

INFLUENCE OF THE NUTRIENTS PRESENT IN SUGAR BEET MOLASSES AND SACCHAROSE SOLUTIONS ON THE QUALITY OF OSMODEHYDRATED CARROT

UTICAJ NUTRITIENATA PRISUTNIH U MELASI ŠEĆERNE REPE I RASTVORIMA SAHAROZE NA KVALITET OSMOTSKI DEHIDRIRANE MRKVE

Gordana KOPRIVICA, Nevena MIŠLJENović, dr. Ljubinko LEVIĆ, dr. Tatjana KULJANIN
Tehnološki fakultet, 21000 Novi Sad, Bulevar cara Lazara
e-mail: gordanak@uns.ns.ac.yu

SUMMARY

The effect of the useful bioactive substances (carbohydrates and minerals) from osmotic solutions on the quality of osmodehydrated carrot was analysed. Saccharose solutions and sugar beet molasses, in different concentrations, were used as osmotic mediums. Osmotic dehydration was conducted at constant temperature at 55°C and atmospheric pressure. At first, the content of the analysed nutrients was examined in fresh and in osmodehydrated samples, after 1, 3 and 5 hours of immersion. During osmotic dehydration, in the samples which were treated in sugar beet molasses, the content of minerals was increased to a great extent and whereas the carbohydrate content was also increased, but slightly. Nutritively and sensorially high-quality product was made. In the carrot which was dehydrated in the saccharose solutions mineral content was greatly decreased and, at the same time, content of analysed carbohydrates was increased. Based on the obtained results, it was shown that sugar beet molasses is the more advantageous osmotic solution. The nutritive and sensory properties of osmodehydrated carrot were improved.

Keywords: osmotic dehydration, sugar beet molasses, saccharose, carrot.

REZIME

Ispitan je uticaj korisnih bio-aktivnih supstanci (ugljenohidratne komponente i mineralne materije) iz osmotskih rastvora na kvalitet osmotski dehidrirane mrkve. Kao osmotski medijumi korišćeni su rastvori saharoze i melase šećerne repe u različitim koncentracijama. Osmotska dehidratacija je izvođena na konstantnoj temperaturi rastvora od 55°C i na atmosferskom pritisku. Sadržaj ispitivanih nutritienata je određivan, najpre, u svežim a zatim i u osmotski dehidriranim uzorcima i to nakon 1, 3 i 5h trajanja imerzije. Tokom osmotske dehidratacije, u uzorcima tretiranim u melasi šećerne repe došlo je do značajnog povećanja sadržaja ispitivanih mineralnih materija kao i do blagog povećanja sadržaja ugljenih hidrata. Kao rezultat dobijen je nutritivno i senzorski vrlo kvalitetan proizvod. U mrkvi dehidriranoj u rastvorima saharoze dolazi do znatnog smanjenja sadržaja mineralnih materija uz istovremeno povećanje sadržaja ugljenih hidrata. Na osnovu dobijenih rezultata može se konstatovati prednost primene melase šećerne repe kao osmotskog rastvora. Poboljšana su kako nutritivna tako i senzorska svojstva osmotski dehidrirane mrkve.

Ključne reči: osmotska dehidratacija, melasa šećerne repe, saharoza, mrkva.

INTRODUCTION

Osmotic dehydration is the process of partial removal of water from fruits and vegetables without a phase change and is often applied as a pretreatment process, which reduces the physical, chemical and biological changes to a minimum.

In the first phase of the process, fruits and vegetables are dipped in hypertonic aqueous solution whereupon, a part of moisture flows from fruits and vegetables as a consequence of difference in osmotic pressure of water in the plant tissue and hypertonic aqueous solution, through the cell walls and surface tissue which act as a semi-permeable membrane. However, as these structures are only partially permeable, at the same time there is a diffusion of solute from osmotic solution into fruits and vegetables (1, 2).

In addition to these two dominant processes there is another occurrence – but much less dominant – a diffusion of cell juices from the plant tissue into osmotic solution which is considered to be minor but it also affects the nutritive value of osmodehydrated fruits and vegetables (3, 4, 5, 6). Partially dehydrated fruits and vegetables can be used directly in human nutrition or like a material for further drying to the appropriate moisture content (7).

The choice of the optimal hypertonic aqueous solution appears to be the key problem in osmotic dehydration. So far, the

pure saccharose, or its combinations with other sugars and sodium chloride, has been proposed as the best solute for hypertonic aqueous solutions (8, 9).

Besides saccharose, sugar beet molasses emerges as a suitable raw material for the preparation of hypertonic solutions. Sugar beet molasses is a concentrated liquid extract that is a by-product of sugar refining. Molasses has a high content of solids (around 80%) and contains, in average, 51% saccharose, 1% raffinose, 0.25% glucose and fructose, 5% proteins, 6% betaine, 1.5% nucleosides, purine and pyrimidine bases, organic acids and bases (10).

Apart from these ingredients, sugar beet molasses is a significant source of numerous micronutrients (vitamins and minerals), especially K, Ca, Na and Mg. The fact especially important is that all mineral components of molasses are in the dissolved state and that the potassium is in much greater quantity than all other cations with share of 75% (10).

Molasses also contains B-complex vitamins but does not contain fats and fibrous materials. Molasses has the humectant and antioxidant properties and influences on the activity of final products (11).

According to high content of solids and diversity of chemical composition of sugar beet molasses, the ideas of testing the possibilities of application of sugar beet molasses as osmotic medium in osmotic dehydration of fruits and vegetables as well as

testing its influence on the nutritional profile and quality characteristics of dehydrated fruits and vegetables, were imposed (7). Extensive research activities have been going on with the aim of introducing molasses as a valuable ingredient in bakery, confectionery and meat processing industry (7, 12).

In this study, the effect of nutrients, present in the sugar beet molasses and saccharose solutions, on the quality of osmodehydrated carrot was analysed.

MATERIAL AND METHOD

Material

Carrots, used for the experiment, were purchased on the local market in Novi Sad, Serbia. Prior to the treatment, the carrots were stored at temperature of 4°C and then thoroughly washed and cut into cylindrical shapes, 20mm in height and diameter with sharp apple corer. As osmotic solutions, saccharose aqueous solutions (solid content: 30%, 50% and 70%) that were prepared by mixing commercial sugar with heated distilled water (30°C) to complete solubility, were used. As another osmotic agent pure sugar beet molasses (around 80% solid content) and sugar beet molasses solutions (with 40% and 60% solid content) were used. Solutions were made by mixing pure molasses with distilled water. Sugar beet molasses was obtained from sugar factory in Bač, Serbia.

Osmotic dehydration

Osmotic dehydration was carried out at 55°C under atmospheric pressure. After measuring the initial mass, samples of carrots were dipped in the hypertonic saccharose solutions and sugar beet molasses.

Saccharose solutions had a concentration of 30% (in the study marked as S1), 50% (marked as S2) and 70% (marked as S3).

Sugar beet molasses solutions had a concentration of 40% (in the further study marked as M1), 60% (marked as M2) and pure molasses with 80% solid content (marked as M3).

Solutions were poured to 600 ml beakers which were used as containers for osmotic dehydration. The material to hypertonic solution ratio was 1:4. After dipping the samples in the osmotic solutions, the lightweights were set over them to ensure that samples were constantly dipped in the solutions. The beakers were placed in the thermostat at 55° C. The immersion lasted for 1, 3 and 5 hours. After osmotic dehydration, the samples were washed with water and gently blotted to remove excessive water from the surface. The next step was to measure the mass of the samples, analyze them and to determine dry matter content, saccharose content, content of total reducing sugar, content of invert sugar and content of some minerals (K, Na, Ca and Mg).

The samples were kept in an oven (Instrumentaria Sutjeska, Serbia) at 105° C for 24h, until constant weight was attained.

The solid content of osmotic solutions was determined by using a refractometer (13). All analytical measurements were carried out in accordance to the AOAC methods (14).

RESULTS AND DISCUSSION

The Tables 1 and 2 show the changes of solid content and the content of analyzed carbohydrates in the osmo-dehydrated carrot samples in the saccharose solutions and sugar beet molasses.

After the results shown in tables 1 and 2 were compared, it was concluded that the increased concentration of osmotic solutions (saccharose solutions and sugar beet molasses) and extended the immersion time, increased the solid content and content of carbohydrates in all osmo-dehydrated carrot samples, regardless of the type of used solution.

It is obvious that the content of dry matter markedly increased in the samples, which were dehydrated in the sugar beet molasses, i.e. better results were achieved by applying this osmotic medium. The maximum dry matter content (37.08%) was achieved by osmotic dehydration of carrots in pure sugar beet molasses (80% dry matter), after 5 h of immersion (Table 2).

Table 1. Changes of dry matter and carbohydrate content of carrots after osmotic dehydration in the saccharose solutions

Tabela 1. Promene sadržaja suve materije i ugljenih hidrata u mrkvi nakon osmotske dehidracije

Osmotic solution	Time, h	Dry matter, %	Saccharose, %	Invert sugar, %	Total reducing sugar, %
S1	0	7.60	2.00	0.82	2.93
	1	12.45	5.13	1.33	6.73
	3	15.77	7.10	1.32	8.79
	5	18.18	8.67	1.49	10.61
S2	0	10.48	2.90	0.58	3.63
	1	18.25	6.90	1.34	8.60
	3	22.98	9.75	2.11	12.37
	5	26.22	11.59	2.28	14.64
S3	0	9.41	2.60	0.68	3.42
	1	20.13	9.64	1.59	11.74
	3	25.41	13.00	2.04	15.72
	5	32.04	18.46	2.43	21.71

Table 2. Changes of dry matter and carbohydrate content of carrots after osmotic dehydration in sugar beet molasses

Tabela 2. Promene sadržaja suve materije i ugljenih hidrata u mrkvi nakon osmotske dehidracije

Osmotic solution	Time, h	Dry matter, %	Saccharose, %	Invert sugar, %	Total reducing sugar, %
M1	0	11.02	2.88	0.93	3.97
	1	19.38	5.43	1.70	7.41
	3	22.72	6.80	1.95	9.10
	5	27.26	8.48	2.43	13.72
M2	0	11.15	3.26	0.51	3.93
	1	20.10	6.29	0.86	7.48
	3	26.03	8.88	1.18	10.52
	5	30.22	11.65	1.45	16.08
M3	0	10.98	3.18	0.54	3.89
	1	20.10	6.18	1.01	7.52
	3	28.82	9.26	1.47	11.22
	5	37.08	13.44	1.94	17.61

The highest increase of saccharose content was determined in samples treated with solution S3 (15.86%) whereas the lowest increase was found after treatment with 40% sugar beet molasses (5.6%).

During the osmotic dehydration, the content of invert sugar and total reducing sugar content gradually increased, in all osmo-dehydrated carrot samples. This increase was more expressed in the saccharose solutions, especially in the solution S3, in comparison with the results obtained by applying pure sugar beet molasses (M3) and its solutions (M1 and M2).

Using the 70 % saccharose solution in the osmotic dehydration of carrots, the invert sugar content (after immersion period of 5 h) was increased by 1.75% and the content of total reducing sugar was increased by 18.3%, in relation to the non-dehydrated samples.

From all above stated, we can conclude that much higher increase of carbohydrate content occurred in the carrots that were dehydrated in the saccharose solutions than in those dipped in sugar beet molasses.

Because of obtaining higher dry matter content and lower content of the analysed carbohydrates in the carrots dehydrated in sugar beet molasses, the application of molasses as osmotic solution appears to be more advantageous. The reason is the fact that the purpose of the application of osmotic dehydration was to encourage the diffusion of water from the sample into the osmotic solution and to decrease uptake of solute (sugar) from the solution into the sample.

It is well known fact that the minerals in solution have irreplaceable importance for normal functioning and revitalization of certain elements of cells, organs and organisms of plants and animals (10).

In the Figures 1, 2, 3 and 4, the loss or increase of the content of the analysed mineral components (K, Na, Ca and Mg) in the carrots that were dehydrated in saccharose solutions and sugar beet molasses, were graphically displayed.

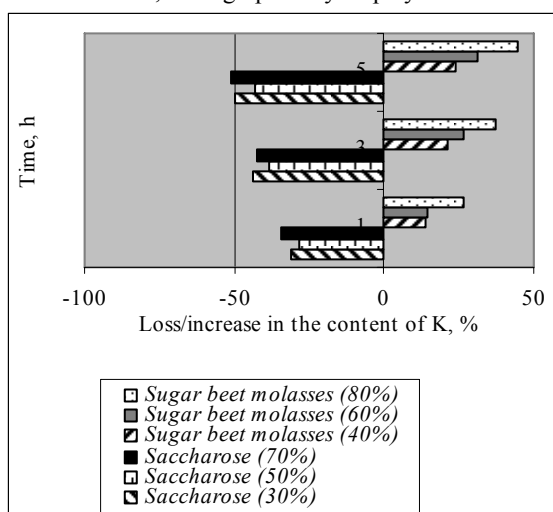


Fig. 1. Loss / increase in the content of K in the carrots during osmotic dehydration

Sl. 1. Gubitak / povećanje sadržaja K u mrkvi tokom osmotske dehidracije

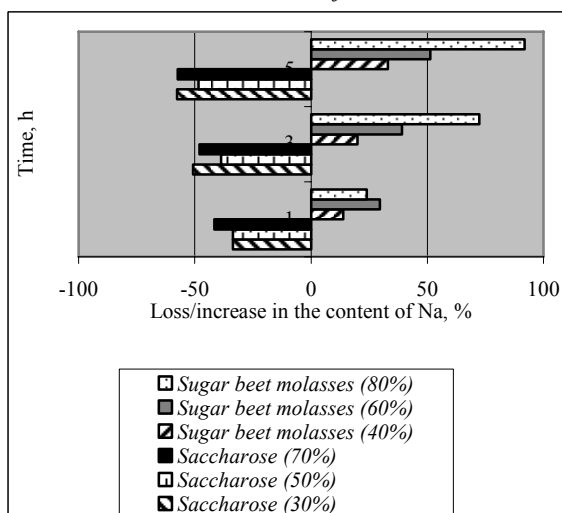


Fig. 2. Loss / increase in the content of Na in the carrots during osmotic dehydration

Sl. 2. Gubitak / povećanje sadržaja Na u mrkvi tokom osmotske dehidracije

It is evident that, in all four cases, the use of saccharose solutions decreased the content of mineral components in osmo-dehydrated carrots. On the other hand, applying sugar beet molasses, as osmotic solution, led to the gradual increase in the con-

tent of mineral substances in the carrot samples. The reason is the presence of these substances in the molasses and their diffusion into the sample during the process of osmotic dehydration.

During dehydration of carrots in the saccharose solutions (Fig. 1), the content of K was reduced more than twice as compared to the fresh, i.e. nondehydrated sample.

The highest reduction in the potassium content occurred after application of 70% saccharose solution as osmotic medium, after 5h of immersion.

The maximum increase of the K content was achieved by applying pure sugar beet molasses (M3) and expressed in percentage it was 44.46%.

It is obvious that the extension of the immersion time enhanced the reduction of Na in all samples treated with the saccharose solutions (Figure 2). Expressed in a percentage (after 5h of immersion), the maximum loss was 57.58% (S3) and the minimum was 48.32% (S2). After the first hour of immersion, the increase of Na content was the highest in the sample M2 and it was 29.61%. At the end of the osmotic dehydration, i.e. after 5 hours, the maximum increase was 91.84% in the carrots dehydrated in pure sugar beet molasses (M3).

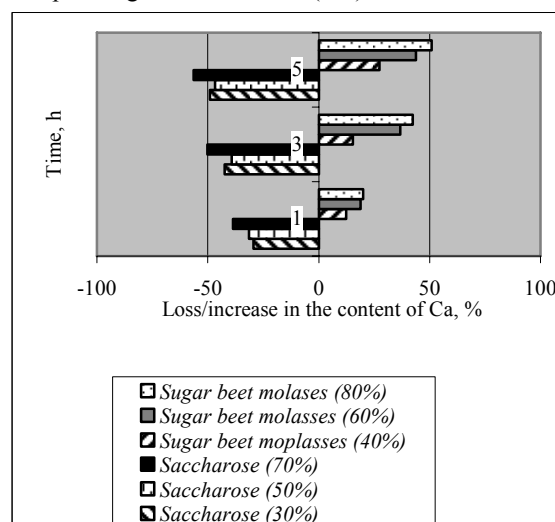


Fig. 3. Loss / increase in the content of Ca in the carrots during osmotic dehydration

Sl. 3. Gubitak / povećanje sadržaja Ca u mrkvi tokom osmotske dehidracije

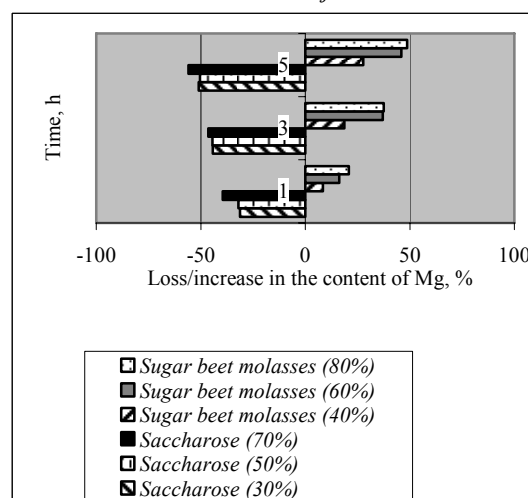


Fig. 4. Loss / increase in the content of Mg in the carrots during osmotic dehydration

Sl. 4. Gubitak / povećanje sadržaja Mg u mrkvi tokom osmotske dehidracije

The loss of Ca from the osmo-dehydrated carrots was minimal in the solution S2 (Figure 3), and after 5h of immersion it was 46.69%. The highest loss was in the sample dehydrated in pure sugar beet molasses M3 (56.37%).

The most distinctive increase in the calcium content was determined in the sample dehydrated in 80% sugar beet molasses and it was 50.88%, which means that the amount of Ca in that sample was higher for about one and half times in comparison to that in the fresh sample.

As in the previous case, the loss of Mg during the process of osmotic dehydration was the lowest in the 50% saccharose solution S2 (Figure 4). The loss of minerals was quite large and after 5 hours in the sample S3, it was 55.93%.

Analyzing the carrot samples dehydrated in sugar beet molasses after 1, 3 and 5 hours of immersion, the results indicated a significant increase in the magnesium content in the final product. The best results were achieved by applying 80% molasses as osmotic medium i.e. the sample M3. This was due to the extensive diffusion of water from the carrots and, thus, better diffusion of soluble substances into the tissue. The quantity of minerals after osmotic dehydration was about one and half times higher in comparison to those before the osmotic dehydration.

CONCLUSION

Analyzing the composition of carrots before and after the osmotic dehydration in saccharose solutions and sugar beet molasses, some advantages of applying molasses as hypertonic solution were observed.

Using saccharose solutions as osmotic medium, the dry matter content in carrots increased by about 22.63% in the case of the most concentrated solution (S3), after 5 h of immersion but in a pure sugar beet molasses (M3) the increase was somewhat higher (26.1%). Dehydration of carrots in the saccharose solutions led to a significant increase of carbohydrate content, regardless of the concentration of solutions and immersion time. Application of sugar beet molasses as osmotic solution also led to an increase of carbohydrate content, but to a lesser extent, which places molasses in front of sucrose since the aim of the experiment was not candying but drying of carrots. The largest differences were exerted in the case of most concentrated solutions used as osmotic medium.

Another advantage of sugar beet molasses as osmotic solution was the fact that the carrots, dipped in sugar beet molasses, had significantly higher content of minerals (K, Na, Ca and Mg) in comparison to those dehydrated in the saccharose solutions.

Diffusion of valuable bioactive components from molasses into carrots occurred, which contributed to the increase of their nutritive value.

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