ESTABLISHMENT OF A CRITERION TO DETERMINE THE OPTIMAL HARVEST DATE OF 'GALA' APPLES BASED ON CONSUMER PREFERENCES

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A B S T R A C T

In order to define a rational criterion to harvest 'Gala' apples based on consumer preferences, an experimental study was carried out with two objectives: (1) to determine the most important fruit quality parameters and their optimal values at harvest to satisfy 'Gala' apple consumers after long term storage, and (2) to identify groups of consumers with different organoleptic preferences and to establish the optimum harvest date depending on the target market. A sample of fruits from twelve commercial orchards of Girona and Lleida were harvested every week for six weeks. At harvest time, fruit quality parameters (background colour, firmness, starch index, soluble solids content and acidity) were measured, and after storage, a consume preference consumer survey was carried out. Starch index and background colour were the best predictors of optimum harvest date in 'Gala' apples based on average consumer preferences. Four groups of consumers with different organoleptic preferences were found. 26% of people preferred firm, crisp and acid apples. 24% of consumers preferred very ripe apples, with a softer texture and a high level of soluble solids. 45% of consumers preferred firm apples with not very high level of soluble solids, and the 5% preferred very sweet firm apples. Excluding the two first groups of people who could be satisfied with other apple cultivars on the market ('Granny Smith', 'Red Delicious' and 'Starking', among others), apples harvested when the starch index was between 5 and 7 on a scale of 1 to 10, and a skin background colour of F2 to F3 on the CTIFL scale, were the apples most preferred by consumers.

Key words: 'Gala' apple, quality, consumer preferences, optimal harvest, starch index, background colour, firmness, soluble solids, acidity

INTRODUCTION

Improving eating quality is one of the most important ways to stimulate consumer demand for apples (Harker, 2001; Harker et al., 2002). High quality apples are those that will ensure consumer satisfaction according to organoleptic preferences. However, no product can satisfy 100% of consumers, but only groups of consumers who respond positively to a particular bundle of sensorial attributes. To identify such segments of consumers would be interesting to provide them with a high quality apple according to their expectations.

Ripeness at harvest is one of the primary factors affecting apple quality. Production of 'Gala' apples has increased significantly in north-eastern Spain during the last few years. Therefore, the volume of 'Gala' apples for long term storage has also increased. Considering that only apples harvested at the optimum maturity stage will be able to ensure consumer satisfaction after a long period of storage, the relationship between quality characteristics of 'Gala' apples at harvest and consumer preferences after a long period of storage was investigated. The purpose of the study was to define a rational criterion to harvest 'Gala' apples based on consumer preferences[1]. Two objectives were planned:

1. to determine the most important fruit quality parameters and their optimal values at harvest to satisfy 'Gala' apple consumers after a long term storage;
2. to identify segments of consumers with different organoleptic preferences and to establish the optimum harvest date depending on the target market.

MATERIAL AND METHODS

Material

Apple fruits from two representative trees per orchard were harvested every week for six, from July 25 to August 30. Fruits were taken from twelve orchards from two different growing regions, Girona and Lleida, and in two seasons, 2002 and 2003. A sample of twenty apples from each orchard and harvest date was randomly selected to measure fruit characteristics

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(background colour, firmness, starch index, sugar and acidity) and about 30 kg of apples were stored under ULO conditions (1ºC, 1.25% O_2, 1.7% CO_2). After five months of storage, consumer sensory testing was performed to determine consumer preferences in relation to apple harvest maturity.

Consumer test

Consumer sensory testing was performed on the campuses of the University of Girona and the University of Lleida and in the city marketplace in Girona. Each consumer evaluated six samples corresponding to six apples from the same orchard harvested at eight days intervals. The apples were presented in randomized order and evaluated for their general appeal on a seven pointed scale, where -3 represents extreme dislike, and +3 represents strong preference. A total of 3250 consumers (62% men and 38% women) completed the test. 71% were between 18 and 30 years old, 20% from 30 to 50 years old, and 9% over 50 years old.

Statistical analysis

Consumer preferences

The purpose of the analysis was to identify which samples were preferred by consumers and hat their fruit quality parameters were at harvest to satisfy consumers after a long period of storage. Average values for each harvest date, orchard and growing season were calculated for fruit quality parameters and consumer satisfaction. An acceptable sample was one which more than 65% of the consumers assigned a positive sensory score (≥ 1). The percentage of acceptable samples depending on fruit quality parameters was calculated and quality differences at harvest date between acceptable and unacceptable samples were analysed to determine the most important parameters and their optimum values for maximum consumer satisfaction.

Analysis of clusters

Preference mapping method was carried out to determine which fruit quality characteristics various consumer groups expected (Scandella et al., 2002; Schlich et al., 2002; Navez et Scandella, 2004). Quality characteristics at harvest of samples with the highest sensory score for each consumer were included in a PCA and graphed in a loading plot of the two first dimensions. The samples ranked the highest by each consumer were represented in the quality map and cluster analysis was used to identify segments of consumers with similar preferences. The mean of firmness, starch index, sugar and acidity was calculated for each group of consumers to determine the quality

parameters that satisfied each consumer group and the optimum harvest date of 'Gala' apples depending on the target market.

RESULTS AND DISCUSSION

Evaluation of different criteria to harvest

Starch index

When samples were classified according to starch index categories at harvest and compared to acceptance by consumers, an average of 65% of the samples harvested at a starch index between 5 and 7 points satisfied consumers (Figure 1). Fruits harvested earlier or later were scored lower. However, 40% of apples with a starch index of 4, were classified as acceptable. Substantial differences between such 40% of acceptable samples and the rest of unacceptable samples with the same starch index were found in soluble solids content, and, to a lesser degree, in acidity. Acceptable samples measured 10.7 ºBrix and 4.1 g/L malic acid, whereas unacceptable apples showed 8.8 ºBrix and 3.6 g/L of malic acid (Table 1). Thus, from apples harvested slightly earlier, consumers preferred fruits with higher sugar content at harvest. Percentage of acceptable samples decreased when starch index was higher than 7. Although differences between acceptable and unacceptable samples were smaller in later harvests, consumer preferred firmer apples.

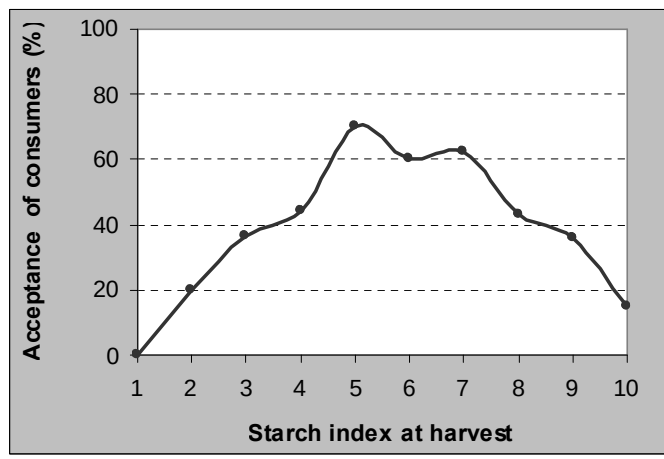

Figure 1. Acceptance of consumers of fruit samples according to starch index at harvest date

Starch index conversion is considered a good predictor of harvest date to ensure consumer satisfaction after storage. Many other investigators have demonstrated that starch index conversion is a good indicator of the maturity

in apples and the most important parameter for the optimum harvest date (Mitcham, 1993; Streif, 1996; Blankenship et al., 1997; Lau and Lane, 1998).

Table 1. Quality differences between accepted and not accepted samples with the same starch index at harvest. Average of firmness, soluble solids content and acidity at harvest for each category of starch index

Starch Index	NOT Accepted samples			ACCEPTED samples		
	Firmness (kg)	Soluble solids (ºbrix)	Acidity (g/L)	Firmness (kg)	Soluble solids (ºbrix)	Acidity (g/L)
1	9.0	8.9	4.0	-	-	-
2	8.8	9.5	3.9	8.5	9.9	3.9
3	8.8	10.2	3.8	8.3	10.1	3.9
4	8.0	8.8	3.6	8.0	10.7	4.1
5	8.0	10.9	3.3	8.0	11.0	3.7
6	7.6	10.2	3.6	7.7	11.4	3.8
7	7.3	11.8	3.8	7.1	11.5	3.6
8	7.0	11.5	3.4	7.3	11.6	3.8
9	6.3	12.3	3.1	6.5	11.4	3.1
10	5.4	11.7	2.5	6.0	11.5	2.9

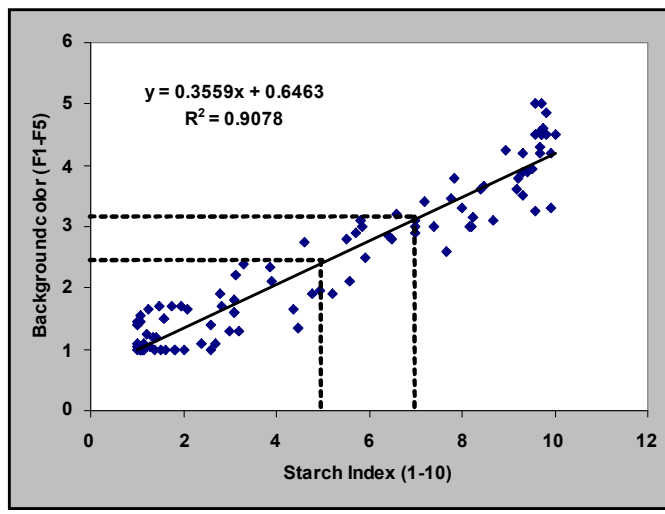

Figure 2. Relationship between background colour and starch index of 'Gala' apples harvested in 2002, 2003 and 2004. Each point represents a sample from the same orchard, growing season and harvest date

On the other hand, starch index is highly correlated with background colour (Figure 2). Fruits from 5 to 7 points of starch index showed a background colour of F2-F3 on the CTIFL scale. Thus, background colour is

also a good criterion to determine harvest date to satisfy most of consumers, but not red blush. The degree of red blush can vary markedly between fruit position in the tree, orchards, and seasons and therefore is not a good index of fruit maturity (Kingston, 1992).

Firmness

Firmness was not as good as starch index to be used as harvest criterion because at most, only 50% of samples could satisfy consumers' expectations when firmness of apples was between 7 and 8 kg (Figure 3). By comparing acceptable and not accepted samples for the same value of firmness, consumers preferred fruits with the highest content of soluble solids and acidity at harvest (data not shown).

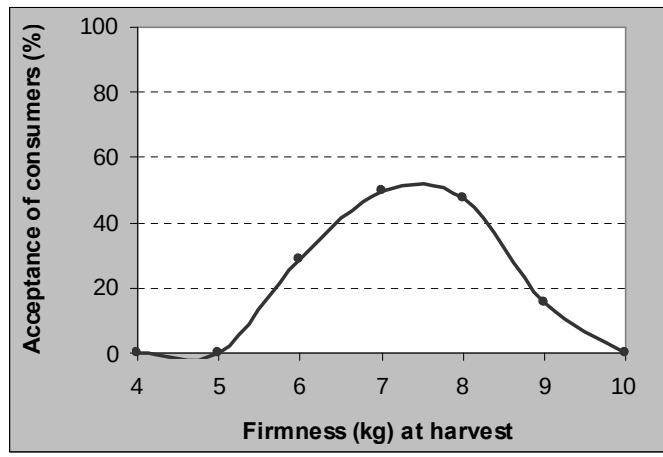

Figure 3. Acceptance of consumers of fruit samples according to firmness at harvest date

Importance of texture properties to consumer acceptability is widely described (Harker et al., 2002). Firmness is one of the many terms to describe sensory texture but penetrometer measurements of firmness are not always good predictors of consumer preferences. Fruits not significantly different in instrumental firmness may still differ in their texture properties (Harker et al. 2002). Firmness alone was not an adequate index to determine optimum harvest date, but the firmness combined with starch index could be a good predictor of fruit quality parameters and consumer satisfaction after storage (Blankenship et al., 1997).

Soluble solids

All samples were categorized according to soluble solids content at harvest. On the one hand, soluble solids content was not as good as starch

index to be used as harvest criterion, because, like firmness, 50% was the highest percentage of acceptable samples (Figure 4). On the other hand, percentage of good samples increased with an increase of soluble solids content up to 13 ºBrix. Fruits with a higher sugar content at harvest were not accepted by consumers. However, such samples were also less firm (6.1 kg) and had a higher starch index (9). Soft and maybe mealy apples did not satisfy consumers, in spite of the high sugar content at harvest. By comparing acceptable and unacceptable fruits with the same value of refractive index, fruits with around 7 kg of firmness and between 5-7 points of starch index were preferred (data not shown). Thus, texture properties of apples were decisive in the opinion of consumers. Consumers preferred apples harvested with higher soluble solids content as long as they were firm.

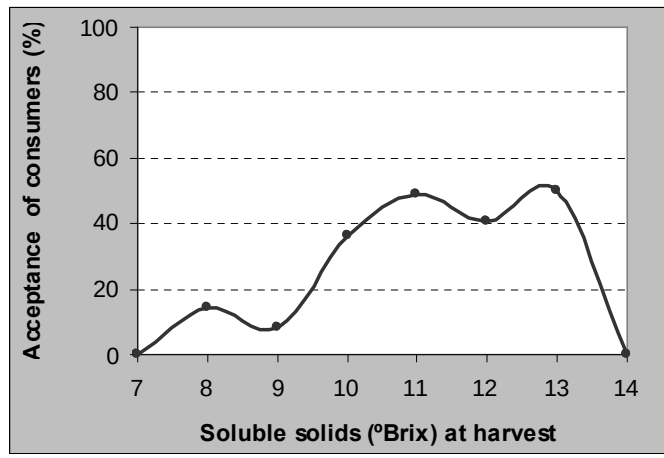

Figure 4. Acceptance of consumers of fruit samples according to soluble solids at harvest date

In addition to texture, taste and flavour are also important predictors of consumer acceptability. However, soluble solids content was not an adequate index to predict harvest date. Although most apples with high soluble solids content at harvest were preferred by consumers, there were apples with high sugar content at harvest which were rejected probably because of their texture properties. Delaying fruit picking waiting for a minimum soluble solid content can lead to disorders such as mealiness, which is a negative attribute that causes most consumers to reject apples (Harker et al., 2002).

In summary, starch index and background colour are the best parameters to be used as harvest criterion to satisfy most of consumers. The optimum harvest window of 'Gala' apples is considered to be the period when starch index is between 5 and 7 or background colour between F2-F3 on the CTIFL scale.

Consumer segmentation

From PCA analysis, consumers were separated into four groups based on their sensory preferences. The first group consisted of 26% of the consumers, who preferred apples harvested with high firmness (8.6 kg), high acidity (3.9 g/L), low starch index (2.3) and low soluble solids content (9.5 ºBrix). This group of consumers who prefer green, acid and firm apples in spite of low sugar content at harvest. Two options could be explored to satisfy this group of consumers: (1) to identify this target market and offer them all early harvested apples, or else (2) to consider that this segment of population is not the target market of 'Gala' apples, because there are in the market for other acid cultivars that could satisfy their quality expectations.

Table 2. Segments of consumers identified according to their quality preferences. Average of firmness, starch index, soluble solid content and acidity at harvest of the highest ranked samples of each group

Quality characteristics	*Segment 1 n=863 26%*	*Segment 2 n=786 24%*	*Segment 3 n=1487 45%*	*Segment 4 n=163 5%*
Firmness (kg)	8.6	6.0	7.5	7.2
Starch Index	2.3	9.3	5.9	7.3
Soluble solids (ºBrix)	9.5	11.7	10.7	13.0
Acidity (g/L)	3.9	2.9	3.6	3.6

The second group consisted of 24% of the consumers, who preferred apples harvested with high soluble solids content (11.7 ºBrix), high starch index (9.3), low firmness (6.0 kg) and low acidity (2.9 g/L). These consumers prefer soft apples harvested with high sugar content. As with the first group, two options could be studied: (1) to identify such target market and offer them all later harvested apples, or else (2) to consider that this segment of population is not the target market of 'Gala' apples, because there are in the market other cultivars that could satisfy their quality expectations.

The third group consisted of 45% of the consumers, who preferred apples harvested with 7.5 kg of firmness, starch index of 5.9, 10.7 ºBrix of soluble solids content and acidity of 3.6 g/L of malic acid. It was the highest segment of population, and probably the target market of 'Gala' apples.

The fourth group consisted of the remaining 5% of consumers who selected fruits with the highest sugar content and a firm texture. They preferred apples harvested with an average of 7.3 kg of firmness and 13 ºBrix of soluble solids content.

Excluding the two first segments of consumers who probably would prefer other apple cultivars, efforts were focused on satisfying the 50% of consumers who responded positively to 'Gala' quality characteristics. Samples tasted by this group of consumers were classified according to starch index (Figure 5). Results not only confirmed that consumers preferred apples

harvested at 5-7 points of starch index, but percentage of acceptable samples increased to 90%.

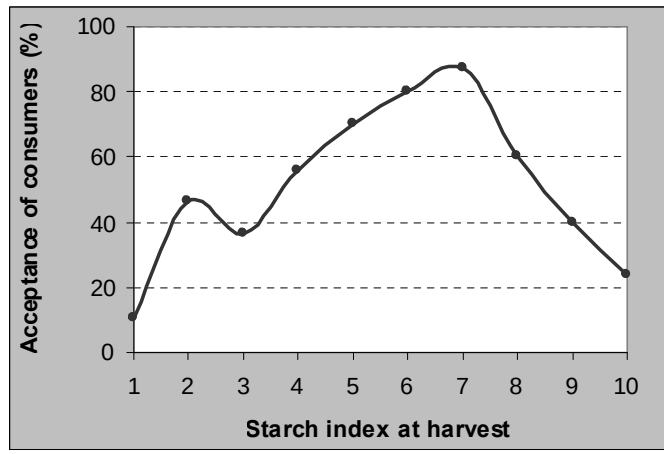

Figure 5. Acceptance of consumers of fruit samples from consumer segments 3 and 4 according to starch index at harvest

CONCLUSIONS

Starch index and background colour were the best predictors of the optimum harvest date of 'Gala' apples to ensure consumer satisfaction after a long period of storage. Using starch index as harvest predictor, more consumers were identified as satisfied than using soluble solids content or firmness.

Four groups of consumers with different organoleptic preferences were identified. 26% of people preferred firm, crisp and acid apples. 24% of consumers chose the most ripen apples, with soft texture and high level of soluble solids. 45% of consumers liked firm apples with not very high content of soluble solids at harvest, and the remaining 5% chose the sweetest firm apples. Excluding the two first groups of people who could be satisfied with other apple cultivars, samples harvested at 5-7 points of starch index and a skin background colour of F2-F3 of CTIFL scale, were the apples most preferred by consumers.

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USTALENIE KRYTERIUM DO OKREŚLANIA OPTYMALNEJ DATY ZBIORU JABŁEK ‘GALA’ NA PODSTAWIE PREFERENCJI KONSUMENTÓW

Mariona Casals, Joan Bonany, Joaquim Carbó, Simó Alegre, Ignasi Iglesias, Diana Molina, Tomás Casero i Immaculada Recasens

STRESZCZENIE

Badania przeprowadzono w celu określenia racjonalnych kryteriów dla zbioru jabłek ‘Gala’ na podstawie preferencji konsumentów. Wyodrębniono dwa zadania: (1) określenie najważniejszych parametrów jakości i ich optymalnych wartości na zbiorze, które będą satysfakcjonować konsumentów jabłek ‘Gala’ po długotrwałym przechowywaniu i (2) rozpoznanie grup konsumentów o różnych preferencjach sensorycznych i ustalenie optymalnego terminu zbioru zależnie od określonych wymagań rynku. Próbki owoców z 12 komercyjnych sadów Girony i Lleidy zbierano co tydzień przez 6 tygodni. Podczas zbiorów charakteryzowano owoce (kolor zasadniczy, jędrność, indeks skrobiowy, zawartość ekstraktu i kwasowość), a po przechowywaniu przeprowadzano badanie preferencji konsumentów. Indeks skrobiowy i barwa zasadnicza były najlepszymi parametrami określającymi optymalną datę zbioru jabłek ‘Gala’ na podstawie średnich preferencji konsumentów. Wyodrębniono cztery grupy konsumentów o różnych preferencjach organoleptycznych. Jabłka jędrne, kruche i kwaśne preferowało 26% konsumentów, 24% wybierało jabłka najbardziej dojrzałe, o teksturze mniej jędrnej i wysokiej zawartości ekstraktu, 45% preferowało jabłka jędrne, o wysokiej zawartości ekstraktu, a 5% wybierało najsłodsze i jędrne jabłka. Wyłączając dwie pierwsze grupy ludzi, których mogą satysfakcjonować inne odmiany jabłek znajdujące się w sklepie (między innymi: ‘Granny Smith’, ‘Red Delicious’, ‘Starking’), najbardziej lubianymi przez konsumentów są jabłka zbierane, gdy ich indeks skrobiowy wynosi 5-7 i barwa zasadnicza skórki F2-F3 w skali CTIFL.

Słowa kluczowe: jabłka ‘Gala’, jakość, preferencje konsumentów, optymalny termin zbioru, indeks skrobiowy, barwa zasadnicza skórki, jędrność, zawartość ekstraktu, kwasowość