

THE EFFECT OF MATURITY STAGE ON NUTRITIONAL VALUE OF LEEK, ZUCCHINI AND KOHLRABI

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Summary

Three field experiments were established in 1996-2003 in order to determine the effects of term of harvest and stage of maturity on biological value of leek, zucchini and kohlrabi. The results of experiments showed that delay the harvest date associated with considerable increment of crop yield caused the enhancement of dry matter, total and reducing sugars in leek and kohlrabi. In zucchini the fruits of smaller size contained higher amounts of dry matter and similar sugars like more developed. Advanced term of harvest appeared to be favourable for vitamin C, phosphorus and potassium content in vegetables. Changes in magnesium and calcium concentration under influence of the stage of maturity were highly dependent on plant species. Plants of kohlrabi and leeks harvested at later stage of maturity contained lower level of nitrates, but in zucchini there was observed the increment of this compound in fruits of a bigger size at harvest.

key words: leek, zucchini, kohlrabi, term of harvest, stage of maturity, nutritional value

INTRODUCTION

Nutritional value of particular vegetable species depends on many factors, among which as the most important are recognized botanical variety as well as cultivar (Bąkowski & Borkowski 1969, Khadi *et al.* 1987, Kołota & Adamczewska-Sowińska 2001). The other important factors that influence the chemical composition of vegetables are climatic conditions, fertilization, method and timing of cultivation, irrigation as well as the stage of plant development at harvest (Kaniszewski 1982, Picha & Hall 1982, Guttormsen & Hoe 1985, Sørensen *et al.* 1995, Cebula & Kalisz 1996).

The common practice in a spring season production of vegetables is the application of the management accelerating the harvest date and finally resulting in the higher prices at the market. Preferable economical effects of such operations for the growers are associated with a lower crop yield and usually some changes in nutritional value of vegetables as a result of the differentiated maturity stage and size of harvested plants.

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Data from literature indicate that process of tomato fruit ripening is followed by the enhancement of dry matter, sugars and vitamin C content (Elkner 1994). Similar relations between the date of harvest and nutritional value of parsley roots was found by Bąkowski *et al.* (1994) and in zucchini by Gajc & Skapski (1991).

Kmiecik & Lisiewska (1989, 1991) and Orłowski & Jadczak (2000) reported that chemical composition of zucchini considerably depend on the size of harvested fruits and much less on the cultivar. On the base of different experimental data Lester (2006) has drawn the conclusion that vegetable and fruit size has a major impact on the concentration of available phytonutrients such as β -carotene, ascorbic acid and folic acid. In general, ascorbic acid decreases with increasing their size, whereas carotenoids and B-complex vitamins increase (Mozofar 1994). This relationship may not always be linear and not always shows the same trend. For example in muskmelon the medium size fruits had the highest concentrations of mentioned phytonutrients (Lester & Eischen 1996, Lester & Crosby 2002). Similar response was observed in vitamins content in carrot (Lee 1986).

The aim of present study was to determine the influence of stage of maturity on nutritional value of edible parts of leek, zucchini and kohlrabi.

MATERIAL AND METHODS

The field experiments were conducted in 1996-2003 at Piastów Horticultural Experimental Station of Agricultural University in Wrocław on a sandy clay soil, with pH 6.8 and organic matter content 1.8%.

In experiment 1 ten weeks old transplants of leek cv. Kilima produced in multicell trays filled with mixture of peat moss and clay soil in the ratio 1:1 by volume were planted into the field on April 10 in spacing of 25 x 20 cm. During harvests carried out on 4th of July and one month later total and marketable yields were determined. In both term samples of edible parts were collected for chemical analysis.

In experiment 2 the seeds of zucchini cv. Astra were sown in the field on May 20 in spacing 100 x 80 cm. During harvest lasted from early July to half of September, fruits at different stages of development, with length 7-14, 15-21, 22-30 cm were picked up. On August 8, in the period of maximum fruit setting samples of fruits were collected for chemical analysis.

In experiment 3 transplants of kohlrabi cv. Delikates Biała produced in greenhouse in multicell trays filled with peat substrate were planted in the field in spacing 30 x 20 cm on April 13. The harvest was conducted in one week intervals since June 4. The samples of kohlrabi edible parts for chemical analysis were collected on June 4 and 25.

Crop management was conducted according to commonly accepted recommendations for particular species. The experiments were established in one factorial design with four replications and plot area of 6 m².

In fresh material of leek, zucchini and kohlrabi there was estimated the level of vitamin C by Tillman's method (PN-90/A-75101/04), total and reducing sugars by Lane Eynon method (PN-90/A-75101/07) and dry matter by drying to constant weight at 105°C (PN-90/A-75101/03). Nitrates were determined using an ionoselective electrode. Content of macronutrients: phosphorus, potassium, magnesium and calcium was determined according to Nowosielski method (Nowosielski 1974).

The results were analysed by standard statistical procedure and the least significant differences calculated by Tukey test at $P=0.05$.

RESULTS AND DISCUSSION

Data of the study proved that the important factor influencing the yield of leeks and nutritional value of the crop appeared to be the term of harvest. Delay of harvest from July to August caused the increament of total and marketable yield from 36.19 and 34.67 to 73.81 and 70.96 t·ha⁻¹, respectively (Table 1) due to enhancement of the mean weight of plant from 102.55 to 196.52 g.

Table 1. The effect of the term of harvest on yielding of leek cv. Kilima

Term of harvest	Total yield (t·ha ⁻¹)	Marketable yield (t·ha ⁻¹)	Average weight of plant in marketable yield (g)
July 4	36.19	34.67	102.55
August 5	73.81	70.96	196.52
LSD _{0.05}	3.55	3.70	9.84

Plants harvested in later stage of maturity contained higher amounts of dry matter, total and reducing sugars and this was accompanied with considerable decrease of vitamin C from 27.03 to 16.42 mg·100 g⁻¹ f.w. (Table 2).

Table 2. The effect of term of harvest on nutritional value of leek cv. Kilima

Term of harvest	Dry matter %	Vitamin C mg·100g ⁻¹ f.w.	Reducing sugars % f.w.	Total sugars	NO ₃ -N mg·kg ⁻¹ f.w.	P	K	Mg	Ca
						% d.m.			
July 4	8.42	27.03	2.66	4.36	913	0.36	1.45	0.16	0.65
August 5	12.63	16.42	3.18	6.15	491	0.30	0.92	0.09	0.66
LSD _{0.05}	0.56	8.67	0.32	0.46	87	n.s.	0.11	0.04	n.s.

Among the tested macroelements, plants characterized as less advanced in development stage at harvest contained a higher level of phosphorus, potassium and magnesium, whereas similar concentration of calcium in comparison to those picked up one month later. As the positive change in nutritional value of later harvested leeks was found to be a significant drop in nitrates concentration from 913 to 491 mg per 1 kg of f.w. This data are in agreement with previous

studies conducted in leeks by Sørensen *et al.* (1995). Taking into account the admitted limit of $\text{NO}_3\text{-N}$ content in leek equal to 400 mg per 1 kg of f.w., plants harvested in early stages of development may not meet the acceptance of the market demand if they are fertilized in recommended rates of nitrogen at the level of 200 kg $\text{N}\cdot\text{ha}^{-1}$.

Results of the experiment 2 confirmed those from the previous studies conducted by Gajc & Skapski (1991) and Orłowski & Jadczak (2000) showing the adverse effect of harvest conducted in early development stage of fruits on yield of zucchini (Table 3). In treatment where fruits 7-14 cm long with corolla still attached were harvested, the total and marketable yield was equal to 21.40 and 20.22 $\text{t}\cdot\text{ha}^{-1}$, respectively and increased to 50.53 and 48.00 $\text{t}\cdot\text{ha}^{-1}$ if they were harvested at 15-21 cm and to 76.04 and 73.15 $\text{t}\cdot\text{ha}^{-1}$ if they reached the length 22-30 cm. Fruits left for longer period of time on plants suppressed subsequent pistillate flowering and caused a decrease in their number per unit area. As a result of this, the total number of fruits diminished from 307.28 to 201.22 and 133.89 thousands per hectare along with their delayed stage of development at harvest.

Table 3. The effect of fruit size on yielding of zucchini cv. Astra

Size of fruit (cm)	Total yield ($\text{t}\cdot\text{ha}^{-1}$)	Marketable yield ($\text{t}\cdot\text{ha}^{-1}$)	Number of fruits in total yield in thousands per ha^{-1}	Number of fruits in marketable yield in thousands per ha^{-1}
7-14	21.40	20.22	307.28	289.69
15-21	50.53	48.00	201.22	190.68
22-30	76.04	73.15	133.89	121.68
LSD _{0.05}	2.49	2.35	9.11	11.93

The stage of maturity considerably influenced the nutritional value of zucchini fruits (Table 4). The results of chemical analysis showed a significant decrease of dry matter, vitamin C, phosphorus, potassium and calcium, whereas some enhancement of magnesium in more developed fruits, and this finding is in agreement with statement of Kmiecik & Lisiewska (1989). The other important meaning for the higher nutritional value of smaller zucchini fruits was much lower content of nitrates in comparison to those harvested in subsequent more advanced stages of development.

Table 4. The effect of fruit size on nutritional value of zucchini cv. Astra

Size of fruit (cm)	Dry matter (%)	Vitamin C ($\text{mg}\cdot 100\text{g}^{-1}$ f.w.)	Reducing sugars % f.w.	Total sugars % f.w.	$\text{NO}_3\text{-N}$ ($\text{mg}\cdot\text{kg}^{-1}$ f.w.)	P	K	Mg	Ca
7-14	6.45	22.91	1.47	1.56	255.4	0.77	5.00	0.55	0.38
15-21	5.35	18.27	1.48	1.57	356.6	0.65	4.66	0.58	0.35
22-30	4.39	15.11	1.49	1.59	481.7	0.59	4.38	0.60	0.31
LSD _{0.05}	0.29	0.99	n.s.	n.s.	28.3	0.05	0.23	0.03	0.02

In experiment 3 with kohlrabi there were observed a similar relations between date of harvest and the yield of the crop like in leek and zucchini (Table 5). Three week's period of delay in harvest term resulted in the increment of tubers yield from 4.50 to 29.18 t·ha⁻¹. Tubers collected at later stage of development contained higher amounts of dry matter, total and reducing sugars and magnesium (Table 6). The reverse changes were found in content of vitamin C, calcium, phosphorus, potassium and nitrates accumulation.

Table 5. The effect of term of harvest on yielding of kohlrabi cv. Delikates Biała

Term of harvest	Total yield		Marketable yield		The mean weight of tuber in marketable yield (g)
	Leaves+ tubers	Tubers	Leaves+ tubers	Tubers	
	t·ha ⁻¹				
June 4	10.04	5.38	9.06	4.50	110.90
June 25	60.44	38.11	43.79	29.18	229.87
LSD _{0.05}	2.14	1.28	1.49	1.21	22.14

Table 6. The effect of term of harvest on nutritional value of kohlrabi cv. Delikates Biała

Term of harvest	Dry matter (%)	Vitamin C (mg·100g ⁻¹ f.w.)	Reducing sugars	Total sugars	NO ₃ -N (mg·kg ⁻¹ f.w.)	P	K	Mg	Ca
			% f.w.	% f.w.					
June 4	7.31	109.34	1.48	3.03	757.50	0.50	4.57	0.22	0.23
June 25	8.88	67.56	1.99	3.39	560.50	0.42	3.62	0.28	0.16
LSD _{0.05}	0.32	15.89	0.21	0.28	89.64	0.06	0.23	0.04	0.08

CONCLUSIONS

1. Delay the harvest date associated with considerable increment of crop yield caused the enhancement of dry matter, total and reducing sugars in leek and kohlrabi. In zucchini the fruits of smaller size contained higher amounts of dry matter and similar sugars like more developed once.
2. Earlier term of harvest appeared to be favourable for vitamin C, phosphorus and potassium content in vegetables. Changes in magnesium and calcium concentration under influence of the stage of maturity were highly dependent on plant species.
3. Plants of kohlrabi and leeks harvested at later stage of maturity contained lower level of nitrates, but in zucchini there was observed the increment of this compound in fruits of a bigger size at harvest.

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WPLYW FAZY DOJRZAŁOŚCI NA WARTOŚĆ ODŻYWCZĄ PORĄ, CUKINI I KALAREPY

Streszczenie

Trzy doświadczenia polowe zostały przeprowadzone w latach 1996-2003 w celu określenia wpływu terminu zbioru i związanego z nim zróżnicowanego stopnia dojrzałości na wartość biologiczną pora, cukini i kalarepy. Uzyskane wyniki badań dowiodły, że wraz z opóźnieniem terminu zbioru następował wyraźny wzrost plonu oraz zwiększenie zawartości suchej masy, cukrów ogółem i redukujących w porze oraz kalarepie. W przypadku cukini, owoce mniej wyrośnięte zawierały więcej suchej masy i podobny poziom cukrów jak owoce bardziej wyrośnięte. Wcześniejszy termin zbioru wpływał korzystnie na zawartość witaminy C, fosforu i potasu w warzywach. Zmiany koncentracji magnezu i wapnia pod wpływem tego czynnika były zróżnicowane u poszczególnych gatunków warzyw. Późniejszy termin zbioru przyczynił się do obniżenia zawartości azotanów w częściach jadalnych pora i kalarepy, natomiast w przypadku cukini wyższy poziom tego składnika stwierdzono w owocach bardziej wyrośniętych.