

OSMOTIC DEHYDRATION IN SUGAR BEET MOLASSES-FOOD SAFETY AND QUALITY BENEFITS

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Abstract

In recent year's osmotic dehydration as a method of food preservation is drawing more attention due to many advantages regarding low energy processing conditions, mild temperatures and the possibility of reusing waste material. One of the most important factors that have a major influence on the efficiency of the osmotic dehydration process is a selection of the most convenient osmotic solution. At the Faculty of Technology, University of Novi Sad, sugar beet molasses has been introduced as an osmotic solution and turned out to be very efficient for the osmotic treatment of both animal and plant row materials.

Reasons that make molasses an excellent osmotic medium are high content off dry matter (80% w/w) and specific chemical composition. Great amount of water and high aw value make food perishable and reduce its shelf life. By treating raw food material with sugar beet molasses as an osmotic solution the water content has been significantly reduced as well as aw value making food safer and longer-lasting. The microbiological profile of food material osmotically treated in molasses indicated that osmotic dehydration is a hygienically safe method and obtained products are safe for further processing. Comparing molasses with other conventional osmotic solutions it has been shown that molasses reduce the total amount of microorganisms in a larger scale than sugar and salt solution do. Sugar beet molasses has rich nutritional composition and during the osmotic process, those nutrients penetrate into treated material and improve its chemical composition, especially the content of minerals. In comparison to traditional osmotic solution osmotic dehydration treatment in molasses leads to higher amount of important minerals in both plant and animal treated material improving their functional properties.

Osmotic dehydration in sugar beet molasses has proven to be valuable not only from food safety but from food quality aspects as well.

Key words: *Osmotic dehydration, Sugar beet molasses, Food safety, Food quality.*

1. Introduction

Osmotic dehydration (OD) is an immersion process of fresh food (fruit, vegetables, herbs or meat) into a hypertonic solution during a certain time and temperature allowing spontaneous water removal from food tissues towards to the osmotic solution while solids transfer from the solution towards to the surface and the interior of the biological material [1].

OD removes water from the food samples up to a certain level, which is still high for food preservation and this process must be followed by another drying treatment (such as pasteurization, sterilization, freezing, chilling or air-drying) in order to lower water content to the required level. Mild temperatures and low energy costs of OD have influenced the process to be used frequently in food industry as a pretreatment to improve nutritional, sensorial and functional properties of raw food without changing its integrity [2, 3].

Comparing with other preservation methods, main advantages of OD are reducing losses of food sensorial properties a long with the texture improvement, increasing pigment stability, and reducing energy requirements [4]. In addition, osmotic dehydration prevents some undesirable quality changes on foods: promotes stabilization of color by reducing non-

enzymatic browning reactions and enhances the texture and flavor of the food [5].

The osmotic dehydration process is influenced by many factors connected with the type of used hypertonic solution, physicochemical properties of the osmotically treated material, and process parameters (temperature, concentration, immersion time, agitation, the ratio of osmotic solution and material) [6,7].

As far as the hypertonic solution is concerned, the most important factors are the chemical composition and the concentration of the solution. The type of osmotic solution determines the degree of diffusion during the process [8]. Among osmotic solutions commonly applied in food industry, the most frequently used are concentrated solutions of sugar (sucrose, glucose, fructose, corn syrup) applied usually for fruits, and sodium chloride used for the osmotic dehydration of vegetables and meat products, [9, 10].

2. Sugar beet molasses as an osmotic medium

Finding new use value for waste products of food industries is an important task that many technologists have set themselves in order to save the environment and reduce the production costs. Having that in mind, the researches from the Faculty of Technology, University of Novi Sad, found the new propose for the waste product of sugar industry. Sugar beet molasses has been used successfully as an osmotic solution for the osmotic treatment of: pork meat [11], chicken meat [12], fish meat [13], fruits [14], vegetables [15, 16], and herbs [17].

Sugar beet molasses has all the necessary properties (high dry matter content and rich nutritive composition) to be a successful osmotic solution by providing high driving force for the water removal during the process of the osmotic dehydration. Reasons that what set it apart from other conventional osmotic mediums are its specific chemical composition, sensory properties and low cost.

Table 1 provides an overview of just the basic chemical composition of the sugar beet molasses that has been used at the Faculty of Technology Novi Sad, University of Novi Sad, while the chemical composition of sugar beet molasses is extremely complex, considering the fact that it contains over 200 different inorganic and organic compounds [18].

Sugar beet molasses has dark brown color that is produced mainly by melanoidins (from Maillard reaction of carbohydrates with amino groups), caramels from overheated sugars, and invert degradation products of alkaline hydrolysis [19].

Table 1. Basic chemical composition of sugar beet molasses used in the research [18]

Chemical parameter	Sugar beet molasses
Dry matter, (%)	85.04
Water, (%)	21.26
Proteins, (%)	10.15
Total phosphates, (%)	0.28
Total ash, (%)	8.46
Fat, (%)	0.10
NaCl, (%)	0.06
Sucrose, (%)	49.11
K, mg/100 g	3311.96
Na, mg/100 g	368.15
Mg, mg/100 g	39.69
Fe, mg/100 g	5.32
Calcium, mg/100 g	296.22

The specific smell and complex taste of sugar beet molasses have great effect on the osmotically treated samples and need to be modified in the process of product finalization.

In order to increase the efficiency of osmotic dehydration, along with cutting the cost and protecting the environment, it was worked on multiple uses of sugar beet molasses as hypertonic medium. According to the literature, the same sugar beet molasses, in spite of reduction in solid content and without the change of the quality of dehydrated product, can be successfully used as an osmotic solution five times in a row [20].

2.1 Change in microbiological profile of osmotically treated food

The high water content and high water activity (a_w) value of food make it a perishable and desirable substrate for the development of microorganisms. Osmotic treatment in sugar beet molasses leads to significant reduction of water content and a_w value making the food material longer lasting and microbiologically safe [18].

Table 2 shows comparison of a_w value of fresh and osmotically dehydrated samples of different meat in sugar beet molasses (80%) after 5 hours of the osmotic dehydration process at 50 °C. Sugar beet molasses has proved to more than efficient for reducing a_w value of all samples. After the process of osmotic dehydration in sugar beet molasses, a_w values of dehydrated meat samples are lower than the limit values for growth of the most microorganisms [18], which is a clear indicator of the positive impact of osmotic dehydration process on microbiological profile of osmotically dehydrated meat.

Sugar beet molasses as an osmotic solution leads to significant reduction of total number of microorganisms during osmotic dehydration process of different food material as numerous research have shown Table 3. Due to its viscosity and high content of dry matter sugar beet molasses is unfavorable medium for the microorganism's growth. The reduction for the presented microorganisms in samples is higher at lower processing temperatures thus higher viscosity

of sugar beet molasses [24].

The results presented in Table 3 confirm high production hygiene of the osmotic dehydration treatment in sugar beet molasses. Other, more conventional osmotic solutions also reduce the number of presented microorganisms in food samples during the osmotic treatment, however in much lower volume than sugar beet molasses does [27, 28, and 29].

According to Chen *et al.*, [30], phenolic compounds, flavonoids and phenolic acid compounds in sugar beet molasses have demonstrated significant antibacterial activities against the foodborne bacteria *S. aureus*, *L. monocytogenes*, *E. coli* and *S. typhimurium*, due to impaired cellular proteins and physiological and morphological changes in bacterial cells.

Microbiological profile of the osmotically treated food in sugar beet molasses indicates that the obtained semi product is safe and stable for further technological processing.

Table 2. Water activity value of different meat samples prior and after osmotic treatment in sugar beet molasses

Parameters	Meat samples					
	Fresh pork [21]	Pork dehydrated in sugar beet molasses [21]	Fresh fish [22]	Fish dehydrated in sugar beet molasses [22]	Fresh chicken breast [23]	Chicken breast OD in sugar beet molasses [23]
a_w value	0.936	0.871	0.944	0.845	0.936	0.809

Table 3. The influence of osmotic treatment in sugar beet molasses on microbiological profile of different food samples

Sample	Total number of bacteria (cfu/g)	Enterobacteriaceae (cfu/g)	Escherichia coli (cfu/g)	Salmonella spp. (cfu/g)	Coliform bacteria (cfu/g)	Sulphite-reducing clostridia (cfu/g)
Raw wild garlic [24]	$(22 \pm 2) \times 10^5$	$(64 \pm 4) \times 10^2$	$(11 \pm 1) \times 10^2$	Negative	$(16 \pm 2) \times 10^2$	-
Wild garlic OD in molasses [24]	$(11 \pm 1) \times 10^3$	$< 10 \pm 0$	$< 10 \pm 0$	Negative	$< 10 \pm 0$	-
Fresh fish meat [22]	$(6.6 \pm 3.4) \times 10^5$	-	Negative	-	-	< 10
Fish meat OD in molasses [22]	$(4.23 \pm 2.6) \times 10^4$	-	Negative	-	-	< 10
Fresh pork meat [25]	$(4.33 \pm 0.31) \times 10^5$	$(1.93 \pm 0.25) \times 10^2$	Negative	Negative	-	-
Pork meat [25]	$(2.17 \pm 0.12) \times 10^4$	(0 ± 0)	Negative	Negative	-	-
Fresh cabbage [26]	$(2.1 \pm 0.02) \times 10^3$	< 10	< 10	Negative	-	< 10
OD cabbage in molasses [26]	$(2.1 \pm 0.02) \times 10^3$	< 10	< 10	Negative	-	< 10

2.2 Influence of sugar beet molasses solution on sensorial and nutritional properties of osmotically treated food

By using instrumental analysis to monitor color and texture of fresh and osmotically treated samples of pork meat in different osmotic solutions it was observed that the process of osmotic dehydration leads to deterioration of textural profile of samples as a consequence of reduced water content. However, the best textural properties of dehydrated meat were noticed at the samples dehydrated in sugar beet molasses due to complexity of its chemical composition [31].

The nutritive profile of dehydrated pork meat after the use of sugar beet molasses (80%) as an osmotic solution has been improved in terms of higher mineral content especially K [32]. Osmotic dehydration in sugar beet molasses leads to a percentage increase of some components of chemical composition of pork meat: protein for 10.47%, fat for 2.95%, NaCl for 0.24%, sucrose for 11.70%, phosphate for 0.15%, K for 1.08%, Na for 0.68%, Mg for 0.02%, Ca for 0.08% and Fe for 0.00115%, in comparison to a fresh meat [33].

Osmotic treatment in sugar beet molasses has a major effect on sensorial properties of treated food. For example, in fish meat (*Carassius gibelio*) samples it has been noticed the change in flavor, color and taste after osmotic treatment in solution containing sugar beet molasses. Considering the facts that sugar beet molasses contains high amounts of melanoidins and other products of caramelization, the dark color of molasses positively affects the change of color of fish meat samples. This can be applicable in the practice as a substitute to harmful nitrite salts that are commonly used for this purpose. Correction of aroma and taste of the samples is necessary in the process of finalizing the product. Various spices, herbal extracts and aromas can be added to the samples to improve final product [18, 34].

Osmotically treated samples in sugar beet molasses can be used to obtain various products. One of potential use of osmotically treated semi product is as addition to fruit yogurt. For instance, osmotically treated apple cubes in sugar beet molasses as an addition (10%) to fruit yogurt improve nutritional value and sweetness of the product [35].

Osmotically treated food material has a great possibility of its application in the baking industry. By adding osmotically dehydrated wild garlic in sugar beet molasses to the biscuits their chemical composition has been improved, where proteins, total sugars, cellulose, ash, Zn, Cu and Fe were increased in amounts of: 1.86, 3.2, 15.8, 5.76, 2.75, 15.33, and 15.84 %, respectively in comparison to the biscuits with added fresh wild garlic [36].

Osmotically treated products have satisfactory influence on the texture attributes (the crust and crumb of the sample appeared to be the softest) when the breads are supplemented with 5 and 10% of fruits/vegetables treated by osmotic dehydration in sugar beet molasses [37].

Studies have shown that the addition of apple, osmosehydrated in sugar beet molasses, as a supplement in bakery products (bread and cookies) could provide positive impact on their color (natural light brown color) and on pleasant sweet taste that comes from molasses [38].

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3. Conclusions

- Sugar beet molasses has proved to be excellent osmotic medium for osmotic treatment of various food samples in terms of reducing water content and a_w value.
- Utilization of sugar beet molasses for osmotic treatment of different food material provides hygienically safe process and obtained semi product is microbiologically safe for further technological finalization.
- Sugar beet molasses improves nutritional and quality aspects of osmotically treated fruits, vegetables, meat and fish. Osmotic treatment in sugar beet molasses provides enhanced quality characteristics of semi products with huge possibility for application in numerous food industries.

4. References

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