Organic Farming as a System to Provide Better Vegetable Quality

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Abstract

Organic farming is commonly regarded as a system improving vegetable quality. The aim of work was to analyse the effects of the organic methods on the vegetable quality during its production and storage on the way to the consumer. Therefore the nutritive, sensory and storage quality of carrots and potatoes from organic farms has been compared to the crops quality from conventional farms. It was found that organic vegetables had lower yields, but most of their nutritive, sensory and storage quality attributes were better than in the conventional crops. It should be emphasised that lower level of nitrates and simultaneously higher content of vitamin C in organic potatoes can have an important anti-carcinogenic impact on human organism. Organic vegetables more readily comply with food requirements for infants and small babies and should be recommended for baby foods.

Organic farming can be considered as a system providing good conditions to improve the vegetable quality. Nevertheless there are many possibilities to ameliorate the methods of cultivation and storage of organic crops to obtain better production and qualitative results.

INTRODUCTION

Organic farming is more and more popular in Europe and other parts of the world. One of the reasons is growing consumer demand for safe and controlled foodstuffs. Organic food is produced under controlled conditions according to the guidelines of EEC Council Regulation no 2092/91. Organic plant products are produced without synthetic pesticides and mineral fertilisers, but with application of the natural animal manure, composts, green manure and diversified rotation. Certification in the organic farming means that a control unit testifies the product as produced according to the accepted rules and production system (EEC Council Regulation no 2092/91).

Organic farming can be regarded as a system to improve vegetable quality. The aim of this study was to analyse the effects of the organic methods on the vegetable quality during its production and storage on the way to the consumer. Therefore the nutritive, sensory and storage quality of carrots and potatoes from the organic farms has been compared to the crops quality from conventional farms.

MATERIALS AND METHODS

Cultivation

'Monanta' and 'Regulska' carrots were cultivated in ten organic farms certified by EKOLAND (Society of the Organic Producers in Poland), located in Torun and Plock provinces and in ten conventional farms, using large volume of agri-chemicals located in Warszawa province and producing for big metropolitan market. Organic carrots were fertilised mostly with compost 30 t/ ha. Conventional carrots were fertilised mostly with mineral fertilisers in a range 200-780 kg NPK/ ha.

'Bryza', 'Sokol', 'Ania' and 'Anielka' potatoes cultivars were produced under the same fertilizer regime as described above, on ten organic farms located in Torun and Plock provinces. They were fertilised with compost or cow manure at a rate ranging from

ten tons per hectare to forty tons per hectare depending on the farm. Identical potato cultivars were cultivated in conventional farms located in the close neighbourhood of the organic farms in Torun and Plock provinces. Potato fields were fertilised with 350 kg NPK/ha in proportion 1:1:1,5.

METHODS OF CHEMICAL ANALYSES

All chemical analyses were carried out for the tuber flash, i.e. with peeled carrots and potatoes. Randomly selected 10 tubers or 10 carrot roots were peeled and homogenized. The following methods were used to determine: dry matter - ISO 1026 Standard [1982]; nitrates and nitrites - ISO 6635.2 Standard [1984]; cadmium and lead - ISO standards [1983] and [1984]; Ca, K and Mg - flame photometry method; total sugars in carrots - Polish Standard PN 90/A-75101/07; ß carotene - Polish Standard PN 90/A – 75101/12; vitamin C - ISO standard [1984]; starch - Krelowska-Kulas (1993); total proteins - application note nr 3112.

All determinations were made in duplicate or triplicate in the case of doubts.

Method of sensory evaluation.

Sensory evaluation of carrots and potatoes was made using the hedonic method (Jellinek 1985). We used a graphic scale with 9 word definitions of desire's intensity. An untrained panel of 100 students was used to obtain objective sensory results.

Method of storage quality evaluation

The evaluation of potato tubers' quality after storage period was conducted according to Polish Standard PN – 82/R-74456.

Statistical calculations

Calculations were conducted by means of the specialist computer software SAS.

RESULTS AND DISCUSSION

Yield and nutritive quality of carrots and potatoes under different cultivation methods

The average yield of 'Monanta' carrots was higher by 33% on organic than conventional farms, but the difference was statistically insignificant (Table 1). Lindner (1991) found a 10 % lower yield in the organic carrot production.

Organic carrots contained 4 times fewer nitrates and 46 % less nitrites than conventional ones (Table 1).

Lindner (1991) found 47 % less nitrates in organic carrots. Many authors (e.g. Kolbe et al. 1995) emphasise that plants quickly assimilate easy soluble and available mineral fertilisers and accumulate nitrate ions in plant tissues. Properly applied organic fertilisation causes lower accumulation of the nitrates in plant tissues (Vogtmann 1985).

The content of lead was similar in organic and conventional carrots, but the content of cadmium was almost 3 times higher in organic carrots. However, the level of heavy metals was generally low in all samples. The contents of mineral compounds (Ca, K, and Mg) were similar in organic and conventional carrot. Leclerc et al. (1991) found more K (and P) but less Ca in organic carrot.

Organic carrots contained less ß-carotene and more total sugars, but the differences were statistically insignificant. Leclerc et al. (1991) and Zadoks (1989) found a higher content of ß-carotene in organic carrots, but Abele (1987) did not find any clear difference in this respect. The average yield of the organic potatoes was significantly lower compared to the conventional potatoes. In better soils some authors found comparable yield of organic and conventional potatoes (Abele 1987) or even higher yield of organic potatoes (Kolbe et al. 1995).

The content of dry matter was as a rule higher in organic potatoes. Kolbe et al. (1995) and Schulz (2000) found also significantly higher content of dry matter in organic potatoes.

The content of nitrates was always significantly lower in organic potatoes and a difference was more distinct in 1994 when the temperatures during the growing season were particularly high. Drought can increase the content of nitrates in potatoes (Hansen and Ostergaard 1991). Many authors found higher nitrates level in the conventional potatoes (Abele 1987, Bulling et al. 1987, Lindner 1991). The content of nitrites was generally low and similar in the organic and conventional potatoes. The content of vitamin C was significantly higher in the organic potatoes. Abele (1987) and Kolbe et al. (1995) also found more vitamin C in organic potatoes.

It should be stressed that lower level of nitrates and simultaneously higher content of vitamin C in organic potatoes can have a double positive health effect on human organism. Nitrates after the reaction with amines can convert into carcinogenic and mutagenic nitrosamines and vitamin C limits in vivo synthesis of the nitrosocompounds (Mirvish 1993).

The content of starch was significantly higher in both potato cultivars from organic farms in 1994. Similar results were obtained by Varis et al. (1996), who indicated that increasing nitrogen fertilisation could decrease the content of starch in potato tubers. Abele (1987) found more starch in organic potatoes only in the first year of study but in next 2 years starch content was higher in conventional tubers.

Total proteins' content was always slightly higher in conventional potatoes. Abele 1987 and Bulling et al. 1987 obtained similar results. The reason is that the Kjeldahl method determines also non-protein nitrogen groups and higher levels of nitrogen fertilisation causes higher content of non-protein nitrogen (Sharma and Arora 1988).

Sensory evaluation of carrots and potatoes dependent on the cultivation method

Sensory parameters (taste and aroma) were better for organic carrots; differences were significant (Table 3). The differences were not so evident when cooked vegetables were compared. Abele (1987) and Zadoks (1989) also found better sensory quality in organic carrots, evaluated as sweeter and with better taste and smell.

All examined potato cultivars obtained better sensory evaluation when they were produced in the organic farms. Bulling et al. (1987) found less taste defects and less flesh darkening in organic potatoes and Varis et al. (1996) found bigger percentage of the best quality tubers and more pleasant aroma in organic potatoes. Schulz (2000) found also better sensory evaluation of the organic potatoes, especially from the biodynamic cultivation. He also found much bigger tendency to darken in flesh of the conventional potatoes.

Storage quality of potatoes dependent on the cultivation method

Organic potatoes showed better parameters of storage quality though most of differences were not statistically different. More distinct and important differences between organic and conventional potatoes concerned 'Bryza' than 'Sokol' cultivar. Length of germs in April was distinctly longer in conventional potatoes in both cultivars. A probable reason was the bigger nitrogen supply in conventional tubers. Bulling et al. (1987) analysing 22 quoted studies found distinctly bigger storage losses (30% of the initial mass) in conventional potatoes compared to organic ones (22% of the initial mass). As a possible reason Bulling et al. (1987) regarded higher content of dry matter in organic tubers what favoured less intensive process of decay and decomposition.

CONCLUSIONS

The average yield of carrots and potatoes from the organic farms was significantly lower compared to the conventional crops. The content of dry matter was, as a rule, higher in organic potatoes. Organic carrots contained 4 times fewer nitrates than conventional ones. The content of nitrates was also significantly lower in organic potatoes and a difference was clearer in year 1994when the temperatures during the growing season were particularly high. The level of nitrites was 46 % lower in organic carrots compared to conventional crop. No differences were found in this respect between the

organic and conventional potatoes. The content of lead was similar in organic and conventional carrots, but content of cadmium was almost 3 times higher in organic carrots; however, the level of heavy metals was generally low. The contents of mineral compounds (Ca, K, and Mg) were similar in organic and conventional carrot. Organic carrots contained less ß-carotene and more total sugars, while the content of vitamin C and starch was significantly higher in the organic potatoes. Total protein content was always slightly higher in the conventional potatoes. Sensory evaluations (taste and aroma) were better for organic carrots and potatoes compared to the conventional ones. Organic potatoes showed also little better parameters of storage quality.

To summarise, this study found that organic vegetables had lower yields, but most of their nutritive, sensory and storage quality attributes were better than in the conventional ones. It should be emphasised that lower level of nitrates and simultaneously higher content of vitamin C in organic potatoes can have an important anti-carcinogenic impact on the human organism. Organic vegetables more readily comply with food requirements for infants and small babies and should be recommended for baby foods.

Organic farming can be considered as a system providing good conditions to improve the vegetable quality. Nevertheless, there are still possibilities to ameliorate the methods of cultivation and storage of the organic crops to obtain better production and qualitative results.

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Tables

Table 1. Selected features of the yield, wholesome and nutritive quality of 'Monanta' arrots from the organic (ORG) and intensive conventional (CONV) farms in 199- x ± SD (average value and standard deviation)

	Carrots from the farms	
Analysed parameter in relation to fresh mass	ORG[1] , n[3] = 10	CONV[2], n= 10
Yield in autumn 1997 in t/ha	37.5 ± 14.1 a [4]	50.0 ± 23.1 a [4]
Dry matter (g/ 100g)	11.55 ± 0.84 a	11.10 ± 0.80 a
Nitrates (mg /kg)	52.2 ± 36.8 a [5]	209.7 ± 175.0 b [5]
Nitrites (mg /kg)	0.57 ± 0.42 a	1.06 ± 0.42 b
Lead (mg /kg)	0.013 ± 0.008 a	0.018 ± 0.008 a
Cadmium (mg /kg)	0.014 ± 0.009 a	0.005 ± 0.006 b
Calcium (mg/100 g)	86 ± 5 a	87 ± 8 a
Potassium (mg/100 g)	226 ± 100 a	266 ± 100 a
Magnesium (mg/100 g)	17 ± 5 a	13 ± 5 a
β carotene (mg /100 g)	13.55 ± 2.18 a	14.49 ± 2.86 a
Total sugars (mg/100 g)	7.53 ± 1.07 a	6.57 ± 0.70 a

[1] Torun and Plock provinces
[2] Warszawa province
[3] n – number of samples; 1 sample = result for 1 farm
[4] values in the same rows marked with the same letters doesn't differ statistically in significant way
[5] values in the same rows marked with different letters differ statistically in significant way

Table 2. Selected features of the yield, wholesome and nutritive quality of 'Bryza', 'Sokol' and 'Ania' potatoes from the organic (ORG) and intensive conventional (CONV) farms in 1997 - x ± SD - Torun and Plock provinces

	Potato cultivars							
Analysed parameter in relation to fresh mass	'Bryza'		'Sokol'		'Sokol'		'Ania'	
Year of study	1994				1995			
N	10	10	10	10	9	9	9	9
	ORG	CONV	ORG	CONV	ORG	CONV	ORG	CONV
Yield in kg (obtained from 15 kg seed potatoes)	57 ± 22.3 a	106.4 ± 59.0 b	73.3 ± 29.5 a	132.2 ± 71.2 b	132.8 ± 105.8 a	167 ± 68.4 a	139.5 ± 91.4 a	168 ± 78.6 a
Dry matter (g/ 100g)	21.43 ± 1.50 a	20.21 ± 1.96 a	20.64 ± 1.86 a	20.79 ± 2.00 a	21.91 ± 1.61 a	20.21 ± 1.89 a	24.12 ± 1.61 a	21.60± 2.79 b
Nitrates (mg /kg)	99.2 ± 57.3 a	228.7 ± 92.6 b	65.3 ± 65.3 a	124.6 ± 83.8 a	38.8 ± 33.2 a	82.1 ± 55.1 b	57.1 ± 38.2 a	81.4 ± 38.0 b
Nitrites (mg /kg)	0.26 ± 0.29 a	0.35 ± 0.32 a	0.28 ± 0.16 a	0.30 ± 0.35 a	0.38 ± 0.27 a	0.39 ± 0.40 a	0.63 ± 0.39 a	0.40 ± 0.16 a
Vitamin C (mg /100 g)	26.7 ± 1.7 a	23.3 ± 2.3 b	25.1 ± 1.7 a	21.5 ± 4.7 b	18.2 ± 3.5 a	15.9 ± 3.4 a	19.0 ± 3.5 a	16.2 ± 3.6 b
Starch (g / 100 g)	15.7 ± 1.4 a	13.7 ± 1.4 b	14.7 ± 2.5 a	13.0 ± 1.8 b	not determined	not determined	not determined	not determined
Total proteins (g / 100 g)	2.2 ± 0.3 a	2.3 ± 0.3 a	2.0 ± 0.3 a	2.3 ± 0.3 b	2.4 ± 0.3 a	2.6 ± 0.5 a	1.9 ± 0.3 a	2.3 ± 0.4 b

Explanations like under table 1

Table 3. Sensory evaluation of 'Bryza', 'Sokol', 'Ania' and 'Anielka' potatoes, 'Regulska' and 'Monanta' carrots from the organic (ORG) and intensive conventional (CONV) farms in 1994 - 1996 - x ± SD - Torun and Plock provinces

Plant, cultivar and period of study	ORG	CONV
n	10	10
'Bryza' potatoes – autumn 1994	5.28[1] ± 0.9 a	4.91 ± 0.8 a
'Sokol' potatoes – autumn 1994	5.14 ± 1.0 a	4.58 ± 0.9 a
'Sokol' potatoes – autumn 1995	5.55 ± 0.53 a	4.25 ± 0.43 b
'Ania' potatoes – autumn 1995	6.17 ± 0.57 a	5.32 ± 0.64 b
'Anielka' potatoes - autumn 1996	6.51 ± 0.81 a	6.39 ± 0.54 a
'Regulska' raw carrots – autumn 1996	6.96 ± 0.77 a	6.58 ± 0.87 a
'Regulska' cooked carrots – autumn 1996	6.95 ± 0.48 a	6.33 ± 0.54 b
'Monanta' raw carrots – autumn 1997	7.34 ± 1.03 a	6.34 ± 0.63 b
'Monanta' cooked carrots – autumn 1997	6.68 ± 0.67 a	6.26 ± 0.66 a

[1] in scale 1 - 9 with hedonic method
Explanations like under table 1

Table 4. Storage quality of potatoes from the organic (ORG) and intensive conventional (CONV) farms (evaluation in April 1995 - x ± SD, n=10 - previous Torun and Plock provinces

	Potato cultivar			
Parameter	'Bryza'		'Sokol'	
	ORG	CONV	ORG	CONV
Outer defects (%)	1.65 ± 2.38 a	3.94 ± 3.64 b	0.77 ± 1.21 a	0.43 ± 0.71 a
Germ length (cm)	8.85 ± 4.18 a	10.85 ± 3.55 b	5.88 ± 1.76 a	7.41 ± 2.12 b
Inner defects (%)	0.84 ± 1.12 a	1.29 ± 1.61 a	1.39 ± 1.61 a	2.63 ± 2.13 a
Mass losses (%)	7.13 ± 2.98 a	10.39 ± 4.20 a	7.55 ± 4.56 a	7.75 ± 2.64 a
Mass losses (%)	23.4 ± 2.2 a	25.6 ± 3.4 a	23.2 ± 1.7 a	25.0 ± 3.8 a

Explanations like under table 1