

SEASONAL TRENDS IN HARVEST INDICES FOR 'GOLDEN SMOOTHIE'[®] APPLES IN SPAIN

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A B S T R A C T

A series of experiments were carried out to more accurately determine optimum harvest date in apples of the 'Golden' group which are to be kept in long term storage. The primary criterion was consumer satisfaction with apples which had been stored for eight months.

In 2002 and 2003, 'Golden Smoothie' apples were picked from six representative orchards in the Lleida production area, and from six representative orchards in the Girona production area. At each orchard, about 30 kg of apples were picked from two different trees with normal crop loads every week for six weeks. For each orchard, a subsample of twenty representative fruits was selected at harvest for fruit quality measurements in the laboratory. After storage, another subsample of twenty representative fruits was selected at harvest for fruit quality measurements in the laboratory, and the rest of the fruits were evaluated in terms of consumer satisfaction.

Seasonal trends in fruit quality parameters and various harvest indices were recorded and correlated with consumer satisfaction scores. The harvest indices calculated included the Streif's index, the Jager index and the FARS index.

Fruit weight, starch index, total soluble solids content, and the TSS/TA ratio steadily increased during the course of the ripening period. The trend was almost linear for starch index, and either quadratic or sigmoid for the other parameters.

Firmness, titratable acidity, Streif's index, Jager index and FARS index steadily decreased during the course of the ripening period. The trend was negatively exponential for Streif's index and FARS index, and linear and almost linear for the other parameters.

This general tendency was similar in both 2002 and 2003, although there were small differences between years.

Preliminary results show that some indexes, such as the Jager index and the Streif's index, could be useful predictors of consumer satisfaction. Even so, they do not seem to be more reliable than the indices currently in use and are furthermore time consuming.

Key words: sensory analysis, hedonic test, maturity, firmness, starch index, Streif's index

INTRODUCTION

In Spain, the production of apples belonging to the 'Golden' group has declined over the past few years. This is mainly due to deterioration of fruit quality during storage which often occurs when the apples are not picked at the right stage of ripeness.

The optimum harvest date for this group of varieties has been traditionally established on the basis of firmness, total soluble solids content, and, more recently, starch index. The most commonly criteria currently used are:

- diameter > 70 mm;
- firmness ≥ 7 kg;
- total soluble solids content approximately 12° Brix; and
- starch index between 5 and 7 on a scale from 1 to 10 scale.

In spite of recent advances in storage technology, the criteria for determining optimum harvest date have still not been reviewed and revised. Some alternative criteria, such as the Streif's index, are not yet widely used (Streif, 1996; De Long et al., 1999). Other alternative criteria, such as the FARS index, have never been commercially used.

A series of experiments were therefore carried out to determine more accurately the optimum harvest date in apples of the 'Golden' group, which are to be kept in long-term storage. The primary criterion was consumer satisfaction with apples which had been stored for eight months.

The aim of this study was to describe seasonal trends in different fruit quality parameters and harvest indices, and to correlate them with sensory testing scores in order to determine which parameters are the best predictors of consumer satisfaction.

MATERIAL AND METHODS

In 2002 and 2003, 'Golden Smoothee' apples were picked from six representative orchards in the Lleida production area, and from six representative orchards in the Girona production area. At each orchard, about 30 kg of apples were picked from two different trees with normal crop loads every week for six weeks. The third and fourth weeks corresponded to the expected peak commercial harvest time, which usually falls between September 1 and 10.

All trees were grafted on EM-9 rootstock and trained with a central leader. Agricultural practices were carried out identically in all orchards.

At each location, a subsample of twenty representative fruits was selected at harvest for fruit quality measurements in the laboratory. Data recorded for each apple included fruit diameter, fruit weight, blushing, background colour, firmness, starch index, total soluble solids content (TSS) and titratable acidity (TA).

The rest of the apples were stored together until May in a controlled atmosphere containing 1% O₂ and 1% CO₂.

After storage, another subsample of twenty fruits for each date and each orchard was selected for fruit quality measurements. Data recorded for each apple included fruit weight, colour, and firmness, total soluble solids content and titratable acidity.

The rest of the apples were evaluated in terms of consumer sensory perception. Peeled samples from each of the six weekly collection dates at a single orchard were presented to each consumer, who expressed global satisfaction on a seven point scale, where -3 is very bad, and +3 is very good. More than 120 consumer tests were conducted for each orchard. Consumers were selected from among the staff at the University of Lleida and the University of Girona. Some testing was also carried out at local markets.

The following indices were calculated:

- TSS/TA ratio R/A ;
- Streif's index (SI) $F/(R * S)$ (Streif, 1996);
- De Jager's index (PFW-1) $F * (11 - S) / R$ (De Jager et al., 1996ab); and
- FARS index $(F * A)/(R * S)$.

Where: F = Firmness (kg),
A = Titratable acidity (TA) (g L⁻¹),
R = Soluble solids content (TSS) (° Brix),
S = Starch index (on a scale from 1 to 10).

Mean values of the fruit quality parameters for each collection date and orchard were plotted against the corresponding mean consumer satisfaction scores.

There was a high degree of variability in consumer satisfaction scores for each parameter because of the interactions among the different parameters. To correct for this, the samples were grouped into intervals. Therefore, different intervals were defined for each given parameter. The mean value of all the samples in a given interval was calculated. The consumer satisfaction score value was recorded as the mean score for all samples in the same interval. The same process was carried out for all fruit quality parameters and harvest indices,, although the number of intervals differed depending on the range in values.

Mean seasonal trends for each location were recorded as the means of mean values for the twenty fruits selected for each orchard. Possible differences in fruit maturity between one orchard and another were not taken into account.

RESULTS AND DISCUSSION

Fruit weight, starch index, total soluble solids content, and the TSS/TA ratio steadily increased during the course of the ripening period. The trend was almost linear for starch index, and either quadratic or sigmoid for the other parameters (Fig. 1).

Firmness, titratable acidity, the Streif's index, the Jager's index and the FARS index steadily decreased during the course of the ripening period. The trend was negatively exponential for the Streif's index and the FARS index, and linear and almost linear for the other parameters.

This general tendency was similar in both 2002 and 2003, although there were small differences between years (Fig. 1 and 2).

In 2002, the consumer satisfaction was highest with the apples picked during the fifth week of the six week collection period. In 2003, the consumer satisfaction scores were highest with the apples picked during the sixth week of the six week collection period. The trend in consumer satisfaction did not seem to correlate with any individual parameter.

The harvest date calculated on the basis of the most commonly criteria currently in use (see Introduction) fell in the third week of sampling in both 2002 and 2003.

In 2002, fruit firmness during the calculated harvest time was lower than 7 kg, which indicated that the apples would have to be picked in a very narrow harvest window in order to prevent loss in firmness during long term storage (Fig. 1). In 2003, fruit firmness during the calculated harvest time was 7.0 kg, the optimum threshold value. This again indicated that the harvest window was very narrow (Fig. 2).

In both 2002 and 2003, fruit diameter at the calculated harvest time was high enough for picking. Fruit diameter was 80.6 mm in 2002, and 74.6 mm in 2003.

During the third and fourth weeks of the collection period, the Streif's index ranged from 0.088 to 0.139 in 2002, and from 0.083 to 0.125 in 2003. The Jager's index ranged from 2.47 to 3.37, and from 2.36 to 3.45 in 2003. The FARS index ranged from 0.48 to 0.82 in 2002, and from 0.41 to 0.63 in 2003. The ranges were therefore about the same in both 2002 and 2003.

The correlations between fruit quality parameters and consumer satisfaction scores were then calculated. First, the 72 samples from the six collection dates at the twelve orchards were grouped into intervals for each parameter. Mean values for each parameter were then calculated for each interval. Consumer satisfaction scores were expressed as the mean of the samples in a given interval.

The correlations between between fruit quality parameters and consumer satisfaction scores for 2002 are presented in Figure 3. TSS and the TSS/TA ratio were both highly correlated with consumer satisfaction scores ($R^2 > 0.8$). The Jager's index was generally more strongly correlated with consumer satisfaction scores than were the Streif's index and the FARS index.

Seasonal trends in harvest indices for 'Golden Smoothie'[®]...

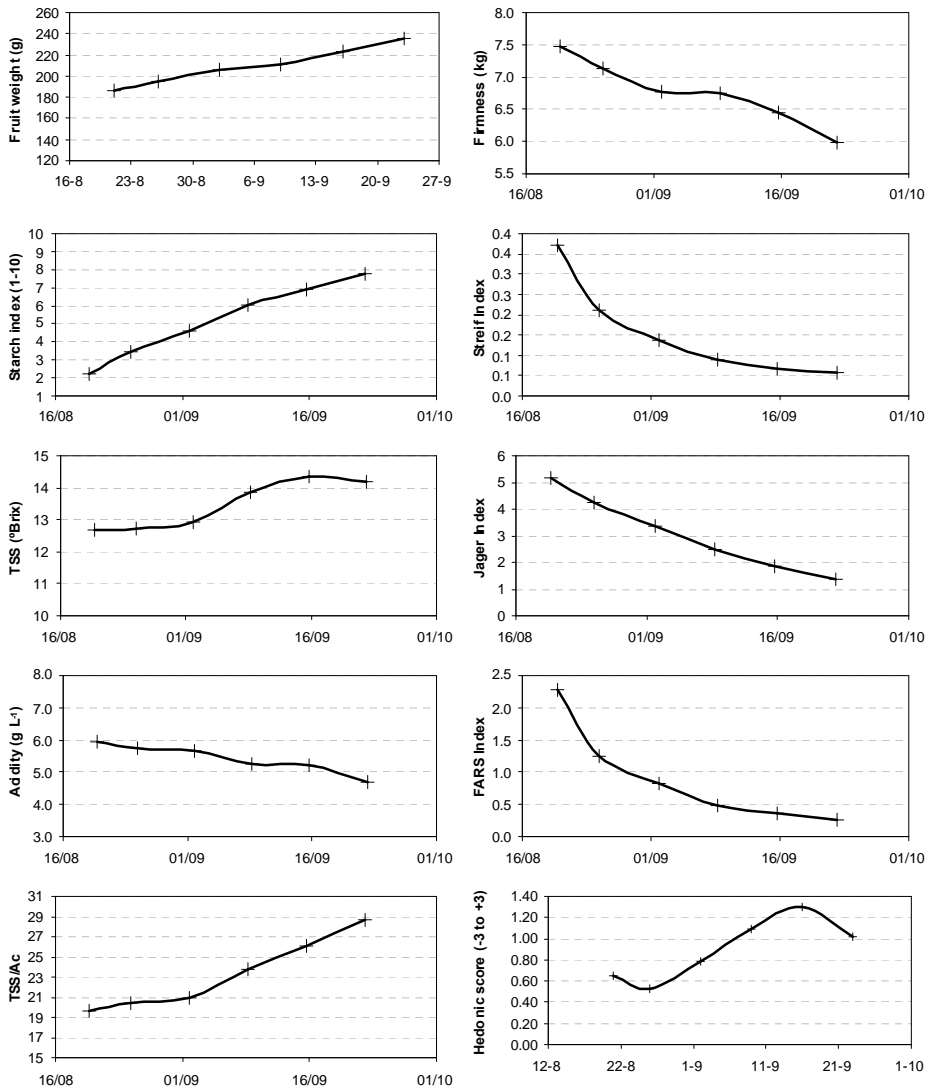


Figure 1. Seasonal evolution of different quality parameters and harvest indexes in 'Golden Smoothie'[®] apples in 2002. Each point represents the mean for six orchards in the Lleida area

The correlations between between fruit quality parameters and consumer satisfaction scores for 2003 are presented in Figure 4. Almost all the parameters were high correlated with consumer satisfaction scores, especially TSS and starch index, which had a correlation coefficient of almost 1.0. As in 2002, the Jager's index was generally more strongly correlated with consumer satisfaction scores than were the Streif's index and

the FARS index. The correlation between the Streif's index and consumer satisfaction was better at lower values for the Streif's index than at higher values.

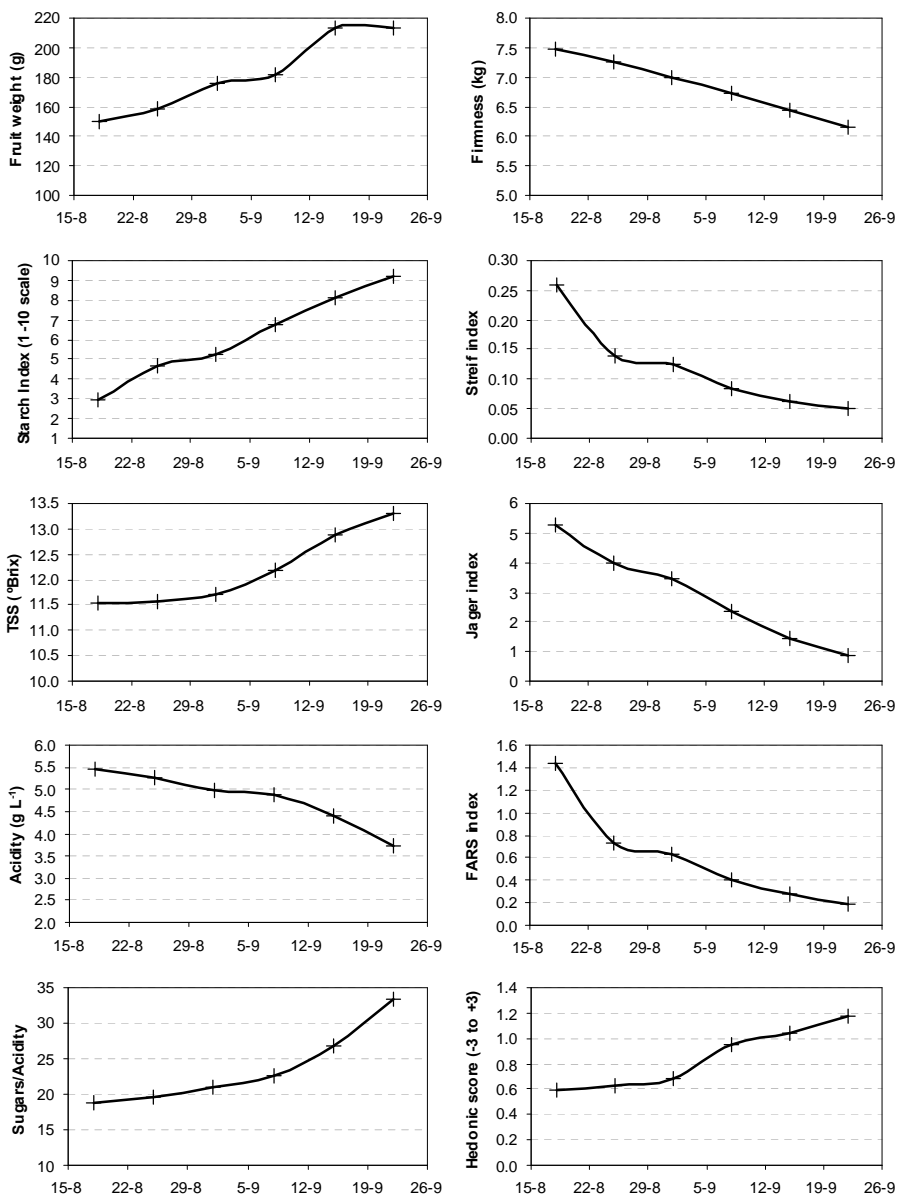


Figure 2. Seasonal evolution of different quality parameters and harvest indexes in 'Golden Smoothie'® apples in 2003. Each point represents the mean for six orchards in the Lleida area

Seasonal trends in harvest indices for 'Golden Smoothie'®...

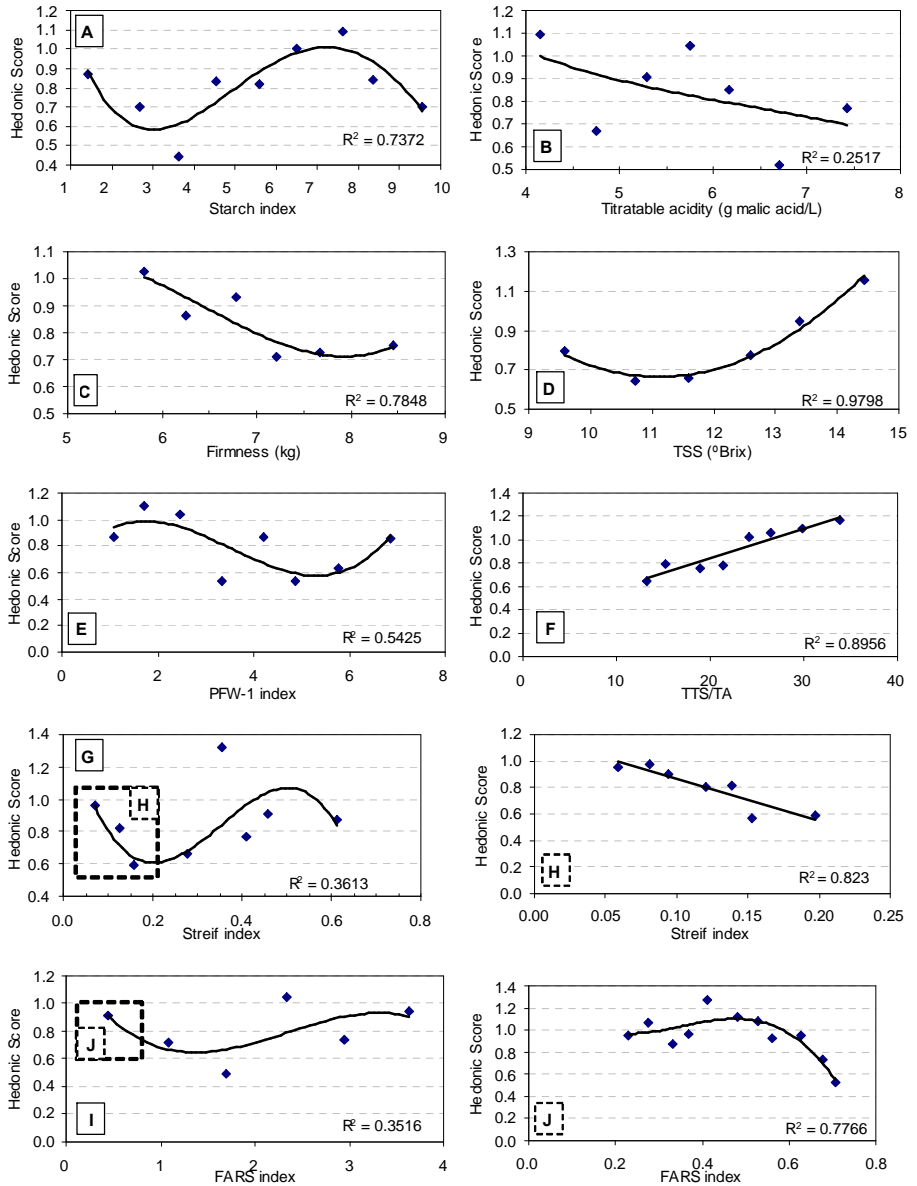


Figure 3. Relationship between mean hedonic score and different parameters and indexes for Golden Smoothie apples from the Lleida and Girona areas in 2002. Each point represents the mean value for all the samples in a given interval. Each sample corresponds to the mean value for 20 fruits harvested on the same day from a single orchard (total 36 samples). Figures represent the relationship between hedonic score (from -3 to +3) and A) Starch index on a 1-10 scale, B) Titratable acidity, C) Firmness, D) Total soluble solids, E) PFW-1 index, F) Ratio between total sugars and titratable acidity, G) Streif's index, H) Streif's index for all samples with values lower than 0.2, I) FARS index, J) FARS index for all samples with values lower than 0.7

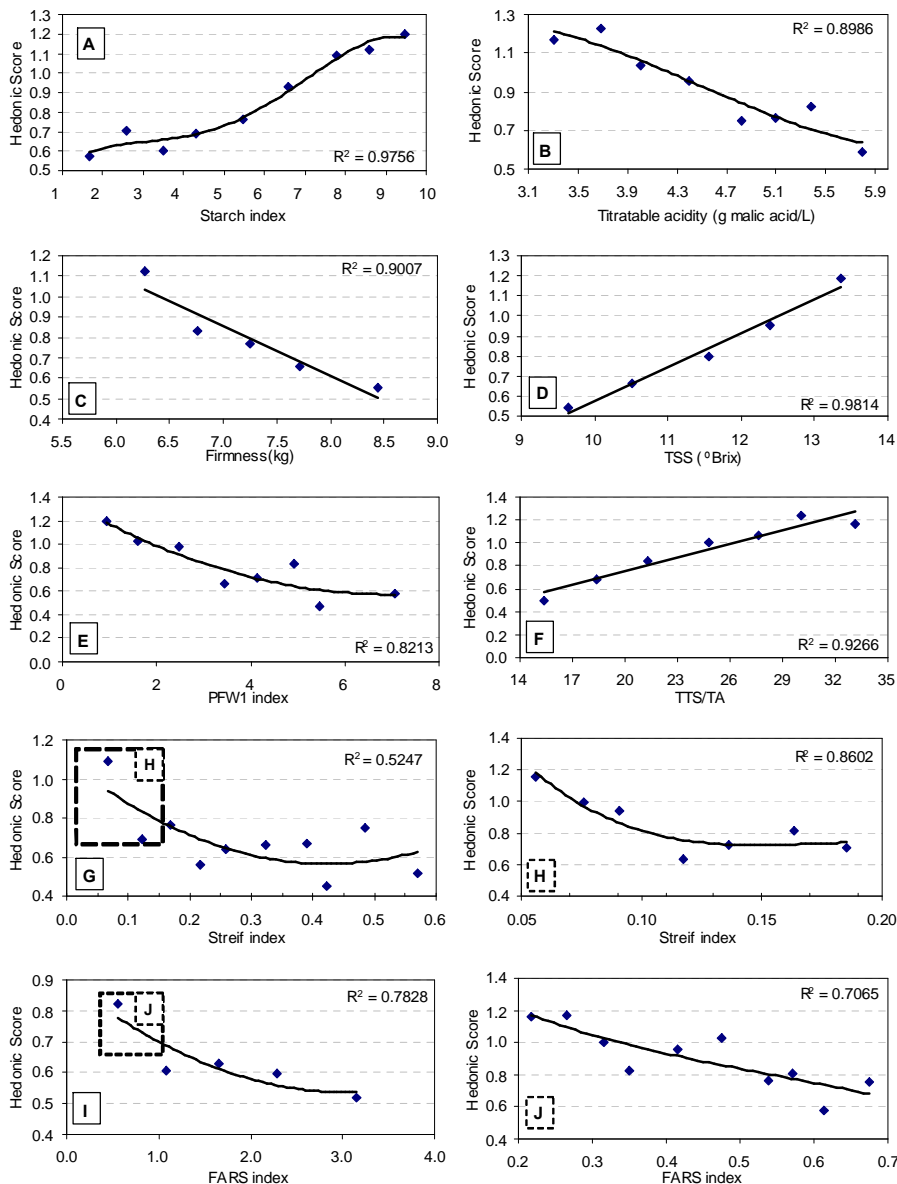


Figure 4. Relationship between mean hedonic score and different parameters and indexes for Golden Smoothie apples from the Lleida and Girona areas in 2003. Each point represents the mean value for all samples in a given interval. Each sample corresponds to the mean value for 20 fruits harvested on the same day from a single orchard (total 36 samples). Figures represent the relationship between hedonic score (from -3 to +3) and A) Starch index on a 1-10 scale, B) Titratable acidity, C) Firmness, D) Total soluble solids, E) PFW-1 index, F) Ratio between total sugars and titratable acidity, G) Streif's index, H) Streif's index for all samples with values lower than 0.2, I) FARS index, J) FARS index for all samples with values lower than 0.7

In general, the correlations between fruit quality parameters and consumer satisfaction scores were better in 2003 than in 2002. There were also differences in general trends between 2002 and 2003.

For example, in 2002, consumer satisfaction was highest in apples with a harvest-time starch index of about 7. In 2003, consumer satisfaction scores continued to rise with increasing starch index, and were highest with apples with a harvest-time starch index of 10.

Likewise, the curve of total soluble solids content versus consumer satisfaction scores was curvilinear in 2002, and strongly linear in 2003.

With recent advances in storage technology, the criteria for determining optimum harvest date have to be continuously reviewed and revised. Harvest time has to be based on either one or a small number of highly reliable indices.

In Spain, firmness has traditionally been one of the most extensively used parameters for defining harvest time. Although firmness is useful for determining the end of the harvest period, it is not reliable for determining the beginning of the harvest period (Alegre et al., 2003).

The consumers consulted in this study preferred fully or almost fully ripe apples with a high TSS and a high TSS/TA ratio. To ensure these conditions, TSS and starch index are the most reliable parameters for determining the beginning of the harvest period. On the other hand, texture and firmness should be used to determine the end of the harvest window because of their implications for shelf life.

Nevertheless, the curves of starch index versus consumer satisfaction scores were different in 2002 and 2003. In 2002, apples with a harvest-time starch index over 7 were overripe. In 2003, even fruits with a starch index of 10 were not overripe, and received the best consumer satisfaction scores.

This may be related to differences in TSS between 2002 and 2003. Apples with a starch index of 7 had a TSS of about 14.5° Brix in 2002, and of about 12.2° Brix in 2003. Consumers probably preferred more mature fruits in 2003 mainly because of the higher sugar content, but also because of the lower proportion of mealy and senescent fruits. The correlation between TSS and consumer satisfaction scores was very strong.

The starch index could be a simple harvest index with a relatively low degree of variability. However, it is also probably associated with TSS at harvest time.

The data on apples collected in 2004 are now being analyzed to confirm whether TSS at harvest time is the best single predictor of post-storage consumer satisfaction, and also to confirm the strong correlations between consumer satisfaction scores and several of the other fruit quality parameters and harvest indices.

Preliminary results show that some indexes, including the Jager's index and the Streif's index, could be useful predictors of consumer satisfaction. Even so, they do not seem to be more reliable than the indices currently in use and are furthermore very time consuming. Non-destructive techniques may

provide more reliable information in a shorter period of time than the new harvest indexes, especially those techniques which measure fruit texture.

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SEZONOWE ZMIANY RÓŻNYCH INDEKSÓW ZBIORCZYCH DLA JABŁEK 'GOLDEN SMOOTHIE'[®] W HISZPANII

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S T R E S Z C Z E N I E

Opracowano i wprowadzono nowy układ eksperymentalny w celu ulepszenia wyznaczania optymalnego terminu zbioru dla długiego przechowywania jabłek 'Golden Smoothee'[®], które uwzględniałoby zadowolenie konsumentów z owoców przechowywanych przez 8 miesięcy. W latach 2002 i 2003 zbierano jabłka 'Golden Smoothee'[®] z sześciu reprezentatywnych sadów w rejonie produkcyjnym Lleida i z sześciu sadów z rejonu Girona. Z każdego sadu zbierano przez sześć tygodni, w tygodniowych odstępach czasu, około 30 kg owoców z dwóch różnych drzew normalnie plonujących. Do oznaczenia jakości owoców na zbiorze i po przechowywaniu wybrano z każdego sadu próbki 20 reprezentatywnych owoców. Oddzielne próbki owoców przygotowano do oceny stopnia zaspokojenia wymagań konsumentów.

Obserwowano sezonowe zmiany parametrów jakości owoców i różnych indeksów zbiorczych (Streifa, Jagera i FARS) oraz określano ich związek z ocenami konsumentów. Masa owoców, indeks skrobiowy, zawartość ekstraktu i stosunek ekstraktu do kwasowości wzrastały w miarę dojrzewania owoców. Wzrost był prawie liniowy w przypadku indeksu skrobiowego i kwadratowy albo sigmoidalny dla pozostałych parametrów. Generalnie, podobne tendencje obserwowano w obu latach doświadczeń, ale pomiędzy sezonami występowały niewielkie różnice.

Pierwsze rezultaty wskazują, że niektóre proste pomiary, takie jak indeks Jagera i indeks Streifa, dostarczają wystarczających informacji i mogą być lepszymi wskaźnikami niż bardziej skomplikowane indeksy zbiorcze, dobrze wiążą się z odczuciami konsumentów i nie są tak czasochłonne.

Słowa kluczowe: analiza sensoryczna, test hedoniczny, dojrzałość, jędrność, indeks skrobiowy, indeks Streifa