

Sensory and Physical Changes During Storage of Zucchini Squash (*Cucurbita pepo* var. *giromontina* Alef.)

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Abstract

In a 3-year experiment (2000-2002) the effect of storage conditions on the quality of zucchini squash 'Astra' was investigated. The fruits were harvested at three maturity stages. Normal atmosphere and two controlled atmospheres (5% CO₂ / 3% O₂ and 3% CO₂ / 3% O₂) were used, at two temperatures (6°C and 3°C). Fruit quality was evaluated at the beginning of experiment and after 4 weeks of storage. Visual quality, puncture force and deformation of fruits were examined and colour of skin was measured. For sensory investigations, the quantitative descriptive analysis (QDA) method was applied. 12 sensory attributes of the fruits were evaluated. The best results were obtained if zucchini was kept at 6°C, in either of the two controlled atmospheres.

INTRODUCTION

Zucchini squash is chilling sensitive, so its harvest and consumption period in Poland is rather short – from July until the end of September. If storage of zucchini fruits could be optimised, this consumption period might be extended. For consumption, fresh or cooked non-matured zucchini fruits are used. However, storage of young fruits is difficult. The quality of fruits decreases quite fast because of transpiration, respiration and rotting processes. According to Suslow and Cantwell (2000), optimal storage conditions are: temperature 5 - 7°C and RH 95%. However, there are reports (Mencarelli et al., 1983; Mencarelli, 1987; Wang et al., 1992) on susceptibility of zucchini fruits to low temperature (about 5°C) during storage. At this temperature skin spots emerge, which results in quick loss of marketable quality. These reports deal also with the alleviating influence of modified atmosphere storage or temperature conditioning on chilling injury.

The aim of experiment was to study the influence of storage methods on some physical and sensory traits of zucchini squash harvested at three maturity stages.

MATERIALS AND METHODS

Experiment was carried out in the Department of Vegetable and Medicinal Plants of Warsaw Agricultural University in 2000 - 2002. Zucchini squash 'Astra' with a green skin was used. Plants were grown in the field. The physiologically non-mature fruits were harvested in August. The factors of experiment were:

A. Stage of maturity of fruits: M-1 (youngest fruits, 4 - 5 days after anthesis, length 10 - 16 cm), M-2 (fruits 6 - 8 days after anthesis, length 16 - 22 cm), M-3 (fruits 9 - 12 after anthesis, length 22 - 26 cm).

B. Temperature of storage: 6°C and 3°C.

C. Gas composition of atmosphere: normal atmosphere, 5% CO₂ : 3% O₂ (CA 5:3) and 3% CO₂ : 3% O₂ (CA 3:3).

Zucchini fruits were stored for 4 weeks in the cold storage rooms, at RH of about 95%. The following parameters were evaluated:

1. Visual quality, on a 1 - 9 point scale. Score 1 - 4 – means unmarketable fruits, with shrinkage, diseases, physiological disorders or excessive softness; 5 - fruits of poor quality; 6 - fruits of acceptable quality; 7 - fruits of good quality; 8 - fruits of very good quality; 9 - fruits of excellent quality.

2. Puncture force of fruit with the skin (firmness), using David Bishop Instr. penetrometer, with a 8 mm-diameter core;
3. Deformation of fruit, measured by compression of a fragment of fruit (length 2 cm), under the force of 20 N;
4. Colour of fruit skin, measured in the CIE system with a Hunter Lab spectrophotometer, determining colour coordinates: L^* , a^* and b^* . Hue angle of skin H° was then calculated, using the formula $H^\circ = \arctg(b/a)$;
5. Sensory characteristics of non-stored and stored fruits, using the quantitative descriptive analysis method (QDA). Attributes were smell, texture, taste and overall quality. Smell attributes were as follows: smell typical for boiled zucchini, 'grassy' smell and off-smell. Texture attributes (mouthfeel) were: flesh and skin hardness, flesh firmness and juiciness. Taste attributes were: taste typical for a boiled zucchini, 'grassy' taste (typical for a fresh-cut grass), sweet, bitter, off-taste (untypical for zucchini). Overall quality impression and consumer's level of acceptance of zucchini were also evaluated. Intensity of each attribute was estimated in 10-points nonstructural scale and its extreme scores were: the lowest level of intensity – the highest level of intensity. Sensory analysis was performed with a trained panel (12 people) in two sessions in each year. Before evaluation, fruits were cut and boiled in water for three minutes, then cooled to room temperature.

Results of the experiment were statistically evaluated, using ANOVA program. The homogenous groups of means were identified using Tukey's test at $p = 0.05$.

RESULTS AND DISCUSSION

CA storage with a gas composition 5:3 at the temperature of 6°C resulted in a higher visual score of fruits (Tab. 1). At 6°C minor chilling injury (sunken spots) of the skin were observed on the youngest fruits (M-1 stage) at the normal atmosphere. At 3°C and normal atmosphere there was more serious injury during storage. Other authors also noted a harmful effect of about 5°C on a quality of stored zucchini fruits (Mencarelli, 1987; Wang et al., 1992). However, no injury was found at both controlled atmospheres.

The puncture force of fruit decreased a little during storage, and there were statistically significant differences between the zucchini stored in the normal and controlled atmospheres (Tab. 1). The deformation of fruit after storage depended strongly on the maturity stage as well as on the atmosphere. Minor fruit deformation value was observed in CA storage, compared to the normal atmosphere. Storage also influenced skin hue angle (Tab. 1). The change of green to yellow, expressed as the skin hue angle H° , was slower in CA storage.

The overall sensory quality of fruits was affected by storage (Tab. 2). After storage, the fruits scored significantly lower (5.68) than before storage (6.49). Acceptance of fruits was also lower (5.55 compared with 6.55). Differences were noted between overall quality scores and acceptance scores of fruits of different maturity stage. The highest score of acceptance were found in fruits of the oldest stage (M-3 - 7.08) and the lowest score in the youngest ones (M-1 - 4.89).

The zucchini stored for four weeks at the normal and controlled atmospheres differed from the non-stored ones in some sensory attributes. The typical smell (smell of a boiled zucchini) got a low score when fruits were stored at normal atmosphere. No other significant differences concerning smell attributes were found (Tab. 2). Sensory analysis also showed significant differences concerning mouthfeel texture attributes - flesh firmness and juiciness between fruits stored in the normal atmosphere and non-stored ones (Tab. 3). No off-taste was noted in stored samples, and only a trace of bitter taste was found in zucchini at the maturity stage M-1, stored at the normal atmosphere (Tab. 4). Acceptance of fruits was highest when they were stored at CA 3:3 (Tab. 5). Storage at CA resulted in lower flesh hardness, compared with fruits stored at the normal atmosphere (Tab. 6). However, flesh firmness was higher during CA storage. Taking into consideration all sensory attributes, the best method for storage was CA 3:3.

Significant positive linear correlation between flesh hardness (mouthfeel) and

puncture force of fruits ($r = 0.565$) and a negative correlation of flesh juiciness and deformation of the fruits ($r = -0.897$) was found (Tab. 8).

CONCLUSIONS

1. Storability of zucchini fruits depends on their maturity stage (age). Older fruits, length above 22 cm, store better and keep their sensory quality better (up to 4 weeks in the normal atmosphere) than younger ones.
2. Changes of physical attributes tested - puncture force, deformation, and skin hue angle – occurred slower in CA storage.
3. Both of the investigated CA (5:3 and 3:3) were suitable for storage of zucchini squash. Sensory quality of the zucchini after controlled atmosphere storage was better than after normal atmosphere storage.
4. Fruit flesh hardness and juiciness, a taste typical for boiled zucchini and the bitter taste changed during storage. The influence of maturity stage on texture and taste attributes of stored fruits was significant.

Literature Cited

- Mencarelli F., Lipton W., Peterson S. 1983. Responses of zucchini squash to storage in low O₂ atmospheres at chilling and non-chilling temperatures. *J. Amer. Soc. Hort. Sci.* 108 (6):884-890.
- Mencarelli F. 1987. Effect of high CO₂ atmospheres on stored zucchini squash. *J. Amer. Soc. Hort. Sci.* 112:985-988.
- Suslow T., Cantwell M. 2000. Squash (soft rind). Recommendation for maintaining post-harvest quality. In: *Produce Facts*. Univ. of California, Postharvest Technol. Res. and Inf. Center.
- Wang C., Kramer G., Whitaker B., Lusby W. 1992. Temperature preconditioning increases tolerance to chilling injury and alters lipid composition in zucchini squash. *J. Plant Physiol.*, 140 (2):229-235.

Tables

Table 1. Characteristics of zucchini harvested at three stages of maturity, after 4 weeks of storage at different temperatures and atmospheres.

Means for factors		Visual quality (score 1-9)	Puncture force of fruits [N]	Deformation [mm]	Changes of skin hue angle H ^o [degrees]
Stage of maturity	M-1	4.71 c	68 a	2.2 a	-1.72 a
	M-2	7.50 b	65 a	2.8 b	-1.77 a
	M-3	8.15 a	69 a	2.8 b	-1.71 a
Temperature [°C]	6	6.96 a	68 a	2.5 a	-1.76 a
	3	6.61 b	67 a	2.6 a	-1.69 a
Atmosphere composition [CO ₂ : O ₂]	n	5.92 c	64 b	2.8 b	-2.87 b
	5:3	7.32 a	70 a	2.5 a	-1.13 a
	3:3	7.13 b	68 a	2.5 a	-1.20 a

Note to Tables 1 – 7: means for factors followed by the same letter do not differ significantly at $p = 0.05$

Table 2. Sensory analysis of zucchini at three stages of maturity, before and after 4 weeks of storage at normal atmosphere, 6°C - overall quality, acceptance and smell attributes (Score 0-10).

Means for factors	Overall quality	Overall acceptance	Smell:		
			of boiled zucchini	'grassy'	off-smell
Before storage	6.49 a	6.55 a	5.84 a	4.39 a	0.19 a
After storage	5.68 b	5.55 b	5.75 a	3.94 a	0.37 a
Maturity M-1	5.60 b	4.89 c	5.65 a	4.24 a	0.40 a
Maturity M-2	6.18 a	6.19 b	5.73 a	4.08 a	0.27 a
Maturity M-3	6.47 a	7.08 a	6.01 a	4.18 a	0.17 a

Table 3. Sensory analysis of zucchini at three stages of maturity, before and after 4 weeks of storage at normal atmosphere, 6°C – attributes of texture (mouthfeel). (Score 0-10)

Means for factors	Flesh hardness	Skin hardness	Flesh firmness	Flesh juiciness
Before storage	6.06 a	4.75 a	6.30 a	5.60 a
After storage	5.44 b	4.47 a	5.23 b	5.24 a
Maturity M-1	5.52 b	5.21 c	5.91 a	4.74 a
Maturity M-2	5.47 b	4.54 b	5.46 a	5.93 b
Maturity M-3	6.27 a	4.07 a	5.93 a	5.58 ab

Table 4. Sensory analysis of zucchini at three stages of maturity, before and after 4 weeks of storage at normal atmosphere, 6°C – attributes of taste. (Score 0-10)

Means for factors	Taste				
	of boiled zucchini	'grassy'	sweet	bitter	off-taste
Before storage	5.62 a	2.57 a	3.65 a	0.71 b	0.11 a
After storage	5.02 b	2.70 a	3.21 a	1.14 a	0.31 a
Maturity M-1	5.01 b	2.71 a	3.11 b	1.17 b	0.31 a
Maturity M-2	5.36 a	2.80 a	3.48 a	0.91 ab	0.11 a
Maturity M-3	5.61 a	2.40 a	3.71 a	0.69 a	0.22 a

Table 5. Sensory analysis of zucchini at maturity stage M-2, before and after 4 weeks of storage at 6°C and different atmospheres - overall quality, acceptance and smell attributes. (Score 0-10)

Means for objects	Overall quality	Overall acceptance	Smell		
			of boiled zucchini	'grassy'	off-smell
Before storage	7.39 a	7.46 a	6.49 a	4.92 a	0.00 a
After storage in normal atm.	6.08 c	6.13 c	5.61 b	4.57 a	0.00 a
After storage in CA. 5:3	6.53 b	5.86 c	6.34 a	4.28 a	0.00 a
After storage in CA 3:3	6.48 b	6.82 b	6.05 a	5.00 a	0.01 a

Table 6. Sensory analysis of zucchini at the maturity stage M-2, before and after 4 weeks of storage at 6°C and different atmospheres - attributes of texture (mouthfeel). (Score 0-10)

Means for objects	Flesh	Skin	Flesh	Flesh
	hardness	hardness	firmness	juiciness
Before storage	6.69 a	4.31 a	6.89 a	6.65 a
After storage in normal atm.	6.11 ab	4.16 a	5.98 b	5.65 b
After storage in CA 5:3	5.84 bc	4.18 a	6.63 a	5.99 b
After storage in CA 3:3	5.33 c	4.32 a	6.14 ab	5.94 b

Table 7. Sensory analysis of zucchini at the maturity stage M-2, before and after 4 weeks of storage at 6°C and different atmospheres – attributes of taste. (Score 0-10)

Means for objects	Taste				
	of boiled zucchini	'grassy'	sweet	bitter	off-taste
Before storage	6.11 a	2.10 a	3.57 a	0.27 a	0.00 a
After storage in normal atm.	5.69 a	2.80 a	2.77 b	0.52 a	0.16 a
After storage in CA 5:3	5.66 a	3.00 a	3.13 a	0.58 a	0.07 a
After storage in CA 3:3	5.69 a	2.75 a	3.07 a	0.20 a	0.00 a

Table 8. Coefficients of linear correlation 'r' of physical traits with sensory attributes of fruits texture.

Physical traits	Sensory (mouthfeel) attributes of texture			
	Flesh hardness	Skin hardness	Flesh firmness	Flesh juiciness
Puncture force of fruits	0.565 *	0.109	0.527	0.302
Deformation of fruits	-0.471	-0.347	-0.641	-0.897 **

* significant dependence of both variables with p = 0.10

** significant dependence of both variables with p = 0.05