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THE USE OF APPLE AND BEETROOT JUICES TO OSMOTIC DEHYDRATION OF APPLES®

Zastosowanie soków z jabłek i buraków ćwikłowych do osmotycznego odwadniania jabłek®

The article presents the possibilities of using apple and beetroot juice concentrates for osmotic dehydration of apples. The use of such concentrates or their mixtures in the process has proved even more advantageous to the commonly used sucrose. Osmotic substances that are concentrates of fruit or vegetable juices allow obtaining products with health-promoting properties. They also influence the forming of sensory features (colour, taste), which increases the attractiveness of the product in the customer's opinion.

Key words: osmotic dehydration, mass exchange, sensory properties.

W artykule przedstawiono możliwości wykorzystania koncentratów soków z jabłek i buraków ćwikłowych do osmotycznego odwadniania jabłek. Zastosowanie takich koncentratów lub ich mieszaniny okazało się nawet bardziej korzystne od powszechnie stosowanej sacharozy. Substancje osmotyczne będące koncentratami soków owocowych lub warzywnych pozwalają na uzyskanie produktów o właściwościach prozdrowotnych. Wpływają też na kształtowanie cech sensorycznych (barwa, smak), co zwiększa atrakcyjność produktu w opinii klienta.

Słowa kluczowe: odwadnianie osmotyczne, wymiana masy, właściwości sensoryczne.

INTRODUCTION

Apples are among the most popular fruits in the world. They are consumed fresh and a valuable raw material in food processing. Apples are noteworthy components in innumerable diets as being the sources of polyphenolic compounds having bioavailability such as monomeric and oligomeric flavonols (e.g. phloridzin), flavonols (e.g. quercetin), p-hydroxybenzoic acids, p-hydroxycinnamic acids and anthocyanidins [4]. Głównym kierunkiem przetwarzania jabłek jest produkcja klarownego soku i koncentratu. Około 70% zbioru stanowi surowiec do produkcji zagęszczonych soków owocowych. Z jabłek powstają również wina owocowe, przeciery, kremogeny, konserwy i susze. The red beetroots are also rich in valuable active compounds such as betanin, carotenoids, saponins [5]. The average amount of red pigment (belatains and batanins) is about 200 mg per 100 g of beetroot [14]. Red beetroot is widely used in food industry as a natural red colourant [6], and to improve the red colour of food (tomato pastes, soups, desserts, jams, sweets) [7]. Beetroot is a raw material for many products. In recent years, dried beetroot chips have appeared on the market, but they have not gained many buyers. There is no information on the use of fresh beet juice concentrate for osmotic dehydration of plant raw materials.

For osmotic dehydration, glucose, sucrose, corn syrup and sodium chloride solutions are most often used. However, excessive carbohydrate intake can contribute to negative health effects. Many health benefits resulting from the consumption of juices have been shown in the literature, including providing vitamins, fiber minerals and other bioactive substances that have a beneficial effect on the human body. Many studies have shown the positive effect of juices (fruit) on reducing the risk of cardiovascular disease, cancer and neurodegenerative diseases [3]. They showed that the use of grape juice concentrate allowed to obtain a product with a higher dry matter content and lower water activity compared to dehydrated melon in sucrose solution. Akharume et al. [1] studied the possibility of replacing the standard sucrose solution with apple juice concentrate during osmotic dehydration of fresh and frozen blueberries. It has been proven that the use of concentrate as a medium resulted in a comparable increase in the amount of

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sugar in the frozen raw material from an initial content of 12.5 to 30.3° Brix; using a sucrose solution up to 32.9° Brix.

Fruit juices can be successfully used for osmotic dehydration of plant tissue [12]. Osmotic solutions can be used in the dehydration process several times. This has benefits, because during the mass exchange some compounds contained in the dehydrated raw material the medium penetrates each other without causing losses as in a traditional process with the use of sugar or salt solutions, which also allows the enrichment of dehydrated material [16].

On the other hand, the use of fruit or vegetable concentrates allows not only to enrich products with additional bioactive ingredients, but also to shape and stabilize colour and taste, which translates into the sensory and nutritional attractiveness of the product. **The aim of the study was to examine the impact of using selected fruit and vegetable juice concentrates for osmotic dehydration of apples on their selected properties, such as mass exchange rates, water activity and colour.**

METHODOLOGY

Material

Apples of the Szampion variety provided from the Experimental Fields of the Department of Horticulture of the University of Life Sciences SGGW were used for the tests, stored in refrigeration conditions for about 3 weeks at a temperature of about 5°C and a relative humidity of 85–90%. Apples washed and hollowed out of the seed nests are cut, using an electric slicer, into 5 mm thick discs (with skin). To stop the colour changes of the samples, before dehydration were placed in a 0.5% citric acid solution at a temperature of about 20°C. For the preparation of osmotic solutions, sucrose as control and concentrates of beet and apple juices purchased from the manufacturer (Döhler Poland Company) were used. The extract content in apple and beetroot concentrates and their 1:1 mixture was approx. 73.0, 68.0 and 70.0° Brix, respectively. The water activity of these solutions was about 0.85.

Technological methods

Osmotic dehydration was carried out in a JW water bath ELECTRONIC type T-OSM enabling maintaining a constant temperature 55˚C for 0 to 180 min and shaking of samples. The process was carried out at a temperature of. The ratio of the solution to the fruit mass was 4: 1.

Table 1. Coding of osmotic dehydration assay designations used in the figures

Tabela 1. Kody próbek jabłek odwadnianych osmotycznie stosowane na rysunkach

CODE	MEANING – osmotic dehydration in:
Apple	apple juice concentrate
Beetroot	beetroot juice concentrate
Apple + Beetroot	1:1 apple and beet juice concentrates
Sucrose	sucrose solution

Source: The own study

Źródło: Opracowanie własne

Analytical methods

Determination of mass loss

Mass loss ML [%] was determined based the equation:

$$ML = \frac{m_p - m_k}{m_p} \cdot 100 \qquad (1)$$

m_p – sample mass before osmotic dehydration [g],

m_k – mass of samples after osmotic dehydration [g].

Water loss WL [g H_2O/g i. d.m.] and solids gain SG [g/g i. d.m.] were calculated on the basis of the equations:

$$WL = \frac{m_p \cdot (1 - dm_o) - m_k - \cdot (1 - dm_k)}{m_p \cdot dm_o} \qquad (2)$$

$$SG = \frac{m_k \cdot dm_k - m_p \cdot dm_o}{m_p \cdot dm_o} \qquad (3)$$

dm_o – dry matter content of raw apples [g],

dm_k – dry content of dehydrated apples [g].

Determination of the water activity was measured in the AQUA LAB CX-2 device at a temperature of about 25°C, according to the manufacturer's instructions. The dry matter content (PN-90 /A-75101/03) was carried out in a chamber drier at a temperature of 70°C for 24 hours.

Colour measurement was carried out using the Konica Minolta CR-300 chromameter in the CIE L*, a*, b* system. The results were presented as the calculation of absolute colour difference DE, reffering to the colour of the raw material (fresh apple).

For sensory evaluation, the samples were subjected to freeze-drying at 30°C and 63 Pa for 24 hours. Samples were evaluated by a team of 15 trained persons who acquainted with the methodologies for assessing individual distinctors in accordance with the standard (PN-ISO 5492: 1997). The five dried samples were evaluated on a 5-point scale.

Statistical analysis

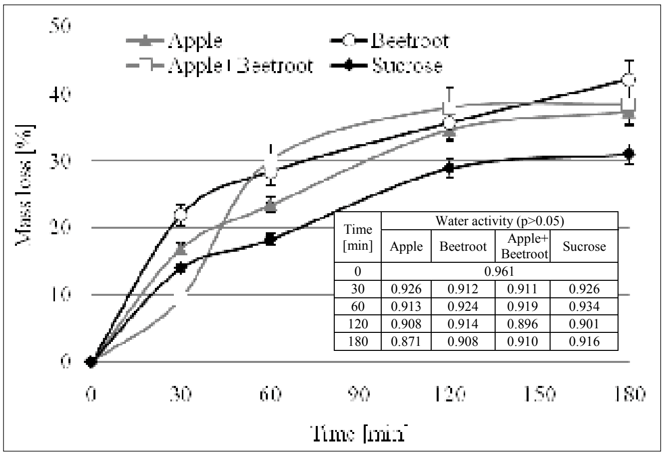
The effect of the type of osmotic solution on selected mass exchange rates and sample properties was determined by one-way analysis of variance in the Statgraphics Plus 12 PL program. Inference was made taking into account significance at the level of α = 0.05. Homogeneous groups were also determined (Fisher's post-hoc test).

RESULTS AND DISCUSSION

Mass loss of osmotically dehydrated apples

Osmotic dehydration is a process that allows partial removal of water from tissue-based material, which results in a change in mass loss.

The type of osmotic solution did not significantly affect the mass loss of dehydrated apples (Fig. 1). However, in dehydrated apples the effect of process time on the mass loss of samples was noted (Fig. 1). Analyzing mass losses throughout the entire measuring range (0-180 min), some trends were observed. Regardless of the drainage time of apples, larger mass loss concerned the use of beet juice concentrate and its mixture with apple juice concentrate. However, compared to these indications, the values obtained in apples dehydrated in sucrose solution were lower by 31–39%. With the extension of time, in the range of 0 to 180 min, there was asignificant increase in mass loss. In addition, based on the obtained homogeneous groups, it was shown that after 30 and 60 min the mass loss values were significantly lower compared to using a longer time (120 and 180 min). Kowalska [10] obtained similar result by dehydrating apples in sucrose solution. The mass loss statistically significantly depended on the duration of the process. Along with extending the time in which samples were dehydrated, their weight loss increased.



Time [min]	Water activity (p>0.05)			
	Apple	Beetroot	Apple+ Beetroot	Sucrose
0	0.961			
30	0.926	0.912	0.911	0.926
60	0.913	0.924	0.919	0.934
120	0.908	0.914	0.896	0.901
180	0.871	0.908	0.910	0.916

Fig. 1. Mass loss in osmotically dehydrated apples in apple depending on the type of osmotic solution (p>0.05) and time (p<0.05); designations as in in tab. 1.

Rys. 1. Ubytek masy w jabłkach odwadnianych osmotycznie w zależności od rodzaju roztworu osmotycznego (p> 0,05) i czasu (p <0,05); oznaczenia jak w tab. 1.

Source: The own study

Źródło: Badania własne

The initial water activity in the raw material was about 0.961 (Fig. 1). Osmotic dehydration reduced the water activity to 0.87-0.92 after 180 min, the lowest values were achieved in dehydrated fruit in apple juice concentrate. Due to the large variation in value, both the time and type of osmotic solution did not have a significant impact on the level of water activity. Similarly, Kowalska and Domurat [9] proved that under mild osmotic dehydration conditions, the water activity of dehydrated apples did not depend on the type of solution and the time of the process.

Water loss, solid gain and water activity of osmotically dehydrated apples

During osmotic dehydration simultaneously with the migration of water from tissues, the osmotic substance penetrates into the dehydrated material. During the osmotic dehydration of apples in juice concentrates and sucrose solution, there was no significant effect of the type of osmotic solution on the water loss and solid gain in the samples, only the water loss from apples significantly dependent on the dehydration time (Fig. 2). As in the case of mass loss, the use of juice concentrates resulted in a slightly higher water loss than the commonly used sucrose solution. A significant water loss was obtained from dehydrated apples, which increased significantly after 60 min and doubled or even tripled after a longer time in the range of 120–180 min.

During the osmotic dehydration of apples in sucrose solution, significant water loss occurred for 120 minutes of the process, and after a longer time changes in this indicator were low. However, dewatering of apples in juice concentrates did not show a desire to achieve a state of equilibrium, and the use of a longer time could result in a further increase in water loss. This demonstrates the possibility of using juice concentrates as osmotic solutions containing sugars and other substances of different molecular weight, which allow obtaining a comparable and even more favourable dehydration effect than sucrose solution.

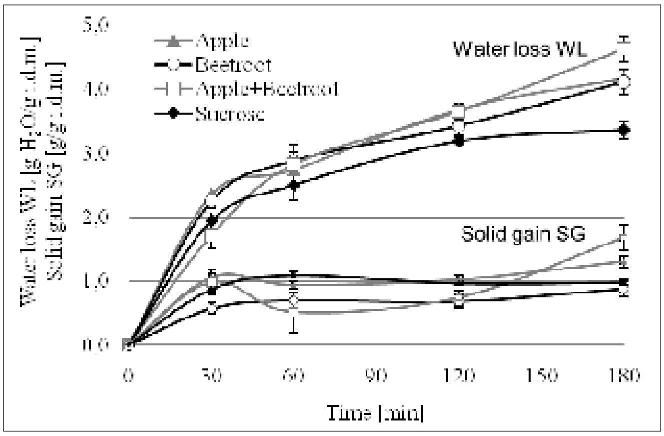


Fig. 2. Water loss in osmotically dehydrated apples in apple depending on the type of osmotic solution (p> 0.05) and time (p <0.05); designations as in in tab. 1.

Rys. 2. Ubytek wody w jabłkach odwadnianych osmotycznie w zależności od rodzaju roztworu osmotycznego (p> 0,05) i czasu (p <0,05); oznaczenia jak w tab. 1.

Source: The own study

Źródło: Badania własne

Extending the time of the process contributed to the increase in water loss, which in turn translated into a reduction in the mass loss of dehydrated apples.

Solid gain for apples was several times lower than water loss and quite various. The increase of its value was observed after 30 min (Fig. 2). After a longer time (60–120 min) there was a decrease or no change in solid gain, and after 180 min inhibition or a slight increase. In apples dehydrated in a mixture of apple and beet juice concentrates after 180 minutes, the highest value was recorded (1.68 g / g i.d.m.). Similarly, in the studies of Bchir et al. [2010] it was found that the largest increase in the value of dry matter weight gain in pomegranate seeds was achieved during the first 20 minutes of dehydration, and then the dry weight gain stabilised.

Compared with the initial water content in apples, after 180 min dehydration in sucrose solution it decreased by about 28.0 and 33.5%, while in samples dehydrated in a mixture of concentrates and apple concentrate, by about 40.0 and 50.0%, respectively. Piasecka et al. [17] proved that the osmotic dehydration process allows to remove 40 to 70% of the initial water content. Konopacka et al. [8] showed that the use of apple juice concentrate increased the drainage efficiency of apples compared to the use of other solutions. It is related to the molecular weight of the components of the solutions. Research carried out by Stawarska et al. [19] showed that apple juice contains a high content of simple sugars, in particular glucose and fructose. This chemical composition contributes to the effective penetration of dry substance into the drained samples. Cranberry juice as a rich source of polyphenols and reducing sugars was also used as an osmotic substance [2].

Colour changes of osmotically dehydrated apples

Colour is one of the most important indicators of food quality assessment. It affects the decisions taken by consumers when choosing products on store shelves. Colour measurement is also used to evaluate technological processes [21]. Under the influence of osmotic dehydration and drying of plant materials, physicochemical changes occur causing colour changes. The intensity of changes depends, among others on the duration of the process, temperature, type and concentration of the osmotic solution. Osmotic dehydration significantly changed the colour of apples (Fig. 3). The total colour change DE was determined on the basis of differences in the L *, a * and b * colour parameters between the raw material and the dehydrated apples.

Apples dehydrated in sucrose solution characterized the smallest changes in colour in relation to the raw material. They were at the level of 2.6–6.3, therefore the colour difference of these samples could be noticed (Fig. 3). As expected, in the case of apples dehydrated in beet juice concentrate or its mixture with apple juice concentrate, the values of the ΔE parameter were the highest; reached values of 70.

According to Samborska [18], increasing the proportion of dry substance in the material as a result of osmotic dehydration, it inhibits enzymatic activity, preventing the phenomenon of enzymatic browning of food, which allows the original colour of fruits and vegetables to be preserved. In addition, osmotic dehydration carried out in juice concentrates under moderate temperature (55°C) conditions resulted in an attractive colour for dehydrated fruit. Similar observations have previously been made by Kowalska et al. [11].

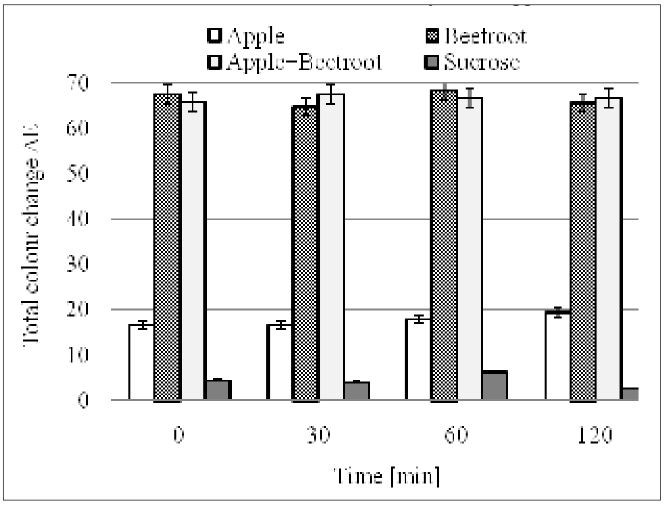


Fig. 3. Total colour change of osmotically dehydrated apples in apple depending on the type of osmotic solution ($p>0.05$) and time ($p<0.05$); designations as in in tab. 1.

Rys. 3. Bezwzględna różnica barwy jabłek odwadnianych osmotycznie w zależności od rodzaju roztworu osmotycznego ($p> 0,05$) i czasu ($p <0,05$); oznaczenia jak w tab. 1.

Source: The own study

Źródło: Badania własne

Sensory evaluation of osmotically dehydrated apples and dried by freeze-drying method

To determine the preference of dehydrated apples in the tested solutions, they were dried by freeze-drying and sensory evaluation by scaling (Table 2). It was observed that all dried samples were rated high. Of all the distinguishing features, the highest scores were obtained for dried apples dehydrated in sucrose solution and mixtures of beetroot and apple juice concentrates (4.4–4.6 points).

The parameter most differentiating all variants of samples was texture. Samples dehydrated in sucrose solution and concentrated apple juice turned out to be too soft and gummy, less attractive for consumers. The highest marks (4.7 points)

Table. 2. Sensory evaluation of osmotically dehydrated apples in apple depending on the type of osmotic solution ($p<0.05$) and time ($p>0.05$); designations as in in tab. 1.

Tabela 2. Ocena sensoryczna jabłek odwadnianych osmotycznie w zależności od rodzaju roztworu osmotycznego ($p< 0,05$) i czasu ($p >0,05$); oznaczenia jak w tab. 1.

Osmoticaly pre-treated samples in:	Appearance [point]]	Colour [point]	Texture [point]	Taste [point]	Overall quality [point]	Average
Without osmotic dehydration	4,4±0,43	4,5±0,34	4,7±0,27	4,5±0,50	4,7±0,37	4.6±0.13
Sucrose solution	4,3±0,61	4,4±0,31	3,6±0,21	4,0±0,52	4,3±0,21	4.1±0.33
Apple juice concentrate	4,0±0,35	3,5±0,54	3,7±0,43	4,2±0,40	4,0±0,27	3.9±0.28
Beetroot juice concentrate	4,2±0,51	4,0±0,47	4,2±0,52	4,2±0,40	4,1±0,47	4.1±0.09
Mixture of beetroot and apple juice concentrates	4,7±0,15	4,7±0,12	4,0±0,30	4,3±0,44	4,4±0,36	4.4±0.29

Source: The own study

Źródło: Badania własne

were obtained by samples obtained by freeze-drying without osmotic treatment. The dried apples were characterised by crunchiness and tenderness. Also other distinguishing features, i.e. taste and overall quality, indicated that this dried fruit was the most attractive to consumers. Literature data shows that freeze-dried products retains taste and aroma due to low drying temperatures [13, 15], and also has an attractive colour [20]. On the other hand, the increased sugar content resulting from the initial osmotic treatment makes it difficult the drying [12]. The dried apples subjected to the initial osmotic dehydration treatment in a mixture of beetroot and apple juice concentrates deserves attention. Samples of these dries were characterized by attractive colour, regular shape and uniform surface.

CONCLUSIONS

The use of apple and beetroot juice concentrates and a mixture of these juices in the osmotic dehydration process proved to be as or more beneficial as the widely used of sucrose solution. Simultaneously, osmotic substances in the form of concentrates of fruit or vegetable juices allow obtaining products with health-promoting properties. The use of juice concentrates for osmotic dehydration of apples enables the production of very attractive products in terms of sensory features. They influence the colour, taste, texture and increase of the content of natural ingredients present in these concentrates.

WNIOSKI

Zastosowanie koncentratów soków jabłkowego i buraczanego oraz mieszaniny tych soków do odwadniania osmotycznego jabłek okazało się równie lub bardziej korzystne niż zastosowanie powszechnie stosowanego roztworu sacharozy. Jednocześnie substancje osmotyczne w postaci koncentratów soków owocowych lub warzywnych pozwalają uzyskać produkty o właściwościach prozdrowotnych. Zastosowanie koncentratów soków do osmotycznego odwadniania jabłek umożliwia wytwarzanie produktów atrakcyjnych pod względem cech sensorycznych. Pozwala też kształtować barwę, smak teksturę oraz zwiększa zawartość naturalnych składników w suszach.

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