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INFLUENCE OF OSMOTIC SOLUTIONS ON EFFICIENCY OF OSMOTIC DEHYDRATION TREATMENT AND SENSORIAL PROPERTIES OF FISH MEAT (*CARASSIUS GIBELIO*)

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Abstract

Osmotic dehydration is well known method that decreases water content of food materials by immersing them in concentrated osmotic solutions. Many different factors have influence on efficiency of the osmotic dehydration. Among process temperature, time and solute concentration, the type of osmotic agent was found to be one of the most significant factors affecting osmotic dehydration process.

Osmotic drying treatment of fish meat (*Carassius gibelio*) was performed for 5 hours in three different osmotic solutions (sugar beet molasses (S1), aqueous solution of sodium chloride (S2) and sucrose and combination of these solutions in a 1 : 1 ratio (S3) under atmospheric pressure, at constant solution temperature of 20 ^{0}C. The main objective was to examine the influence of different osmotic agents on the efficiency of osmotic treatment and sensorial quality of dehydrated semi-product. The efficiency of osmotic treatment was monitored by determining significant kinetic parameters: rate of water loss (RWL), rate of solid gain (RSG), rate of weight reduction (RWR) and dehydration efficiency index (DEI), after 1, 3 and 5 hours of dehydration.

According to the results, all three osmotic agents were effective in reducing water content of the samples and the diffusion occurred most rapidly during the first 3 hours of the process. Using descriptive sensory analyses four quality factors of the fish meat samples were estimated: color, aroma, taste and aftertaste. The results obtained for fresh and dehydrated fish meat in three different solutions were compared. Sensory evaluation of dehydrated fish samples has found that the process of osmotic dehydration greatly affects the change of sensory descriptors.

It can be concluded that osmotic dehydration is the most intensive at the beginning of treatment and all three solutions are satisfying osmotic agents. Solutions containing sugar beet molasses (S1 and S3) had greater effect on sensorial quality factors of fish meat.

***Key words**: Osmotic dehydration, Fish meat, Sensorial properties, Sugar beet molasses.*

1. Introduction

Osmotic dehydration process has received greater attention in recent years as an effective and simple method that facilitates preservation of fruits, vegetables and meat [1]. Water removal in liquid form, the application of mild temperatures and the ability to reuse osmotic solution are the main advantages of the process of osmotic dehydration in comparison with other methods of drying [2].

Process of osmotic dehydration involves the immersion of the food material in concentrated solutions where both partial removal of water from the samples and solid uptake form osmotic solution are obtained [3]. Driving force for osmotic dehydration process is the difference in osmotic pressure between the surrounding solution and submerged samples. During osmotic dehydration, water from the sample tissue, flows out into the osmotic solution while osmotic solutes diffuse from the solution to the tissue. Simultaneously, third transfer process takes place, leaching of tissue's own solutes into the osmotic solution, but it is quantitatively negligible compared to the first two transfers [4].

The type of osmotic medium is very significant factor that determines the rate of diffusion during the process of osmotic dehydration. The common osmotic agents are: sucrose, glucose, sorbitol, glycerol, glucose syrup, corn syrup and fructo-oligosaccharide [5, 6]. Multi-components salt-sugar aqueous solutions with salt as a main component have been successfully used for osmotic treatment of meat or fish. However in some countries are well-known sweet salted fish products obtained by immersion in salt and sweet hypertonic solutions [7, 8].

Current research has shown that sugar beet molasses represents an excellent osmotic medium for dehydration process, primarily due to the high content of dry matter (80%), which provides high osmotic pressure in the solution as well as the specific chemical composition characterized by high contents of vitamins, minerals, antioxidants and betaine [9].

Melanoidins and caramelization products affect the appearance of dark colour of molasses and due to dominant component of molasses - sucrose (51%) and numerous micronutrients, especially: potassium, calcium, iron, magnesium, sodium, and vitamin B complex, sugar beet molasses has complex taste [10].

During the proces of osmotic dehydration besides decrease of water content, solid uptake form osmotic solution is obtained and it has major impact on sensorial properties of dehidrated sample [4].

Sensory analysis is a standard and accepted method to evaluate the quality of fish meat. With this analysis is possible to evaluate multiple parameters at once, but the lack of sensory analysis is subjectivity, because it depend on the individual assessment of personal attitudes, as well as the different difficulties during the assessment of the product/s [11].

This study was aimed at investigating the influence of different osmotic solutions and immersion times at room temperature on the efficiency of osmotic dehydration process of fish meat by defining the rate of mass transfer during the process. Sensorial quality of dehydrated fish semi-product was evaluated after the osmotic dehydration process to determine the acceptability of the resulting intermediate products.

2. Materials and Methods

2.1 Osmotic dehydration

The osmotic dehydration was carried out in laboratory jars under atmospheric pressure at constant solution temperature of 20 ^{0}C. Fish *(Carassius gibelio)* was purchased on a local market in Novi Sad, Serbia, shortly prior to the experiment. The initial moisture content of untreated samples was 75.34%. Fish samples were filleted and cut into shapes (1 x 1 x 0.5 cm) using kitchen slicer and scissors.

Sugar beet molasses was obtained from the sugar factory Crvenka, Serbia with initial dry matter content of 85.04% w/w, and with distilled water it was diluted to concentration of 80% w/w (solution S3). Osmotic solution-S1 was water solution of sodium chloride and sucrose concentration of 70%w/w, while osmotic solution-S2 was mixture of two other osmotic solutions (S1 and S3) in mass ratio of 1 : 1. After preparation, samples were measured and immersed in hypertonic solutions. Sample to solution ratio was 1 : 5 (w/w) which can be considered high enough to neglect the changes of solution concentration during the process.

On every 15 minutes, the fish samples in osmotic solutions were stirred to provide better homogenization of the osmotic solution, considering the amount of diffused water from the samples. After 1, 3 and 5 hours fish samples were taken out from solutions, lightly washed with distilled water, gently blotted with paper to remove excessive water from the surface, and weighed. Dry matter content of the fresh and treated samples was determined by drying the material at 105 ^{0}C for 24 hours in a heat chamber (Instrumentaria Sutjeska, Croatia). All analytical measurements were carried out in accordance to [12].

In order to describe efficiency of osmotic dehydration process, the experimental data for three key process variables were used: the moisture content, the change in the weight, and the change in the soluble solids. Using these, significant kinetic parameters: rate of water loss (RWL), rate of solid gain (RSG), rate of weight reduction (RWR) and dehydration efficiency index (DEI) were calculated as described by Koprivica *at al.*, [13].

2.2 Descriptive sensory analysis

Descriptive sensory evaluation of osmotic dehydrated meat fish was carried out according to SRPS ISO 11035:2002 [14].

Fresh and osmotic dehydrated fish were evaluated by a panel of six members. Assessors are trained and were familiar with the specific sensory properties of dried fish meat, and guidelines for the selection, training and monitoring of assessors was applied (SRPS ISO 8586-1:2002 [17]).

The evaluation was performed in the laboratory with cabins equipped according to SRPS EN ISO 8589:2012 [16].

Panelists have identified the descriptors shown in Table 1 and formed a descriptive profiles, during training assessments of sensory properties of dried meat fish in all three osmotic solution. Then, the selected descriptors for: color, aroma, taste and aftertaste were rated using 5-point intensity on a scale where: 0 stands for: it is not observed, and 5 stands for: it is strong compared to the selected property.

Table 1. Descriptors, definitions and standards of descriptive sensory analysis

Descriptor	Definition
Color D1	
1. Whitish gray	Typical color of fresh fish meat *(Carassius gibelio)*
2. Brownish red	The meat is intense brown with a tone of red
Aroma D2	
1. Fish complex	Typical aroma of fresh fish perceived through smell
2. Smoky	Perception of any type of smoke aroma
3. Molasses	Aroma associated with molasses: has a sharp, slight sulfur and/or caramelized character
4. Caramelized	Sweet aromatic, characteristic of browned sugars and some other carbohydrates
Flavor D3	
1. Fish complex	Typical aroma of fresh fish meat perceived through smell
2. Sweet	Level of sweetness (not to very sweet)
3. Salty	Level of salinity (not to very sweet)
Aftertaste D4	
1. Bitter	The taste on the tongue associated with caffeine
2. Pungent	Pungent taste derives from the elements of Fire and Air

To each panelist 10 g of dried pieces of meat fish was given in two batches, encrypted with randomly selected three-digit numbers. In order to remove the residual taste between the two evaluation, panelists were using water and apples.

3. Results and Discussion

Table 2 shows the mass transfer rate during the osmotic dehydration of fish meat, as a function of the immersion time and type of osmotic solution. According to obtained results, osmotic dehydration treatment was the most intensive at the beginning of the process. The rate of water loss, the rate of solid gain and the rate of mass reduction were the highest during the first hour of the process. During the process mass transfer rate (both water and solids) decreased continuously from the first to the third hour, and after the third hour showed a tendency of slowing down.

The mass transfer rate was slightly more intensive when fish meat samples were immersed in solution 3, due to greater difference between the osmotic pressures of the hypertonic medium and the animal tissue. The results indicated that the rate of water loss from the samples was faster than the rate of penetration of solute from osmotic solution into the fish samples. The highest values of RWL (13.5000 ± 0.006 g/(gi.s.w.s)10^5), RSG (2.8631 ± 0.002 g/(gi.s.w.· s)·10^5) and RWR (10.6390 ± 0.004 g/(gi.s.w.· s)·10^5) were obtained in samples dehydrated is sugar beet molasses osmotic solution (S3) after first hour of the process.

Table 2. Mass transfer rate and dehidration efficiency index during osmotic dehydration of fish meat

Type of osmotic solution	Time, (h)	RWL g/(gi.s.w.·s)·10^5	RSG g/(gi.s.w.·s)·10^5	RWR g/(gi.s.w.·s)·10^5	DEI
S1	1	12.4720 0.003	2.6111 0.002	9.8611 0.001	4.77550.003
	3	4.3889 0.004	0.9167 0.008	3.4722 0.004	4.78780.005
	5	2.6778 0.003	0.6167 0.001	2.6611 0.002	4.34230.001
S2	1	13.361 0.005	2.8611 0.002	10.5000 0.003	4.66990.003
	3	4.7685 0.004	1.0000 0.007	3.7685 0.003	4.76850.002
	5	2.9111 0.001	0.6722 0.004	2.2389 0.003	4.33060.002
S3	1	13.5000 0.006	2.8631 0.002	10.6390 0.004	4.77840.004
	3	4.9074 0.003	1.0278 0.003	3.8796 0.001	4.79470.003
	5	2.9944 0.001	0.6889 0.001	2.3056 0.001	4.44670.001

Value of dehydration efficiency index - DEI (water loss/ solid gain ratio) is the most significant indicator of the osmotic dehydration process effectiveness [9]. This paremeter is considered to be the best in the efficiency of the osmotic treatment prediction. High DEI values point to intensive water removal from the samples accompanied with minimal solid gain, while, low DEI values are associated with increased diffusion of solute to the sample with minimal water removal which is unacceptable considering the aim of the dehydration treatment.

According to results in Table 2, the highest value of DEI (4.79470.003) was achieved in by using sugar beet molasses as osmotic medium after 3 h of osmotic treatment.

To test the acceptability of the resulting intermediate products, after five hour of the process of osmotic dehydration, sensory evaluation of fresh and osmotically dehydrated fish meat in the three osmotic solution was performed. Four quality factors: color, aroma, taste and aftertaste were estimated.

The results of descriptive sensory analysis are presented in Figure 1.

Color is one of the most important quality parameters of dried fish meat appearance, because a negative change in color reduces the cost of the final product on the market [18].

Results of descriptive sensory analysis of colors indicates high impact of sugar beet molasses on fish meat color change from characteristic D11 - greyish white to D12 - brownish red. The fish samples dehydrated in S3, brownish red was the most intensive, D12 = 5, while in the samples dehydrated in S2, was also observed effect of molasses on color change, with a little lower intensity D12 = 4.

Due to the high content of melanoidins and other products of caramelization dark molasses color positively affects the change of color of meat fish, which can be utilized in practice to eliminate the use of harmful nitrite salts, which are for this purpose applied [6].

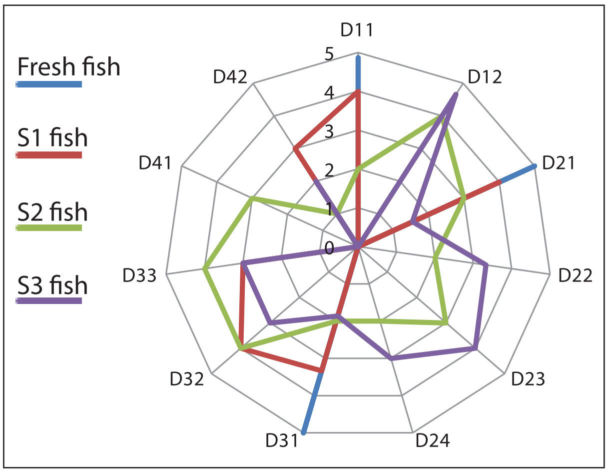

Figure 1. Sensorial evaluation of fresh and osmotically dehydrated fish meat: D1 - color, D2 - aroma, D3 - taste, and D4 - aftertaste

Color of osmotically dehydrated meat fish in S1 (D11 = 4) was not significantly changed compared to the color of fresh meat fish (D11 = 5).

Sensorial analysis of aroma indicate on a high value of descriptors D24 = 5, for the fresh meat and D24 = 4 for the dehydrated fish meat in S1, while the samples dehydrated in osmotic solutions of S2 and S3 had a more complex aroma.

In samples dehydrated in S2, aroma of fresh meat fish (D21 = 3), smoke flavoring (D22 = 2), aroma of molasses (D23 = 3) and the aroma of caramel (D24 = 1) were observed. Significant change of flavor of osmotically dehydrated fish meat in S2 in comparison to the samples of fish meat dehydrated in S1 and fresh meat fish, is the result of complex molasses aromas which is a part of the osmotic solution.

Fish meat dehydrated in sugar beet molasses had the most obvious change in flavor to molasses (D23 = 4) with flavor to caramel (D22 = 3.4) and smoke (D24 = 2).

Sensory analysis of taste showed that after the process of osmotic dehydration a change of taste and aftertaste of fish meat dehydrated in all three osmotic solution occures. Changes of taste of dehidrated meat fish are the result of solid gain, due to the diffusion of solute from osmotic solution to samples of fish meat.

Fresh fish meat had caracteristic fish flavor (D31 = 5) without any after taste.

Fish meat dehydrated in S1 kept the taste of the fresh fish meat (D31 = 3), but also occured a rise in the value of descriptors for the sweet taste (D32 = 4) and an increase in the value of descriptors for the salty taste (D33 = 3). Also, residual pungent taste (D42 = 3) was observed. The increase of sucrose content and NaCl in the fish flesh due to osmotic treatment in S1, have caused this change in taste of dehydrated fish semi product.

Complex chemical composition of the osmotic solution S2 influenced on the occurrence of the frail taste of fresh fish meat (D31 = 2), and expressed sweet taste (D32 = 4) and savory (D33 = 4) with an after taste of bitter (D41 = 3) and pungent (D42 = 1).

Samples of fish meat dehydrated in sugar beet molasses had a somewhat milder expressed taste in the sweet (D32 = 3) and salty (D33 = 3), while the after taste was slightly pungent (D42 = 2).

By sensory evaluation of dehydrated fish samples it was found that the process of osmotic dehydration greatly affect the change of the aroma and taste of dried fish meat. The most pronounced changes of sensory descriptors in relation to fresh fish meat was observed in the samples dehydrated in osmotic solutions with molasses.

In order to improve the sensorial quality of osmotically dehydrated fish semi products, correction in aroma and taste is required in the process of finalizing the product. Sensorial properties and shelf life of dehydrated fish products can be improved by the addition of various spices, herbal extracts and aromas [19, 20].

Osmotically dehydrated silver carp meat can be used as the main or additional material for the production of a variety of different products of fish: fish sticks [21] fish pasta [22], expanded corn snack products with fish meat [23], the rice snack products with fish meat [24], fish crackers [25], extruded fish snack products [26] and other products.

Low price, availability in large quantities and high nutritional value are the main advantages of the meat of this fish species.

4. Conclusions

- Osmotic dehydration of fish meat, in all three osmotic solutions, has shown that water removing process was most rapid at the beginning, and after 3 hours had tendency of slowing down, therefore processing time can be limited to 3 hours. According to presented results it can be concluded that all three solutions are effective osmotic mediums. The highest values of observed parameters were obtained in sugar beet molasses osmotic solution.

- Sensorial evaluation of osmotically treated samples has found that the process of osmotic dehydration affects the change of flavor, color and taste of the dehydrated fish meat. The most pronounced changes in sensory descriptors, in comparison to the fresh fish meat, were observed in the samples treated with the osmotic solutions containing sugar beet molasses (S2 and S3). To improve the sensory quality of osmotically dehydrated semi product, correction of aroma and taste are needed in the process of finalization of the product.

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