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Original scientific paper

Influence of Heat Treatment Process on the Acceptability of Pasteurized Beetroot

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Abstract: A heat-treated beet is defined as a food that is subject to a temperature, high enough to destroy microorganisms and to preserve all the nutrients. The aim of the study presented in this paper was to investigate the effect by cooking on the properties of heat threated beetroot in the temperature range between 75 °C and 115 °C during the 40, 50 and 60 minutes of cooking. In order to determine the optimal conditions for the implementation of various heat treatment procedures consequently, was followed the influence of heat treatment conditions (temperature/time) on the composition, rheological properties, pH, color change (L*, a*, b*) and sensory characteristics during the development of the "pasteurized/sterilized" beet product. This study has shown that the optimum time and temperature for processing of beetroot is 105 °C at 50 minutes. Samples of beetroot, processed under these conditions had the best softness, the most acceptable taste and color (sensory and instrumentally determined).

Key words: beetroot, beetroot color, cooking of beetroot

Introduction

Vegetables and fruits in the diet are a special group of food. Their nutritional value is appreciated, primarily because of the content of minerals and vitamins that in the human body has a protective role (Ljubisavljević 1989; Shahid et al 2013).

Beetroot originates from the Mediterranean coast, but is grown all over the world now. The crosses of species were obtained many types of beetroot and it falls into useful medicines and vegetable crops. Beetroot (Beta vulgaris) is a long-standing herbaceous plant that has dark green leaves, and root round or conical shape, red in color and grown in gardens or planted in fields as industrial plant. Because of its medicinal ingredients, the most used is root, it contains few calories and plenty of useful ingredients, vitamins and minerals (Figiel 2010; Bhupinder and Bahadur 2014).

For feeding is used thickened root of various sorts of beetroot. The root is most often used cooked in the form of salads, sweet or sour. It is very appreciated because of its characteristic fresh taste and extremely red colour. It is believed that beetroot has a highest quality when it reaches the size of oranges (Shyamala and Jamuna 2010; Bhupinder and Bahadur 2014)

Root of beetroot is rich in carbohydrates, especially sucrose. The protein content is not expressed, but the most important amino acids are represented. It contains betaines, important for the synthesis of choline in the human body. Emphasizes the richness of mineral substances, in particular Fe, K, Mn, Zn. It is also rich in folate, soluble and insoluble fiber and antioxidants (Dolores et al 1999; Zhou et al 2009; Ninfali and Donato 2013; Daniela et al 2014).

Fruits and vegetables, as well as all other perishable products must be somehow conserved by processing. This operation in fact ensures that product can be kept for a longer period without change and that

can be used out of production season and site. Thermal treatment in terms of preserving foods, should be run at the lowest temperature and in the shortest time. In the extreme case of exceeding the required temperature, the nutrient value of the product can be partially lost (Vereš 2004; Creed 2010).

Better digestibility of the food is achieved by thermal treatment, and the way in which we prepare food affects its nutritional composition. High temperature destroys most bacteria and parasites that cause poisoning, but also eliminates many useful substances from the food, such as, for example, vitamins. Food is thermally treated in several ways - by cooking in water or by steaming, blanching, braising, baking, frying etc. (Savage and Martensson 2010; Nguyen et al 2010; Thussu and Datta 2012).

One of the products which are conserved by pasteurization is also beetroot salad. Beetroot has recently become, in some ways, very requested and appreciated vegetable culture, especially because of certain anti-cancer properties. Accordingly, it is wanted as fresh, in form of juice, and also as a highly valued salad of beetroot. Root of beetroot is intended for the production of salads, as well as other root's vegetables (Figiel 2010; Bhupinder and Bahadur 2014).

Food safety system must be priority, so that adequate preparation and thermal processing of food are becoming indispensable factors of proper nutrition. Thanks to new scientific knowledge, humans are increasingly changing their eating habits, and preparing meals has become easier, food contains more quality nutrients, and at the same time preserves the natural taste (Grujic at al 2010a; Creed 2010; Daniela et al 2014).

The aim of this paper is to investigate the influence of temperature and different methods of heat treatment process on preserving of beetroot. In order to determine the optimum processing conditions of beetroot, during these tests, beetroot processing is carried out at different temperatures in a given temperature range from 75 °C to 115 °C, as well as in different times 40, 50 and 60 minutes. After that, pH was determined, dry matter content, cook loss, sensory properties, color changes, as well as changes in hardness of beetroot during heat processing. Results of examined changes that take place during heat treatment will contribute to a better understanding of problems before and during treatment of beetroot, as well as identifying the major patterns that may adversely affect the quality of heat treated beetroot.

Materials and methods

Samples of beetroot, Kestrel F-1, were processed by treating at temperatures and times as shown in the following table:

Temperature	75°C	85°C	95°C	105°C	115°C
Time 1	40 min.	40 min.	40 min.	40 min.	40 min.
Time 2	50 min.	50 min.	50 min.	50 min.	50 min.
Time 3	60 min.	60 min.	60 min.	60 min.	60 min.
Sample	A	B	C	D	E

The basic raw material is beetroot and brine consisting of softened water, salt and acetic acid 2,5% in relation to the salt and 1,5% acetic acid, and cumin is used as a spice. Before the heat treatment beetroot is washed, peeled and cut down mechanically into slices with a thickness of 2 to 4 mm. Dosing was carried out in glass jars of 730 g. The jar is poured with prepared brine and a small amount of spices, cumin (used for eliminating land odors). Thus prepared sample is manually closed in a jar, after which it was taken on the conveyor system in a tunnel pasteurizer. When the sample is thermally processed, the following parameters were determined:

Determination of the pH. For determination of the pH is used the device Eutech Instruments pH 510. In the contents of the jars is immerse probe of the above device, on which is the pH reading.
Determination of dry matter. The dry matter is determined by the instrument HI 90813 Wine Refractometar. two to three drops of beetroot juice are applied on the prisms of device and then the value of the dry matter was read.

Cook loss is determined by the weighed raw beet before thermal processing and after thermal processing.

Sensory evaluation of the samples was done by trained evaluators. Sensory evaluation included: cross section, consistency, taste, smell and color of samples, marks were from 1 to 5. Worse property is assessed with grade 1, and the best with 5.

Determination of color. Was measured by device (Minolta Chroma Meter CR-410) with 50 millimeter diameter areas of measurement and standard illumination for beetroot (D65), calibrated for the range of colors L*, a*, b* (CIE Lab). Color was measured on the surface of a sample of raw beetroot and heat-treated beetroots.

Determination of texture properties. The texture of beet was determined instrumentally by using texturometer TA-HD Plus Texture Analyser. Hardness was determined for each temperature in the observed temperature range.

The experiment was a completely randomized design with four replications. Data were subjected to analysis of variance (ANOVA) and means were separated by Duncan's multiple range test at $p<0.05$; $p<0.01$; $p<0.001$ significance level.

Results and Discussion

The table below (Table 1) shows the results of measurements of pH and dry matter (DM) of raw beetroot and beet root, which is subjected to different heat treatment temperatures in the observed time intervals.

Table 1: Change of pH value and dry matter content during heat treatment of beetroot

Sample	pH	DM (%)
Raw beetroot	6,24	10,2
Cooked beetroot	6,35	10,0
St.Dev.	0,670	0,643
A1	4,26	8,8
A2	4,27	8,9
A3	4,26	8,4
B1	4,22	9,0
B2	4,26	9,5
B3	4,23	9,6
C1	4,27	8,9
C2	4,24	9,1
C3	4,33	9,3
D1	4,29	8,8
D2	4,29	9,0
D3	4,31	10,1
E1	4,31	9,8
E2	4,35	9,6
E3	4,32	10,9

From the table (Table 1) it can be noted that the pH value and the value of dry matter reduces during thermal processing of beetroot compared to raw and cooked beets. Also from the table it can be seen that an increase in temperature does not significantly affect pH values and dry matter content. The pH value of the raw beet was 6,24, the value of thermally processed beets ranged from 4,22 to 4,35. The reason for the change in the pH is presence of acetic acid which is added in beetroot in the form of brine. Thus, the value of the dry matter of raw and heat-treated beetroots essentially remained the same.

The table below (Table 2) shows the results of weighed samples of beetroot before and after heating. The table shows that the weight does not change too much during the heat treatment. Cook loss depends on the time of harvesting the beetroot. Depending on how much is the vegetable kept in storage, it will affect how much the beetroot will receive or release water, which has a significant impact on weight loss. In the present study it is indicated that a statistically significant cook losses changed ($p \leq 0,01$) from 0,40 to 2,04% during heat treatment.

Table 2: Cook loss change during thermal processing of beetroot

Sample	Gross g	Tara g	Net g	Yield g	Brine g	Net before pasteurization g	Cook loss %
A1	1025	300	725	445	280	732	0,95
A2	1035	330	705	460	245	712	0,98
A3	1040	310	730	450	280	733	0,40
B1	1045	310	735	455	280	740	0,67
B2	1025	300	725	500	225	732	0,95
B3	1015	300	715	470	245	728	1,78
C1	1025	310	715	485	230	729	1,92
C2	1035	310	725	480	245	734	1,22
C3	1015	310	705	500	205	715	1,39
D1	1025	305	720	475	245	735	2,04
D2	1020	310	710	490	220	719	1,25
D3	1000	310	690	480	210	704	1,98
E1	1015	300	715	470	245	725	1,37
E2	1000	310	690	460	230	702	170
E3	1010	310	700	465	235	711	1,54

The table below (Table 3) shows the results of the mean value of the sensory quality evaluation. For all modes of heat treatment the following was evaluated: color, intersection, consistency, smell and taste, ranging from 1 to 5. Weaker property was assessed lower and better with higher grades.

Table 3: Results of the mean values of sensory evaluation quality of beetroot

Sample	Color	Intersection	Consistency	Smell	Taste
A1	5.00	5.00	1.80	4.60	3.00
A2	5.00	5.00	2.00	4.60	3.20
A3	5.00	5.00	2.40	4.60	3.20
B1	5.00	5.00	2.60	4.40	2.80
B2	5.00	5.00	3.00	4.20	3.00
B3	5.00	5.00	3.00	4.00	3.40
C1	5.00	5.00	3.60	4.20	3.60
C2	4.60	5.00	3.60	4.20	3.80
C3	4.80	5.00	3.80	4.20	4.00

D1	4.60	5.00	4.40	4.20	4.40
D2	4.60	5.00	5.00	4.60	4.80
D3	4.40	5.00	5.00	4.40	4.40
E1	2.80	4.80	3.20	3.80	2.20
E2	2.40	4.80	2.80	3.80	2.20
E3	2.20	4.80	2.60	3.40	1.40
Stdv	1.006	0.082	0.984	0.350	0.925

The change of temperature and time causes changes and sensory properties of thermally processed beetroots. The best mean value of sensory evaluation has sample D2 (4,64) which is a sample of beetroot, and subjected to the temperature regime of 105 °C and a time interval of 50 minutes, and worst mean value of sensory evaluation has sample E3 (2,88) which is subjected to the temperature regime of 115 °C and time of 60 minutes.

Increasing the temperature up to 105 °C improves the consistency, and after 105 °C the consistency sharply deteriorates. At 75 °C, beetroot is very tough and durable, retains its original shape. During exposure to temperatures up to 105 °C beetroot becomes softer but stability and the original form will remain the same as at the temperature of 75 °C. Beetroot has extremely poor consistency at temperatures above 105 ° C, where the loss of its original shape and durability occur, i.e. falling apart and becoming mash.

Temperature does not affect significantly the smell of beets. The initial smell of beetroot originates from the land, where it was harvested neutralized by the addition of spices cumin. At higher temperatures, it has an unpleasant smell. Beetroot exposed to temperatures of 115°C has extremely bad taste. At these temperatures it is very distasteful, bitter and insipid. At the temperature of 105 °C beetroot shows the best flavor and juiciness. At lower temperatures from 75 °C to 95 °C it is distasteful and hard to chew.

The table below (Table 4) shows the results with a standard deviation of the color for beetroot samples parameters L *, a * and b * for all samples separately.

Table 4: Color change of thermally processed beetroot

Sample	L*				a*				b*			
	Max	Min	X	Stdv	Max	Min	X	Stdv	Max	Min	X	Stdv
A1	28,38	26,39	27,08	0,6381	11,47	8,43	9,54	0,8916	1,84	0,73	1,16	0,3124
A2	29,12	27,40	27,85	0,5206	13,14	9,28	11,18	1,2169	2,16	1,33	1,72	0,2481
A3	34,70	24,12	28,40	3,6958	7,08	4,20	5,59	0,8660	1,13	-0,31	0,41	0,4916
B1	29,04	26,83	27,48	0,6152	11,75	7,30	9,43	1,2289	1,71	1,06	1,37	0,2282
B2	40,14	26,82	30,61	4,6031	5,36	2,43	4,46	0,9138	0,73	-1,63	0,00	0,6810
B3	34,60	26,11	29,77	2,5556	16,55	7,22	12,39	2,5838	3,59	-0,05	2,18	0,9824
C1	36,52	24,90	28,74	3,6210	13,21	7,78	10,69	2,0809	3,04	0,57	1,87	0,8213
C2	35,46	26,48	28,42	2,5922	14,79	5,49	10,61	2,3069	2,81	-0,80	1,58	0,9417
C3	35,07	25,74	28,66	3,2817	12,24	5,35	8,48	2,1296	1,50	-0,64	0,81	0,6214
D1	32,67	26,35	29,29	1,9932	13,95	8,39	10,86	2,0384	2,77	0,78	1,84	0,8002
D2	30,57	25,52	28,09	1,7335	8,68	6,38	7,61	0,7298	1,80	0,72	1,23	0,3536
D3	29,78	26,23	27,66	1,0679	12,11	9,08	10,15	0,9877	2,44	1,31	1,83	0,3619
E1	28,61	27,05	27,87	0,4740	14,23	8,66	11,60	1,9452	5,61	2,93	4,11	0,8805
E2	33,61	29,83	30,66	1,1233	18,23	13,89	15,86	1,3225	7,40	5,40	6,35	0,6422
E3	34,22	28,64	29,94	1,7681	18,92	11,43	14,64	2,2363	6,90	3,97	5,17	1,0159

The parameter L * indicates lightness of the sample. The higher the value of the parameter L * the sample is brighter. From the table it can be seen that the maximum value of the parameter L* has a sample E2, which means that it is the lightest, and smallest value of the parameter L * has a sample A1, which means that it is the darkest.

The value of the parameter a* indicates the measure of red color for positive values and for negative values of the parameter a* sample is green color. From the table it can be seen that the maximum value of the parameter a* has a sample E2, which means that it is the reddest, and the lowest value of the parameter a* has a sample beetroot B2.

A positive value of the parameter b* is a measure of the intensity of the yellow color, while a negative value represents a measure of the intensity of the blue color. The table shows that the highest value of the parameter b* has a sample beetroot E2, and the lowest value of the parameter b* has a sample B2.

Table 5: Change in hardness of beetroot during heat treatment

Sample	F (kg)	D (mm)	t (s)
A1	0.823±0.105	11.572±4.166	11.573±4.166
A2	1.013±0.411	12.301±1.078	12.285±1.078
A3	0.877±0.102	10.906±1.313	10.908±1.131
B1	0.950±0.026	11.822±2.168	11.803±2.168
B2	1.001±0.259	9.831±3.522	9.832±3.522
B3	0.805±0.148	10.788±2.194	10.79±2.195
C1	0.598±0.265	13.854±1.91	13.838±1.97
C2	0.728±0.204	13.654±0.766	13.565±0.768
C3	0.555±0.021	9.268±3.095	9.27±3.096
D1	0.266±0.055	10.764±1.978	10.766±1.979
D2	0.178±0.033	9.282±3.14	9.723±3.14
D3	0.101±0.017	11.914±2.223	11.916±2.223
E1	0.092±0.036	13.061±1.696	13.63±1.696
E2	0.099±0.048	11.15±1.784	11.151±1.784
E3	0.195±0.005	11.476±0.851	11.478±0.851
Row beetroot	1.034±0.353	9.625±2.654	11.122±3.694

As shown in the table above, value of the hardness for heat-treated beetroot samples significantly decreases ($p \leq 0{,}001$) with increasing heat treatment temperature and time in the observed temperature range.

Conclusion

Thermal processing of beetroot was conducted by sterilization and pasteurization. The samples of beetroot were processed at temperatures of 75 °C, 85 °C, 95 °C, 105 °C and 115 °C, and at times of 40, 50 and 60 minutes. Heat treatment was performed in pasteurizer and autoclave. Color measurement showed intense color development in heat treated samples of beetroot than in raw beetroot. Experimental results have shown that the most intensive red color has a sample E2 that was thermally treated at 115 °C for a period of 50 minutes. Sensory analysis showed that the best grades obtain samples which were heat treated at 105 °C for 40, 50 and 60 minutes, with exception that the sample which was heat-treated at 105 ° C for a period of 50 minutes was assigned with the best grade, 4,8. Below this temperature samples were not well boiled, without satisfying flavor and juiciness, and above these temperatures the samples were decomposed

and bitter. Rheological tests showed a constant decrease in hardness with increasing temperature during the heat treatment. Considering the above, the most appropriate temperature for heat treatment of beetroot samples are in the range of 100 °C to 105 °C.

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