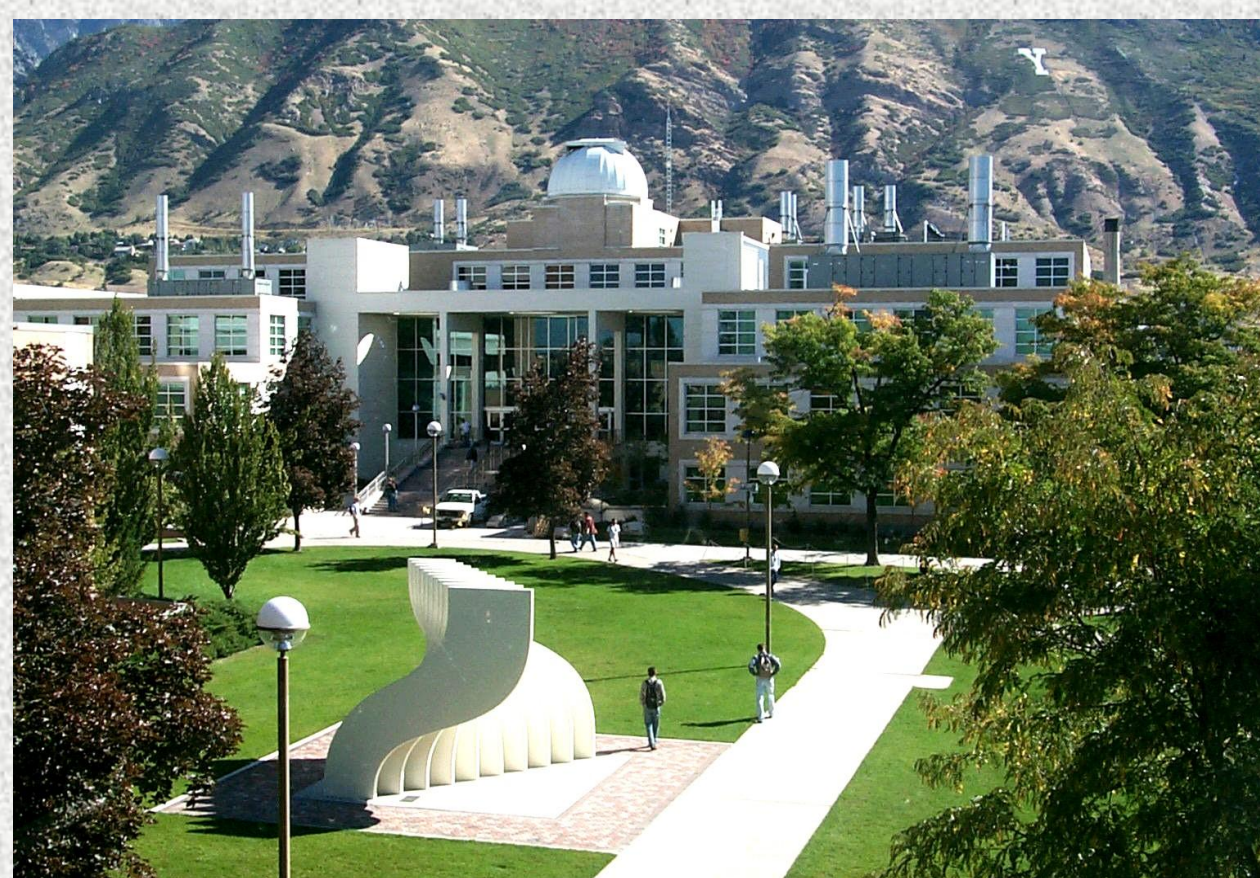
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# Quality and adequacy for long-term storage of dehydrated apple slices packaged in No. 10 cans

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## ABSTRACT

Dehydrated food commodities can be packaged in restaurant-size No.10 cans intended for long-term storage for such uses as personal storage, emergency relief efforts and military rations. Because foods packaged for long-term storage are seldom opened soon after purchase, the quality of the product or the adequacy of the packaging could be unknown to the buyer for months or even years. The objective of this research was to compare the quality of various brands of dehydrated apple slices sold at the retail level in No.10 cans and to evaluate the adequacy of the packaging for long-term storage.

Nine brands of dehydrated apples packaged in No. 10 cans were obtained from retail distributors in four states. All brands were labeled as being pre-treated with sulfur dioxide to prevent browning. All cans contained oxygen absorbers and were labeled as having an oxygen-free environment. A 50-member consumer panel evaluated aroma, flavor, and overall acceptability using a 9-point hedonic scale. Other observations included headspace oxygen, can seam evaluation, product color, water activity and Vitamin C content.

Hedonic scores for overall acceptability ranged from 4.8 to 5.8 with significant differences between brands. Headspace oxygen ranged from <0.01 to 21%. Four of the nine brands exhibited head space oxygen levels of 2% or greater. Wide variation in can seam quality was observed, with a direct correlation between poor seams and high head space oxygen levels. No significant differences in Hunter color values were observed. Water activity ranged from 0.20 to 0.31. Only 5 brands listed Vitamin C content on their label, and the actual content in each brand was less than half the amount listed.

There appears to be wide variation in head space oxygen levels and can seam quality of dehydrated apple slices packaged for long term storage and available for sale at the retail level. Manufacturers need to ensure accurate labeling and proper packaging to optimize product quality during extended storage.

## INTRODUCTION

Apples have been called the most important temperate fruit in the world (Taiwo 2001). Dehydrated apples (approx. 3% moisture) are commonly stored in No. 10 cans for long-term storage purposes such as emergency relief efforts, military rations and personal storage. Dehydrated apples have been found to retain their flavor, color, and odor for as long as three years when properly stored (Smock and Neubert 1950; Norseth 1986).

Because foods packaged for long-term storage are seldom opened soon after purchase, the quality of the product or the adequacy of the packaging could be unknown to the buyer for months or even years. The objective of this research was to compare the quality of various brands of dehydrated apple slices retail packaged in No. 10 cans and to evaluate the adequacy of the packaging for long-term storage.

## METHODOLOGY

### Samples

Nine brands of dehydrated apples, packaged in No. 10 cans, were obtained from retail distributors in four states. Eight of the brands were apple slices and one brand (Brand C) was cubed apple dices. All the brands were stored in oxygen free environments, contained oxygen absorbers and were pretreated with sulfur dioxide. Product codes indicated the samples were less than 1 year old. Duplicate samples of each brand were evaluated.

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

Headspace oxygen was measured using the 3500-Series Headspace Oxygen Analyzer (Illinois Instruments, Inc., Johnsbury, IL). Can seams were evaluated using the SeamMate System (Onevision Corporation, Westerville, OH) to measure the following seam dimensions: thickness, width, body hook, cover hook, and overlap. Seam tightness was rated on a scale of 0-100%. The seams were given an overall rating of good, fair, and poor by an experienced evaluator. Water activity was measured using an Aqualab CX-2 (Decagon Devices, Inc., Pullman, WA).

### Sensory Evaluation

Sensory analysis was conducted at the BYU Sensory Laboratory using standard procedures. Samples were served from the can, without further preparation, in a randomized manner to a 50-member consumer panel in 4 visits. Panelists evaluated aroma, flavor, and overall acceptability using a 9-point hedonic scale.

### Color

CIE L\*a\*b\* color values were measured using a Hunterlab ColorFlex Spectrophotometer (Hunter Associates Laboratory, Inc., Reston, VA), with three measurements taken on each sample.

### Vitamin C

Vitamin C analysis was conducted following the method of Ruckemann (1980) using an Agilent Model 1100 high performance liquid chromatograph (Agilent Technologies, Palo Alto, CA) equipped with a C18 reverse phase column (Phenomenex, Inc., Torrance, CA) and a diode array detector. Determinations were carried out under subdued light.

### Data Analysis

Data was analyzed for significance using Statistical Analysis System software (SAS Institute, 1999). A mixed model analysis of variance (PROC MIXES) with Duncan's Multiple Range Test was used for the sensory data. Significant differences were defined as  $p < 0.05$ .

## RESULTS

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

Headspace oxygen varied between brands, with the lowest at <0.01% and the highest at 20.8% (Fig. 1). Can seam quality also differed between brands as shown in Fig. 2. The two brands containing atmospheric levels of oxygen also had poor can seams. Water activity within brands ranged from 0.20 to 0.31 (Fig 3). The cubed apple pieces had the lowest water activity of all the brands.

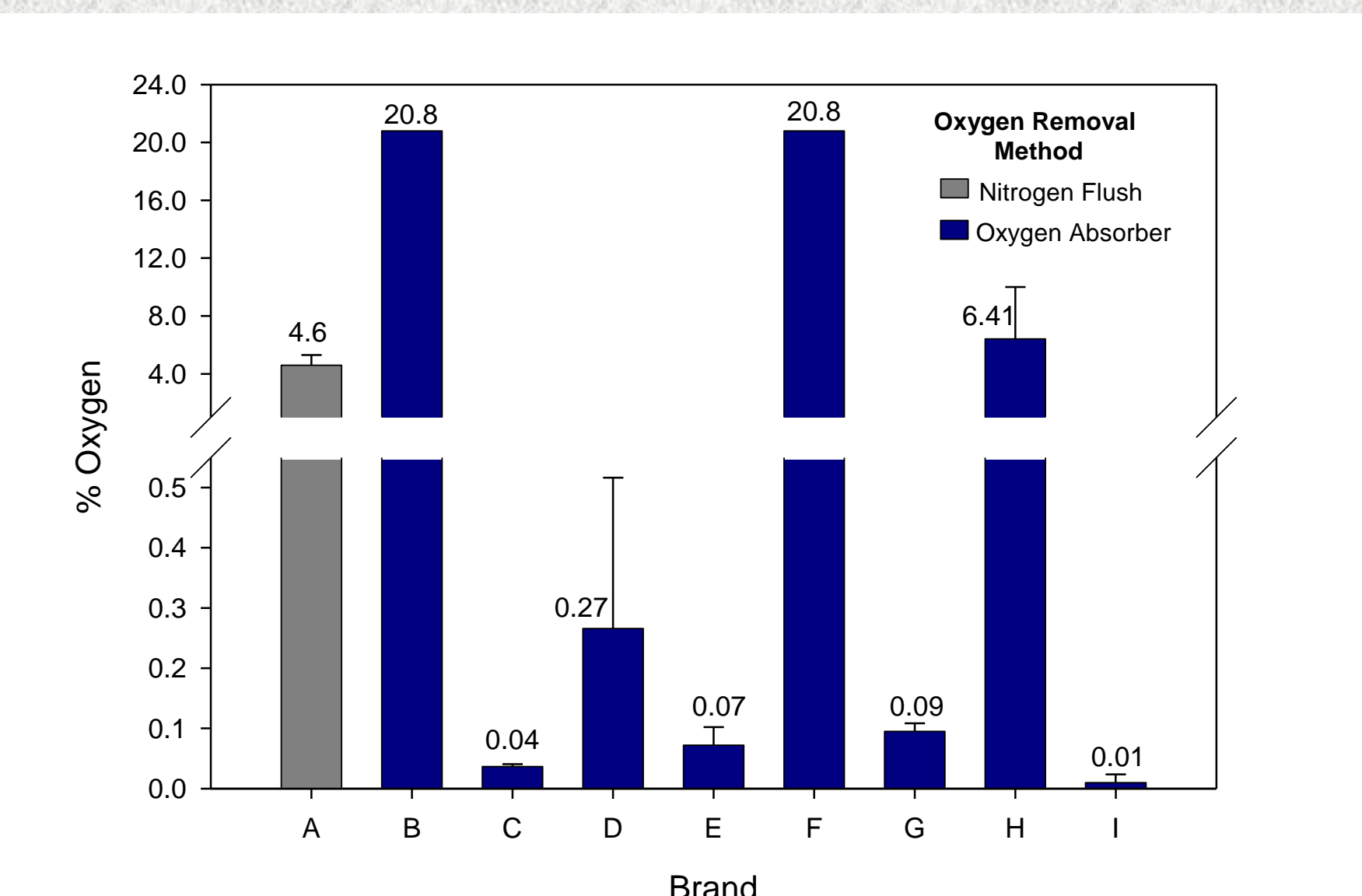


Fig. 1. Headspace oxygen content in cans of dehydrated apples. Error bars represent standard deviation.

Brand	A	B	C	D	E
Seam Cross Section					
Tightness Rating	90%	19%	46%	100%	95%
Overall Seam Rating	GOOD	POOR	FAIR	GOOD	GOOD

Brand	F	G	H	I
Seam Cross Section				
Tightness Rating	10%	85%	81%	85%
Overall Seam Rating	POOR	GOOD	POOR	FAIR

Fig. 2. Can seam cross section, tightness rating and overall seam rating, for each brand of dehydrated apples.

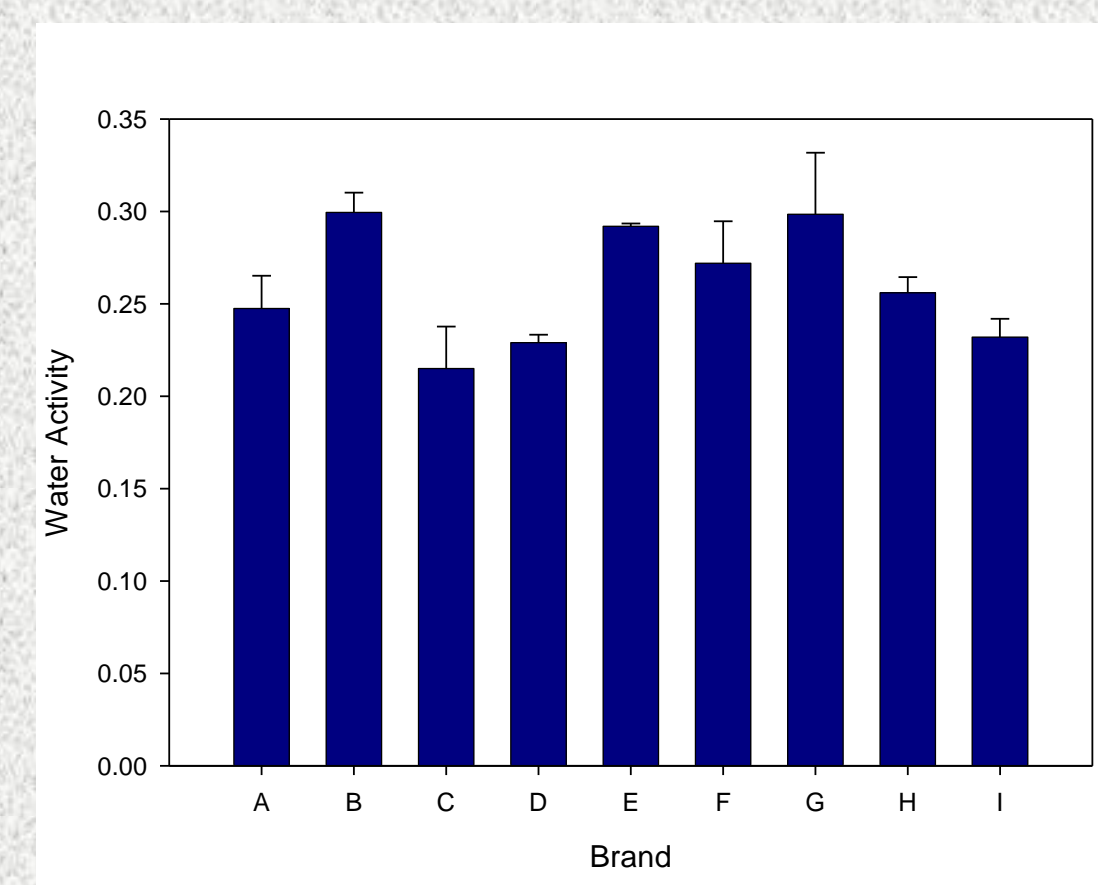


Fig. 3. Water activity of canned dehydrated apples. All brands are slices except Brand C which is cubes. Error bars represent standard deviation.

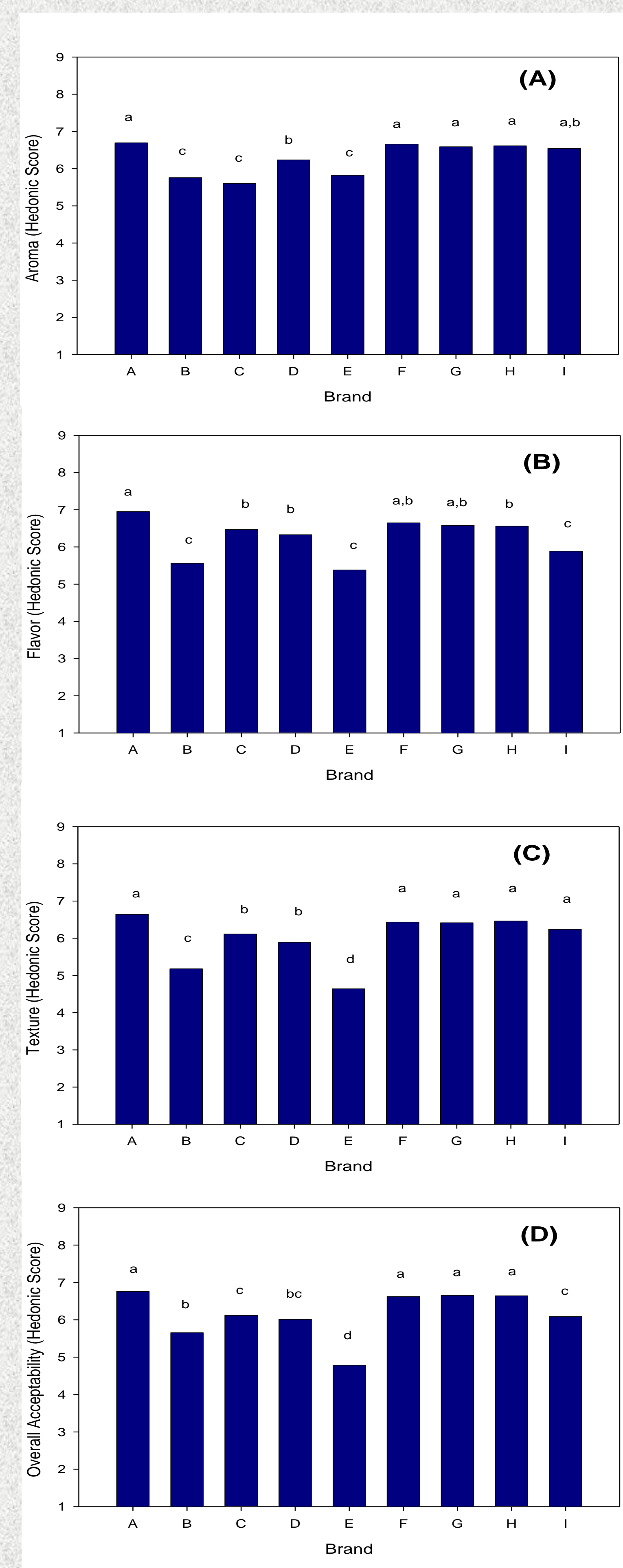


Fig. 4. Sensory scores for aroma (A), flavor (B), texture (C), and overall acceptability (D) of canned dehydrated apples. All brands are slices except Brand C which is cubes. Brands with like superscripts are not significantly different ( $p > 0.05$ ).

The United States standard for dehydrated (low moisture) apples requires a 3% moisture content for grade A apple slices. This corresponds to a water activity between 0.2 and 0.3 (Iglesias 1982). Although water activity varied between brands, all values were within this range.

### Sensory Evaluation

Hedonic scores, shown in Fig. 4, ranged from 4.6 to 7.0 (dislike slightly to like moderately). Scores for aroma, flavor and texture mirrored the overall acceptability score for each brand, which ranged from 4.8 to 6.8. Though there were significant differences between brands, seven of the nine brands had overall acceptability scores above 6.0 (like slightly).

### Color

CIE L\*a\*b\* values are shown in Table 1. There was little variation in color or the general appearance of the dehydrated apple slices. The sample of cubed dehydrated apples was visibly darker and redder in appearance, as reflected in the L\* and a\* scores.

### Vitamin C

Vitamin C content of each brand is shown in Fig 5. There was some variation between brands, but all brands exceeded the USDA National Nutrient Database for Standard Reference amount for dehydrated apples (22  $\mu\text{g/g}$ ). The high content is likely due to an osmotic dehydration process that includes ascorbic acid in the syrup. Acidic osmotic syrups increase water loss during processing (Monsalve-Gonzalez 1993). Ascorbic acid was not reported as a preservative or nutritional additive by any of the brands. Brands D, E, F, G, and H reported vitamin C on their labels, but each of these brands had measured amounts that were less than half the label amount. Brands A and B reported 0% vitamin C though it was found in both brands. Brands D and I did not show a nutrition facts box on their label, but vitamin C was present both brands.

Table 1. CIE L\* a\* b\* color values of various brands of canned dehydrated apples.

Brand	Type	L* value	a* value	b* value
A	Slices	70.79 0.03*	4.57 0.83	33.32 0.59
B	Slices	64.65 2.73	6.266 .874	35.07 1.77
C	Cubes	55.335 .645	15.855 .365	36.955 .001
D	Slices	74.63 4.33	3.83 .03	28.065 .315
E	Slices	56.095 2.175	4.98 .45	28.295 .345
F	Slices	62.745 3.9	3.155 .855	32.97 2.02
G	Slices	68.395 2.62	3.525 .675	30.935 .425
H	Slices	69.725 3.365	4.815 2.095	34.42 4.45
I	Slices	69.625 1.395	4.945 .75	44.51 1.00

\* Mean of two cans  $\pm$  standard deviation

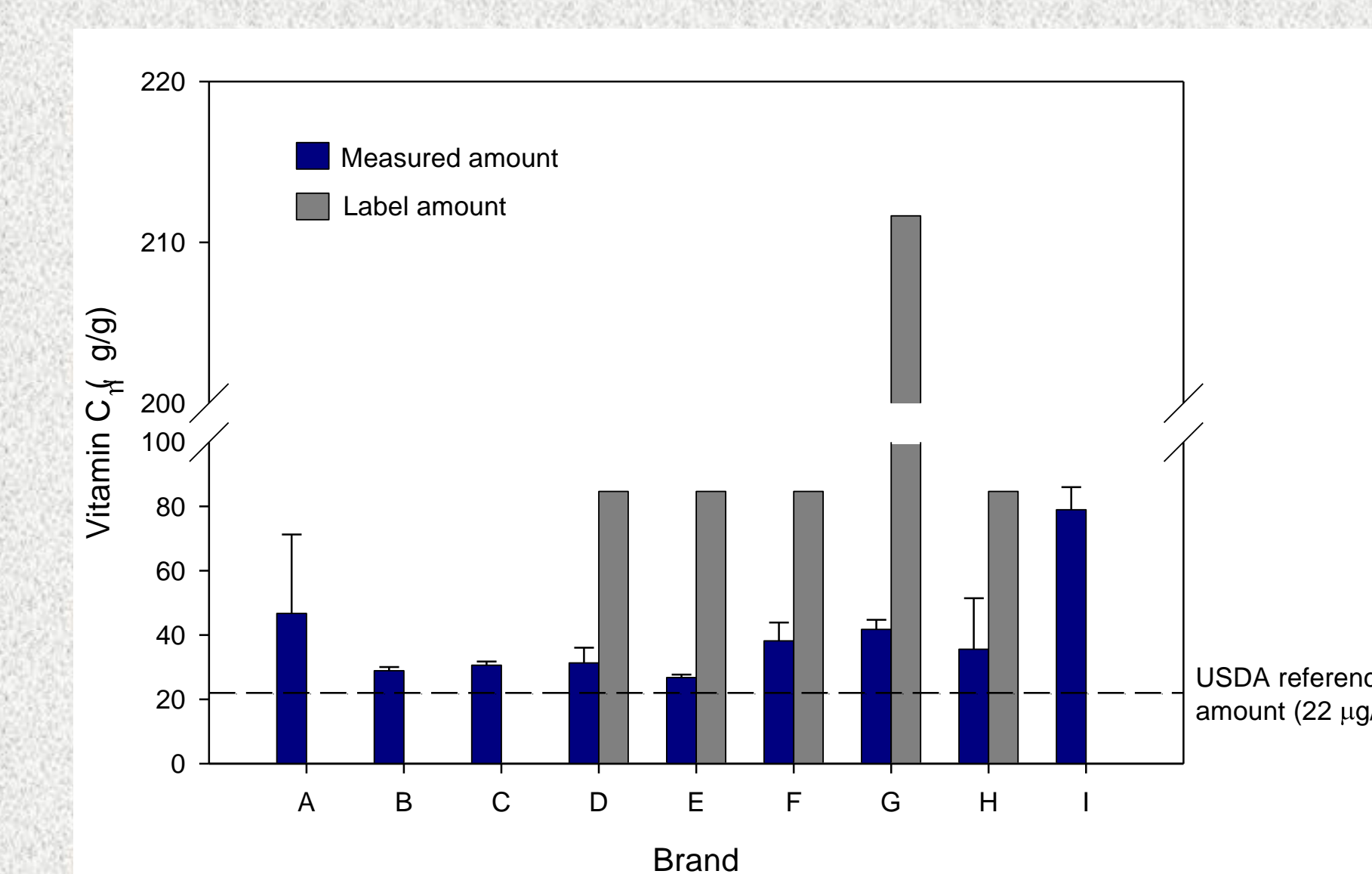


Fig. 5. Vitamin C content of canned dehydrated apples. All brands are slices except Brand C which is cubes. Error bars represent standard deviation. Brands C and I lacked a nutrition facts label, and Brands A and B were labeled as having 0% Vitamin C.

## CONCLUSIONS

There appears to be wide variation in head space oxygen levels and can seam quality of dehydrated apple slices packaged for long term storage and available for sale at the retail level. Manufacturers need to ensure accurate labeling and proper packaging to optimize product quality during extended storage.

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USDA National Nutrient Database for Standard Reference. Available online: [http://www.nal.usda.gov/fnic/cgi-bin/nut\\_search.pl](http://www.nal.usda.gov/fnic/cgi-bin/nut_search.pl)

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