M. Pudzianowska*, M. Gajewski, J. L. Przybył, A. Buraczyńska, O. Gaczkowska, M. Matuszczak

Warsaw University of Life Sciences – SGGW
Faculty of Horticulture and Landscape Architecture
Department of Vegetable and Medicinal Plants

Nowoursynowska 159, Warsaw
http://krwil.sggw.pl
* ✉ marta.pudzianowska@gmail.com

Influence of storage conditions on flavonoids content and antioxidant activity of selected shallot (*Allium cepa* L. Aggregatum Group) hybrid cultivars

INTRODUCTION

Allium crops are well known for their biological activity resulting from the presence of sulphur compounds in bulbs, however other compounds, namely flavonoids and other polyphenols, have been in the area of interest lately. Flavonoids show wide range of biological properties, mainly connected with beneficial effect on cardiovascular system and with their antioxidant activity (Hollman and Katan, 1999). Flavonoids show several different ways of antioxidant action, such as free radicals scavenging, breaking the chain of their formation, inhibition of enzymes and bounding metal ions catalyzing oxidation processes and stimulation of critic gene for glutathione transcription resulting in increased concentration of intracellular glutathione (Sikorski, 2002; Moskaug et al., 2005). Flavonoids are divided into several groups: flavones, flavonoles, flavanoles, flavanones, isoflavones and anthocyanindines. Allium vegetables are rich in flavonoles, primarily quercetin, and among the onion varieties the most abundant in quercetin are shallots and red onions (Di Garlo et al.., 1999; Kyle and Duthie, 2006). Several investigations were performed to recognize the changes of flavonoids during storage of shallot bulbs (Horbowicz and Kotlińska, 2001, Horbowicz, 2006; Tendaj and Mysiak, 2010), however the influence of controlled atmosphere storage was not explained. Controlled atmosphere storage is recommended in literature for long-term storage of onions and several other vegetable crops, as a method for better keeping product quality, including its biological value (Bartz and Brecht, 2003). The objective of the study was to identify flavonoids in bulbs of hybrid cultivars of shallot, examine their antioxidant activity (AA) and influence of storage under different atmosphere compositions on flavonoids content and AA.

MATERIAL AND METHODS

The experiment was carried out in in 2009 and 2010. For the investigation three hybrid cultivars of shallot ('Conservor' F1,'Bonilla' F1 and 'Matador' F1, Bejo Zaden Holland) were chosen. Bulbs of 'Bonilla' F1 are of garlic-like shape, have light brown and yellow dry and fleshy scales. 'Conservor' F1 and 'Matador' F1 are characterized by red and brown tints of dry scales, of different intensity, and pink tint of inner scales. 'Matador' F1 bulbs are of of garlic-like shape, with light brown dry scales. 'Conservor' F1 bulbs have red-brown dry scales and elongated, spindle shape. The plants were cultivated in the experimental field on a medium-loam soil. Mature bulbs were harvested in the third week of August and cured in a shed, at ambient temperature, for one month. Bulbs were stored for 7 months in CA cold storage at 0 – 1 °C, 65 % RH. Five atmosphere compositions were tested: (1) 5 % CO2 + 5 % O2, (2) 5 % CO2 + 2 % O2, (3) 2 % CO2 + 5 % O2, (4) 2 % CO2 + 2 % O2 and (5) normal atmosphere. Because of lack of recommendations for shallot, CA conditions suitable for common onion were chosen. The experiment was established in three replications, with thirty bulbs in each. For chemical analyses good quality, healthy bulbs had been chosen. For each cultivar antioxidant activity (AA) was determined and identification of flavonoids by HPLC was conducted. To estimate AA two assays were performed: FRAP and DPPH.

LITERATURE

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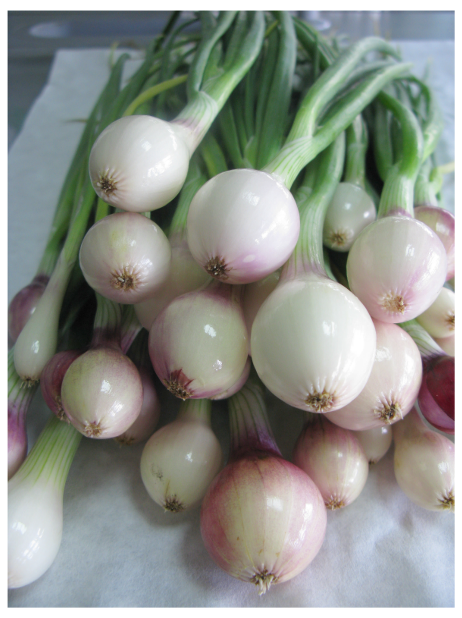
RESULTS



Young shallot plants

'Conservor' F_1

'Matador' F_1

'Bonilla' F_1

Table 1. Quercetin 3,4'-di-O-glucoside content in shallot bulbs (mg/100g DW)

Cultivar (B)	Storage (A)						Mean
	After harvest	After storage					(B)
		1	2	3	4	5	
Conservor F_1'	251.0	841.6	687.0	512.1	353.4	852.8	583.0 a
Matador F_1'	329.3	866.1	752.0	475.7	363.6	585.9	562.1 a
Bonilla F_1'	334.6	766.1	770.3	592.9	531.0	514.8	585.0 a
Mean (A)	305.0 a	824.6 c	736.5 c	526.9 abc	416.0 ab	651.2 bc	
LSD AxB p = 0.05				519.8			

1: 5% CO_2 + 5% O_2; 2: 5% CO_2 + 2% O_2; 3: 2% CO_2 + 5% O_2; 4: 2% CO_2 + 2% O_2; 5 (control): 0 % CO_2 + 21% O_2

Note to Tab. 1 – 5: Means marked with different letters differ at P = 0.05

Table 2. Quercetin 3-O-rutinoside (Rutoside) content in shallot bulbs (mg/100g DW)

Cultivar (B)	Storage (A)						Mean
	After harvest	After storage					(B)
		1	2	3	4	5	
Conservor F_1'	19.4	28.1	16.5	12.7	20.7	9.8	17.9 a
Matador F_1'	14.0	36.7	23.4	15.3	10.2	15.7	19.2 a
Bonilla F_1'	26.1	34.7	22.6	14.4	12.6	20.8	21.9 a
Mean (A)	19.9 ab	33.2 b	20.8 ab	14.1 a	14.5 a	15.5 a	
LSD AxB p = 0.05				25.6			

1: 5% CO_2 + 5% O_2; 2: 5% CO_2 + 2% O_2; 3: 2% CO_2 + 5% O_2; 4: 2% CO_2 + 2% O_2; 5 (control): 0 % CO_2 + 21% O_2

Table 3. Quercetin 4'-O-glucoside (Spiraeoside) content in shallot bulbs (mg/100g DW)

Cultivar (B)	Storage (A)						Mean
	After harvest	After storage					(B)
		1	2	3	4	5	
Conservor F_1'	195.3	383.6	256.4	445.9	296.2	585.9	360.5 a
Matador F_1'	407.1	651.1	368.8	384.9	375.3	378.3	427.6 a
Bonilla F_1'	348.8	587.6	556.0	459.9	442.4	459.9	475.7 a
Mean (A)	317.1 a	540.7 b	393.7 ab	430.2 ab	371.3 ab	474.7 ab	
LSD AxB p = 0.05				378.2			

1: 5% CO_2 + 5% O_2; 2: 5% CO_2 + 2% O_2; 3: 2% CO_2 + 5% O_2; 4: 2% CO_2 + 2% O_2; 5 (control): 0 % CO_2 + 21% O_2

Table 4. Quercetin content in shallot bulbs (mg/100g DW)

Cultivar (B)	Storage (A)						Mean
	After harvest	After storage					(B)
		1	2	3	4	5	
Conservor F_1'	42.4	23.3	19.3	30.6	19.7	25.5	26.8 a
Matador F_1'	39.2	34.4	22.9	28.3	28.5	21.9	29.2 a
Bonilla F_1'	44.5	27.1	27.2	24.6	29.4	20.4	28.9 a
Mean (A)	42.0 b	28.0 ab	23.1 a	27.8 ab	25.9 ab	22.6 a	
LSD AxB p = 0.05				29.1			

1: 5% CO_2 + 5% O_2; 2: 5% CO_2 + 2% O_2; 3: 2% CO_2 + 5% O_2; 4: 2% CO_2 + 2% O_2; 5 (control): 0 % CO_2 + 21% O_2

Table 5. Antioxidant activity of shallot bulbs measured with DPPH (mg TE/100g DW)

Cultivar (B)	Storage (A)						Mean
	Before storage	After storage					
		1	2	3	4	5	
Conservor F_1'	230.2	186.1	202.0	209.4	177.4	215.0	203.3 a
Matador F_1'	201.0	169.0	171.4	175.2	191.1	173.6	180.2 a
Bonilla F_1'	205.9	182.2	145.0	171.8	250.3	319.5	212.5 a
Mean	212.4 a	179.1 a	172.8 a	185.5 a	206.2 a	236.0 a	
LSD AxB p = 0.05				112.5			

1: 5% CO_2 + 5% O_2; 2: 5% CO_2 + 2% O_2; 3: 2% CO_2 + 5% O_2; 4: 2% CO_2 + 2% O_2; 5 (control): 0 % CO_2 + 21% O_2

Table 6. Antioxidant activity of shallot bulbs measured with FRAP (mmol Fe2+/100g DW)

Cultivar (B)	Storage (A)						Mean
	Before storage	After storage					(B)
		1	2	3	4	5	
Conservor F_1'	3.9	5.8	7.3	4.9	4.1	2.5	4.7 a
Matador F_1'	4.0	4.3	3.8	3.4	3.9	3.2	3.8 a
Bonilla F_1'	4.3	5.0	4.4	4.3	5.9	4.3	4.7 a
Mean (A)	4.1 ab	5.0 ab	5.2 b	4.2 ab	4.6 ab	3.3 a	
LSD AxB p = 0.05				3.0			

1: 5% CO_2 + 5% O_2; 2: 5% CO_2 + 2% O_2; 3: 2% CO_2 + 5% O_2; 4: 2% CO_2 + 2% O_2; 5 (control): 0 % CO_2 + 21% O_2

Table 7. Correlation coefficient between flavonoids content in shallot bulbs and antioxidant activity (DPPH and FRAP)

Compound	DPPH	FRAP
Quercetin 3,4'-di-O-glucoside	0.21*	0.54**
Quercetin 3-O-rutinoside (Rutoside)	0.36**	0.56**
Quercetin 4'-O-glucoside (Spiraeoside)	0.33**	0.43**
Quercetin	0.38**	0.37**

CONCLUSIONS

Four flavonoids were identified in shallot bulbs in this study, quercetin 3,4'-di-O-glucoside and spiraeoside were present in the highest amounts. Two assays used to measure the AA of shallot extracts gave different results. Results of FRAP showed moderately strong relationship with flavonoids content in the bulbs. Atmosphere composition during storage of the bulbs influenced flavonoids content and FRAP values for the bulbs. Increase of quercetin 3,4'-di-O-glucoside, rutoside and spiraeoside and AA (FRAP) in some atmosphere compositions during the storage was observed. There were no significant differences in flavonoids content and AA between shallot cultivars.

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