

Chemical and Sensory Characteristics of Three Apple Cultivars (*Malus x domestica* Borkh.)

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Summary

Chemical and sensory characteristics of three apple cultivars 'Idared', 'Granny Smith' and 'Pink Lady' were investigated. Cultivar Idared is predominant in cultivation and on the market in Republic of Croatia, while 'Pink Lady' is only present in certain regions of Croatia because of specific growing requirements; however in the world market it achieves very good results. Fruit of analyzed cultivars was grown in Neretva Valley, and harvested in optimal maturity time. Differences in fruit firmness, total acids and soluble solids were determined. Cultivar Pink Lady had significantly highest firmness (7.3 kg cm⁻²), in comparison to 'Granny Smith' (6.4 kg cm⁻²) and 'Idared' (4.5 kg cm⁻²). Total acids were highest in 'Granny Smith' (0.69 %, expressed as malic acid), somewhat lower in 'Pink Lady' (0.54 %) and significantly lower in cultivar Idared (0.45 %). Values obtained for soluble solids (°Brix) ranged from 16.4 for Pink Lady, 15.4 for 'Idared' and 12.5 for cultivar 'Granny Smith'.

Characteristics of firmness, juiciness, relation between sugars and acids, aroma and general impression were valued by sensory test. Cultivar Idared received lowest grades for most characteristics, except for juiciness, which is its predominant characteristic. Cultivar Granny Smith got good grades for firmness, juiciness, aroma and general impression, while relationship between sugars and acids got low grades. Cultivar Pink Lady got the highest grades from testers, which is in agreement with chemical analysis and cultivar Idared had the lowest grades, while cultivar Granny Smith was well accepted because of its freshness. Result of this research will be used for recommendation of cultivars when planting new orchards.

Key words

Malus x domestica Borkh. cultivar, fruit quality, sensory characteristics

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Introduction

Apple is a fruit cultivar that is mostly taken fresh and it ripens from late summer to winter. Even though Croatia has good edaphic and climatic factors they are not used enough to meet potential for production. Apple is eaten through all the seasons. It has to be available for most of the season and they have to appeal to the customer with its colour, shape, size and taste. Basic factors of quality that most researchers are mentioning are: size, shape, colour, taste, scent, hardness and firmness (Abbott et al., 2004; Hoehn et al., 2003).

Quality of fruit is made of its external and internal (morphological – physical, biochemical and organoleptic) factors. With its quality it has to correspond to wishes of many consumers so that it can satisfy most of their needs, preferences, tastes and habits (Harker et al., 2002). Texture and taste are key elements of quality that affects on attractiveness of apple by consumer. Quality is not to be taken as a fact. It changes with time as consumers taste changes (Harker et al., 2002). Along with quality, the biological value of fruit is also of utmost importance so that they can satisfy the needs of body for valuable nutritive elements. Apple fruit has great amount of vitamins, organic acids, soluble sugars and fibres. It is great source of natural antioxidants (antocyanins, ascorbic acid) and, due to mentioned, they have diet – therapeutic and health value (Stankovic et al., 1973). Chemical composition of apple fruit is very complex. It consists of numerous organic and inorganic compounds and macro biogenic and micro biogenic elements. Most represented are sugars, acids, pectin, tannins, starch, cellulose, vitamins, enzymes and phytohormones, while most represented chemical elements are nitrogen, phosphorus, potassium, calcium, sulphur, iron and magnesium. Fruits which in time of optimal ripe have most of the stated compounds in harmony are of great nutritive value, because in our regular diet we have a deficiency in compounds and elements that are in apple.

For determination of quality and control of fruit it is necessary to measure the relevant quality indicators and also sensory characteristics, nutritive facts, chemical constitution, mechanical values and some deformations and lacks.

Measurements of quality with certain instruments are used in research and for commercial matters rather than sensory measurement (Abbott et al., 2000).

That is the way to ensure common language in judgement of quality between scientists, industry and consumers. The choices, what to measure, how to measure, what are the margin values are to be determined by the person or institution that is conducting the research.

The appearance of fruit is the best way to attract a consumer because the consumer is buying with his “eyes”

even though that mainly has no relevance with quality of the fruit. Today the quality of fruit is the most important factor when we choose assortment and we need to know the indicators that are used to determine that quality: mass and size, firmness, soluble dry matter, acidity, colour of skin (Abbott et al., 2004). It depends on factors that can be controlled (e.g. cultivar, rootstock, ecological requirements, agrotechnics, pomotechnics, growth regulators, pest control and diseases, harvesting and storage) and some that cannot be controlled (climatic factors). By analyzing the characteristics of fruit in different cultivars it is possible to give more objective evaluation of its quality and assess its potential.

Our objective was to determine chemical and sensory characteristics of three apple cultivars: ‘Idared’, ‘Granny Smith’ and ‘Pink Lady’. ‘Idared’ and ‘Granny Smith’ are highly ranked on Croatian market. Cultivar Granny Smith is very appealing without question but ‘Idared’ is losing on its attractiveness. Pink Lady cultivar is relatively new on the market and it is characterized with high quality.

Material and methods

Physical and chemical analysis

All apples were picked at optimal harvest time in Neretva Valley orchards. At harvest, firmness was 6.0 to 7.6 kg cm⁻²; starch index was 2.5 to 3.5; content of soluble solids was 10.0 to 11.5°Brix and Streif index was 0.08 to 0.16. Harvested apples were stored in NA (Normal Atmosphere) at +1°C and 85% of relative humidity for four weeks. After that time fruit chemical and sensory analyses were done. Experiment comprised 20 apples of each cultivar. Firmness was measured with penetrometer (Effigy FT 327) with a scale in kg cm⁻² and with piston diameter 11 mm. Soluble solids content was measured with refractometer (Carl Zeiss) and given in Brix (°Brix). Acids were measured by titration with 0.1 M NaOH and bromthimol blue as an indicator and given in % as malic acid.

Sensory evaluation

Evaluators of sensory characteristics were students of Faculty of Agronomy that were given instructions before they actually started. They were given lessons on cultivar characteristics, the procedure and parameters to which they have to give some consideration. But we have to mention that they were not trained panelists. They were from different parts of Croatia (different preferences); altogether 38: 11 males and 27 females with age range 22 – 27.

We used hedonistic scale with grades from 1 - 9; 1 representing dislike and 10 representing excellence. Skin was removed from fruit minute before the test. Apples were sliced and served to evaluators. Between two cultivars the bread was given to neutralize the taste.

They tested firmness, juiciness, relation between sugars and acids, aroma and general impression.

Results were then processed by analyzing the variance (ANOVA).

Results

Physical and chemical analysis

Fruit firmness is reflection of its storage capability but it is not the only factor. Storage capability depends on many factors, such as cultivar, maturity and storage conditions. By analyzing firmness (Fig. 1) we come up with conclusion that 'Pink Lady' is the hardest cultivar with average value of 7.3 kg cm⁻². 'Granny Smith' had average value of 6.4 kg cm⁻² while 'Idared' had average firmness of 4.5 kg cm⁻². We determined significant difference in firmness between varieties with $p \leq 0.01$.

In further analysis we determined that 'Pink Lady' had higher content of soluble dry matter (16.36 °Brix). Lowest average value was one of 'Granny Smith' (12.48 °Brix) and 'Idared' was in the middle with 15.36 °Brix (Fig. 2)

Results of acid content analysis confirmed our expectations and it had shown that 'Granny Smith' had highest acidity – 0.69 % that gives her amazing freshness, Pink Lady was the second with 0.54 % and Idared had the lowest amount of acids 0.45% (Fig. 3)

In relation to 'Pink Lady' and 'Idared', 'Granny Smith' had also shown lower balance between acids and SDM (Fig. 4) due to higher acid content of the apple.

Sensory analysis

The analyzed results of sensorial factors (Tab. 1.) were telling us about very high significant difference (***) between cultivars considering firmness while for other factors there were high significant differences (**).

There was significant difference in flavour and sweet/sour balance considering sexes which can be interpreted in a way that men and women have different perception of those factors.

Table 1.
F values for analysis of variance between cultivars and sexes

Characteristic	Variety	Sex
	Idared/Granny Smith/Pink Lady	Male/Female
Hardiness	56.89**	0.05
Juiciness	4.38*	0.1
Sweet sour balance	9.17**	4.74
Flavour	15.32**	6.86*
General impression	23.82**	2.82

* significant at $P \leq 0.05$, ** high significant at $P \leq 0.01$;

*** very high significant at $P \leq 0.001$

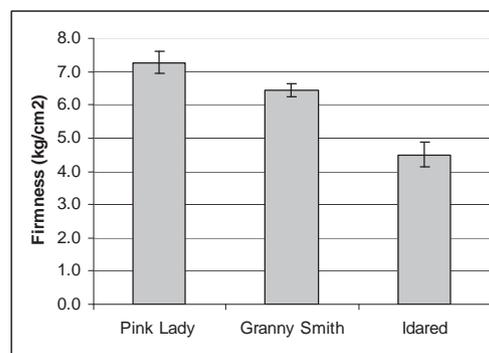


Figure 1. Mean values with SD for firmness for apple cultivars investigated

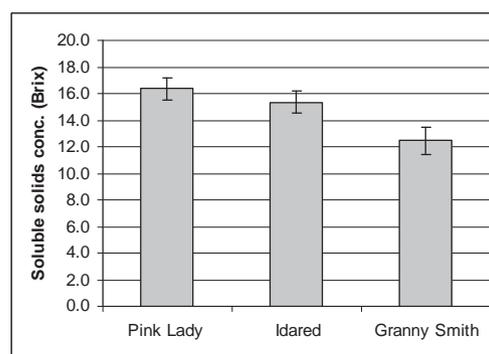


Figure 2. Mean values with SD for soluble solids conc. (SSC) for apple cultivars investigated

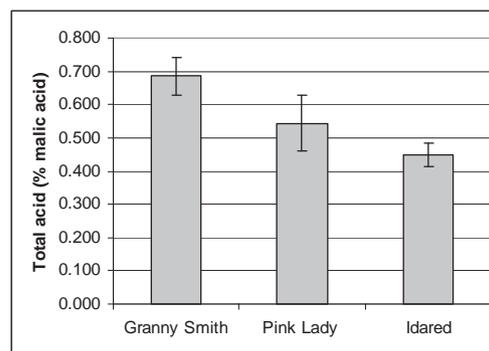


Figure 3. Mean values with SD for Titratable Acids - TA (as malic acid) for apple cultivars investigated

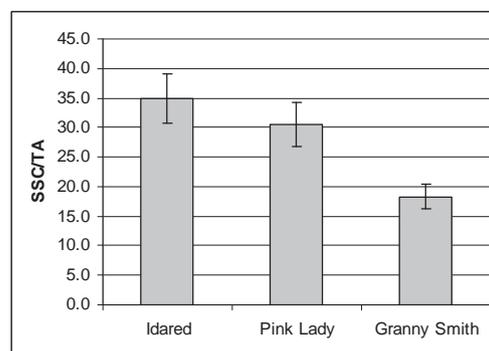


Figure 4. SSC/TA with SD for apple cultivars investigated

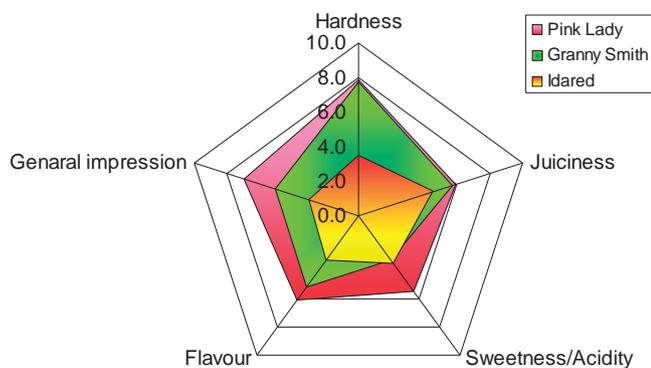


Figure 5. Comparable figure of all analysed sensory characteristics of apple cultivars investigated

Relation of factors in testing is shown in “radar” view (Fig. 5) that gives us clear picture about quality of fruits and variations from ideal pentagram. It can be concluded that ‘Idared’ had the lowest values. Results of sensory test only confirm analytical testing concerning firmness (4.5 kg cm^{-2}). For ‘Idared’ it can be shown that all parameters are quite good but modest (meaning that the space that it fills is small) and we can say that according to testers this cultivar is balanced but low quality. It acquired the lowest grades for four factors and it had slightly higher grades for sweet/sour balance than ‘Granny Smith’. The highest and we can say the most important factor for ‘Idared’ was juiciness. Regarding this results we can say that ‘Idared’ is good for processing industry because it is balanced and in chemical analysis it showed quite good results. With ‘Granny Smith’ there was disproportion of tested factors but it has quite big space. This cultivar had quite good results. The highest grades were for firmness ($7.7/9$) and juiciness ($5.7/9$) while the lowest grade was for sweet sour balance ($3.2/9$). High value of firmness was also found in physical testing (6.4 kg cm^{-2}) so two analyses corresponded.

Low value of sweet sour balance was expected due to chemical analysis which corresponds to other researches (Abbot et al., 2004).

However, this disproportion did not influence relatively high grades of general impression, which was also expected since apple ‘Granny Smith’ was well accepted because of higher acid content that gives its freshness.

In this research cultivar Pink Lady was the best graded among the three investigated cultivars. Not only that it attained the highest grades but it was also the most uniformly graded (Fig. 5). Namely, the space that it occupies is very close to ideal pentagram.

The best way to see differences in quality was if we put three investigated cultivars in a relationship. We could conclude that cultivar Idared does not satisfy more and more distinguished taste of consumers, while cultivar Pink Lady

was much better accepted by student panelists. If we add to this results of chemical and physical analyses, and the results are similar, Pink lady has significantly better quality. It is hard to observe ‘Granny Smith’ apple in comparison to other cultivars, because as it was previously stated, it also does not have ideal shape of “pentagram”, so reason for its acceptance can be explained as favoring of certain characteristics for example acidity.

Discussion

Quality specifications for apples in commerce rely mainly on size and colour (Hoehn et al., 2003). However, eating as well as nutritional quality and hence acceptance of apples by consumers is determined by many other aspects (Babic-Zielinska, 1999; Jaeger, 2000).

Fruit firmness is considered one of the most important criteria concerning eating quality of apples and meeting demands in this respect represents a big challenge for the industry. In a recent and comprehensive review DeEll et al. (2001) discussed preharvest and postharvest factors influencing fruit firmness. In detail many factors including genetics, growing factors, mineral nutrition (Johnson, 2000), harvest maturity (De Jager et al., 1996) and storage affect firmness (Meberg et al., 2000).

Soluble solids content is a good indicator of sugar content of apples and presumably of sweetness (Hoehn et al., 2003). Brix and Brix/titratable acidity may be better at explaining consumer perception of sweetness (or preference) than they are at explaining sweet scores obtained from by sensory panels. However, the evidence for such a relationship between Brix (and Brix/titratable acidity) and consumer acceptability and perception of sweetness is often unreliable in the case of apples. In some studies the relationship has probably been clouded by the influence of fruit maturity and starch index (e.g. Yuen et al., 1995), while other studies show good relationship between Brix or Brix/titratable acidity and acceptability (Thiault, 1970).

Titratable acidity may be an important tool in predicting taste of apples (Harker et al., 2002). This may be important during the assessment of fruit quality, since consumers often have distinct preferences for acid or sweet tasting apples (Daillant-Spinnler et al., 1996).

Harker et al. (2002) demonstrated that sensory attributes of apples are not always adequately predicted by instrumental tests. Harker et al. (2002), showed that while sensory differences were always found when the firmness-threshold was exceeded, sensory differences did sometimes exist in treatments where no significant difference in instrumental values was apparent. Thus, they recommend that assessment of fruit by trained and/or consumer panels remain a critical part of fruit quality assessment. Karlsen et al. (1999) showed that sensory firmness, chewiness and

mushiness correlated well with instrumentally measured force and with the work required for penetration through the flesh. The sensory attributes associated with taste and flavour (odour intensity, sour and sweet taste and aroma intensity) correlated poorly with penetrometric and compression parameters, which was understandable since these techniques measure only the mechanical properties of the apple tissues (Mehinagic et al., 2004).

Watada et al. (1980) showed that analytical methods (determination of total acids and firmness) give poor correlation with sensory evaluation of the same parameters.

Relations between sensory and instrumental analyses are in great dependence on cultivar group (Mehinagic et al., 2004). The same author states that in their research panelists gave better grades to newer cultivars 'Golden Rush' and 'Fuji' than to 'Granny Smith' and 'Golden Delicious'.

Cultivar Granny Smith is generally tart, crisp to crunchy and juicy; but it lacks "flavor" other than tartness, i.e., concentrations of aromatic flavor volatiles are low. It has a low browning potential, low ethylene production and stores well, although it is susceptible to development of superficial scald (Abbott et al., 2004).

'Pink Lady' was rated higher for acceptability than 'Granny Smith' and 'Red Dougherty' by a consumer panel in New Zealand (Corrigan et al., 1997).

Less expressed acids in cultivar 'Idared' than in other cultivars (Yoon et al., 2005) and less harmonious and incomplete taste, which makes it fairly unacceptable for consumers (Gliha, 1978) was also confirmed in our investigations.

Conclusion

Based on conducted research we can conclude the following:

- cultivar Pink Lady is the best graded cultivar based on chemical and physical analyses and also based on grades of student panelists, however this research should be expanded and trained panelists should be included,
- cultivar Idared had the lowest grades,
- cultivar Granny Smith was well accepted by panelists,
- sensory test is maybe the best indicator of some apple fruit quality and in this way producers can easily obtain data on preferences of potential consumers,
- in regeneration of old and planting of new apple orchards in Republic of Croatia, more attention should be given to cultivar quality and its acceptance by consumers, hence it is necessary to conduct this kind of research.

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