INTEGRATING SENSORY ANALYSIS AND HEDONIC EVALUATION FOR APPLE QUALITY ASSESSMENT

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ABSTRACT

Apple cultivars were subjected to a consumer test in order to appreciate individual preferences and set up a protocol for a practical hedonic-sensory evaluation. Cultivars subjected to the test were "Golden Delicious," "Modì," "Pink Lady" and "Fuji" of two different origins. Apples had the sensory profile defined by a trained panel and were evaluated by 154 consumers. According to their preferences, consumer population could be divided in six clusters. Consumer preference responses clearly associated the two "Fuji" and showed "Modì" and "Pink Lady" to have appeal on the same consumers groups. Besides expressing hedonic judgment, consumers were requested to indicate the positive sensory attributes determining their choice. Consumers appreciated "Golden Delicious" and "Fuji" on the basis of sweetness and aroma, while preferences for "Pink Lady" and "Modì" were expressed by consumers appreciating crispness, juiciness and a certain degree of acidity. The involvement of consumers in defining attributes driving preferences provides details useful for weighing up the consistency between consumers' response and sensory panel profile.

PRACTICAL APPLICATIONS

This work contributes to the knowledge on consumer preferences and concerning apple sensory quality. In particular, the tested varieties could be divided in three groups on the basis of perceived attributes. Knowledge of consumer preferences related to apple qualities can be a key point in planning production and marketing strategies. A protocol integrating sensory characteristics defined by a trained panel, hedonic consumer judgments and sensory preference drivers is proposed.

INTRODUCTION

Apple cultivars are numerous and can provide a wide range of variation in sensory quality, which with the correct information, can convert in drivers for sustaining apple consumption through an increased consumer satisfaction. In a condition of high competition, as the apple industry has been experiencing for a number of years (Harker *et al.* 2003), customer contentment is a key point in determining product overall quality and commercial value and should be deeply analyzed when planning production and marketing strategies. However, as related to fresh fruits' and vegetables' quality assessment, instrumental methods are preferred to sensory evaluation, which is preferred over consumer testing, despite the different approaches being in the opposite order in terms of extrapolation of results to the real world (Shewfelt 1999). Focusing on

consumer-oriented quality expectations offers tools more responsive to the marketplace changes. However, the assessment of relationships between hedonic judgments and product characteristics is not only an opportunity but still, a fundamental problem of sensory sciences. A comprehensive sensory evaluation should include a trained panel providing accuracy, sensibility and repeatability of judgment. This panel can perform a Type I sensory evaluation, as defined by O'Mahony (1988), based on reliability of judges. Panel evaluation interpreted through a Type II analysis, involving consumers, since consumers' acceptance judgment is necessary to understand sensory data in terms of consumer-perceived quality. For an effective quality level assessment, the reference benchmark is consumer opinion (Lawless 1995). Furthermore, when perishable products such as apple are under investigation, an unavoidable biological variability among

fruits providing variable sensory experience can be predicted (Harker *et al.* 2002). The lack of homogeneity among fruits suggests subjecting to evaluation a dependable number of individual fruits to counteract variability. These amounts could be analyzed only with the involvement of a reliable number of consumers, while the trained panel contribution, due to the limit in terms of number of samples per assessor, can usually provide data only on a reduced number of individual fruits, which, although carefully selected, always raise the problem of the sample being satisfactorily indicative of average quality. The problem of biological variability within samples was already underlined in discrimination tests of fruit and vegetables (Harker *et al.* 2005).

On the other hand, it is known how difficult it is to acquire good consumer preference data, and correlate them to intrinsic characteristics of the products. Consumers must be representative of a consumer population, or provide indication of clear differences addressable to a subpopulation. Relevance and reliability of consumer response data in fruit tasting should be possibly validated by the identification of sensorial preference drivers, which could be evaluated by a trained panel as experimented in other food products (Green-Petersen *et al.* 2009). Several authors investigated consumer preferences for apples (Daillant-Spinnler *et al.* 1996; Jaeger *et al.* 1998; Kókai *et al.* 1998; Kühn and Thybo 2001). Among the most important drivers for apple preference were texture, aroma and taste. A major factor negatively affecting consumer judgment was mealiness (Jaeger *et al.* 1998).

The aim of the present research was to investigate if consumers can associate apple cultivars not only on the basis of hedonic rating but indicating specific attributes. Sensory evaluation of different apple cultivars was performed by a trained panel and subjected to a consumer test in order to appreciate consistency in assessment and set up a simple protocol for a suitable consumer evaluation of apples. The aim of the present work was to assess consumer preference and verify how they are based on effective perception of sensory attributes.

MATERIALS AND METHODS

Apples (*Malus domestica* Borkh.) were obtained on the last decade of November 2006, from a fruit supplier in the Ferrara province, Emilia Romagna, Italy. Cultivar subjected to test were "Golden Delicious;" "Pink Lady," "Fuji" and "Modì;" "Golden Delicious" was chosen as a standard classic cultivar. It is described as being sweet, spicy and moderately acidic, firm at harvest, with a tendency to soften in storage (Abbott *et al.* 2004). "Pink Lady" is described as having excellent sensory attributes, including crispness and juiciness, and has a high sugar–acid balance (Lopez *et al.* 2007). "Fuji" is indicated among the cultivars with high sensory quality (Dunemann *et al.* 2009), and described as a juicy, firm, crisp, fine-grained apple sweet, with a high sugar and low acid content (Yoshida *et al.* 1995; Brooks and Olmo 1997). "Modì" has a crisp and juicy flesh (Pellegrino and Guerra 2008). Two "Fuji" differing for origin were tested: Ferrara, Emilia Romagna (Fuji_FE) and Trentino Alto Adige (Fuji_TN).

Fruits were selected for assessment if there was an absence of disease and disorder and they were between 75 mm and 85 mm (diameter). Representative apples of each cultivar were used to determine firmness and soluble solids content (SSC). Fruits were removed from cold storage and equilibrated to room temperature for 24 h before analysis and tests. Firmness and SSC were determined on a sample of 12 fruits per cultivar. Firmness was measured, after removing apple skin, on both sides of each fruit, with a penetrometer (Fruit tester, Effegi, Alfonsine, Italy) fitted with an 11.1-mm probe. SSC was measured on fruit juice using a portable refractometer (Brixstix, Techniquip Corporation, Livermore, CA).

Panel Test

Apples were evaluated by a panel composed of 12 judges, experienced in the sensory evaluation of fruits. Attributes chosen on the basis of previous experiences (Predieri and Gatti 2009), were firmness, crispness, juiciness, sweetness, acidity, aroma and mealiness. A specific training on apple attributes' intensity evaluation was provided to panelists to ensure panel consistency. For panel test, samples were prepared having each fruit washed in purified water and cut in slices down the axis before being presented, with a three-digit code, to the panelist. Four replicates were executed, with samples' order randomized to prevent any statistical effects of order or carryover. Attributes were expressed on a 100-mm line scale, and intensity quantified by measuring the distance of the mark from the origin (Dever *et al.* 1996).

Consumer Test

Consumers were contacted in a gallery of a commercial shopping center, in Bologna, without any preliminary contact or selection. Consumers were first asked to taste apple samples and fill in a questionnaire, expressing for each of them an acceptance judgment on a 1–9 hedonic scale from 1: "I completely dislike" to 9: "I like very much." Each consumer tested five anonymous samples, represented by apple slices, prepared as for panel test, identified only with a random three-digit code. The second part of the questionnaire asked consumers to focus only on the sample receiving the highest score, and to indicate attributes determining their preference, choosing among five sensorial descriptors used by panelists: crispness, juiciness, sweetness, acidity and aroma. Two attributes evaluated by the panelists were excluded since firmness has a close correlation with crispness, and mealiness being a known negative attribute. Consumers properly com-

pleting the hedonic test were 154 (50% women, 50% men); 144 (94%) indicated also descriptors determining preference. Ages ranged from 18 to 75 years. For statistical analysis, the population was divided in three categories (<35: 39%; 36–55: 36%; over 55: 24%).

Statistical Analyses

Analytical, sensory and consumer data were processed using SAS software 9.1.3 (SAS Institute Inc., Cary, NC). Means were separated by least significant difference test at $P \leq 0.05$. Descriptive statistics were performed for each set of data in order to identify outliers, extreme observations and observe distributional properties of data. Descriptive measures (moments, basic measures of location and variability, confidence intervals for the mean, standard deviation and variance), analyses of variance and principal components analyses of sensory variables were performed. Correspondence analysis, preference mapping and multidimensional preference analysis were performed in order to investigate relationships among apple cultivars and individual differences in consumer preferences. Subsequently, hierarchical clustering was performed on consumer preferences data after transformation in distance matrix (Euclidean distances) in order to describe consumer profiles.

RESULTS

Firmness and SSC were measured to define standard intrinsic traits. "Golden Delicious" had the lowest firmness and SSC (40.2 ± 0.4 N; 12.3 ± 0.4%, respectively); "Fuji_TN" (51.0 ± 0.1 N; 15.4 ± 0.5%) and "Fuji_FE" (60.8 ± 0.3 N; 16.9 ± 0.4%) had higher firmness and SSC as compared to "Golden Delicious." "Modì" and "Pink Lady" had the highest firmness (80.4 ± 0.2 N and 80.4 ± 0.1 N, respectively) while differed as related to SSC (15.8 ± 0.4% and 14.6 ± 0.3%, respectively). The multidimensional preference map, describing consumer preferences, indicates that "Fuji_FE" and "Fuji_TN" were clearly preferred by a consistent group of consumers. "Pink Lady" and "Modì" appeared very close in consumer preferences, while only a reduced number of consumers expressed preference for "Golden Delicious" (Fig. 1). Consumers indicated a good appreciation for tested apples (average score 6.4). The highest evaluations were recorded by "Fuji_FE" (7.2) and "Fuji_TN" (6.8), followed by "Pink Lady" (6.2) and "Modì" (6.0). "Golden Delicious" obtained the lowest score (5.7; Table 1). Little information was derived by dividing the population according to sex or age. Only "Pink Lady" showed a significant difference, being appreciated more by women (6.5) than by men (5.9; data not shown). Hierarchical clustering was applied to divide the consumer population in six clusters, according to their hedonic scores. The multidimensional preference map illus-
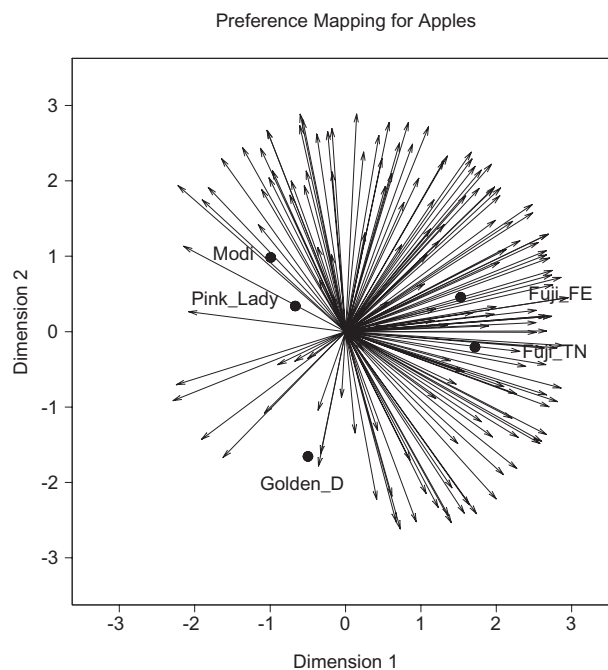

Preference Mapping for Apples

FIG. 1. MULTIDIMENSIONAL PREFERENCE ANALYSIS ON CONSUMER PREFERENCES DATA
The consumer vectors point in approximately the direction of the most preferred apple, with preference increasing as the vector moves from the origin.

trates cultivar associations on the basis of the obtained six clusters preference vectors (Fig. 2). A relatively small cluster (1), corresponding to 9% of the population, gave the highest evaluation to "Modì" (7.8) and "Pink Lady" (6.9) and low evaluations to "Golden Delicious" (4.4) and "Fuji_TN" (3.4). A significant segment, 55% of the consumers, expressed the preference for the two "Fuji," it was divided in three clusters (2, 3, 4) on the basis of the preference assigned to the other cultivars. Cluster 5, including about one quarter of consumers, gave relatively high evaluations to all the tested samples (6.7), the highest appreciation was yielded by "Fuji_TN" and "Pink Lady." Cluster 6, corresponding to 11% of the population, showed preferences opposite to cluster 1: "Golden Delicious" and the two "Fuji" were the most appreciated, while negative scores were attributed to "Modì" and "Pink Lady." The cluster showing the highest average appreciation for the five tasted apples was cluster 3 (7.6), including 23% of the consumers, with the two "Fuji" recording scores close to the maximum (8.7 for "Fuji_FE" and 8.1 for "Fuji_TN"; Table 1).

Sensory evaluation performed by the trained judges (Table 2) showed how for firmness, crispness and acidity "Modì" and "Pink Lady" obtained the highest values. The two "Fuji" reached the highest rates for sweetness and aroma and were also perceived as juicy. "Golden Delicious" had the

TABLE 1. CLUSTERS DEFINED BY CULTIVAR PREFERENCES OF CONSUMERS

	Cluster 1		Cluster 2		Cluster 3		Cluster 4		Cluster 5		Cluster 6		Whole population	
Population (%)	9		14		23		18		25		11		100	
	Score	Rank	Score	Rank	Score	Rank	Score	Rank	Score	Rank	Score	Rank	Score	Rank
Fuji_FE	5.9 ± 0.5	3	8.0 ± 0.1	1	8.7 ± 0.1	1	6.7 ± 0.3	1	6.2 ± 0.2	4	6.9 ± 0.5	1	7.2 ± 0.1	1
Fuji_TN	3.4 ± 0.5	5	7.8 ± 0.1	2	8.1 ± 0.1	2	6.5 ± 0.2	2	7.5 ± 0.2	1	5.0 ± 0.5	2	6.8 ± 0.1	2
Golden Delicious	4.4 ± 0.4	4	5.9 ± 0.2	3	6.5 ± 0.3	5	4.9 ± 0.3	4	6.5 ± 0.3	3	6.9 ± 0.4	1	5.7 ± 0.2	5
Modì	7.8 ± 0.2	1	4.7 ± 0.3	5	7.6 ± 0.2	3	3.9 ± 0.3	5	6.2 ± 0.3	4	4.3 ± 0.5	3	6.0 ± 0.2	4
Pink Lady	6.9 ± 0.4	2	5.3 ± 0.3	4	7.1 ± 0.2	4	5.6 ± 0.3	3	7.1 ± 0.2	2	4.1 ± 0.3	4	6.2 ± 0.1	3

Data are means of judgments of 154 consumers. Each consumer tested the five cultivars and expressed a vote on a scale from 1 to 9.

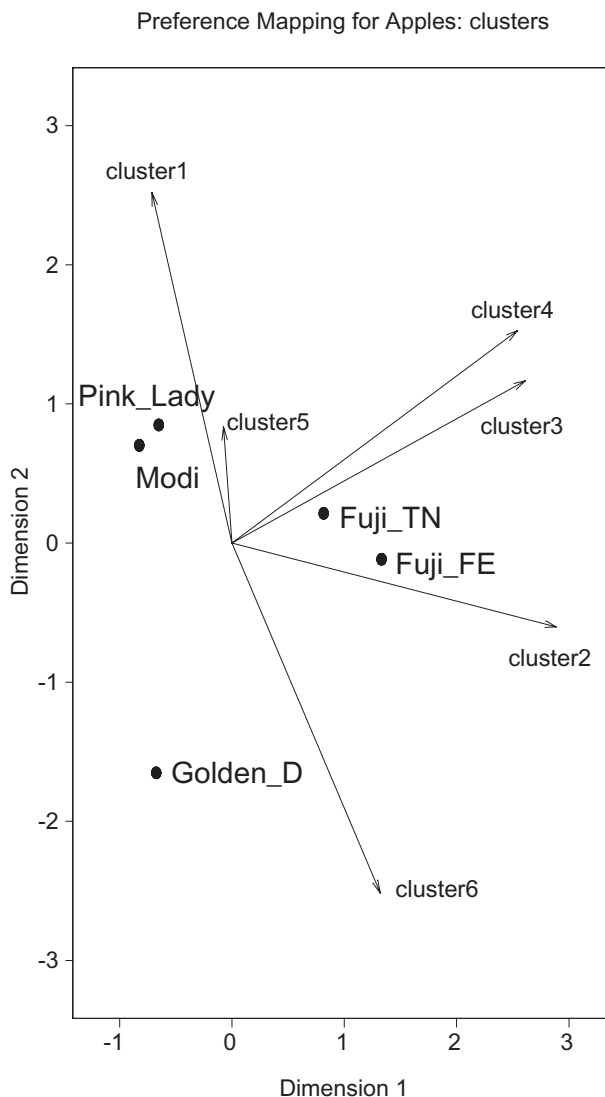Preference Mapping for Apples: clusters

FIG. 2. MULTIDIMENSIONAL PREFERENCE ANALYSIS ON CONSUMER CLUSTERS

lowest firmness, crispness and juiciness, intermediate acidity and the highest mealiness.

Principal component analysis based on panel sensory profile is shown in Fig. 3. The first two principal components explained about 98% of the variance. "Fuji" was associated with attributes such as sweetness, aroma and juiciness. "Golden Delicious" was associated with mealiness. "Pink Lady" was associated with acidity, and shared with "Modì" attributes such as firmness and crispness. Firmness and crispness had a high correlation ($r^2 = 0.75$). Preference mapping of the seven sensory variables displayed in the plot of the first two principal components of the apple preference data, showed consistency with cultivar associations as determined by trained judges (Fig. 4). As related to reasons driving con-

Cultivar	Firmness	Crispness	Juiciness	Mealiness	Sweetness	Acidity	Aroma
Fuji_FE	54.9 b	55.7 bc	59.0 a	19.1 b	56.8 a	23.7 c	49.7 ab
Fuji_TN	53.6 b	50.9 c	58.1 ab	19.6 b	50.9 a	22.6 c	52.3 a
Golden D	28.7 c	24.6 d	37.6 c	43.4 a	34.9 b	35.0 b	34.7 c
Modì	71.4 a	67.1 a	49.5 b	16.1 b	29.6 b	51.7 a	38.2 c
Pink Lady	68.5 a	62.3 ab	51.8 ab	17.9 b	28.6 b	59.4 a	41.6 bc

TABLE 2. SENSORIAL PROFILE DEFINED BY A TRAINED PANEL

Data are means of four repetitions. Means followed by different letters are significantly different at *P* < 0.05 (LSD test).

sumer preferences, consumers were glad to explain sensory reasons determining their choice, straight and clear in indicating attributes. The first two dimensions of simple correspondence analysis explained more than 98% of the inertia. Consumers preferring "Pink Lady" liked in particular its acidity. "Modì" based its appeal on crispness and juiciness. Consumers choosing "Fuji" were driven in particular by sweetness and by aroma. Since only positive attributes orienting choice were requested, thus mealiness was excluded, sensory attributes driving preference for "Golden Delicious" resulted the same than for "Fuji" (Dimension 1, Fig. 5).

DISCUSSION

The knowledge of consumer preferences for apple qualities and of their effective capacity to correlate liking to specific sensorial attributes is important for increasing consumer satisfaction in apple consumption. In the present study, sensorial differences among apple cultivars were clearly defined by

panel test and perceived by consumers. Tested samples could be divided in three groups: (1) "Modì" and "Pink Lady" being perceived as firm, crisp and acid; (2) the two "Fuji" perceived as sweet and aromatic; and (3) "Golden Delicious," with intermediate acidity, was rated as the less firm, crisp and juicy, and the highest mealiness. Sensory classification was in accordance with measured firmness and SSC and with common qualitative description of cultivars (Kühn and Thybo 2001).
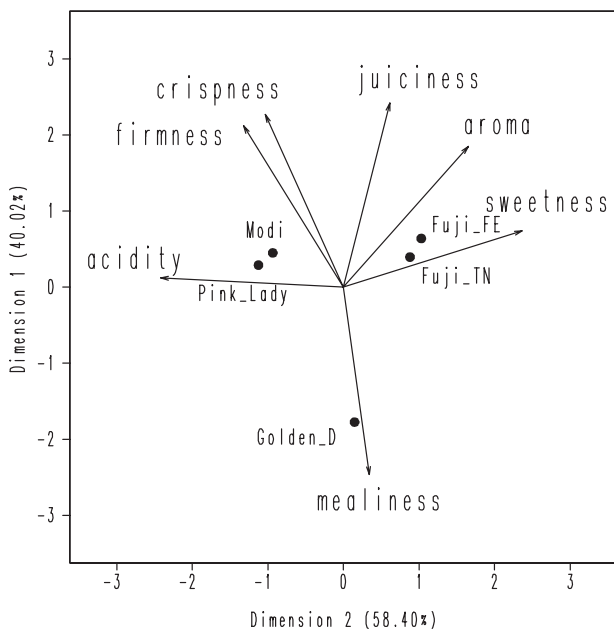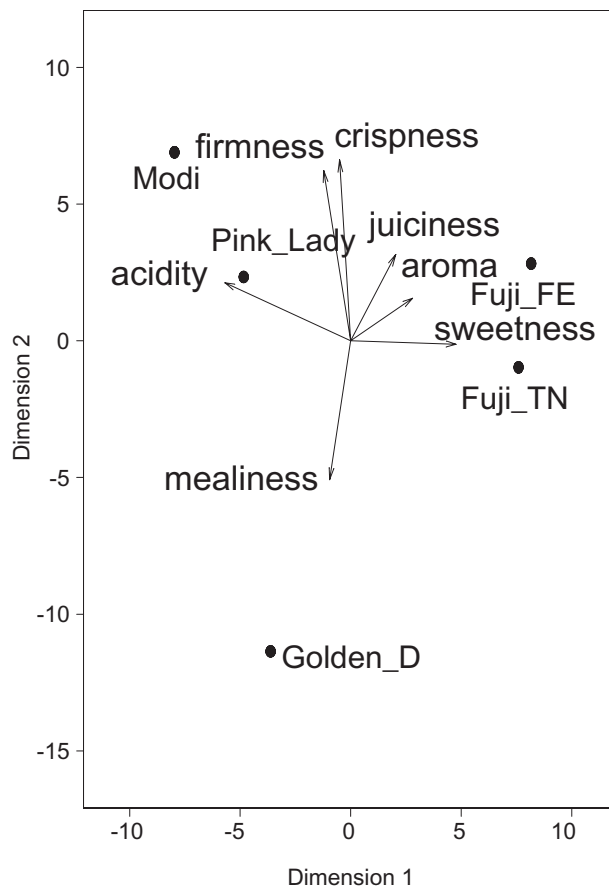
FIG. 4. EXTERNAL PREFERENCE MAPPING BASED ON SENSORY PROFILE DEFINED BY TRAINED PANEL AND PREFERENCES ATTRIBUTED BY CONSUMERS
Each sensory attribute is represented as a vector that points in approximately the direction of the apples with larger values of the attribute.
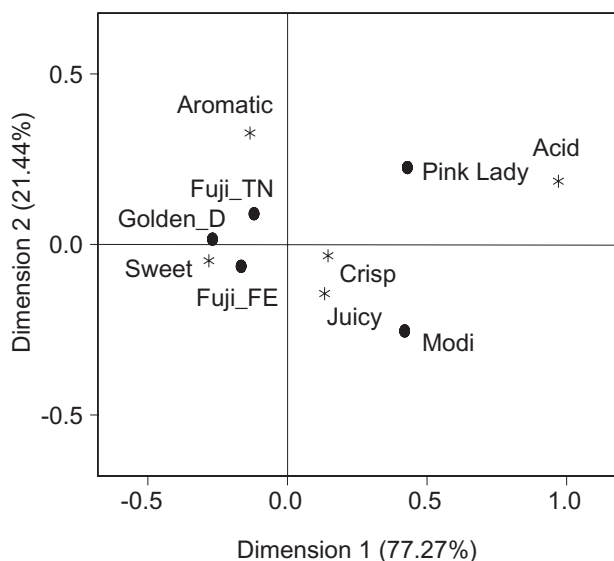
FIG. 3. PRINCIPAL COMPONENT ANALYSIS ON DATA PROVIDED BY TRAINED PANEL TEST

FIG. 5. SIMPLE CORRESPONDENCE ANALYSIS OF POSITIVE SENSORY ATTRIBUTES INDICATED BY CONSUMERS

Consumer preference for apples is generally associated with firmness, juiciness and sweetness (Jaeger *et al.* 1998; Harker *et al.* 2008). Daillant-Spinnler *et al.* (1996) found that consumers could be split into two groups: those preferring a sweet and hard apple and those preferring an acidic and juicy one. Preference map results show the split between acid and sweet liking, as determined by expert panel and confirmed by consumers. By dividing consumers in clusters according to their preferences, about 55% preferred the two "Fuji;" "Pink Lady" and "Modì" obtained a good ranking while "Golden Delicious" was first choice only by a small percentage of consumers.

The investigation about consumer motivation for choosing a specific apple was limited to positive sensorial attributes, with the aim of better focusing on what a consumer expect from a specific cultivar. Apples' defects can be easily and more correctly detected by experts, thus consumers were not requested to comment on mealiness, a well-known negative quality attribute, associate it with long-term stored, not-fresh apples (Jaeger *et al.* 1998). The expected high correlation between firmness and crispness, confirmed by panel test data, motivated the choice to propose to consumers only one of the attributes. Crispness was chosen since it has been found to be associated by consumers to freshness, shown to be a primary criterion for apple choice by consumers (Péneau *et al.* 2006). On the basis of descriptors of preferred apples "Golden Delicious" and "Fuji" appeared to compete for the same category of consumers: those choosing essentially sweet and aromatic fruits. "Pink Lady" and "Modì" appeared to be able to satisfy the consumer appreciating crispness, juiciness and a certain degree of acidity.

In this research, consumers appeared able to clearly express sensory preferences, indicating the positive attributes perceived in the tasted fruits. This could be of help in identifying quality attributes, which a specific cultivar should satisfy at consumption. Consumer sensory responses appeared well correlated with panelist description. The observation that "Fuji" can be appreciated by "Golden Delicious consumers" can be of interest. In fact, "Golden Delicious" is far more the most produced and sold apple in Europe, despite problems affecting its quality, mainly mealiness. An alternative apple providing higher and consistent quality level may be of help in sustaining apple market on the basis of consumer satisfaction. The applied method of considering sensory attributes as defined by a panelist and perceived by consumers appears promising. However, it has been highlighted (Kühn and Thybo 2001) that when studying quality differences, cultivars' attributes are affected by a number of factors including maturity at harvest and storage modality. These problems should be faced through a close collaboration between post-harvest physiologists and sensory experts. Obviously, it should be also taken into account that consumers from different areas may have different preferences, thus data presented here are based on consumers of a Northeast Italian Region. On the other hand, the results of the European project ISA-FRUIT (Predieri *et al.* 2009) indicates more similarity than differences among European consumers from different countries as related to apple cultivars. An enhanced alignment of sensory expectation research with the approached used in marketing has been suggested by Jaeger and MacFie (2001). A more detailed investigation of similarity between apple cultivars can be of help in proposing to the consumers not only names or label but a clear assurance of satisfaction of expected product sensory attributes.

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REFERENCES

ABBOTT, J.A., SAFTNER, R.A., KENNETH, C., GROSS, A., BRYAN, T., VINYARD, B. and JANICK, J. 2004. Consumer evaluation and quality measurement of fresh-cut slices of "Fuji," "Golden Delicious," "GoldRush," and "Granny Smith" apples. Postharvest Biol. Technol. *33*, 127–140.

BROOKS, R.M. and OLMO, H.P. 1997. *The Brooks and Olmo Register of Fruit and Nut Varieties*, American Society Horticulture Science Press, Alexandria, VA.

DAILLANT-SPINNLER, B., MACFIE, H.J.H., BEYTS, P.K. and HEDDERLEY, D. 1996. Relationship between perceived

sensory properties and major preference directions of 12 varieties of apples from the southern hemisphere. Food Qual. Prefer. *7*, 113–126.

DEVER, M.C., MACDONALD, R.A., CLIFF, M.A. and LANE, W.D. 1996. Sensory evaluation of sweet cherry cultivars. HortScience *31*, 150–153.

DUNEMANN, F., ULRICH, D., BOUDICHEVSKAIA, A., GRAFE, C. and WEBER, W.E. 2009. QTL mapping of aroma compounds analysed by headspace solid-phase microextraction gas chromatography in the apple progeny "Discovery" 3 "Prima". Mol. Breed. *23*, 501–521.

GREEN-PETERSEN, D., HYLDIG, G., SVEINSDÓTTIR, K., SCHELVIS, R. and MARTINSDÓTTIR, E. 2009. Consumer preference and description of salmon in four northern Atlantic countries and association with sensory characteristics. J. Aquat. Food Prod. Technol. *18*, 223–244.

HARKER, F.R., GUNSON, F.A., BROOKFIELD, P.L. and WHITE, A. 2002. An apple a day: The influence of memory on consumer judgement of quality. Food Qual. Prefer. *13*, 173–179.

HARKER, F.R., GUNSON, F.A. and JAEGER, S.R. 2003. The case for fruit quality: An interpretive review of consumer attitudes and preferences for apples. Postharvest Biol. Technol. *28*, 333–347.

HARKER, F.R., KUPFERMAN, E.M., MARIN, A.B., GUNSON, F.A. and TRIGGS, C.M. 2008. Eating quality standards for apples based on consumer preferences. Postharvest Biol. Technol. *50*, 70–78.

HARKER, F.R., NORQUAY, C., AMOS, R., JACKMAN, R., GUNSON, A. and WILLIAMS, M. 2005. The use and misuse of discrimination tests for assessing the sensory properties of fruit and vegetables. Postharvest Biol. Technol. *38*, 195–201.

JAEGER, S.R. and MACFIE, H.J.H. 2001. The effect of advertising format and means-end information on consumer expectations for apples. Food Qual. Prefer. *12*, 189–205.

JAEGER, S.R., ANDANI, Z., WAKELING, I.N. and MACFIE, H.J.H. 1998. Consumer preferences for fresh and aged apples: A cross-cultural comparison. Food Qual. Prefer. *9*, 355–366.

KÓKAI, P., SASS, B., SIPOS, M., ERDÉL, Y.I. and FERENCZY, A. 1998. *Consumer preference tests on sensory quality of apple varieties*. Publication Universitas Horticulturae Industriaeque Alimentariae. LVII, 5–11.

KÜHN, B.F. and THYBO, A.K. 2001. The influence of sensory and physiochemical quality on Danish children's preferences for apples. Food Qual. Prefer. *12*, 543–550.

LAWLESS, H. 1995. Dimensions of sensory quality: A critique. Food Qual. Prefer. *6*, 191–199.

LOPEZ, M.L., VILLATORO, C., FUENTES, T., GRAELL, J., LARA, I. and ECHEVERRIA, G. 2007. Volatile compounds, quality parameters and consumer acceptance of "Pink Lady®" apples stored in different conditions. Postharvest Biol. Technol. *43*, 55–66.

O'MAHONY, M. 1988. Sensory difference and preference testing: The use of signal detection measures. In *Applied Sensory Analysis of Foods* (H.R. Moskowitz, ed.) pp. 145–175, CRC Press, Boca Raton, FL.

PELLEGRINO, S. and GUERRA, W. 2008. Innovazione varietale. In *Il Melo* (C. Fideghelli, ed.) pp. 378–433, Bayer Cropscience, C. ART Servizi Editoriali, Bologna, Italy.

PÉNEAU, S., HOEHN, E., ROTH, H.R., ESCHER, F. and NUESSLI, J. 2006. Importance and consumer perception of freshness in apple. Food Qual. Prefer. *17*, 9–19.

PREDIERI, S. and GATTI, E. 2009. Effects of cold storage and shelf life on sensory quality and consumer acceptance of "Abate Fetel" pear. Postharvest Biol. Technol. *51*, 342–348.

PREDIERI, S., SANSAVINI, S., DONATI, F., GRANDI, M. and MARTINELLI, A. 2009. Gold Chief per il gusto, Kanzi per L'aspetto, preferite nei "consumer test" europei. Rivista di Frutticoltura *11*, 46–51.

SHEWFELT, R.L. 1999. What is quality? Postharvest Biol. Technol. *15*, 197–200.

YOSHIDA, Y., FAN, X. and PATTERSON, M. 1995. "Fuji" apple. Fruit Var. J. *49*, 194–197.