

## Sensory and instrumental analysis of selected cultivars of apples from organic and conventional production

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### Abstract

*The aim of the study was to compare the sensory quality and selected physicochemical attributes of apples (*Malus domestica* Borkh.) from the organic and conventional production. Three-year studies were conducted on the following apple cultivars: Red Boskoop, Lobo and Jonagold coming from three pairs of orchards. The sensory values of the organic apples were mostly similar and only in some cases higher compared to the conventional ones: juiciness in Lobo cultivar and hardness in Jonagold cultivar. Also in the consumer evaluation organic Lobo fruits had higher overall palatability compared to the conventional apples.*

*The organically grown apples showed higher content of soluble solids, total sugars and reduced sugars in comparison to the apples from the conventional orchards. The physicochemical parameters of fruits varied depending on the cultivar. The highest content of soluble solids, total sugars, reduced sugars and organic acids were found for Red Boskoop cultivar, whereas Jonagold cultivar had the highest firmness and the ratio of total sugars to organic acids. The organic apples as having better nutritional value and comparable sensory quality should be recommended to be consumed daily.*

**Keywords:** apples, sensory quality, organic cultivation, conventional cultivation

### Introduction

Quality is defined as the degree of excellence and usefulness of the product. The components of the food product quality are sensory attributes (appearance, texture, taste and odour), nutritional value, chemical components, mechanical and functional features and lack of defects (Abbott, 1999). Apples as consumed in large amounts and permanently present in the diet of Polish consumers should demonstrate the best quality. Production of apples in Poland is the largest and most widespread. In 2004 Poland was the biggest producer of apples in the European Union with the harvest of 2 522 thousand tons (Market analyses, 2005; Krupa, 2005).

More and more consumers take care about their health status and environmental protection and look for health-safety food, that organic products can guarantee. Recently increase of interest in organic farming has been observed. Organic plant produce is grown without application of chemically synthesized pesticides and easily soluble mineral fertilizers, but with the use of natural plant protection products and animal fertilizers (manure, compost) as well as green fertilizers (Council Regulation No 834/2007). Organic food contains less contaminations, however it is not fully proved that it has higher sensory quality and nutritional value in comparison to food produced conventionally (Woese et al., 1997; Rembiałkowska, 2002). Currently not many studies that would explain that issue explicitly are available (Kopp & Boss, 2005). Therefore scientific study on organic produce quality is needed.

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The aim of this study was to compare sensory quality and the selected physicochemical attributes of apples from organic and conventional production, where both the influence of the cultivar and the production method on selected quality features were analysed.

## **Material and methods**

### Plant material

The study was conducted on three apple cultivars (*Malus domestica* Borkh.): Red Boskoop, Lobo and Jonagold coming from three pairs of orchards. Every pair came from certified organic orchard and corresponding conventional orchard situated in the same area. Apple trees in orchards, from which research material was obtained, were grown in similar climatic and soil conditions and with the use of similar farming practices. Furthermore they must show similarity within cultivars, age of orchard, harvest time and method of collection of the samples. Fertilizers and plant protection products used in selected organic orchards fulfilled requirements included in the Law of April 2004 (Journal of Laws nr 93, p. 898) on organic farming. In above-mentioned orchards fertilizers like precomposted manure and green fertilizers were applied delivering on average 44 kg ha<sup>-1</sup> N in one year. In conventional orchards mineral fertilizers were used entering to soil 129 kg ha<sup>-1</sup> N in one year.

Orchards were situated in Mazovia and Łódź Province. In the study harvest of every cultivar was represented by 45 kg of fruits. Sensory and physicochemical analyses were conducted on apples at the commercial maturity stage. Apples used to the study were harvested in 2003, 2004 and 2005. The results from 3 study years have been presented as the average values for all studied quality parameters.

### Sensory analysis

Sensory assessment of apples consisted of two parts: sensory profile evaluation conducted by experts and semi-consumer study performed by untrained assessors.

### Sensory profiling

Sensory evaluation was carried out by Quantitative Descriptive Analysis (QDA) (Stone & Sidel, 1985; ISO 13299: 2003). The analysis was preceded by preliminary session, where individual attributes of odour, texture and flavour were determined. Table 1 presents the list of terms describing sensory attributes of apples and anchoring points of the unstructured scale. The ten-person panel having good theoretical and practical knowledge of sensory methodology and expert qualification in accordance with the guidelines included in the ISO 8586-2:1994 performed sensory assessments in two independent sessions.

### Semi-consumer study

In the semi-consumer study the scaling method was used (ISO 4121: 1998) with structural graphic scale (9-graded) anchored from 'unpalatable' (meaning 'it does not suit me completely') to 'very palatable' (meaning 'it suits me very much'). Consumers were obliged to mark the place (grade) on the scale that corresponded to their palatability of odour, juiciness, crispiness, flavour and overall palatability of the samples. Fifty consumers were involved in the consumer evaluation. Only persons who declared that they included apples in their diet were chosen to the evaluation.

Table 1. Distinguishing features and their definitions for profile evaluation of apples.

Attributes	Definition	Anchoring points
Acid odour	Unripe apple and plum odour	none - very intensive
Aromatic sweet-nectar odour	Soft apple and nectar odour	none - very intensive
Other fruit odour	Sweet fruit odour (for example: pear, peach, apricot)	none - very intensive
Grassy odour	Odour typical for freshly cut grass or bark torn from a tree	none - very intensive
Firmness	Resistance that trial shows after warming it up	soft - hard, solid
Juiciness	Degree of juiciness	dry, mealy - very juicy
Sweet taste	Basic taste quality does not need to be defined	none - very intensive
Sour taste	Basic taste quality does not need to be defined	none - very intensive
Astringent taste	Styptic feeling, especially at the edge of tongue	none - very intensive
Aromatic apple taste	Taste typical for fresh, fully ripe and aromatic apple, for example Koksa	empty, watery full - aromatic
Overall quality	Overall sensory sensation of harmonizing all the taste and odour attributes	low - high

### Sensory preparation and presentation

The apples were taken from cold storage one day before sensory evaluation and kept at room temperature. According to procedure used in the Research Institute of Pomology and Floriculture in Skierniewice, the samples consisted of selected fruits in respect to their colour and size. All apples in the trial had similar size and degree of colour typical for batch of fruits. Individual sample consist of two segments of apple that made for 1/8 part of an apple. Samples were given in random order in neutral plastic containers with 250 ml capacity. Mineral water was used as to neutralize the taste of samples. The red light was used in order to minimize impression caused by darkening of apple pulp.

### Evaluation conditions

All sensory assessments were carried out in the Sensory Analysis Laboratory (in the Department of Functional Food & Commodities at WULS-SGGW) fulfilling general requirements of ISO standards (ISO 8589:1998) for the sensory testing conditions. Computerized sensory system (ANALSENS NT) was used to perform the random generation of coded numbers of the samples, record the individual results and data collection and processing.

#### Physicochemical analysis (Instrumental analysis)

Trial in the physicochemical study consisted of eatable parts from 15 fruits having different sizes and degree of dyeing. The measurement of the studied physicochemical parameters were conducted on two apple segments cut out from every apple, one from the side with the blush and the other from the opposite side of the fruit. Solely the apple firmness measurements were carried out on the whole fruit. The trial was collected in accordance with the procedure applied in the Research Institute of Pomology and Floriculture in Skierniewice (Szczepański & Rejman, 1987). From every batch of material 3 samples were selected to the study with two repetitions.

#### Texture

Measurement of firmness was conducted by piercing the pulp of evaluated fruit on 8 mm depth with the use of standard tang with 11 mm in diameter (Lange, 2000; Konopacka & Rutkowska, 2001). The results were expressed in  $\text{kg cm}^{-2}$ .

#### Soluble solids

Soluble solids content was determined by the refractometry method in juice pressed from the fragmented fruits according to PN-90/A-74101/02). The results were expressed in  $\text{g } 100\text{g}^{-1}$ .

#### Total and reducing sugars

Total and reduced sugars content were determined by the Luff-Schoorl method based on reduction reaction of copper(II) ions contained in Luff's liquid (sodium carbonate, citric acid, copper(II) sulphate(VI)) by the reduced sugars present in the studied solution (Żegarska, 2000; Fortuna et al., 2001). The results were expressed in  $\text{g } 100\text{g}^{-1}$  d.m.

#### Total acidity

Total acidity was determined with the use of potentiometric according to PN- 90/A 75101/04). The results were expressed in  $\text{g } 100\text{g}^{-1}$  d.m. of apple in conversion to malic acid.

#### Data analysis

One-way analysis of variance (ANOVA) was performed using Tukey's test ( $\alpha < 0.05$ ) to check the significance of differences.

### **Results and Discussion**

#### Impact of the cultivation and apple cultivar on sensory characteristic

The results of the sensory evaluation conducted by the profile method are presented in Table 2. It was shown that cultivation method (organic/ conventional) had no significant influence on most of the sensory attributes like: sour odour, sweet-nectar odour, other fruit odour, grassy odour, hardness, juiciness, sweet taste, sour taste, astringent taste,

aromatic apple taste and overall quality of the studied apple cultivars. Only juiciness in Lobo organic apples and hardness in case of organic Jonagold cultivar were evaluated significantly higher compared to the conventional apples.

Table 2. Effect of the cultivation and apple cultivar on the profiling attribute means (averages from years 2003-2005) and significance of differences

Attributes	Cultivar						p-Value
	Red Boskoop		Lobo		Jonagold		
	org.	conv.	org.	conv.	org.	conv.	
sour odour	3.19 b	3.53 b	2.29 a	2.40 a	2.30 a	2.06 a	<0.001
sweet-nectar odour	3.01 a	2.89 a	3.91 b	3.74 b	4.72 c	5.14 c	<0.001
other fruit odour	1.24 a	1.02 a	1.12 a	0.97 a	2.74 b	3.39 c	<0.001
grassy odour	0.97 a	0.93 a	0.97 a	0.77 a	0.88 a	0.65 a	0.4561
hardness	5.54 b	5.48 b	3.52a	3.38 a	7.29 c	6.69 d	<0.001
juiciness	5.46 c	5.17 c	4.43 b	3.86 a	7.46 d	7.22 d	<0.001
sweet taste	3.49 ab	3.00 a	3.95 b	3.62 b	5.12 c	5.34 c	<0.001
sour taste	4.73 b	4.68 b	2.49 a	2.38 a	2.87 a	2.70 a	<0.001
astringent taste	1.31 bc	1.51 c	0.86 a	0.84 a	1.38 bc	1.07 ab	<0.001
aromatic apple taste	4.44 bc	4.34 bc	3.82 ab	3.25 a	4.89 cd	5.20 d	<0.001
overall quality	5.78 b	5.56 b	4.77 a	4.37 a	7.09 c	7.17 c	<0.001

**Note:** p value <  $\alpha$  ( $\alpha = 0.05$ ) shows that differences were statistically significant; a,b – mean values with different letter in rows are significantly different,  $p \leq 0.05$

The significant influence of the cultivar has been found on most studied sensory attributes, except for grassy odour.

The results of the consumer evaluation of Lobo apple cultivar showed that organic fruits were significantly more desirable as regards to overall evaluation in comparison to the conventional apples (Figure 1). The rest of cultivars haven't shown any significant sensory difference between the organic and conventional apples.

Only few studies on sensory evaluation of organic apples have already been described in the literature. Weibel et al. (2000) found that apples from organic production were

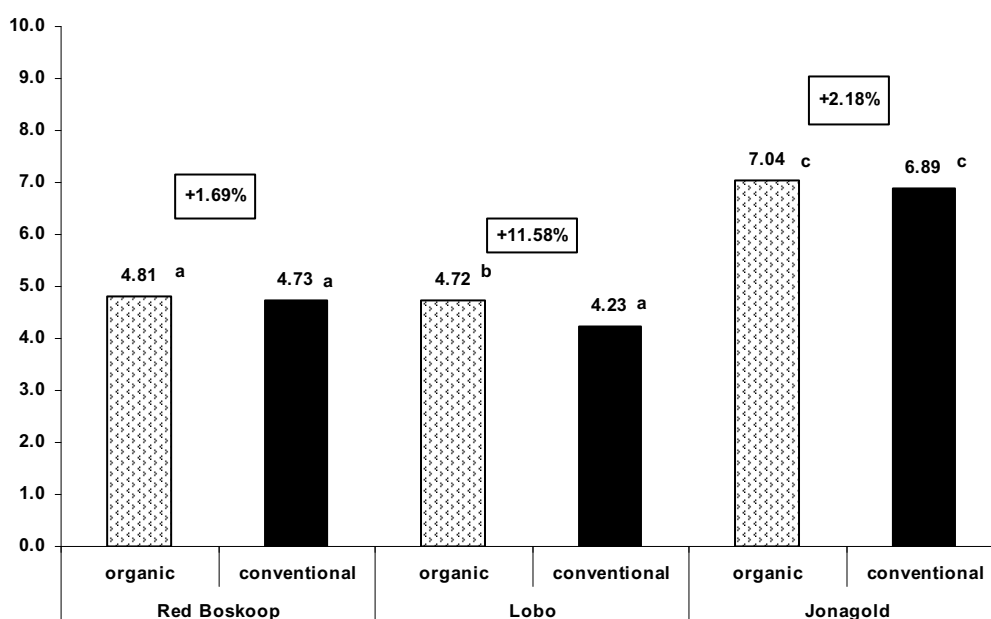


Figure 1. Results of the overall palatability of the sensory attributes of the studied apple cultivars from organic and conventional cultivation (average from years 2003-2005). Different letters mean the statistically significant differences,  $p$ -value  $< 0.001$ . The same letters mean no significant differences.

evaluated higher in respect to aroma and overall quality in comparison to fruits from integrated cultivation. Other studies showed that McIntosh and Cortland apples from organic and conventional orchards did not differ in respect to juiciness, sweetness and sourness. Differences were only noted for McIntosh cultivar in the firmness analysis – organic apples were evaluated higher (DeEll and Prange 1992).

According to Reganold et al. (2001) apples from organic cultivation were sweeter and less sour after storage than from conventional and integrated cultivation. No significant differences were observed between 3 production systems in reference to firmness, texture and overall acceptance. After storage flavour was evaluated higher in apples from integrated orchards. According to Kołodziejczak (1998) the highest marks in the taste evaluation of Szampion apples were given to fruits from conventional and integrated production, organic apples received the lowest marks. Results from own studies and literature review don't allow to draw any clear conclusion in respect to the sensory quality of the organic vs. conventional apples.

Considerable differences in sensory quality can be explained by different content of compounds influencing the sensory attributes of apples. Composition of volatile substances determining aroma depended on cultivar (Kondo et al., 2005). Cultivars differ significantly in this respect (Karlsen et al., 1999). Differences in texture between apple cultivars may result from the saccharides and organic acids content (Nara et al., 2001, Pieniążek, 2000).

#### Influence of production system and cultivar on physicochemical parameters of apples

The results of the selected physicochemical parameters are presented in table 3. Obtained results showed that apples from organic cultivation had significantly higher content of soluble solids, total and reduced sugars when compared to the conventional apples.

Significantly higher content of organic acids in organic apples was found only in case of Red Boskoop. There was no significant influence of the cultivation method on organic acid content in case of other cultivars. Differences in firmness and ratio of total sugars to organic acids between apples from both production systems were not statistically significant.

Some of the results of physiochemical parameters of apples may confirm the rightness of the growth and differentiation balance theory (Brandt and Mølgaard, 2001). This theory says that when nitrogen (N) is easily accessible, plants first produce compounds with high nitrogen content like: proteins used to proper growth and secondary plant metabolites containing nitrogen, for example alkaloids. When nitrogen content is lower and is less accessible for plants (that may happen in organic cultivation), higher amounts of compounds containing carbon are produced, for example carbohydrates, cellulose and other non-nitrogen secondary plant metabolites.

In the current literature the results comparing physiochemical parameters of organic and conventional apples were diversified. In the studies conducted by DeEll and Prange (1992) and Weibel et al. (2000) the organic and integrated cultivation had no significant influence on the firmness of apples. On the contrary, in the studies of Reganold et al. (2001) it was found that organic fruits after harvest were more firm than those from conventional and integrated production.

Table 3. Effect of the cultivation and apple cultivar on the profiling attribute means (averages from years 2003-2005) and significance of differences

Attributes	Cultivar						p-Value
	Red Boskoop		Lobo		Jonagold		
	org.	conv.	org.	conv.	org.	conv.	
Firmness [kg cm <sup>-2</sup> ]	5.85 b	5.83 b	4.93 a	4.90 a	6.18 c	6.15 c	<0.001
Soluble solids [g 100g <sup>-1</sup> d.m.]	15.22 f	14.48 e	12.38 b	11.86 a	13.91 d	13.27 c	<0.001
Total sugars [g 100g <sup>-1</sup> d.m.]	11.64 f	11.06 e	10.11 b	9.68 a	11.74 d	11.20 c	<0.001
Reducing sugars [g 100g <sup>-1</sup> d.m.]	7.15 f	6.79 e	5.97 b	5.71 a	6.90 d	6.61 c	<0.001
Total titratable acidity [g 100g <sup>-1</sup> d.m.]	0.75 d	0.71 c	0.42 ab	0.41 a	0.44 b	0.42 ab	<0.001
Ratio of total sugars to organic acids	15.56 a	15.82 a	23.87 b	23.70 b	26.72 c	25.84 c	<0.001
Note like in Table 2.							

The presented results confirmed studies conducted by DeEll & Prange (1992), Andrews et al. (2001) and Reganold et al. (2001), in which soluble solid and total sugars content were higher in organic apples in comparison to conventional apples. In the experiment conducted by Naumann & de Haas (1972), Vetter et al. (1983), Reinken et al. (1990),

Pither & Hall (1990), Bordeleau et al. (2002) and Kołodziejczak (1998) there were no significant differences with respect to soluble solids and carbohydrates between apples from organic and conventional cultivation. Similarly according to Weibel et al. (2000) there was no significant influence of the organic and integrated cultivation method on soluble solid and organic acid content. Also in the experiment by DeEll & Prange (1992) no significant differences were found in reference to organic acid content between organic and conventional apples. In the study by Bloksma et al. (2004) there were no differences in soluble solid content depending on the type of organic and conventional fertilization. According to Andrew et al. (2001) and Bordeleau et al. (2002) apples from conventional cultivation had higher titratable acidity than organic fruits.

Among studied cultivars Red Boskoop cultivar contained the highest levels of soluble solids, total and reduced sugars, and organic acids. Jonagold cultivar had the highest firmness and ratio of total sugars to organic acids. The presented results confirmed the significant differences between apple cultivars found by other authors (Płocharski et al., 1990; Perring, 1993; Johnson, 2000; Pajor, 2000; Planchon et al., 2004).

## Conclusions

1. The sensory values of the organic apples were mostly similar and only in some cases higher compared to the conventional ones: juiciness in Lobo cultivar and hardness in Jonagold cultivar. Also in the consumer evaluation organic Lobo fruits had higher overall palatability compared to the conventional apples.
2. The organically grown apples showed higher content of soluble solids, total sugars and reduced sugars in comparison to the apples from the conventional orchards.
3. The physiochemical parameters of fruits varied depending on the cultivar. The highest content of soluble solids, total sugars, reduced sugars and organic acids were found for Red Boskoop cultivar, whereas Jonagold cultivar had the highest firmness and the ratio of total sugars to organic acids.
4. The organic apples as having better nutritional value and comparable sensory quality should be recommended to be consumed daily.

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