Thinning via shading: the sensory quality of apples grown by a new technique

Maria Laura Corollaro[1,2]*, Isabella Endrizzi[1], Eugenio Aprea[1], M. Luisa Demattè[1], Fabrizio Costa[1], Franco Biasioli[1], Luca Corelli Grappadelli[2], Flavia Gasperi[1]

1. Department of Food Quality and Nutrition, Research and Innovation Centre, Fondazione Edmund Mach (FEM), via E. Mach 1, 38010 San Michele all'Adige (TN), Italy
2. Dipartimento Scienze Agrarie, University of Bologna, V.le Fanin 46, 40127 Bologna, Italy
* Corresponding author: marialaura.corollaro@fmach.it

Introduction

The prediction of eating quality of apples based on pomological descriptors, such as fruit shape, size, colour, soluble solids content, titratable acidity, and penetrometer measurements, is often insufficient for an exhaustive fruit quality description, because of the interaction among several sensory attributes (Harker et al., 2006; Echeverría et al., 2008). Sensory analysis is the only approach able to give meaning to sensory perception, in qualitative and quantitative terms.

In apple production, the satisfaction of market demand while providing at the same time fruit of the highest possible quality is a difficult compromise. The crop load management is a key factor for that: The most convenient way to make thinning is the application of phytochemicals which cause fruit drop. An innovative method consists in shading apple trees by hail nets with a large reduction in the availability of light (Zibordi et al, 2009). Recently, photoselective coloured nets have been proposed to promote specific physiological responses by differential spectral transmission of solar radiation (Shahak et al., 2004). Some works studied the quality of apples coming from shading treatments (Solomakhin and Blanke, 2010; Amarante et al., 2011; Widmer et al., 2008) but sensory analysis was never applied to evaluate eating quality of such fruit.

This work reports the impact of thinning via shading on sensory quality of apple (*Malus* × *domestica* Borkh.) by applying quantitative descriptive analysis coupled with an instrumental characterisation of texture parameters. Fruit from chemical and shading thinning treatments were analysed in order to compare conventional and innovative thinning methodologies; apples subjected to different photoselective hail nets were then studied to evaluate the effect of variations in the spectral light composition on the sensory quality of the fruit. Texture properties and cell anatomical features were also studied by instrumental measurements, to give interpretation to any possible sensory differences. Indeed, selection of light spectra during early fruit growth is suspected to influence physiological mechanisms of cell division, which is responsible for texture properties of the product.

The final purpose of this study is to provide information about the sensory quality of fruit grown by new methods involving less chemicals, in order to help the development of safer and more ecological production systems.

Material & Methods

1. Fruit material

Apples were harvested from experimental orchards at University of Bologna in 2011 season. "Rosy Glow"/M9 trees were thinned by chemical and by 90% neutral shading cloth applied for one week 30 days after full bloom. The efficacy of the two treatments on fruit drop were comparable, although costs for shading are still very high. "Fuji" apples were sourced from sectors of an orchard covered with photoselective hail nets: black (control), white, red, yellow, or blue.

Apples were analysed after three months of storage (2°C, 95% RH). They were cut in small flesh cylinders (1.2cm high; 1.8cm diameter) and provided for the sensory analysis in plastic cups (8 cylinders/cup).

2. Trained panel and sensory analysis

Ten trained judges, all volunteers from Fondazione Edmund Mach, evaluated the samples according to a quantitative descriptive method based on a consensus vocabulary, as described by Corollaro et al. (2013). Specific definition, an evaluation procedure and reference standards were provided to the panel for each attribute of the protocol (two visual: green and yellow flesh, 4 flavour: overall flavour, sweet and sour taste and astringency; overall odour and 6 texture attributes: hardness, crunchiness, juiciness, flouriness, graininess and fibrousness). For this work, the samples were proposed in three replicates, in randomized balanced order. Data were acquired by the software FIZZ 2.46A (Biosystemes, Couternon, France). Because of the different harvest periods for the two varieties, different sensory analysis sessions were dedicated to Fuji and Rosy Glow samples.

3. Instrumental analysis

A TA-XT Texture Analyzer equipped with an Acoustic Envelope Detector (Stable MicroSystem Ltd., Godalming, UK) was used to analyse samples coming from the same material provided to the panel. From the mechanical and acoustic profiles/curves, 11 and 4 parameters were extracted respectively following the method by Costa et al. (2011) that permits to study the physical structure of apple flesh.
Cell anatomy was studied by microscopy following the method by Goffinet et al. (1995) which evaluates the number of cells per volume and relative air spaces.

4. Statistical analysis

Panel performance was studied by ANOVA for each assessor and attribute using the PanelCheck V1.4.0 software (Nofima Mat, Technical University of Denmark and University of Copenhagen). Differences among the samples for sensory and instrumental data were studied by mixed-factorial ANOVA with the STATISTICA 9.1 software (StatSoft, Inc., USA), considering judges and products as factors. Spider plots on sensory data and Generalized Procrustes Analysis (GPA) were performed by the Senstools 3.1.6 software (OP&P Product Research BV, Utrecht, the Netherlands).

Results and Discussion

1. Panel performance

On the data-set developed for this work, except for few judges and attributes, a good consistency was generally observed for all the texture sensory attributes, green flesh and sour taste. Discriminant capacity was low (mean p-value for all the judges and attributes: 0.265) probably due to the existence of few differences among samples of one variety only proposed in each session.
Panel efficacy is confirmed by analyses on the data-set of 30 apple varieties previously evaluated by the same judges during the period September-December 2011: Judges showed good consistency and discriminant ability for all the texture and taste descriptors (mean p-value for all the judges and attributes: 0.019). Overall odour, flavour and astringency gave some problems related to discriminant ability; one judge only showed problems for reliability on astringency attribute.

2. Sensory and instrumental analysis

Analysis on the whole data-set, considering both the varieties, shows that the panel was able to discriminate between the different cultivars (Fig.1).

Mixed-factorial ANOVA, considering judge and product as random and fixed factors respectively, was performed on Rosy Glow and Fuji data-sets separately. As for Rosy Glow, no sensory differences were perceived for any attribute between the two thesis coming from chemical and shading thinning treatments; regarding Fuji apples grown under different photoselective hail nets, significant differences were found for yellow flesh and sweet taste. Low but significant differences were also found for hardness attribute (Fig. 2). Judge effect was significant for all the attributes in both data-sets, while judge-product interaction was not significant for any descriptor, except for astringency in Rosy Glow data-set.

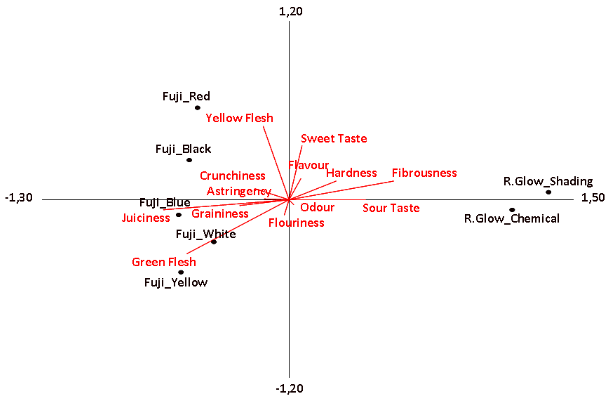

Fig. 1: GPA bi-plot on sensory data for all Rosy Glow and Fuji thesis (Dim.1: 60.14%; Dim.2: 11.43%).

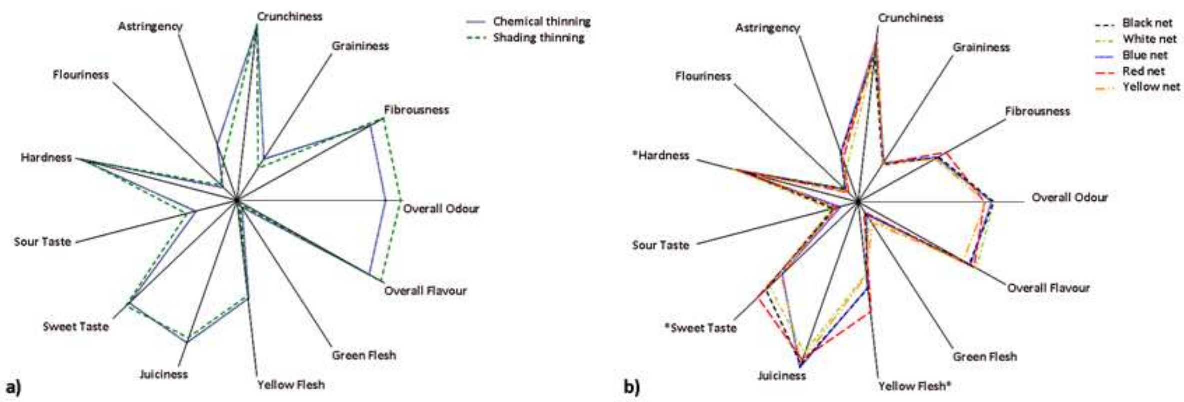

Fig. 2: Spider plots for sensory profiles of Rosy Glow apples coming from chemical and shading thinning (a) and Fuji coming from photoselective hail nets (b). * = p-value < 0.05.

No differences were found for instrumental and anatomical analyses on Rosy Glow apples, confirming sensory data results and suggesting that an overall light intensity reduction does not influence cell division and expansion rates during fruit growth.

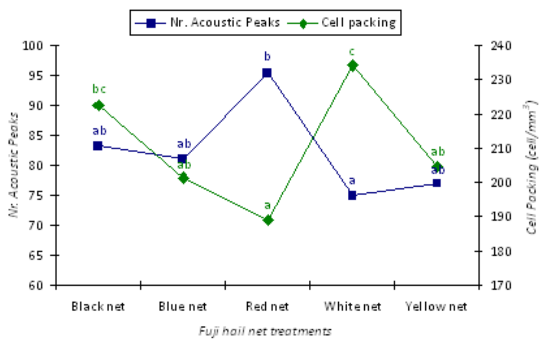

Fig. 3: Mean values of nr. of acoustic peaks measured by TA-XT Texture Analyzer (left "y" axis) and cell packing (cell/mm^3) (right "y" axis) for Fuji apples.

As concerned Fuji apples, Texture Analyzer analysis showed significant differences for two mechanical and three acoustic parameters related to differences in cell packing: Light spectrum selection seems to influence physiological mechanisms during fruit growth, with changes in texture properties. The most interesting results were observed for red and white hail net treatments: The former gives apples with the lowest number of cells per volume (big cells not tightly packed) and the highest acoustic response at compression,

whereas the latter viceversa (Fig. 3). As a matter of fact, the sound produced during the compression is related to the expansion of the liquid subjected to turgor pressure from damaged cells to the surrounding air spaces (Duizer, 2001): The higher the volume of air spaces, the higher the sound is.
However, the differences highlighted by instrumental measures among the Fuji thesis do not correspond to the slight differences in hardness perceived by the panel. Harker et al. (2002) demonstrated that a minimum difference of 6 N is needed in puncture measurements by an 11mm probe to allow a trained panel to perceive differences in fruit texture: This threshold corresponds to a 0.8 N difference for a 4mm probe. In our case, Texture Analyzer measurements by a 4mm probe showed a difference of 0.7 N in maximum force between the two Rosy Glow thesis and an average difference of 0.4 N among Fuji different thesis, confirming the hard task in identifying sensory differences in texture properties between the compared products.

Conclusion

These preliminary results show how it is possible to apply sensory analysis to understand the real impact of new pre-harvest treatments on the final quality of apples.
Instrumental and anatomical analysis highlighted significant differences in physical structure of the thesis for Fuji apples which were not perceived by the trained panel. The efficacy of the panel was previously measured on a wider data-set, confirming that the results above are due to a real high similarity among the samples.
Thinning via shading seems to be a potential alternative to chemical, since it allows to achieve comparable results without affecting fruit sensory quality. Moreover, the differences developed during fruit growth in different light spectrum conditions are not strong enough to be perceived by the human senses.

References

Amarante C.V.T., Steffens C.A., Argenta L.C. (2011) Scientia Horticulturae, 129: 79-85.

Corollaro M.L., Endrizzi I., Bertolini A., Aprea E., Demattè M.L., Costa F., Biasioli F., Gasperi F. (2013) Postharvest Biology and Technology, 77, : 111-120.

Costa F., Cappellin L., Longhi S., Guerra W., Magnago P., Porro D., Soukoulis C., Salvi S., Velasco R., Biasioli F., Gasperi F. (2011) Postharvest Biology and Technology, 61: 21-28.

Duizer L. (2001) Trends in Food Science & Technology, 12: 17-24.

Echeverría, G., Graell, J., Lara, I., Lòpez, M.L., Puy, J. (2008) Journal of Sensory Studies, 23: 656-670.

Goffinet M.C., Robinson T.L., Lakso A.N. (1995) Journal of Horticultural Science, 70(3): 375-387.

Harker, F.R., Amos, R.L., Echeverria, G., Gunson, A. (2006) Journal of Food Science, 71: S77-S82.

Harker, F.R., Maindonald, J., Murray, S.H., Gunson, F.A., Hallett, I.C., Walker, S.B. (2002) Postharvest Biology and Technology, 24: 225-239.

Shahak, Y., Gussakovsky, E., Cohen, Y., Lurie, S., Stern, R., Kfir, S., Naor, A., Atzmon, I., Doron, I. and Greenblat-Avron, Y. (2004) Acta Horticulturae, 636: 609-616.

Widmer A., Kockerols K., Schwan S., Stadler W., Bertschinger L. (2008) In: Boos, Markus (Ed.) Ecofruit - 13th International Conference on Cultivation Technique and Phytopathological Problems in Organic Fruit-Growing: Proceedings to the Conference from 18thFebruary to 20th February 2008 at Weinsberg/Germany, 314-318.

Zibordi M., Domingos S., Corelli Grappadelli L. (2009) Journal of Horticultural Science & Biotechnology, - ISAFRUIT Special Issue: 138-144.