

Reducing and Total Sugar Content in Onion During Storage in the Republic of Macedonia

Zvezda Bogevska¹, Rukie Agic¹, Gordana Popsimonova¹,
Margarita Davitkovska¹, Igor Iljovski¹

¹Faculty of Agricultural Sciences and Food - Skopje,
Ss. Cyril and Methodius University in Skopje, Macedonia

Abstract

In Macedonia, sweet onion landrace ‘*buchinska arshlama*’ is traditionally stored during winter period from October until April. The objective of this research was to determine the content of reducing sugar and total sugar in onion bulbs during storage period in a traditional way and in cold rooms. Every month, samples were taken for chemical analysis. The results were statistically processed and tested with t-test. The average reducing sugar content in onion stored in a traditional way was 4.8%, while the average reducing sugar content in onion stored in cold rooms was 4.6%. The average total sugar content in onion stored in a traditional way was 6.0%, while the average total sugar content in onion stored in a cold room was 5.6%. These results showed that onion ‘*buchinska arshlama*’ can be successfully stored in a traditional way until the beginning of February or longer in cold rooms.

Key words: onion, ‘*buchinska arshlama*’, storage, traditional way, cold room

Introduction

Onion is a very important vegetable in the Republic of Macedonia and worldwide since it is grown in 126 countries covering 2.3 million hectares (Lawande, 2001).

According to scientific studies, from 1992 to 2002, world production of onions increased by at least 25% (about 44 million tons) compared with the period before 1992 (Griffiths et al., 2002). More recent data obtained from FAOSTAT suggest that the production of onions from 2002 to 2011 was almost doubled and amounted to about 85 million tons. Therefore, onion is the second most important vegetable after tomato. In our country onion in the last ten years is grown on an area of 3.529 ha, with a total production of 49.293 tones and an average yield of 13.97 t/ha and has an increasing trend (Statistical Yearbook of the Republic of Macedonia, 2010-2015). The importance of onion comes from its nutritional value. Generally, onion contains: moisture (88.6 to 92.8%), protein (from 0.9 to 1.6%), fat trace (0.2%), carbohydrates (from 5.2 to 9.0%), and ash (0.6%) (Lawande, 2001). The biggest part (60-80%) of the dry matter content of onion takes the non-structural carbohydrates (glucose, fructose, sucrose and fructans) (Brewster, 2008). Sugar content during storage can be affected by cultivar, storage temperature and post-harvest treatments showing either a constant or a fluctuating pattern, hence the conflicting reports in literature (Chope et al., 2007; Hansen, 1999). Also, sugar content could be correlated with the other physiological factors such as dormancy break and sprouting (Sharma & Lee, 2016). According to Sharma et al. (2015) there are two types of sugar content behavior. According to the first one, the concentration of sugar changes with storage time following a regular pattern such as a monotonous increase, decrease, or a stable behavior. Another type of behavior consists in strong fluctuations of sugar content, with the amplitude and period of fluctuations showing no regular pattern.

The research was done in order to determine the reducing and total sugar content and their pattern during storage of `buchinska arshlama` onion in a traditional way and in cold area from October until April.

Material and Methods

In order to achieve the main objective, the local landrace `buchinska arshlama` grown in the village Vogjani in Pelagonia region was chosen as material. This type of onion was stored outdoors in the yard of the farmer Igor Veljanoski and in cold rooms of the company „Altra“- Gevgelija.

The temperature in a cold room was maintained from 0 °C to 2 °C and the relative humidity was from 90% to 95% during storage period. This experiment was repeated for three consecutive years (2010-2011, 2011-2012 and 2012-2013), with storage period from October to April with two weeks of shelf life at a temperature of 14 to 16°C for onion bulbs that were stored in a cold room. The chemical analyses were done in the Centre for Public Health in Veles, R. Macedonia. Every month, samples of sound and intact bulbs were taken from storage, kept in a traditional way and in a cold room. The analyses were done according to methods from "Rulebook for carrying out a method for chemical and physical analysis due to quality control of fruit and vegetable products" published in the Official Gazette of the SFRY no. 29/83. Reducing and total sugar content were measured according to the method of Luff-Schoorl (Vračar, 2001).

This volumetric method is based on the ability of reducing sugar to convert copper (II) sulphate from Luff-Schoorl's solution in copper (I) oxide. Any unused copper (II) ions are titrated with sodium thiosulphate in order to determine sugar. Sucrose must be previously converted or hydrolysed to reducing monosaccharides with acid and then it can be determined by Luff-Schoorl's solution. Thus it can be calculated the total sugar content in the sample.

The statistics of the data obtained during the survey were done with statistical program SPSS for Windows 13.0. The analyzed parameters are displayed with descriptive statistics or mean values and standard deviation (SD). In order to test the significance of differences between the analyzed parameters, the Analysis of Variance and Student's t-test were used. For a certain level of significance, a value of $p < 0.05$ was taken; however, a value of $p < 0.01$ was taken for a high significance.

Results and Discussion

The percentages of reducing sugar for onion bulbs that were stored in the traditional way over the course of the three examined years are shown in Table 1. In 2010/2011 the average reducing sugar content was $4.692 \pm 0.49\%$, in 2011/2012 it was $4.82 \pm 0.49\%$, and in 2012/2013 the average content of reducing sugar was $5.02 \pm 0.49\%$. The differences concerning the average values of reducing sugar in 2010/2011, 2011/2012 and 2012/2013 were statistically insignificant ($p = 0.42$). The year of storage didn't have significant influence on the reducing sugar content in onion bulbs.

The average content of reducing sugar in the onion bulbs that were stored in a cold room, in 2010/2011, 2011/2012 and 2012/2013, was statistically different in terms of the level of $p = 0.017$.

Tab. 1. Reducing sugar content in onion bulbs stored in the traditional way %
Садржај редукујућих шећера у луковицама складиштеним традиционално (%)

Period of measurement <i>Вријеме мјерења</i>	2010/2011	2011/2012	2012/2013
Harvest / <i>жетва</i>	4.65	5.05	4.75
October / <i>октобар</i>	4.40	4.30	4.43
November / <i>новембар</i>	4.95	5.00	5.67
December / <i>децембар</i>	4.31	5.10	5.78
January / <i>јануар</i>	3.86	5.30	5.15
February / <i>фебруар</i>	5.42	3.86	5.05
March / <i>март</i>	5.10	5.10	4.65
April / <i>април</i>	4.85	4.85	4.68
Mean/ <i>средња</i> \pm SD	4.69 \pm 0.49	4.82 \pm 0.49	5.02 \pm 0.49
2010/11 - 2011/12 - 2012/13	Analysis of Variance/ <i>Анализа варијансе</i> F = 0.9; p = 0.42		

Tab. 2. Reducing sugar content in onion bulbs that were stored in a cold room in %
Садржај редукујућих шећера у луковицама складиштеним у хладној комори (%)

Period of measurement <i>Вријеме мјерења</i>	2010/2011	2011/2012	2012/2013
Harvest / <i>жетва</i>	4.65	5.05	4.68
October / <i>октобар</i>	4.40	4.30	4.43
November / <i>новембар</i>	4.60	4.70	4.85
December / <i>децембар</i>	4.00	4.85	4.78
January / <i>јануар</i>	3.80	5.00	4.85
February / <i>фебруар</i>	4.48	4.06	4.80
March / <i>март</i>	5.05	4.85	4.65
April / <i>април</i>	4.01	4.48	5.72
Shelf life 2 weeks on 14-16°C <i>На рафовима 2 седмице на 14-16°C</i>	3.80	4.20	5.15
Mean/ <i>средња</i> \pm SD	4.31 \pm 0.43	4.61 \pm 0.36	4.88 \pm 0.37
2010/11 - 2011/12 - 2012/13	Analysis of Variance/ <i>Анализа варијансе</i> F = 4.81 p = 0.017* 2010/2011 - 2011/2012 p = 0.25 2010/2011 - 2012/2013 p = 0.013* 2011/2012 - 2012/2013 p = 0.32		

In 2010/2011, the average reducing sugar content was $4.31 \pm 0.43\%$, which was slightly lower than the average reducing sugar content in 2011/2012 of $4.61 \pm 0.36\%$ ($p = 0.25$) and significantly lower than the average content of reducing sugars in 2012/2013 of $4.88 \pm 0.37\%$ ($p = 0.013$).

Statistically insignificant difference in the average content of reducing sugar was found in the onion bulbs that were stored in cold rooms in 2011/2012 and 2012/2013 ($p = 0.32$) (Table 2). The average values for reducing sugar content were insignificantly different concerning the traditional way of storage and storage in cold rooms for the three analyzed years ($p = 0.23$, $p = 0.33$ and $p = 0.51$) (Table 3).

Tab. 3. Tested differences in average values of reducing sugar content in onion bulbs that were stored in a traditional way and in cold rooms

Разлике у просјечној вриједности садржаја редукујућих шећера у луковцима складиштеним на традиционалан начин и у хладним коморама

Storage period <i>Складиштење</i>	Traditional storage <i>Традиционално</i> Mean/средње \pm SD	Cold room storage <i>Хладне коморе</i> Mean/средње \pm SD	t-test <i>t-тест</i>	p – value <i>p – вриједност</i>
2010/2011	4.692 \pm 0.49	4.31 \pm 0.43	1.21	0.23
2011/2012	4.82 \pm 0.49	4.61 \pm 0.36	1.015	0.33
2012/2013	5.02 \pm 0.49	4.88 \pm 0.37	0.67	0.51

Karmarkar & Joshi (1941) cited by Kukanoor (2005), Ilić et al. (2009) and Benkeblia et al. (2005) found that reducing sugar content increased during storage at low temperatures, while Kukanoor (2005) found the opposite. In our studies the content of reducing sugar during storage in a traditional way and in a cold room didn't show constant pattern neither increasing nor decreasing. The initial and final value of reducing sugar content in the traditional way of storage negligibly increased in 2010/2011 and slightly decreased in 2011/2012 and 2012/2013, whereas in the cold room conditions in 2010/2011 and 2011/2012 the content of reducing sugar was slightly decreasing while in 2012/2013 it was increasing. Reducing sugar content in our research showed amplitude and periods of fluctuations having no regular pattern. According to Sharma et al. (2015) this behavior can hardly be attributed to a known physiological process and suggests the existence of unrecognized, non-controlled but important influencing factors. It can be a function of temperature as in the study of Hurst et al. (1985), the sugar percentage monotonously decreased with time at 1°C but fluctuated at 4°C and 21°C.

Generally the total sugar content in onion bulbs is from 5.2 to 9.0% (Lawande, 2001). According to Simonov (1980), the total sugar content was 5.1% in `buchinska arshlama`. In our studies the average content of total sugar in onion bulbs of `buchinska arshlama` that were traditionally stored in 2010/2011 was 6.015 \pm 1.07%, in 2011/2012 was 5.89 \pm 0.67%, and in 2012/2013 the average total sugar content was 6.05 \pm 0.74%. The differences in

the average values of total sugar content were insignificant in the three-year research (Table 4).

The average value of total sugar content in onion bulbs that were stored in cold rooms in 2010/2011 amounted to $5.86 \pm 0.99\%$, in 2011/2012 it was $5.53 \pm 0.7\%$, and in 2012/2013 it was $5.52 \pm 0.6\%$.

The differences in the average values of the total sugar content in onion bulbs that were stored in cold rooms were statistically insignificant during the three years of research ($p = 0.6$) (Table 5).

Tab. 4. Total sugar content in onion bulbs that were stored in the traditional way in %
Садржај укупних шећера у луковицама складиштеним традиционално (%)

Period of measurement <i>Вријеме мјерења</i>	2010/2011	2011/2012	2012/2013
Harvest / <i>жетва</i>	6.59	6.78	6.68
October / <i>октобар</i>	6.50	6.20	6.17
November / <i>новембар</i>	6.00	6.08	6.78
December / <i>децембар</i>	5.17	5.60	6.27
January / <i>јануар</i>	4.40	6.00	6.46
February / <i>фебруар</i>	7.68	4.59	6.27
March / <i>март</i>	6.70	5.49	4.90
April / <i>април</i>	5.08	6.38	4.90
Mean/ <i>srednja</i> \pm SD	6.015 ± 1.07	5.89 ± 0.67	6.05 ± 0.74
2010/11 – 2011/12 – 2012/13	Analysis of Variance/ <i>Анализа варијансе</i> $F = 0.08$ $p = 0.92$		

Tab. 5. Total sugar content in onion bulbs that were stored in cold room in %
Садржај укупних шећера у луковицама складиштеним у хладној комори (%)

Period of measurement <i>Вријеме мјерења</i>	2010/2011	2011/2012	2012/2013
Harvest / <i>жетва</i>	6.59	6.78	6.68
October / <i>октобар</i>	6.50	6.20	6.17
November / <i>новембар</i>	5.10	5.59	5.17
December / <i>децембар</i>	4.37	5.30	5.07
January / <i>јануар</i>	4.88	5.60	5.17
February / <i>фебруар</i>	6.47	4.78	5.07
March / <i>март</i>	7.47	5.17	4.90
April / <i>април</i>	5.98	5.88	5.88
Shelf life 2 weeks on 14-16°C <i>На рафовима 2 седмице на 14-16°C</i>	5.35	4.50	5.58
Mean \pm SD	5.86 ± 0.99	5.53 ± 0.70	5.52 ± 0.61
2010/11 – 2011/12 – 2012/13	Analysis of Variance/ <i>Анализа варијансе</i> $F = 0.53$ $p = 0.6$		

In all three analyzed years insignificant differences in the average total sugar content were registered depending on the method of storage of onion bulbs, either the traditional way or in a cold room (Table 6).

According to Kukanoor (2005) the percentage of total sugar content increased with the increase of the storage period while in our research it didn't.

In contrast, Ilić et al. (2009) found that depending on the variety, the total sugar content slightly decreased in long-term storage (depending on storage temperature).

Tab. 6. Tested differences in the average values of total sugar content in onion bulbs that were stored in the traditional way and in a cold room
Разлике у просјечној вриједности садржаја укупних шећера у луковицама складиштеним на традиционалан начин и у хладним коморама

Storage period <i>Складиштење</i>	Traditional storage <i>Традиционално</i> Mean/средње ± SD	Cold room storage <i>Хладне коморе</i> Mean/средње ± SD	t-test <i>t-тест</i>	p – value <i>p – вриједност</i>
2010/2011	6.015 ± 1.07	5.86 ± 0.99	1.11	0.27
2011/2012	5.89 ± 0.67	5.53 ± 0.7	1.07	0.30
2012/2013	6.05 ± 0.74	5.52 ± 0.6	1.63	0.12

This was confirmed in our research if we take into account the value of total sugar content at the beginning and at the end of storage. A more recent study (Petropoulos et al., 2016) showed that total sugar content increased during storage for all the genotypes at 5 °C, apart from 'Sivan F1' where after an initial increase, sugar content decreased significantly. At 25 °C, total sugar content either increased ('Sivan F1', 'Vatikiotiko' and 'Creamgold') or slightly decreased ('Red Cross F1'). It was concluded that sugar composition was affected by genotype and storage temperature with no specific trends to be observed.

Conclusion

Based on the three-year research for storing the onion 'buchinska arshlama' in a traditional way and in a cold room, the following conclusions can be specified:

- The average values for reducing and total sugar content did not differ significantly between the traditional way of storing and storing in a cold room over the three analyzed years.
- Having in mind the losses of weigh, sprouting and rotting which were previously published (Bogevska Z. et al., 2014) and the changes of chemical composition in onion bulbs of 'buchinska arshlama' it can be

concluded that this onion landrace can be successfully stored traditionally from October to early February and then in controlled conditions (cold room) until April or longer.

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Садржај редукујућих и укупних шећера у црвеном луку током складиштења у Републици Македонији

Звезда Богевска¹, Рукие Агич¹, Гордана Попсимонова¹,
Маргарита Давитковска¹, Игор Иљовски¹

¹Пољопривредно-прехрамбени факултет Скопје,
Универзитет Св. Кирил и Методиј, Република Македонија

Сажетак

У Македонији, локална популација црвеног лука '*buchinska arshlama*' се традиционално складишти током зимског периода од октобра до априла. Циљ овог рада је било одређивање садржаја редукујућих и укупних шећера у луковицама црвеног лука током периода складиштења на традиционални начин и у хладним коморама. Сваког мјесеца, узимани су узорци за хемијску анализу. Резултати су статистички обрађени при чему је за тестирања кориштен t-тест. Просјечан садржај редукујућих шећера у црвеном луку који је складиштен на традиционални начин је износио 4,8%, док је просјечан садржај редукујућих шећера у црвеном луку који је складиштен у хладним коморама износио 4,6%. Просјечан садржај укупних шећера у црвеном луку који је складиштен на традиционални начин је износио 6,0%, док је просјечан садржај редукујућих шећера у црвеном луку који је складиштен у хладним коморама износио 5,6%. Резултати су показали да се локална популација црвеног лука '*buchinska arshlama*' може успјешно складиштити на традиционалан начин, до почетка фебруара, или у хладним коморама у дужем периоду.

Кључне ријечи: црвени лук, '*buchinska arshlama*', складиштење, хладна комора

Zvezda Bogevska
E-mail address: zvezdabogevska@gmail.com

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