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THE CONTENT OF NITRATES V AND III AND VITAMIN C IN JUICES OBTAINED FROM ORGANIC AND CONVENTIONAL RAW MATERIALS

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The content of nitrates V and III, and vitamin C in vegetable, fruit and fruit-vegetable juices obtained from organic and conventional raw material was determined. A total of 189 juice samples were examined, including 63 juices with the expiry date of only one day and 48 juices obtained from organic raw material. The juices were purchased in the local food stores. The research covered the period of May–September of 1999. The content of nitrates V and III in juices was different and dependent on the raw material origin and the producer. The lowest content of nitrates had apple juice (0.6–10.0 mg $NaNO_3/dm^3$) and orange juice (1.2–1.8 mg $NaNO_3/dm^3$), and the highest content of nitrates had fresh beetroot juice from the juice bar (718.7–1118.2 mg $NaNO_3/dm^3$). Juices obtained from organic raw material and juices of renowned brands had a similar content of nitrates V and III. The vitamin C content of juices was variable and fell in the range 2.8–38.9 mg/100 g. The highest content of vitamin C (26.6–42.6 mg/100g) was found in fermented vegetable juices obtained from organic raw material.

INTRODUCTION

Drinking juices are among the food products, the production and consumption of which is continuously growing. The reasons for this trend, as they might be concluded based on the marketing research, are the fashion for the consumption of juices (quickly spreading over Poland from the Western Europe) on the one hand, and the advertising campaign for changes in dietary habits on the other hand [Szponar *et al.*, 1998]. Fruits and vegetables and their products play an important role in preventing civilisation diseases, particularly because of high content of vitamin C, β-carotene, polyphenols, catechins and fibre. A regular consumption of minimum 500 g of fruits, vegetables or their products per person per day has been suggested; they should be added to every single meal [Heimendinger & Chapelsky, 1996]. Apart from supplying the human organism with valuable nutrients and dietary components, the juices are above all the source of water, the main component of all beverages. The most common technique for producing juice is based on diluting juice concentrates with water, adjusting the taste and pasteurisation [Jarczyk, 1999]. Water used for reconstituting concentrates may influence to a large degree the content of various pollutants (including nitrates V and III) in juices. No special regulations exist in Poland on the requirements for water intended for juice reconstitution. Drinking water is required to contain no more than 10 mg $NaNO_3/dm^3$, in the absence of nitrites [Jarczyk, 1999]. Basic requirements for water used for juice reconstitution in the European Union countries have been specified by AIJN (Association of the Industry of Juices and Nectars from Fruit and Vegetables). The suggested method of water treatment is the reverse osmosis [Code of Practice for evaluation of fruit and vegetable juices, Brussels, 1996].

The enormous role played by juices requires their strict hygiene and health safety. The issue of safety is connected with the presence and level of nitrates V and III. The necessity to control them carefully results from the fact that juices are among the foodstuffs introduced the earliest into nutrition. The content of nitrates V and III in fruit and vegetable juices is determined mainly by the content of these compounds in raw material – fruit and vegetables. Introduction of nitrogen fertilisers in agriculture aims at increasing the crops yields. Unfortunately, the excess of nitrates in soil induces their accumulation in crops. Nitrates V, and particularly their reduction products nitrates III, are not neutral compounds to humans. Many papers report on the acute and chronic toxicity of nitrates V and III. Toxic efficacy of these compounds on the human organism are connected, among others, with nitrite methaemoglobinaemia, increased risk of stomach cancer and dysfunction of small intestine [Hill, 1991; Vittozzi, 1992]. Among the factors influencing the content of nitrates and nitrites in field crops, there are particularly: fertilising conditions, plant susceptibility, climate, soil, and activity of soil and root microflora [Vogtmann *et al.*, 1984]. The content of nitrates in vegetables grown in Poland is variable, ranging from several mg to over 20 g $NaNO_3$/kg [Gajda & Karłowski, 1993]. Large quantities of nitrates have been mainly detected in early vegetables. Alternative production of early vegetables with organic methods allowed significant reduction of the nitrate content [Śmiechowska & Przybyłowski, 2000]. Vegetables originating from organic cultivation contain less nitrates V and III [Evers, 1989; Rembiałkowska, 1998; Śmiechowska, 2001; Vogtmann *et al.*, 1984]. The content of nitrates V and III in vegetables stored in cellars and clamps and later used for

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processing is influenced mainly by: storage temperature, ventilation, access to daylight and microbiological quality of stored vegetables [Hiller *et al.*, 1987]. The content of nitrates V and III in vegetable juices may be also influenced by pretreatment and technological or thermal process [Markowska *et al.*, 1995]. Recently, successful attempts have been made to reduce nitrates in vegetable products by biotechnological methods using the denitrifying bacteria and nitrates V and III reductase [Walkowiak-Tomczak *et al.*, 1996]. In search of alternative methods for food production, limiting a widespread chemicalisation of agriculture and food processing, attention was paid to organic agriculture and processing. Organic production excludes the possibility of reconstitution for juice production, because the conditioned water never has the quality and properties of the intracellular water. Product marked as a natural juice should refer only to a juice that is a squeeze of fruit or vegetables. In the EU countries, natural juices are marked as NFC (not from concentrate).

The publications on the quality of processed organic food are lacking in Poland. Therefore, this research was carried out in an attempt to answer the question about the quality of processed organic products, on the example of juices. The objective of this work was to determine the content of nitrates V and III, and vitamin C in vegetable, fruit and fruit-vegetable juices obtained from organic and conventional raw material.

MATERIALS AND METHODS

Material. The research material was the following vegetable, fruit and fruit-vegetable juices manufactured from conventional material by Polish leading producers: orange, apple, black currant (producer FX); tomato, apple, carrot, carrot-apple, multi-vegetable, black currant (producer FA); and carrot, carrot-apple (producer PZ). The juices were pasteurised products and were packed in 1 L Tetra Pak packages. The material included also fresh carrot juice from the producers DC and MA and multi-vegetable, beetroot, cabbage, beetroot-apple, and apple juices from a juice bar. The juices manufactured by DC and MA firms were packed in glass bottles with a volume of 330 mL and had only one day expiry date, valid in the day of the purchase of the juice. The juices from the juice bar were sampled into sterile glass bottles and were taken immediately to the laboratory for analysis. The organic juices (EKO) examined included tomato, sour beetroot, multi-vegetable sour and carrot-apple juice. These were manufactured by the firm having an Ekoland (Polish Federation of Organic Food Producers) attestation. They were pasteurised and packed in glass bottles with a volume of 250 mL. All examined juices were purchased in the Tri-City (Gdańsk–Sopot–Gdynia) food stores and in a local juice bar. The assortment of juices was selected on the basis of marketing research, indicating these juices as the most preferred by consumers [Kubiak & Rembowski, 1999]. The research was conducted in the period of May–September 1999.

Methods. The content of nitrates V and III was determined by spectro-photometrical method based on a Griess reaction [ISO Standard, 1984]. The reduction of nitrates V to nitrates III was carried out on a cadmium column, according to the modifications by Przybyłowski *et al.* [1983]. The content of vitamin C was determined as L-ascorbic acid according to the ISO standard [1984] using 2,6-dichlorophenylindophenol for titration.

RESULTS AND DISCUSSION

The content of nitrates V and III in juices was different and dependent on the raw material (organic or conventional) and the producer. The lowest content of nitrates V and III was found in fruit juices (Table 1). Fruit is generally a moderate source of nitrates. Their content of domestic fruit is 1.2–65.1 mg $NaNO_3$/kg [Markiewicz *et al.*, 1998]. According to the research of Nabrzyski and Gajewska [1994], the lowest content of nitrates V was found in apples: 1.32–9.67 mg KNO_3/kg (1.11–8.13 mg $NaNO_3$/kg). Occasionally, however, apples can contain significant amounts of these compounds. Baryłko-Pikielna and Tyszkiewicz [1991] quote after Międzobrodzka *et al.* that the content of nitrates in apples may reach 285.5 mg KNO_3/kg, what corresponds to 239.8 mg $NaNO_3$/kg.

Among the fruit juices examined there were no products obtained from organic raw materials. This results from the difficulties in supplying of organic fruit in quantities sufficient to maintain continuous production of juices. The Polish fruit-farmers are dominated by the producers using conventional methods or an integrated method, for which the use of small, necessary amounts of pesticides and crop-protection chemicals is characteristic [Horubała, 1999]. Organic farms tend to balance the matter and energy flows, therefore specialised fruit orchards are basically lacking. The feature of organic agriculture is the existence of orchard or garden within a farm, along with cultivation of cereals and roots and breeding of animals. Fermented juices prevailed among the organic vegetable juices (Table 2 and 3). The research works have evidenced that upon fermentation nitrates are decomposed and that fermented vegetable products are wholesome [Miśkiewicz *et al.*, 1988].

TABLE 1. The content of nitrates V and III in fruit juices manufactured by various producers.

Juice	Producer	n	$NaNO_3$ [mg/dm^3]			$NaNO_2$ [mg/dm^3]		
			$\bar{x}$±SD	Range	V [%]	$\bar{x}$±SD	Range	V [%]
Apple	HX	19	3.1±2.3	0.6–10.0	72.85	0.07±0.12	0.00–0.38	83.21
	FA	12	2.3±0.8	0.6–3.6	34.88	0.00	0.00	-
	Juice bar	12	7.7±0.9	5.5–8.5	12.16	0.44±0.15	0.00–0.51	33.36
Black currant	HX	12	54.6±24.8	26.4–117.4	45.50	0.36±0.32	0.28–0.61	28.73
	FA	12	81.9±31.4	62.2–176.3	38.33	0.77±0.11	0.66–0.84	6.71
Orange	HX	6	1.4±0.3	1.2–1.8	22.13	0.00	0.00	-

TABLE 2. The content of nitrates V and III in organic and conventional vegetable juices.

Juice	Producer	n	$NaNO_3$ [mg/dm^3]			$NaNO_2$ [mg/dm^3]		
			$\bar{x}$±SD	Range	V [%]	$\bar{x}$±SD	Range	V [%]
Multivegetable	FA	3	67.1±3.7	63.3–70.8	5.60	0.30±0.07	0.25–0.38	24.74
	Juice bar	12	389.3±109.3	151.5–491.7	28.08	0.73±0.12	0.38–0.89	16.79
Multiveg. sour	EKO	16	142.3±19.7	99.3–164.9	13.88	3.33±1.56	1.27–5.08	48.14
Carrot	FA	10	32.9±6.2	25.7–47.0	18.94	0.02±0.05	0.00–0.13	10.82
	PZ	4	87.4±9.2	78.9–97.1	10.58	0.19±0.07	0.13–0.25	38.49
	DC	11	419.5±37.0	375.7–498.7	8.81	0.97±0.22	0.63–1.14	22.89
	MA	16	330.1±74.4	293.6–604.7	70.50	0.60±0.13	0.38–0.76	21.05
	Juice bar	12	73.6±11.8	61.3–95.6	16.04	0.20±0.20	0.00–0.51	98.80
	EKO	16	7.4±1.1	6.1–10.1	15.30	0.29±0.24	0.00–0.76	81.62
Tomato	FA	10	21.2±4.2	15.9–28.6	20.01	0.04±0.06	0.00–0.13	61.01
	EKO	16	16.9±2.7	12.3–21.6	15.84	0.29±0.13	0.00–0.38	44.44
Fresh cabbage	Juice bar	9	232.2±99.5	68.9–307.6	42.84	1.06±0.54	0.25–1.52	51.26
Fresh beetroot	Juice bar	12	938.9±158.8	718.7–1118.2	16.91	1.06±0.54	0.25–1.52	51.26
Sour cabbage	EKO	12	94.6±5.5	83.2–103.0	5.78	0.85±0.24	0.13–1.01	28.84
Sour beetroot	EKO	12	7.4±1.8	3.1–8.6	24.71	0.90±0.17	0.51–1.01	18.51

TABLE 3. The content of nitrates V and III in organic and conventional fruit-vegetable juices.

Juice	Producer	n	$NaNO_3$ [mg/dm^3]			$NaNO_2$ [mg/dm^3]		
			$\bar{x}$±SD	Range	V [%]	$\bar{x}$±SD	Range	V [%]
Carrot-apple	PZ	14	40.4±6.1	29.4–47.6	15.07	0.04±0.06	0.00–0.13	39.23
	EKO	14	7.4±1.1	5.5–8.5	15.30	0.29±0.24	0.00–0.76	81.62
Beetroot-apple	Juice bar	12	547.8±124.2	356.5–577.9	22.67	1.07±0.44	0.63–1.65	41.61

One of the factors strongly influencing the nutritional value of juices is the content of vitamin C. Vitamin C participates in the reduction of nitrates V and III and, in addition, it is an efficient inhibitor of nitrosation [Sobala *et al.*, 1991]. The content of vitamin C in the examined juices was found to be different. Among fruit juices, the apple juice contained the least amount of vitamin C. The average content of vitamin C in the examined fruit juices was consistent with other authors' results [Cichoń, 2000]. The content of vitamin C in vegetable juices was different and dependent on juice production method (Tables 4 and 5). The vitamin C content of carrot juices might suggest their fortification, the fact not always declared by the producer on a packaging. It arises from earlier studies that the vitamin C content of carrots is influenced not only by the type of farming (organic or conventional), but also by the carrot cultivar [Śmiechowska & Przybyłowski, 1996]. The Regulation of Polish Ministry of Health [DzU 2001 r. Nr 9, poz. 72] does not specify the permissible content of ascorbic acid in juices. Ascorbic acid, acidity regulator and antioxidant used in drinking juices, should be added according to good practice, *i.e.* in the lowest dose necessary to achieve a desired technological effect. The regulation specifies, however, the amount of vitamin C added to juices intended for children younger than 3 years old at the level of 0.3 g/L. Ascorbic acid is also on the list of positive additives and improving substances allowed in the processing of crops from organic farming [EEC Council Regulation No. 2092/91]. The juices from fermented vegetables were

TABLE 4. The content of vitamin C (mg/100 g) in organic and conventional fruit and fruit-vegetable juices.

Juice	Producer	n	$\bar{x}$±SD	Range	V [%]
Apple	HX	19	2.9±1.2	1.2–4.9	40.76
	FA	12	2.8±1.2	1.5–6.1	43.72
	Juice bar	12	8.0±1.3	5.0–9.1	15.87
Black currant	HX	12	18.2±1.6	16.0–20.3	9.10
	FA	12	25.4±1.6	21.3–26.8	9.10
Orange	HX	6	28.0±2.7	25.6–31.9	9.73
Carrot – apple	PZ	14	15.9±3.6	10.6–21.0	22.81
	EKO	14	33.9±2.7	29.6–38.8	7.89
Beetroot – apple	Juice bar	12	13.5±2.0	15.0–15.9	15.13

TABLE 5. The content of vitamin C (mg/100 g) in organic and conventional vegetable juices.

Juice	Producer	n	x±SD	Range	V [%]
Multivegetable	FA	3	9.5±0.2	9.3–9.8	2.64
	Juice bar	12	8.3±0.7	6.9–9.1	9.10
Multiveg. sour	EKO	16	38.9±2.4	35.0–42.6	6.13
Carrot	FA	10	12.2±3.0	6.8–16.3	24.82
	PZ	4	18.7±1.8	16.0–20.0	9.90
	DC	11	19.5±7.5	9.6–29.6	38.33
	MA	16	20.9±7.0	10.6–31.0	33.52
	Juice bar	12	16.5±5.2	10.3–23.6	79.91
	EKO	16	33.9±2.7	29.6–38.8	7.89
Tomato	FA	10	12.2±3.0	6.8–16.3	24.82
	EKO	16	15.9±2.5	11.6–18.6	15.86
Fresh cabbage	Juice bar	9	23.7±6.9	17.0–36.0	28.95
Fresh beetroot	Juice bar	12	14.9±0.5	14.0–15.2	3.11
Sour cabbage	EKO	12	31.7±1.6	29.5–35.2	4.96
Sour beetroot	EKO	12	29.7±3.6	25.6–39.9	12.15

found to contain more vitamin C than juices from fresh vegetables, which corresponds with results reported by other authors [Wieczorek & Traczyk, 1995]. It was impossible to make the variance analysis for the influence of farming type (organic or conventional) on the vitamin C content of juices, because of different juice production methods. The juices from organic raw materials are not produced by reconstitution from concentrates and they are often fermented. A considerable influence of farming type on the content of nutrients and pollutants in vegetables has been earlier evidenced [Evers, 1989; Rembiałkowska, 1998; Śmiechowska & Przybyłowski, 1996; Vogtmann *et al.*, 1984].

The level of nitrates V and III in juices must be controlled, since these compounds are toxic, impair the B vitamins utilisation and oxidise vitamin A and carotenes [Livissier *et al.*, 1976]. The research on the quality of juices, including nitrate V, nitrate III and vitamin C content, should be continued also because of the changes in dietary habits, especially among young people. Many people are on vegetarian or slimming diets that include juice drinking. The products polluted to a significant degree with nitrates V and III would pose a serious health threat.

It seems that the changes observed in the manner of nutrition and in dietary habits result from dietary education on the one hand, and evolution of new consumer attitudes as influenced by fashion and advertisement' on the other hand.

CONCLUSIONS

1. Considering the content of nitrates and vitamin C, the quality of drinking juices is different. The quality of conventional juices produced by renowned brands is similar to the quality of organic juices.

2. Fruit juices obtained from conventional raw material contained diversified quantities of nitrates V. The lowest content of nitrates was determined in apple juice (0.6–10.0 mg $NaNO_3/dm^3$), while the highest in black currant juice (26.4–176.3 mg $NaNO_3/dm^3$). The content of nitrates III ranged from 0.00 to 0.84 mg $NaNO_2/dm^3$.

3. The vegetable juices obtained from conventional raw materials by renowned producers and the juices obtained from organic raw materials were characterised by low nitrate V and III content, amounting 3.1–103.0 mg $NaNO_3/dm^3$ and 0.00–5.08 mg $NaNO_2/dm^3$, respectively. The content of nitrates V in conventional juices of other producers and juices from juice bar is significantly higher and amounts 232.2–938.9 $NaNO_3/dm^3$. Juices containing beetroot were characterised by the highest quantities of nitrates, independent of production method and material origin. This is consistent with the well-known tendency for nitrate accumulation in beetroot.

4. In the case of nearly 50% of fresh juices produced in juice bar and the juice from small manufacturers declaring only one day expiry date, an increased content of nitrates V was detected, more than 500 mg $NaNO_3/dm^3$. Poor quality of raw material was most likely the possible reason for this.

5. Fermented (sour) juices from cabbage and beetroot contained ten times less nitrates than juices from fresh vegetables.

6. The content of vitamin C in fruit juices from conventionally-cultivated fruit was different. Apple juice contained the least amount (1.2–9.1 mg ascorbic acid /100 g) and orange juice – the highest amount (25.6–31.9 mg /100 g) of vitamin C.

7. Fermented (sour) juices from cabbage and beetroot originating from organic cultivation contained 2 times more vitamin C than juices from fresh vegetables.

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ZAWARTOŚĆ AZOTANÓW (V) I (III) ORAZ WITAMINY C W SOKACH PITNYCH OTRZYMANYCH Z SUROWCÓW EKOLOGICZNYCH I KONWENCJONALNYCH

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Oznaczono zawartość azotanów V i III oraz witaminy C w sokach pitnych owocowych, warzywnych i owocowo-warzywnych otrzymanych z surowców ekologicznych i konwencjonalnych. Ogółem przebadano 189 próbek soków zakupionych w sklepach na terenie Trójmiasta (Gdańsk–Sopot–Gdynia), w tym 63 próbki soków o jednodniowym terminie przydatności do spożycia i 48 próbek soków otrzymanych z surowców ekologicznych. Badania przeprowadzono w okresie maj–wrzesień 1999 roku. Zawartość azotanów V i III w sokach pitnych była zróżnicowana i zależała nie tylko od pochodzenia surowca, ale także od producenta. Najmniej azotanów V zawierał sok jabłkowy 0.6–10.0 mg $NaNO_3/dm^3$ i sok pomarańczowy 1.2–1.8 mg $NaNO_3/dm^3$, a najwięcej sok ze świeżych buraków pochodzący z pijalni soków 718.7–1118.2 mg $NaNO_3/dm^3$ (tab. 1 i 2). Soki otrzymane z surowców ekologicznych oraz soki wyprodukowane przez renomowane zakłady posiadały zbliżoną zawartość azotanów V i III. Zawartość witaminy C w sokach pitnych była zróżnicowana i kształtowała się średnio w zakresie 2.8–38.9 mg/100 g. Najwięcej witaminy C zawierały soki warzywne fermentowane otrzymane z surowców ekologicznych 26.6–42.6 mg/100 g.