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The possibility of increasing the antioxidant activity of celery root during osmotic treatment

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Abstract: Osmotic treatment of celery root was studied in two osmotic solutions (sugar beet molasses and a ternary solution of water, sucrose and salt), at three temperatures (20, 35 and 50 °C), and three different immersion periods (1, 3 and 5 h), at atmospheric pressure. The aim was to examine the influence of the type of the used hypertonic agent, the temperature and the immersion time on the water loss, solid gain, water activity, dry matter content, antioxidant activity (expressed by *DPPH*) and colour attributes (described by CIELAB coordinates *L**, *a** and *b**). During the experiments, the antioxidant activity of celery root was increased in sugar beet molasses, while the *DPPH* value tended to decrease in the ternary solution. The experimental data of osmotic dehydration was used for PCA modelling. The standard scores analysis revealed that the optimum process parameters were gained with an immersion time of 5 h and a temperature of 35 °C.

Keywords: antioxidant capacity; celery root; osmotic treatment; sugar beet molasses; optimization.

INTRODUCTION

From old times, celery (*Apium graveolens* L.) has been known as a special medicinal herb or spice, due to the presence of many healthful and aromatic substances.[1,2] Celery is a source of digestible carbohydrates, proteins, and high amount of dietary fibres, and proven rich in bioactive compounds, such as vitamins, free amino acids and minerals.[3,4] The main bioactive components in celery responsible for its healing properties are flavonoids (mostly apiin and apigenin), essential oils (*α*-limonene and selinene, butylphthalide, celerin, apiol and

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myristicin), organic acids (chlorogenic acid and caffeic acid), bergapten, niacin, inositol, *etc*.[5]

Presently, there is an increasing interest in phenolic compounds derived from celery, mainly phenolic acids and flavonoids, because of their strong antioxidant properties.[6] Phenolic substances are known to be the most responsible for the antioxidant activity of celery plants, thereby for their physiological functionalities, such as lowering cholesterol levels, and anti-inflammatory, antimicrobial and anticancer activities.[7] Current studies have confirmed that celery can lower blood pressure, regulate heart function, as well as the blood glucose level by stimulating the pancreas to insulin secretion, and hence, it could be used to reduce complications caused by diabetes.[8] Antioxidants in celery also possess the potential to retard lipid oxidation, which is one of the major causes of chemical spoilage of foods, and inhibit various types of oxidizing enzymes. Therefore, celery can be added to foods as a preservative, to improve nutritional quality and food safety, and to reduce the need for synthetic food antioxidants.[9,10]

Since celery is highly perishable, with a high moisture content, several drying treatments could be used to extend its shelf life. For certain fruit and vegetable products, traditional drying processes may not be satisfactory, due to texture degradation, colour alteration and nutritional loss.[11,12] The application of osmotic treatment (OT) at a mild temperature in food preservation has been widely applied as it presents many advantages as compared to traditional drying treatments.[13] The foodstuff is not exposed to high temperatures, the changes in the initial sensory characteristic are minimal, while the nutritional value and the functional properties of the product are kept on the same level, or even improved. Furthermore, OT is an environmentally acceptable and energy efficient process due to the low temperature and energy requirements and less waste material.[14,15] OT involves soaking a food, mostly fruit or vegetable, in a hypertonic solution to reduce the moisture content of the food, with minimal processing under ambient or modified environmental conditions. The driving force for water removal is the concentration gradient between the surrounding hypertonic solution and the immersed plant material.[16,17] The complex cellular structure of plant tissue acts as a semi-permeable membrane, which allows two main counter-current flows: water outflow from the plant tissue into the osmotic solution and the simultaneous migration of solids from the solution to the tissue.[18] The leaching out of the own solutes from the tissue can affect the quality of the final product to a lesser extent.[19]

The choice of the hypertonic solution depends on the expected water loss (*WL*) and solid gain (*SG*), and the sensory properties of the final food product.[20] A concentrated sucrose solution, sodium chloride solutions and their combinations are usually used as hypertonic solutions.[21,22]

Recent research showed that sugar beet molasses is a highly effective osmotic medium for the treatment of fruits, vegetables and meat. High dry matter content and high water loss, a specific nutrient composition and nutritive quality of osmo-dehydrated product, and low costs and energy requirements are a few of the main reasons why sugar beet molasses is a useful osmotic solution.[17,23]

Molasses, the thick, dark syrup obtained as a by-product from the processing of sugar beet into sucrose, consists of fermentable carbohydrates (sucrose, glucose and fructose) and several non-sugar organic materials (betaine and other amino acids; minerals, mainly potassium; vitamins, especially of the B-group, *etc*.).[24,25] Various studies evidenced that molasses is a rich source of phenolic compounds playing possible roles in the prevention of several chronic diseases involving oxidative stress. Maillard browning, carbohydrate–amino acid condensation products, formed during sugar processing are also present in very high concentrations in molasses in the range from low organic compounds to complex aromatic polymers, and they were reported to have antioxidant activities. Therefore, molasses has health benefits in the human diet, beyond its special taste and flavour, due to it being rich in minerals and antioxidants.[26,27]

The colour of any food product, depending upon the nature and content of pigment and coloured substances present in food material, may be represented in terms of the CIELAB coordinates L^*, a^* and b^* system. The L^*, a^* and b^* values explain a three-dimensional colour space. The L^* value is the vertical axis and defines the lightness, and the a^* and b^* values are perpendicular horizontal axes and define red-to-green and blue-to-yellow, respectively.[18,28]

The objective of the presented work was to investigate the effects of the type of osmotic solution, the processing time and temperature on the mass transfer phenomena during osmotic treatment of celery root in sugar beet molasses and an aqueous ternary solution. The aim was to determine the water loss (*WL*), solid gain (*SG*), water activity (a_w), dry matter (*DM*), antioxidant activity (expressed by *DPPH*) and the colour attributes (described by CIELAB coordinates L^*, a^* and b^*) as a function of the process variables and to determine the optimum conditions for the osmotic treatment.

EXPERIMENTAL

Osmotic treatment

Sugar beet molasses, obtained from the sugar factory Crvenka, Serbia, with an initial dry matter content of 85.04 % was diluted to a concentration of 80 % (this solution was marked as S_1). The aqueous ternary osmotic solution was made from 1.200 g sucrose and 350 g NaCl per kg distilled water. This solution (S_2) was diluted with distilled water to a concentration of 60 %.

Celery root (*Apium graveolens* L. var. *rapaceum*, Alabaster variety) was purchased on a local market in Novi Sad, Serbia, shortly prior to the experiment. Prior to acquisition, the samples had been stored in a sales gondola at ambient temperature. The celery root samples were cut into cubes ($1\times1\times1$ cm^3) using a kitchen knife. After preparation, the samples were measured and immersed in the hypertonic solutions. The sample to solution ratio was 1:5,

which can be considered high enough to neglect the influence of solution concentration changes during the process.

After each sampling time (1, 3 and 5 h), samples of celery root were removed from the solutions (S_1 and S_2), lightly washed with distilled water, gently blotted with paper to remove excessive water from the surface and weighed. The dry matter content of the fresh and treated samples was determined by drying the material at 105 °C for 24 h in a heat chamber (Instrumentaria Sutjeska, Croatia). The a_w values of the osmotically-treated samples were measured using a Testo 650 water activity measurement instrument (Testo, Lenzkirch, Germany) with an accuracy of ±0.001 at 25 °C.

Preparation of celery root extracts

To prepare the extracts for antioxidant analysis, fresh and osmotically dehydrated celery root samples were dried at 50 °C in a heat chamber (Instrumentaria Sutjeska, Croatia) until constant weight. The dried samples were ground to a powder using a universal laboratory mill type WZ-1 (Spolem, ZBPP, Bydgoszcz, Poland). The powder (2 g) for each sample was extracted with 200 mL of boiled water. After extraction at room temperature for 10 min, obtained aqueous extracts were filtered using Whatman No. 1 filter paper. The extracts were stored in a refrigerator (4 °C) until further use.

Determination of free radical scavenging ability by the DPPH radical scavenging assay

The antioxidant capacity of celery root during osmotic treatment was determined using the DPPH radical scavenging assay,[29] with some modifications. Briefly, 100 μL of the extract was added to 1.9 mL of 0.094 mM 2,2-diphenyl-1-picrylhydrazyl (DPPH) in methanol and made up to 2 mL, followed by vigorous vortexing. The free radical scavenging capacity of the sample was evaluated by measuring the absorbance at 517 nm after 30 min using an Evolution 300 UV/Vis spectrophotometer (Thermo Fisher Scientific, Waltham, MA, USA). The antioxidant capacity is expressed as mmol L^{-1} trolox equivalents, calculated using a calibration curve of trolox (0–1000 μM), a water-soluble vitamin E analogue. All determinations were performed in triplicate.

Investigation of the colour attributes

Colour images of the experimental results were captured by a Canon PowerShot A550 (Canon Europe Ltd., Uxbridge, UK), which is a common digital camera for home use. All the acquired images were 24 bit RGB (16.8 million colours) with a 1024×768 spatial resolution. The macro-function of the digital camera was used to cover a scenic area of approximately Ø60 mm. Samples were placed on a white paper napkin set on a flat white painted surface, inside a closed chamber, 15 cm below the digital camera. Paper napkins were used in order to avoid undesired reflection effects from chamber walls. With this setup, it was possible to capture images with negligible shadows and without specula reflections. The acquired images were transferred to a personal computer in the form of JPEG compressed image files. The images were imported to an originally developed computer program used for this investigation, and the colour data for each image were transformed to a three-dimensional array of R (red), G (green) and B (blue) values, ranging from 0–255. The frequency of colour indexes was recorded, and the maximum values were observed. Subsequently, these data were transformed to CIELAB colour coordinates, using a Java algorithm for RGB to *XYZ* and *XYZ* to Lab colour coordinates.[30]

Statistical analysis

The experimental results are expressed as means and standard deviations (*SD*) for each treatment. Collected data were subjected to ANOVA to explore the effects of the process variables. Furthermore, pattern recognition techniques, including PCA and CA, were successfully applied to classify and discriminate the different samples. An evaluation of RSM, ANOVA, PCA and CA of the obtained results was performed using Statistica® software, version 12 (StatSoft Inc. 2012, USA).[31]

The experimental data used for the analysis were derived using a Box and Behnken fractional factorial (3 level–2 parameter) design, 2 blocks, according to the RSM. Independent experimental factors for each of the five mixtures are given in Table I.

TABLE I. Independent experimental factors and their levels

Experimental factor	Symbol	Coded factor's level		
		–1 (low)	0 (centre)	+1 (high)
Time, h	X_1	1	3	5
Temperature, °C	X_2	20	35	50

The RSM equations describe the effects of the test variables on the observed responses, determine the inter-relationships between the test variable and represent the combined effect of all test variables in the observed responses.

The following second order polynomial (SOP) model was fitted to the experimental data. Eight models of the following form were developed to relate the eight responses (Y) and two process variables (X), for each of the different osmotic treatments:

$$Y_k^l = \beta_{k0}^l + \sum_{i=1}^{2} \beta_{ki}^l X_i + \sum_{i=1}^{2} \beta_{kii}^l X_i^2 + \beta_{k12}^l X_1 X_2 \text{ , } k,l \in N\text{: } k \in [1,8],\ l \in [1,2] \quad (1)$$

where: β_{k0}^l, β_{ki}^l, β_{kii}^l, β_{k12}^l are constant regression coefficients; Y_k^l is either *WL*, *SG*, a_w, *DM*, *DPPH*, *L**, *a** or *b**, while X_1 is time, and X_2 is temperature. A model describing osmotic treatment in S_1 solution is marked with $l = 1$, while treatment in S_2 is marked with $l = 2$.

Determination of normalized standard scores

In order to obtain a more complex observation of the ranking of the quality of osmotic-treated celery root, standard scores (SS) are evaluated using a chemometric approach by integrating the measured values generated from different measuring methods.

Min–max normalization is one of the most widely used technique to compare various characteristics of complex samples determined using multiple measurements, where samples are ranked based on the ratio of raw data and extreme values of the measurement used.[27] The evaluation is performed, according to following equations:

$$\overline{x}_i = 1 - \frac{\max\limits_i x_i - x_i}{\max\limits_i x_i - \min\limits_i x_i}, \quad \forall i \text{ in the case of "the higher, the better" criterion} \quad (2)$$

or

$$\overline{x}_i = \frac{\max\limits_i x_i - x_i}{\max\limits_i x_i - \min\limits_i x_i}, \quad \forall i \text{ in the case of the "the lower, the better" criterion} \quad (3)$$

where x_i represents the raw data.

Normalized scores of most of the properties were evaluated using these equations, except for the L^*, a^* and b^* parameters, which were evaluated according to the initial values, as follows:

$$\overline{x}_i = \min_i (x_i - x_0), \quad \forall i \tag{4}$$

For a sample, the sum of the normalized scores of different measurements when averaged give a single unitless value, termed as SS_i, which is a specific combination of data from different measuring methods with no unit limitation. This approach also enables the ease of employing some other sets of osmotically treated celery root samples to this elaboration in future comparisons. Standard scores were calculated and the results are given in Table II.

TABLE II. Experimental design for kinetics investigation, antioxidant activity and colour attributes during osmotic treatment of celery root and standard score analysis

Solution	Sugar beet molasses solution									Ternary solution								
Case	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Time	1	1	1	3	3	3	5	5	5	1	1	1	3	3	3	5	5	5
Temp.	20	35	50	20	35	50	20	35	50	20	35	50	20	35	50	20	35	50
SS	0.61	0.65	0.60	0.53	0.57	0.56	0.64	0.77	0.74	0.42	0.51	0.49	0.42	0.41	0.40	0.45	0.47	0.45

RESULTS AND DISCUSSION

All analytical measurements were performed in accordance with AOAC[32] and repeated three times, according to experimental plan described in Table II. The obtained results are presented in Fig. 1, which shows that the sugar beet molasses was the better solution for OT, with respect to obtaining higher values of *WL* and *DM*, and lower values of *SG* and a_w.

The maximum values of *WL* (0.78 g g^{-1} i.s.) and *DM* (63.02 %) were achieved after an immersion time of 5 h and a temperature of 50 °C. In addition, the superiority of sugar beet molasses as an osmotic solution was confirmed from the aspect of retaining and even increasing the antioxidant activity of the treated celery. OT in molasses provoked an increase in the *DPPH* values in all samples of celery root from initially 0.41 to 0.45 mM TE L^{-1}. The *DPPH* values for all samples treated in the ternary solution decreased proportionally to the increase in temperature and immersion time (from the initial 0.41 to 0.26 mM TE L^{-1}). In comparison with molasses, the use of the ternary solution in the OT of celery root could be considered less convenient, if the comparison is based on the antioxidant activity, as a general indicator of potential health effects. Enhancement in *DPPH* values in celery root treated in molasses confirmed that molasses is a rich source of antioxidants. Probably, some phenolic compounds from the molasses penetrated into the tissue of the celery during OT. Moreover, the results showed a reduction in the L^* values and an increase in the a^* values for samples treated in molasses, which indicate a darkening because of the diffusion of coloured substances from the molasses into the dehydrated samples during the process. The

penetration of coloured substances from molasses was proportional to the increasing temperature. It was found that the colour CIELAB parameters significantly correlated with the *DPPH* values. It seems that there is a relationship between the increase in the colour parameters and the antioxidant activity in the samples treated in molasses, and this is probably because some of the pigments in molasses are known for their antioxidant properties.

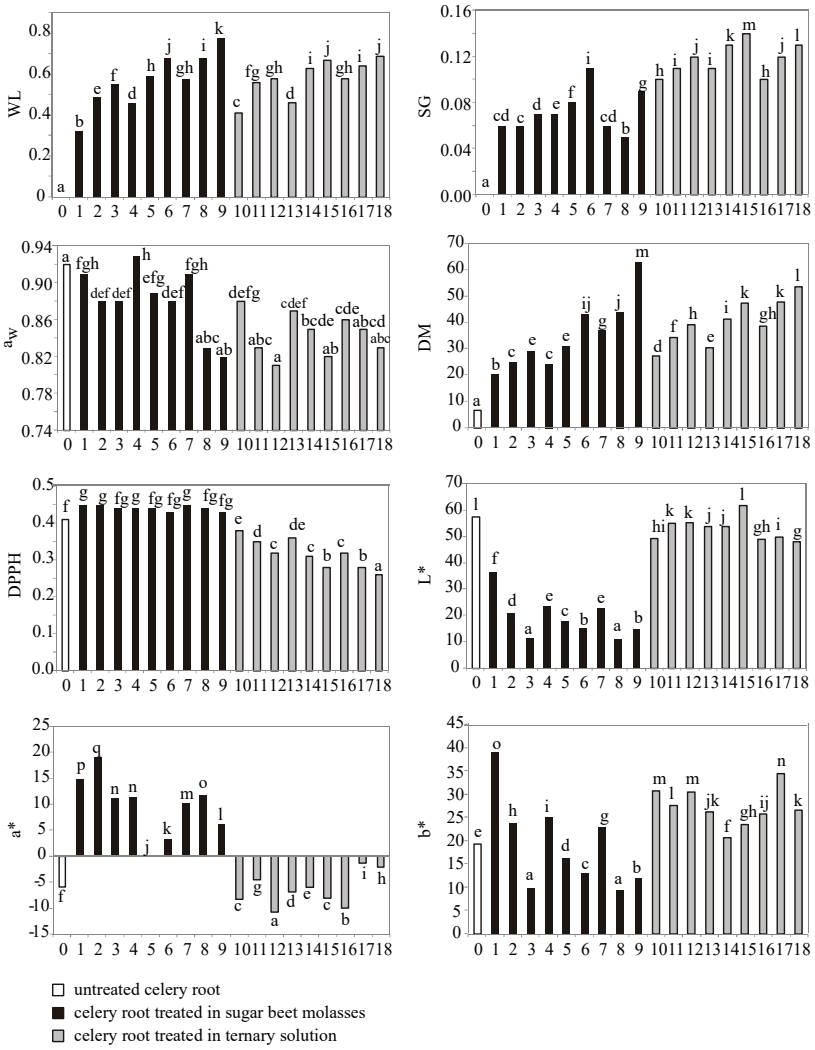

Fig. 1. Experimental results of kinetics parameters, antioxidant activity and colour attributes during osmotic treatment of celery root; *WL* – water loss, *SG* – solid gain, a_w – water activity, *DM* – dry matter content, *L**, *a**, *b** – colour coordinates. [a-q] Different letters written in superscript within the same column in the table show significantly different means of observed data (at the $p < 0.05$ level); $n = 3$. The immersion time in h is given at *x*-axes.

Principal component analysis (PCA)

Principal component analysis (PCA) is a mathematical procedure used as a central tool in exploratory data analysis.[33] PCA is a multivariate technique in which the data are transformed into orthogonal components that are linear combinations of the original variables. PCA is realized by eigenvalue decomposition of a data correlation matrix.[34] This transformation is defined in such a way that the first component has the largest possible variance. This analysis is used to achieve maximum separation among clusters of parameters.[27] This approach, evidencing spatial relationship between processing parameters, enabled a differentiation between the different samples in both solutions (S_1 and S_2).

The PCA, applied to the given data set, Fig. 1, showed a differentiation between the samples according to the observed process parameters and was used as a tool in exploratory data analysis to characterize and differentiate neural network input parameters. As could be seen, there is a neat separation of the observed samples according to used assays. The quality results show that the first two principal components, accounting for 83.14 % of the total variability for solution S_1 and S_2, could be considered sufficient for data representation. Considering the map of the PCA performed on the data, *SG* (which contributed 20.4 % of total variance, based on correlations), *DM* (12.1 %) and *L** (8.8 %) exhibited positive scores according to first principal component, whereas a_w (16.6 %) and *a** (11.8 %) showed negative score values according to the first principal component (Fig. 2). *WL* (which contributed 23.5 % of total variance, based on correlations) and *DM* (16.7 %) showed the positive influence towards the second principal component, while a negative impact was observed by the colour coordinates *L** (23.1 %) and *b** (18.7 %).

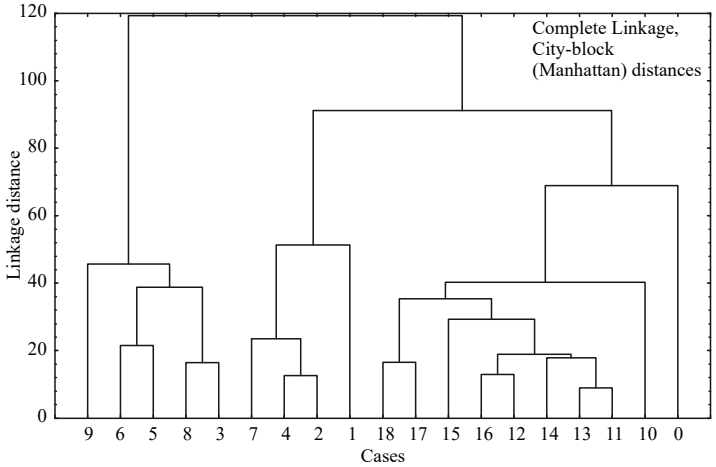

Fig. 2. Tree diagram for the osmotic treatment of celery root in the solution of sugar beet molasses and the ternary solution.

The PCA graphics show quite good discrimination between solutions S_1 and S_2. The influence of processing parameters could be observed in Fig. 3, with the samples processed for shorter immersion times and lower temperatures located at the bottom left side of the graphic. Samples treated in the sugar beet molasses solution are located at the upper left side of the graphic, showing increased *DPPH* and *a** values, while samples treated with the ternary solution showed increased colour attributes *L** and *b**. Furthermore, it is evident that *SG* is augmented for samples treated in the ternary solution, especially for samples with increased immersion time and temperature.

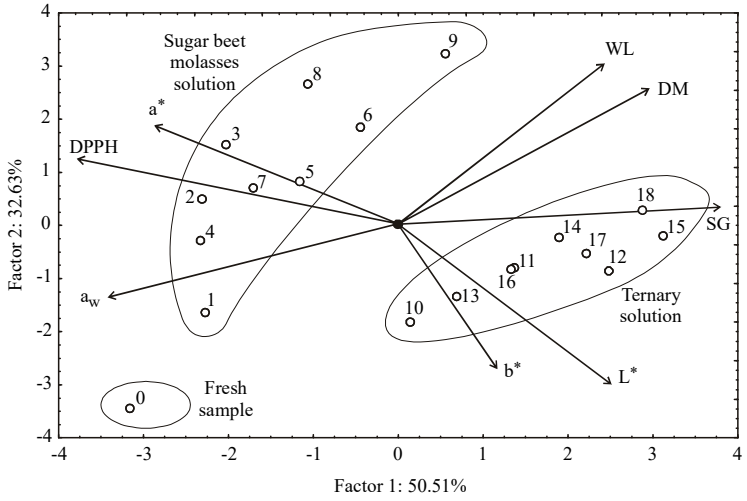

Fig. 3. Biplot graphic of the osmotic treatment of celery root in the solution of sugar beet molasses and the ternary solution.

Cluster analysis (CA)

The CA dendrogram of for the osmotic treatment of celery root in sugar beet molasses solution and ternary solution is shown in Fig. 2. The complete linkage algorithm and City block (Manhattan) distances were used as the measure of proximity among the samples. City block distances (shown on the ordinate axis) are measured as the average difference across the dimensions of the observed samples. This distance measure yields results similar to the Euclidean distance, but in this measuring technique, the effect of single large differences (outliers) is dampened (since they are not squared). The dendrogram presented in Fig. 2 is based on experimental data. The resulting dendrogram showed three main clusters; the first cluster contained samples 3, 5, 6, 8 and 9 (samples treated with the S_1 solution, with increased *DM*), the second cluster included 1, 2, 4 and 7, while the third cluster contained samples treated with the S_2 solution. The linkage distance (shown on the ordinate axis) between the main clusters was nearly 120.

Response surface methodology (RSM)

The ANOVA calculation showed the effects of the independent variables on the responses (Table III). The SOP models for all variables were found to be statistically significant and the response surfaces were fitted to these models.

TABLE III. The ANOVA calculation for the osmotic treatment of celery root in the solution of sugar beet molasses and the ternary solution; $^{+}$significant at the $p < 0.01$ level, $^{++}$significant at the $p < 0.05$ level; **significant at the $p < 0.10$ level; unmarked terms were not statistically significant; *df* - degrees of freedom; i.s. - initial sample

Parameter	*df*	*WL* g g^{-1} i.s.	*SG* g g^{-1} i.s.	a_w	*DM* %	*DPPH* mM TE L^{-1}	*L**	*a**	*b**
Sol.	1	0.0004	0.0094^{+}	0.0054^{+}	100.3^{+}	0.0679^{+}	5061.7^{+}	1183.9^{+}	317.2^{+}
T	1	0.0894^{+}	0.0001	0.0008	985.8^{+}	0.0035^{+}	91.7**	3.7	74.9**
t^2	1	0.0004	0.0012^{+}	0.0008	15.8	0.0000	20.4	69.2**	50.6
Temp	1	0.1069^{+}	0.0021^{+}	0.0086^{+}	800.4^{+}	0.0038^{+}	67.0	11.2	247.1^{+}
Temp^2	1	0.0048^{++}	0.0001	0.0005	1.1	0.0000	15.7	20.9	12.2
Sol.×*t*	1	0.0097^{+}	0.0000	0.0012**	77.0^{++}	0.0022^{+}	4.5	60.4**	56.7
Sol.×Temp	1	0.0020**	0.0001	0.0000	7.7	0.0022^{++}	249.4^{+}	32.8	211.1^{++}
t×Temp	1	0.0012	0.0001	0.0000	50.3^{++}	0.0000	13.5	12.4	46.6
Error	9	0.0042	0.0007	0.0025	73.7	0.0002	189.8	150.2	181.5
r^2	–	0.981	0.953	0.843	0.965	0.998	0.967	0.903	0.848

Linear terms of immersion time and process temperature were the most influential variables for the *WL* and *SG* calculations (statistically significant, at $p < 0.01$ level). The linear term of solution type in the SOP model was the most influential factor for *SG* calculation, as well as for the colour properties (*L**, *a** and *b**). The linear term of solution type was very important for the calculation of a_w and *DPPH*, while the linear term of process temperature in the SOP model for a_w exerted the highest impact.

The residual variance is shown in Table III, where the lack of fit represents other contributions of higher order terms. A significant lack of fit generally shows that the model failed to represent the data in the experimental domain at which points were not included in the regression.[35] All SOP models had an insignificant lack of fit tests, which means that all the models represented the data satisfactorily.

The coefficient of determination, r^2, is defined as the ratio of the explained variation to the total variation. It is also the proportion of the variability in the response variable that is accounted for by the regression analysis. A high r^2 is indicative that the variation was accounted for and that the data fitted satisfactorily to the proposed model.

The r^2 values for *WL* (0.981), *SG* (0.953), a_w (0.843), *DM* (0.965), *DPPH* (0.998), *L** (0.967), *a** (0.903) and *b** (0.848) were very good and show the good fit of experimental results to the model.

Standard score analysis

SS as the mean value of standard score transformed from the initial data generated with different methods (assays) for each item was calculated according to the following equation:

$$SS = 0.2 \cdot \left(\overline{WL} + \overline{SG} + \overline{a_w} + \overline{DPPH} + \frac{\overline{L^*} + \overline{a^*} + \overline{b^*}}{3} \right) \quad (2)$$

The maximum value of *SS* represents the optimal parameters for the processing, and the optimum for the response variables. The graphs of the dependent variables with significant parameters were obtained using an objective function to determine the optimum production conditions, plotted on an optimization graph. If the value of the membership trapezoidal function is close to 1, it shows the tendency of tested processing parameters to be optimal.

In this article, standard scores were calculated for various properties and the obtained data are presented in Table II. An *SS* above 0.60 stands for a high standard. Samples with an *SS* value below 0.60 are attributed with poorer characteristics. Using standard score analysis and the determination of the *SS* of different samples and different processing parameters can be referenced for developing strategies for improving the characteristics of the final product.

Analysis of the standard scores showed that the optimum characteristics of osmotically dehydrated celery root were realised at a temperature of 35 °C, during 5 h of treatment, with sugar beet molasses as osmotic solution (0.77), while the *SS* for osmotic treated celery root in ternary solution was quite lower (0.47). Generally, sugar beet molasses was a much better solution for osmotic treatment of celery root, according to the *SS* results and *DPPH* values.

CONCLUSIONS

Based on the presented results, it could be concluded that both solutions are adequate for effective dehydration, considering the satisfactory losses of water and decrease of the a_w values during all experiments. Since the quality of osmotically treated celery root is influenced by many parameters that are altered as the technological treatments change, standard score analysis was applied for evaluating the quality, in conjunction with PCA and CA. These analyses compiled various properties of the products. Similar results were obtained with these analyses, indicating that the osmo-dehydrated celery root samples treated in sugar beet molasses, processed at the optimal processing parameters (temperature 35 °C for 5 h), gained the best score (0.77 of 1.00). Despite the fact that molasses proved to be superior as an osmotic solution, the most important finding in this study presents its effect on increasing initial antioxidant activity of celery root. This finding increases the possibility of embedding the molasses as a natural ing-

redient in various food formulations, in spite of its unpleasant sensory characteristics. In addition, the use of sugar beet as the osmotic agent is economy and environmentally reasonable, because the molasses is a side product of the sugar industry. It could be concluded that celery root osmotically treated in molasses, with extended shelf life and improved antioxidant properties, is suitable as a food additive or functional food ingredient. As an additive to soups, yogurt, mayonnaise, sauces and other complex systems of food, it has the potential to contribute to an overall improvement of their oxidative stability, nutritional value and taste. Likewise, its use as a natural preservative could reduce the need for applying artificial preservatives, additives and antioxidants in food.

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ИЗВОД

МОГУЋНОСТ ДА СЕ ОСМОТСКИМ ТРЕТМАНОМ ПОВЕЋА АНТИОКСИДАТИВНА АКТИВНОСТ КОРЕНА ЦЕЛЕРА

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У овом раду је испитиван осмотски третман корена целера у два осмотска раствора (раствору меласе шећерне репе – S1 и тројном воденом раствору – S2), на три температуре (20, 35 и 50 °C) и три различита периода потапања (1, 3 и 5 h), при атмосферском притиску. Циљ рада је био да се покаже утицај врсте хипертоничног раствора, температуре и периода потапања на губитак воде, прираштај суве материје, активност воде (a_w), садржај суве материје, антиоксидативну активност (изражену преко *DPPH*) и боју корена целера (описану колорним координатама CIELAB, L^*, a^* и b^*). Током експеримента, антиоксидативна активност корена целера се повећавала у раствору S1, али је вредност *DPPH* имала тенденцију смањивања у раствору S2. Анализом стандардне оцене показано је да су оптимални параметри процеса постигнути при времену потапања од 5 h и температури од 35 °C.

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