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Research Article

Selected Qualitative and Quantitative Parameters Comparison of Apples from Bio- and Conventional Production

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Abstract

Aims of the work were to compare quantitative and qualitative parameters of apples from organic and conventional (integrated) production in following attributes: fruit weight, fruit diameter, juice yield, total sugar content, total acid content, fructose, glucose, malic acid, total soluble solids (TSS) and pH. A statistically significant difference between fruit diameter and fruit weight in organic and conventional system was observed. In evaluation of significance in nutrition values between all 11 varieties in each parameter between the two production systems the significance was only in pH value confirmed. By all other parameters the significance was not confirmed. According to measured parameters variety groups were created. The best variety for organic production was Kanzi, followed in second row by Morgenduft, Red Delicious and Red Chief. For conventional production Fuji and Gala were the best followed by Braeburn, Golden Delicious and Pink Lady. As indifferent varieties Granny Smith and Envy were evaluated.

Keywords: Organic; Apple; Nutritional Value; Integrated; Total Sugar

Introduction

Apple (*Malus domestica*), belonging to the family *Rosaceae*, is one of the most nutritious and popular among all the fruits [1]. Apple has been one of the most important fruit since the advent of the time. The famous fruit that is known to keep the doctors away is actually the proposition that describes the endless properties and benefits it hold, in nutshell. Apples actually extract 15 tons of carbonite oxide and give 6 tons of oxygen in return [2].

Apples constitute is an important part of the human diet, as they are a source of sugars, acids, and various biologically active compounds, such as phenolic compounds, which are responsible for most of the antioxidant activities of the fruit [3]. Malic acid occurs naturally in the fruits and is highly incorporated into the juices. It is the primary acid in the apples. Malic acid and citric acids in the apples are basically the acids that develop during the metabolism of the fruit. The strong assencene and the flavor in the fruit, that stinginess in some acetic fruits are because of this acid [4].

In fruits, soluble sugars are mainly composed of sucrose, fructose, and glucose, whilst malic, citric, and tartaric acids are the primary organic acids [5]. Glucose, fructose, and sucrose are the main sugars in fruits. The right proportion of these sugars attributes to the quality of the fruits [6]. Apple fruits are rich in fructose, which accounts for 44 - 75% of the total sugars [3]. Malic acid is the dominant acid in apple fruits, accounting for up to 90% of the total organic acids [3,7] and has an important influence on the sour taste of apples.

In cultivars with low amounts of malic acid, the sweet taste becomes predominant. (Verberic., *et al.* 2009); therefore, its content decreases during storage, particularly when high-oxygen content is present [8].

Conventional (integrated) production is a concept of sustainable agriculture developed in 1976 which has gained international recognition and application. The concept is based on the use of natural resources and regulating mechanisms to replace potentially polluting inputs. The agronomic preventive measures and biological/physical/chemical methods are carefully selected and balanced taking into account the protection of health of both farmers and consumers and of the environment (IOBC, 2017).

Organic production is an ecological production management system that promotes and enhances biodiversity, biological cycles and soil biological activity. It is based on minimal use of off-farm inputs and on management practices that restore, maintain and enhance ecological harmony (IOBC, 2017). Aims of the work were to compare selected quantitative and qualitative parameters of apples from organic and conventional (integrated) production in following attributes: fruit weight, fruit diameter, juice yield, total sugar content, total acid content, fructose, glucose, malic acid, total soluble solids (TSS) and pH value.

Material and Methods

Apples come from company FROM® Società Agricola Cooperativa, Terlano, Bolzano, Italy. In total 11 varieties from organic production system and the same 11 varieties from conventional (integrated) production were evaluated. Evaluated varieties were Braeburn, Envy, Fuji, Gala, Golden Delicious, Granny Smith, Kanzi, Morgenduft, Pink Lady, Red Delicious and Red Chief.

Fruit processing and analysis took place on 13 February 2017. For quantitative evaluation 10,000g for one variety was used, for nutritional value determination 1000g for one variety was used. Fruits were cut after washing and put into a low-speed centrifugal juicer (type Magimix Le Duo Plus XL), fruits were trimmed at 1200 rpm. Subsequently, the juice was filtered through a fine sieve and homogenized by mixing. The smear was plated into eight 15 ml tubes, placed in centrifuges, and centrifuged for 120 seconds and 6000 rpm. The centrifuged juice was separated through the filter paper and, using a syringe, the juice was injected into the analyzer (Bruker Optics, Alpha Wine Analyzer, juice module, FT-NIR UV / VIS spectrophotometer).

Values were exported to MS Office Excel and Stagraphics Centurion XVII program. The significance was calculated at $P < 0.05$ by LSD in ANOVA (Stat graphic Centurion XVII), n = 11 values (varieties). The juice yield was obtained by measuring of juice volume from 1000g of fruit after juicing.

Results and Discussion

Fruit Diameter

In general, a statistically significant difference between fruit diameter in organic and conventional system was observed - *fruit from organic farming were smaller*. Fruits from organic farming were 5.46 % smaller than fruits from conventional production and fruits from organic system were 16.23 % lighter than fruits from conventional production. The biggest negative difference in fruit diameter was by variety Envy, fruits were 13.78 % smaller then from conventional production. The biggest positive difference in fruit diameter was by variety Morgenduft, fruits were 2.93 % bigger than from conventional production.

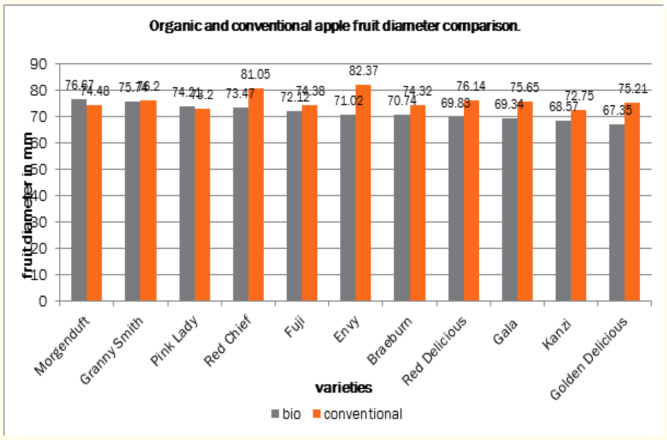

Figure 1: PComparison of Apple Fruit Diameter from Organic and Conventional Farming System.

Fruit Weight

In general, a statistically significant difference between fruit weight in organic and conventional system was observed - fruits from organic farming were lighter. The biggest negative difference in fruit weight was by variety Envy, fruits from bio were 39.38 % lighter than from conventional production. The biggest positive difference in fruit weight was by variety Pink Lady, fruits from bio were 2.65 % heavier than from conventional production. Our results were similar to [9] in which also a significant difference between organic and conventional fruit weight was confirmed.

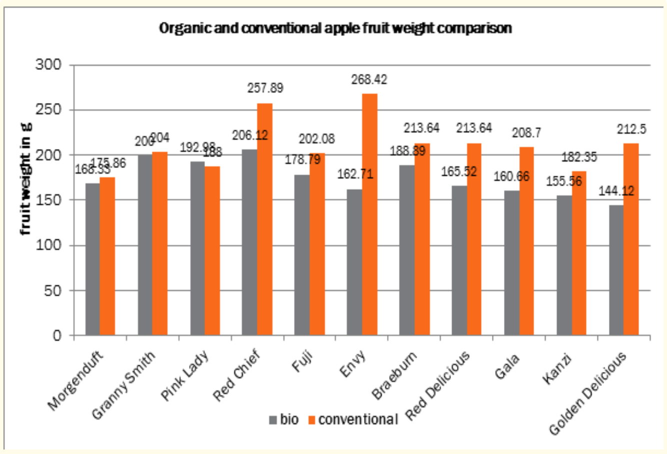

Figure 2: Comparison of Apple Fruit Weight from Organic and Conventional Farming System.

Juice Yield

No statically significant differences in juice yield was observed, biggest positive difference was by variety Red Delicious, juice yield was 22.99 % higher in organic system and biggest negative difference was by variety Envy, juice yield was 11.56 % lower in organic system. Variety with the biggest juice yield in organic farming was Red Delicious with 70.73 % of yield, which means 707.3 ml juice from 1000g of fruits. Variety with the lowest juice yield in organic farming was Morgenduft with 57.0 8% of yield, which means 570.8 ml juice from 1000 g of fruits. Average juice yield from organic apples were 64.56 %, which is 645.6 ml juice from 1000g of fruits.

Variety with the biggest juice yield in conventional farming was Fuji with 74.38 % of yield, which means 743.8 ml juice from 1000g of fruits. Variety with the lowest juice yield in conventional farming was Morgenduft with 54.25 % of yield, which means 542.5 ml juice from 1000g of fruits. Average juice yield from conventional apples were 64.08 %, which is 640.8 ml juice from 1000g of fruits.

Variety	Organic	Conventional	Difference
	(%)	(%)	(%)
Braeburn	69.60	65.81	5.75
Envy	58.48	66.13	-11.56
Fuji	68.25	74.38	-8.25
Gala	65.89	66.17	-0.43
Golden Delicious	57.42	57.38	0.07
Granny Smith	67.62	67.28	0.51
Kanzi	68.57	66.29	3.44
Morgenduft	57.08	54.25	5.23
Pink Lady	65.72	69.09	-4.88
Red Delicious	70.73	57.51	22.99
Red Chief	60.76	60.63	0.21
average	64.56	64.08	0.74

Table 1: Comparison of Juice Yield in % Between Organic and Conventional Apple Production Systems.

Nutritional Values

In organic apple production system, average share of fructose in apples were 77.2 % from total sugar content, average share of glucose in apples were 14.8 % from total sugar content. Average share of malic acid in apples were 98.5 % from total acid content. Our results are similar to [3], where fructose was the most dominant sugar in the different apple cultivars, followed by glucose and sucrose, while malic acid was the principal organic acid.

The highest fructose content was by variety Envy 114.17 g/l, lowest content was by variety Granny Smith 79.08 g/l. The highest glucose content was by variety Red Delicious 28.16 g/l, lowest content was by variety Envy 7.26 g/l. The highest total soluble solids (TSS) content was by variety Envy 14.45 °Brix, lowest content was by variety Morgenduft 11.64 °Brix. In study of [9] TSS value of organic apples were 12.66 °Brix, while 12.4 °Brix for conventional apples. The highest malic acid content was by variety Granny Smith 9.58 g/l, lowest content was by variety Envy 4.63 g/l. The highest pH level was by variety Envy 3.46, lowest level was by variety Granny Smith 3.20, respectively Kanzi 3.19. In study of [9] pH value of organic apples was 4.11 and 4.13 for conventional apples. The highest total acid content was by variety Granny Smith 10.26 g/l, lowest content was by variety Golden Delicious 4.99 g/l. The highest total sugar content was by variety Envy 136.43 g/l, lowest content was by variety Morgenduft 101.93 g/l. We confirmed also a study of [10] the acid content of both production types was similar.

In conventional apple production system, average share of fructose in apples were 77.0 % from total sugar content, which was also confirmed by [3]. Average share of glucose in apples were 17.5 % from total sugar content. Average share of malic acid in apples was 98.5 % from total acid content, which was also confirmed by [3,7].

ORAGANIC	fructose	glucose	TSS	malic acid	pH	total acid	total sugar
	(g/l)	(g/l)	(°Brix)	(g/l)		(g/l)	(g/l)
Braeburn	91.07	12.69	12.29	6.20	3.29	6.37	109.27
Envy	114.17	7.26	14.45	4.63	3.46	5.24	136.43
Fuji	88.46	23.79	13.61	5.66	3.34	5.33	119.71
Gala	84.84	16.70	11.92	5.72	3.37	5.28	104.86
Golden Delicious	98.51	8.97	12.65	5.05	3.33	4.99	109.05
Granny Smith	79.08	25.34	13.00	9.58	3.20	10.26	120.60
Kanzi	97.18	14.69	13.64	8.00	3.19	8.71	119.73
Morgenduft	74.14	16.32	11.64	7.24	3.24	7.15	101.93
Pink Lady	95.50	8.25	12.82	6.88	3.28	7.44	119.20
Red Delicious	84.61	28.16	13.39	5.40	3.36	5.07	120.49
Red Chief	81.45	27.88	13.50	5.70	3.33	5.38	120.05
average value	*89.91*	*17.28*	*12.99*	*6.37*	*3.31*	*6.47*	*116.48*
standard dev.	*11.14*	*7.86*	*0.83*	*1.45*	*0.08*	*1.74*	*9.62*

Table 2: Selected Nutritional Values in Organic Apple Production.

The highest fructose content was by variety Envy 102.76 g/l, lowest content was by variety Red Delicious 78.04 g/l. In study of [8] the fructose content in organic apples was 61.2 g/l and in conventional system 62.3 g/l. The highest glucose content was by variety Red Chief 32.91 g/l, lowest content was by variety Pink Lady 10.52 g/l.

In study of [8] the glucose content in organic apples was 12.55 g/l and in conventional system 13.3 g/l. The highest TSS content was by variety Fuji 14.41 °Brix, lowest content was by variety Morgenduft 11.15°Brix. The highest malic acid content was by variety Granny Smith 9.82 g/l, lowest content was by variety Red Chief 5.08 g/l. In study of [8] the malic acid content in organic apples was 7.35 g/l and in conventional system 7.52 g/l.

The highest pH level was by variety Envy 3.31, lowest level was by variety Granny Smith 3.12, respectively Pink Lady 3.13. The highest total acid content was by variety Granny Smith 10.34 g/l, lowest content was by variety Red Chief 4.64 g/l. The highest total sugar content was by variety Fuji 126.27 g/l, lowest content was by variety Morgenduft 97.32 g/l. Our results are similar to [10] and declare, that total sugar content of most cultivars from integrated cultivation ranged between 115 and 160 g/kg.

CONVENTIONAL	fructose	glucose	TSS	malic acid	pH	total acid	total sugar
	(g/l)	(g/l)	(°Brix)	(g/l)		(g/l)	(g/l)
Braeburn	86.95	17.58	12.42	7.28	3.16	7.78	112.62
Envy	102.76	10.62	13.16	5.29	3.31	5.45	121.78
Fuji	91.41	29.17	14.41	6.79	3.21	6.61	126.27
Gala	86.99	18.43	12.83	6.97	3.24	6.84	112.05
Golden Delicious	92.82	18.25	13.23	6.24	3.19	6.31	115.63
Granny Smith	78.92	25.63	11.70	9.82	3.12	10.34	108.47
Kanzi	92.74	17.53	13.21	7.61	3.20	7.83	115.52
Morgenduft	80.06	12.13	11.15	6.12	3.16	6.16	97.32
Pink Lady	96.97	10.52	12.92	7.28	3.13	8.17	118.64
Red Delicious	78.04	26.97	11.97	5.42	3.28	4.89	110.29
Red Chief	78.10	32.91	12.57	5.08	3.26	4.64	116.35
average value	*87.80*	*19.98*	*12.69*	*6.72*	*3.21*	*6.82*	*114.09*
standard dev.	*8.37*	*7.67*	*0.88*	*1.35*	*0.06*	*1.65*	*7.56*

Table 3: Selected Nutritional Values in Conventional Apple Production.

In evaluation of statistically significance between all 11 varieties in each parameter between the two production systems the significance was only in parameters fruit weight, fruit diameter and pH value confirmed. By all other parameters the significance was not confirmed, fruits from both production systems were in the same homogenous groups. Our result was similar to [8,9,11,12], in which also a not significant difference between organic and conventional TSS, pH value, malic acid, respectively total acids was confirmed.

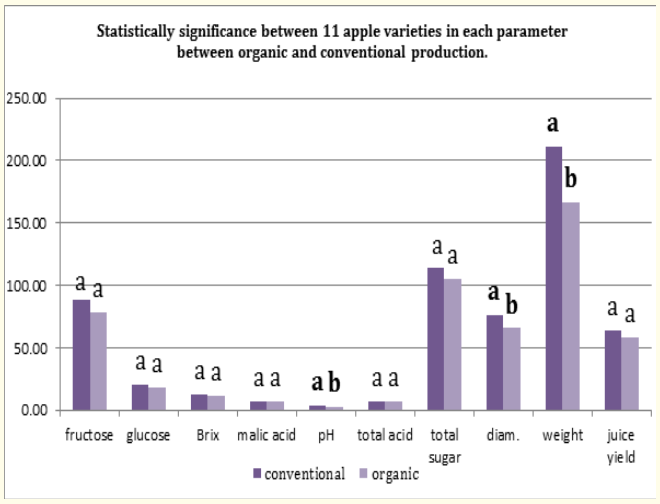

Figure 3: Statistically Significance (Homogenous Groups) Between 11 Apple Varieties in each Parameter Between Organic and Conventional Production.
* Different Letters in the Frame of each Parameter Denote Significantly Different at P < 0.05by LSD in ANOVA (Statgraphic Centurion XVII), N = 11 Values (Varieties).

Differences in nutritional values between conventional and organic apples

By evaluation of differences in nutritional values between conventional and organic apple production systems the highest negative difference in fructose content was in variety Morgenduft -7.39 %, the highest positive difference was in variety Envy with 11.1 %, it means, that the fructose content of variety Morgenduft was 7.39 % lower in comparison to fructose content in Morgenduft in conventional system and in variety Envy the fructose content was 11.1 % higher in organic system. The highest negative difference in glucose content was in variety Golden Delicious -50.85 %, the highest positive difference was in variety Morgenduft with 34.54 %.

The highest negative difference in TSS content was in variety Gala -7.09 %, the highest positive difference was in variety Red Delicious with 11.11 %. The highest negative difference in malic acid content was in variety Golden Delicious -19.07 %, the highest positive difference was in variety Morgenduft with 18.30 %. The highest negative difference in pH level was in variety Kanzi -0.31 %, the highest positive difference was in variety Pink Lady with 4.79 %. The highest negative difference in total acid content was in variety Gala -22.81 %, the highest positive difference was in variety Morgenduft with 16.07 %. The highest negative difference in total sugar content was in variety Gala -6.42 %, the highest positive difference was in variety Envy with 12.03 %. Our results are similar to [13] where some significant differences in carbohydrates content was measured depending to variety.

According to measured parameters variety groups were created. The best variety for organic production was Kanzi (6/1), 6 parameters were higher in organic production system and only one in conventional system, followed in second row by Morgenduft (5/2), Red Delicious (5/2) and Red Chief (5/2). The best variety for conventional (integrated) production were Fuji (0/7) and Gala (0/7), followed by Braeburn (1/6), Golden Delicious (1/6) and Pink Lady (1/6). As indifferent varieties Granny Smith (3/4) and Envy (3/4) were evaluated [14].

Difference conventional/organic	fructose	glucose	TSS	malic acid	pH	total acid	total sugar
	(%)	(%)	(%)	(%)	(%)	(%)	(%)
Braeburn	4.74	-27.82	-1.05	-14.84	4.11	-18.12	-2.97
Envy	11.10	-31.64	9.80	-12.48	4.53	-3.85	12.03
Fuji	-3.23	-18.44	-5.55	-16.64	4.05	-19.36	-5.20
Gala	-2.47	-9.39	-7.09	-17.93	4.01	-22.81	-6.42
Golden Delicious	6.13	-50.85	-4.38	-19.07	4.39	-20.92	-5.69
Granny Smith	0.20	-1.13	11.11	-2.44	2.56	-0.77	11.18
Kanzi	4.79	-16.20	3.26	5.12	-0.31	11.24	3.64
Morgenduft	-7.39	34.54	4.39	18.30	2.53	16.07	4.74
Pink Lady	-1.52	-21.58	-0.77	-5.49	4.79	-8.94	0.47
Red Delicious	8.42	4.41	11.86	-0.37	2.44	3.68	9.25
Red Chief	4.29	-15.28	7.40	12.20	2.15	15.95	3.18
Average	2.40	-13.51	2.36	-5.21	3.12	-5.13	2.09

Table 4: Differences in % in Nutritional Values between Conventional and Organic Apple Production.

Suitability organic/conventional	fruct.	gluc.	TSS	malic acid	pH	total acid	total sugar	org.	conv.
Braeburn								1	6
Envy								3	4
Fuji								0	7
Gala								0	7
Golden Delicious								1	6
Granny Smith								3	4
Kanzi								6	1
Morgenduft								5	2
Pink Lady								1	6
Red Delicious								5	2
Red Chief								5	2
Average								3	4

better for organic production | better for conventional production

Table 5: Suitability of Tested Apple Varieties for Organic or Conventional Production Systems According to Overall Nutrition Values.

Conclusions

In general, a statistically significant difference between fruit diameter in organic and conventional system was observed - *fruit from organic farming were smaller*. Fruits from organic farming were 5.46 % smaller than fruits from conventional production and fruits from organic system were 16.23 % lighter than fruits from conventional production. In general, a statistically significant difference between fruit weight in organic and conventional system was observed - *fruits from organic farming were lighter*. The biggest negative difference in fruit weight was by variety Envy, fruits from bio were 39.38 % lighter than from conventional production. For juice yield, no significantly differences were found.

Variety with the biggest juice yield in organic farming was Red Delicious with 70.73 % of yield, which means 707.3 ml juice from 1000 g of fruits. Variety with the lowest juice yield in organic farming was Morgenduft with 57.08 % of yield, which means 570.8 ml juice from 1000g of fruits. Variety with the biggest juice yield in conventional farming was Fuji with 74.38 % of yield, which means 743.8 ml juice from 1000g of fruits. Variety with the lowest juice yield in conventional farming was Morgenduft with 54.25 % of yield, which means 542.5 ml juice from 1000g of fruits.

In evaluation of statistically significance in nutrition values between all 11 varieties in each parameter between the two production systems the significance was only in pH value confirmed. By all other parameters the significance was not confirmed, fruits from both production systems were in the same homogenous group.

According to measured parameters variety groups were created. The best variety for organic production was Kanzi (6/1), 6 parameters were higher in organic production system and only one in conventional system, followed in second row by Morgenduft (5/2), Red Delicious (5/2) and Red Chief (5/2). The best variety for conventional (integrated) production were Fuji (0/7) and Gala (0/7), followed by Braeburn (1/6), Golden Delicious (1/6) and Pink Lady (1/6). As indifferent varieties Granny Smith (3/4) and Envy (3/4) were evaluated.

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