Biblid: 1821-4487 (2014) 18; 1; p 36-39
UDK: 635.13:641

Original Scientific Paper
Originalni naučni rad

CHANGES IN CARROT TEXTURE DURING COOKING

PROMENE TEKSTURE MRKVE TOKOM KUVANJA

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ABSTRACT

The aim of this research was to compare different instrumental methods for determining the textural characteristics of cooked carrots. The changes of different texture parameters during cooking were also examined in order to find the optimal cooking time. Two previously prepared commercial carrot samples were cooked for 5, 10, 15 and 20 minutes. Texture analysis was performed using a TA.XT Plus Texture Analyser equipped with different fixtures. The coefficient of variation values obtained for firmness determined by penetration test and texture profile analysis have shown that these tests are most suitable for determination of cooked carrot texture. Experiments should be conducted on larger number of carrot samples in order to draw general conclusions. Further research should include carrots cooked in smaller intervals (1 min) to find out the optimal cooking time. Results should be correlated with texture profile evaluated by a trained panel.

Key words: *carrot, cooking time, texture parameters.*

REZIME

Cilj ovog istraživanja je bio poređenje različitih instrumentalnih metoda za određivanje teksturnih svojstava kuvane mrkve. Promene različitih teksturnih parametara tokom kuvanja su takođe ispitane da bi se našlo optimalno vreme kuvanja. U istraživanju su korišćena dva komercijalna uzorka mrkve koja su kuvana 5, 10, 15 i 20 minuta. Analiza teksturnih svojstava je sprovedena pomoću TA.XT Plus analizatora teksture opremljenog različitim nastavcima i mernom ćelijom od 30 kg. Pre kuvanja, mrkva je isečena na diskove debljine 10 mm za testove penetracije, sečenja nožem i analizu profila teksture (TPA). Cele mrkve i mrkve isečene po uzdužnoj osi na polovine su korišćene za testove sa dva tipa Warner-Bratzler (WB) noževa. Za sva merenja su izračunati koeficijenti varijacije, a ANOVA i Duncan-ov test značajnosti razlike su primenjeni za poređenje srednjih vrednosti na nivou značajnosti od 5%. Vrednosti koeficijenta varijacije dobijene za čvrstoću mrkve određenu testom penetracije i TPA testom pokazuju da su navedeni testovi najpogodniji za određivanje teksture kuvane mrkve. Testovi kojima se određuje žilavost i žvakljivost kuvane mrkve su se pokazali manje pouzdanim. Eksperimenti bi trebalo da se sprovedu na većem broju uzoraka da bi se mogli doneti opšti zaključci. Dalja istraživanja bi trebalo da uključe mrkve kuvane u manjim intervalima (1 min) da bi se našlo optimalno vreme kuvanja na osnovu pokazatelja čvrstoće, određene instrumentalno i uz primenu panela odabranih i utreniranih ocenjivača.

Ključne reči: *mrkva, vreme kuvanja, teksturna svojstva.*

INTRODUCTION

Textural changes during processing of fruits and vegetables are often intensive during processing. They are related with enzymatic and non-enzymatic changes in pectin, especially with degradation of pectin catalyzed by pectinmethylesterase (PME) and polygalacturonase (PG), which leads to drastic softening of plant tissue (*Vu et al., 2004*). Much of the research has been done on this topic, mostly focusing on the modification of processing techniques so that more of the fresh product's texture can be retained (*Greve et al., 1994a*).

Carrot *(Daucus carota* L.) is one of the most important vegetables cultivated in the world due to its nutritional value, characteristic flavour, and an excellent crispy texture (*Lin et al., 1998; Rico et al., 2007*). The textural quality of carrot is strongly dependent on cell wall polymers (*Sila et al., 2005*). Investigations have been directed toward understanding the tissue factor that contributes to the eating texture of both fresh and cooked carrot. The primary focus has been on the changes in the plant cell wall because tissue firmness decreases during ripening, storage and processing. (*Greve et al., 1994b*). Beside integrity of cell walls, turgor pressure also contributes on the textural properties of carrots during heating (*Greve et al., 1994a*).

The eating quality of carrot can be measured directly by sensory methods or indirectly by instrumental measurements. These quality parameters should be easily measurable for practical reasons, so faster, simpler or cheaper instrumental methods are demanded for quality control. On the other hand, measurement of the basic mechanical properties can also give a better understanding of the mechanisms that result in plant tissue texture (*De Belie et al., 2002*), and also provides more reliable and repeatable tests then sensory evaluation (*Bourne, 2002*). Different mechanical failure tests were conducted to measure the texture of carrots frequently based on compression, shearing or a combination of both (*De Belie et al., 2002*). Penetration/puncture test was used by different authors (*Lin et al., 1998; De Belie et al., 2002; Rico et al., 2007, Bajkin et al., 2011b*) to measure the force required to penetrate the carrot disc by probe. Warner-Bratzler blade was used to measure the force needed to cut through the carrot cylinder (*Lin et al., 1998; Rastogi et al., 2008; Ayhan et al., 2008*). Compression tests performed using cylinders were also used in order to determine the carrot firmness (*Vu et al., 2004; Rastogi et al., 2008*). Klaiber et al. (*2005*) used 10-blade probe and a standard Kramer shear-compression cell to measure the maximum peak force required to cut through 20 g of shredded carrots placed in the cell. Most of these experiments were carried out on the carrots processed as in industrial plants, and only few of them investigated changes of textural properties during cooking in laboratory conditions.

The aim of this research was to compare different instrumental methods for determining the textural characteristics of cooked carrots. The changes of different texture parameters during cooking were also examined in order to find the optimal cooking time in relation to carrot firmness.

MATERIAL AND METHOD

Material

Two commercial carrot samples, labelled as sample A and sample B, were purchased in market place. The samples were washed, peeled and stem end and lower part of the root (opposite to the stem end) were shredded using a meat slicer (Krups, Germany) before analysis.

Methods

For penetration test, shearing/cutting test performed with Extended Craft Knife (A/CKB) and TPA (Texture Profile Analysis), nine discs with an approximate height of 10 mm were taken; three from the upper part of the carrot root (I), three from the middle part (II), and three from the lower part (III). Height of each carrot disc was measured using a measurement tool (Vernier calliper). The discs were put in a sufficiently large volume (about 1.5 L for 9 discs) of boiling water (100 °C) for 5, 10, 15, and 20 min. After heat treatment they were immediately submersed in cold tap water for a few minutes, after which discs were put on the paper towel to soak up the water.

Texture analysis of carrot was conducted using a TA.XT Plus Texture Analyser (Stable Micro Systems, England, UK).Measurements were performed on three carrots from the each sample, using a 30 kg load cell.

Penetration test was performed with a 2 mm diameter stainless steel flat cylinder probe (P/2) (Fig. 1a). Instrumental settings were taken from the sample project (GRP1_P2) of the software package (Texture Exponent Software TEE32, version 6,0,6,0, Stable Micro Systems, England, UK), and according to published data (*De Belie et al., 2002*). The probe penetrated into the centre of carrot disc (xylem part) to a distance of 5 mm.

For the cutting/shearing test, which was carried out by Extended Craft Knife (A/CKB), carrot discs were prepared in the same way as for the penetration test (Fig. 1b). The test settings were taken from the sample project (GUM1_CKB) of the software package (Texture Exponent Software TEE32, version 6,0,6,0, Stable Micro Systems, England, UK).

TPA was performed to measure cooked carrot firmness, springiness, cohesiveness, gumminess, chewiness, and resilience at the same time. Carrot disc was placed on the heavy duty platform (HDP/90) and compressed twice with a 75 mm diameter stainless steel cylinder, using a 30 kg load cell. Instrumental settings taken from the sample project (TPA.PRJ) of the software package (Texture Exponent Software TEE32, version 6,0,6,0, Stable Micro Systems, England, UK) were modified so that the cylinder compressed the discs to 30% of their height (strain 30%) (*Sila et al., 2005*). Therefore the probe height had been calibrated to 15 mm before this test was performed.

In order to further examine the change of textural characteristics of carrot during cooking, the additional shearing/cutting tests were carried out using two types of Warner-Bratzler (WB) knife blade fixtures (Fig. 1c and d) using a 30 kg load cell. For the second test carrots were cut along the longitudinal axis in two halves before the cooking. The cooking procedure used was the same described above, with the three whole carrots or their halves cooked in 2.0 L of boiling water. The instrumental settings for the both tests were applied according to the sample project (SAU2_WBB) of the software package (Texture Exponent Software TEE32, version 6,0,6,0, Stable Micro Systems, England, UK). Path length of the both WB knives was 40 mm. Whole carrot was firstly cut at the middle, and then at the middle of the upper and lower parts for measurements by WB flat knife blade (Test 1, Fig. 1c). Test 2 was performed by WB knife blade at the middle of the carrot half, second at the middle of the upper part, and third at the middle of the lower part (Fig. 1d).

Results were expressed as the mean of replications ± SD for all measurements. Coefficient of variation (CV) was also calculated. The significant differences for each parameter between samples were determined with ANOVA and the means were compared using Duncan's multiple range tests (P < 0.05). All statistical analyses were performed using STATISTICA (StatSoft, Inc. (2011), version 10.0 (www.statsoft.com).

RESULTS AND DISCUSSION

If we compare different instrumental methods for determining the textural characteristics of cooked carrots, we can observe that the greatest difference between samples (Fig. 2) accompanied by the smallest CVs (Table 1) is obtained by measuring firmness using TPA test. The coefficient of variation is a relative measure of error because it weights the standard deviation for the size of the mean and therefore can be used for the comparison of variation from different methods or scales. In this test, the texture parameter "firmness" is defined as the peak force of the first compression of the sample (*Vu et al., 2004*). On the contrary, chewiness determined by TPA test was the least suitable parameter for determining cooked carrot texture because of very high CVs and low discrimination between different cooking times.

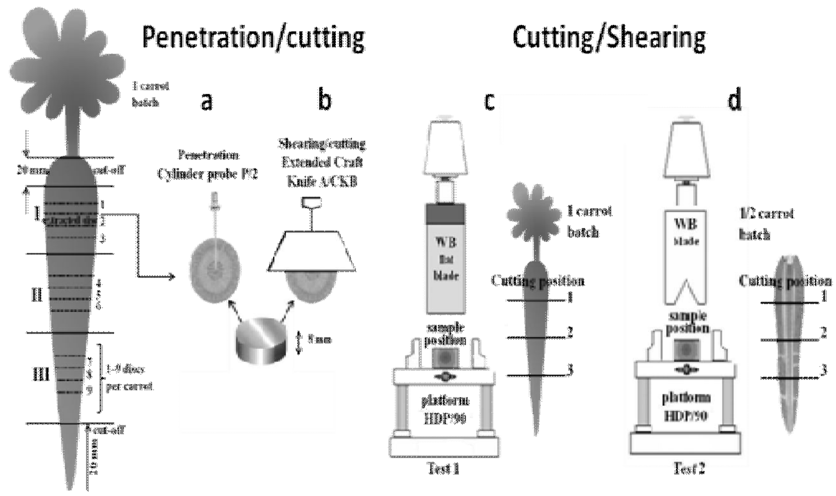


Fig. 1. Sample preparation for penetration and shearing/cutting tests using different fixtures

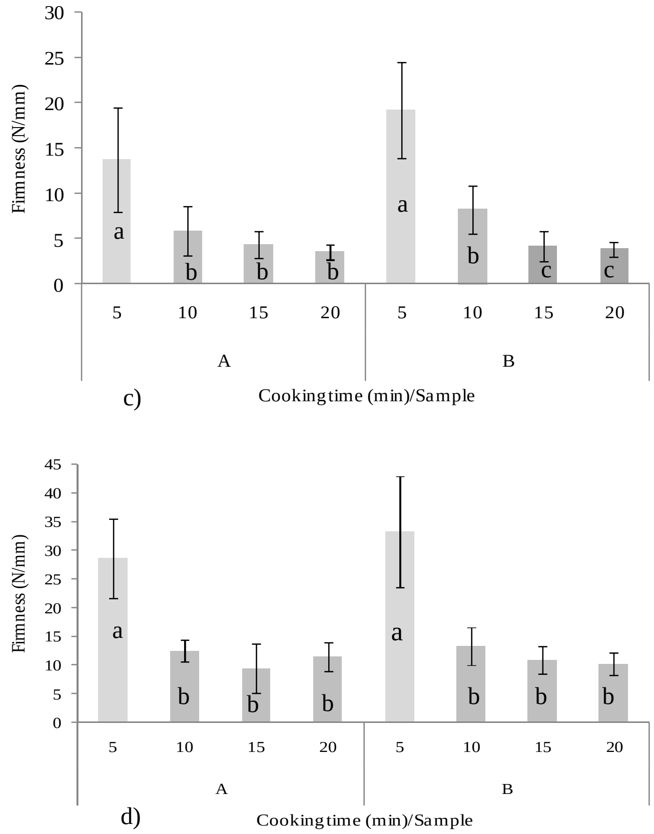
Next to the TPA test by CVs was penetration test, which differentiated 10th and 15th min of cooking of carrot sample A. This test was showed to be the most suitable for determining the texture of fresh carrots in previous researches (*Pestorić et al., 2013*). However, it should be performed in the same measuring point (xylem) in order to decrease the variation between the measurements (*Bajkin et al., 2011a, Bajkin et al., 2011b*).

Cutting/shearing tests had very high CVs, although application of craft knife blade and WB blade led to discrimination between 10th and 15th min of cooking of one carrot sample. Shearing tests are used predominantly to measure product's toughness (*Lin et al., 1998*). In presented research, tests used to determine toughness and chewiness were less reliable than tests used to measure firmness by penetration or compression. However, more samples should be tested to draw general conclusion on the most suitable method for cooked carrot texture characterization.

Change of textural parameters during cooking of carrot samples is also presented on Fig. 2. All examined texture parameters showed significant change between 5th and 10th min of cooking. However, none of them changed significantly between 15th and 20th min, indicating that optimal cooking time of carrots lies between 10 and 15 minutes. In paper published by De Belie et al. (*2002*), constant value for firmness was not obtained between 10 and 15 min of cooking. Therefore further research should include carrots cooked in smaller intervals (1 min) to find out the optimal cooking time in relation to firmness evaluated by texture analyser and trained panel assessors.

CONCLUSION

Obtained lower values of the coefficient variation for firmness determined by penetration and TPA tests have shown that these tests are most suitable for analysis cooked carrot texture. Experiments should be conducted on much larger number of representative carrot samples in order to draw general conclusions. Further research should include carrots cooked in smaller intervals (1 min) to find out the optimal cooking time and the obtained results of textural characteristics should be correlated with texture profile evaluated by an expert panel or a panel of trained assessors.



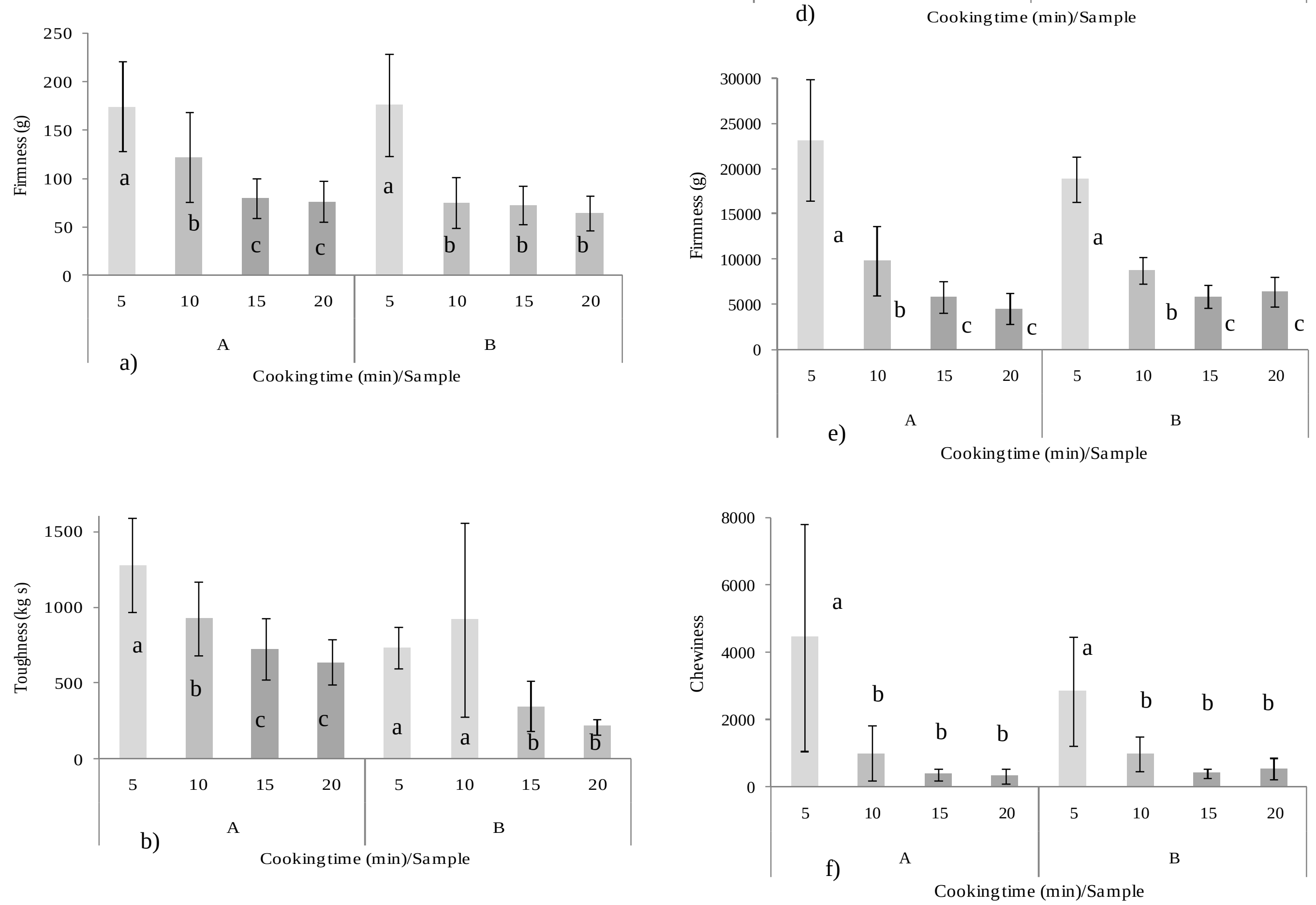


Fig. 2. Change of textural parameters during cooking of carrot samples A and B:
a) penetration test, b) craft knife shearing test, c) Warner-Bratzler blade shearing test,
d) Warner-Bratzler flat blade shearing test, e) TPA test – firmness, f) TPA test – chewiness;
columns marked with different letters indicate significant difference

Table 1. Coefficients of variation for different methods

Method/attachment	Sample A				Sample B			
	5 min	10 min	15 min	20 min	5 min	10 min	15 min	20 min
Penetration/firmness (g)	26.80	38.04	25.50	27.96	30.16	34.89	27.16	27.63
WB blade shearing/ firmness (N/mm)	41.84	47.13	33.61	24.18	27.77	32.40	39.25	23.13
WB flat blade shearing/ firmness (N/mm)	24.60	15.62	45.72	21.90	29.25	24.66	22.35	19.51
CKB shearing/ toughness (kg s)	24.47	25.94	27.82	23.74	18.73	69.66	47.17	23.35
TPA/Firmness (g)	29.14	39.45	29.81	37.70	13.45	16.95	21.61	25.22
TPA/Chewiness	76.00	83.36	51.34	70.40	57.20	54.42	36.10	57.87

ACKNOWLEDGEMENT: This paper is a result of the researches within the project III 46001 (Development and utilization of novel and traditional technologies in production of competitive food products with added value for national and global market – CREATING WEALTH FROM THE WEALTH OF SERBIA, 2011-2014), financed by the Ministry of Education, Science and Technological Development, Republic of Serbia.

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Received: 21.02.2014. Accepted: 04.03.2014.