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Shelf-life estimation of 'Fuji' apples: Sensory characteristics and consumer acceptability

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Abstract

Apple texture can deteriorate during cold storage, resulting in softness and mealiness. The purpose of this work was to estimate shelf-life and to study the behavior of 'Fuji' apples kept at 20 °C in a normal atmosphere until consumption following 7 months refrigerated storage (1 °C) in a controlled atmosphere (2% O_2, 2% CO_2). Survival analysis methodology was used to estimate shelf-life. Its key concept is to focus the shelf-life hazard on the consumer rejecting the product rather than on the product deteriorating. The shelf-life estimated of 'Fuji' apples was 23 days with a 50% rejection probability and 17 days with a 25% rejection probability. Consumer acceptability and descriptive sensory analyses for storage periods of up to 28 days at 20 °C indicated that the greatest quality loss was associated with increased mealiness, ripe taste and alcoholic taste and odor. Texture instrumental compression measures reflected the loss of rigidity of the apple tissue. The Thiault index and acceptability test results showed that the quality of the apples recently removed from cold storage was barely acceptable.

Keywords: Fuji apples; Cold storage; Shelf-life; Survival analysis; Descriptive sensory analysis; Consumer acceptability

1. Introduction

The shelf-life of apples is affected by a number of factors, such as growing, harvesting operations or storage conditions (Soliva-Fortuny et al., 2002). With present day technology it is possible to store apples in excellent physical condition well into the year following their harvest, but fruit quality depends strongly on temperature and humidity during storage. During cool storage, apple texture can deteriorate, resulting in a soft and mealy texture (Williams and Carter, 1977; Gómez et al., 1998). The ultimate goal of storage must be to extend keepability while maintaining or enhancing consumer acceptance of fruit. Storage has been the subject of many studies; in general, regimes have been optimized for minimal losses due to physiological disorders and maximum retention of firmness during long term storage, but long-stored apples should meet consumer expectations (Hoehn et al., 2003).

Previous studies have focused on analyzing the characteristics of different varieties of apples immediately after removal from varying periods of cold storage

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under differing conditions (temperatures and gases). However, fruit is kept at ambient temperature by small-scale distributors and retailers and for daily home consumption, so the question arises of how long the apples will remain fit to eat after having undergone a prolonged period of storage. Sensory quality and consumer acceptability criteria over the shelf-life of apples once kept at ambient temperature therefore need to be defined (Andani et al., 2001).

New bi-colored apple varieties, particularly 'Fuji', are becoming very popular throughout Europe at the expense of traditional major commercial varieties like 'Red Delicious', 'Golden Delicious' and 'Granny Smith'. These changes have created a growing awareness of the importance of keeping 'Fuji' quality in line with consumer preferences (Jaeger et al., 1998). Echeverría et al. (2004) studied the effect of four different atmospheres on 'Fuji' apple quality from a sensory approach, selecting the one of best performance for preservation of physical and chemical parameters. They observed the changes occurring over only 10 days after the removal from the store, measuring global acceptability and ordering the samples from weak to strong perceptions; they have not assessed shelf-life, so further work is still needed in this field.

The purpose of this study was to estimate the shelf-life of 'Fuji' apples stored at ambient temperature in a normal atmosphere until consumption after 7 months' refrigerated storage in a controlled atmosphere. The sensory descriptive parameters that determine their shelf-life life were examined and changes in consumer acceptability were analyzed.

2. Materials and methods

2.1. Plant material and storage conditions

'Fuji' apple fruit (*Malus domestica* Borkh. cv. Fuji) were harvested at commercial maturity from a Spanish orchard (Lleida, Spain) in October 2003. Immediately after harvest a batch of apples were selected for uniformity and absence of defects and placed in cold storage at 1 °C in a controlled atmosphere with 2% O_2 and 2% CO_2 for 7 months. Sub-batches were subsequently transferred to storage at 20 °C without atmosphere control, where they remained for 0, 7, 13, 18, 24 and 28 days for the different storage times. The apples were transferred to this storage at different dates to obtain the different storage times in order to be analyzed on the same day. Prior to storage at 20 °C the apples were sanitized with a 200 ppm chlorine solution for 10 min, rinsed and individually dried.

2.2. Sensory evaluation

Testing was carried out in a sensory laboratory equipped with individual booths (AENOR, 1997). The samples were peeled and cut into 1.5 cm sided cubes for evaluation. Cutting took place at 8 °C, 1 h at most before the evaluation.

2.2.1. Descriptive analysis

2.2.1.1. Selection of terms and panel training. A panel of 11 assessors with wide experience in descriptive analysis selected the descriptors using the Check List Method (Moskowitz, 1983; Powers, 1988; Lawless and Heymann, 1998). Selected descriptors are shown in Table 1. Once the terms had been selected, a consensus about their usage was reached; this implied precisely defining descriptors and how to evaluate them to quantify attribute intensity. For standardization of descriptors and panel training, various samples of "Fuji" apples were used: fresh (recently taken from CA) and accelerated aged (stored at 30 °C for different periods) in order to obtain samples with clearly different characteristics. Training involved two stages, the first one

Table 1
Sensory attributes selected for descriptive analysis

Attribute	Associated descriptor
Appearance	Roughness
Odor	Ripe
	Alcoholic
	Aged
Oral texture	Hardness
	Crunchiness
	Sound produced
	Mealiness
	Granularity
	Juiciness
Taste	Fresh
	Sweet
	Acid
	Ripe
	Alcoholic
Aftertaste	Astringent
	Alcoholic