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OSMOTIC DEHYDRATION OF FISH (*CRASSUS GIBELIO*) A PRETREATMENT IN THREE DIFFERENT OSMOTIC SOLUTIONS

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Abstract

This research was conducted in order to examine changes in osmotic dehydration fish (*Carassius gibelio*) the use of hypertonic solutions.

The change were followed during in three different osmotic solutions (sugar beet molasses, the mixed solution of sodium chloride and sucrose and combination of these solutions in a 1:1 ratio), under atmospheric pressure, at temperature of 20 ^{0}C. The effects of osmotic dehydration on chemical composition (dry matter, protein, fat, total ash, minerals), water activity and microbiological safety of fish, were investigated in order to determine the usefulness of this technique as pre-treatment for further treatment of fish.

The highest content of protein (60.03%) was reached during osmotic dehydration with sugar beet molasses. The contents monitored minerals (P, Ca, Mg, K, Fe and Na), was approximately 2 times increased, while Hg amount was 2 times decreased during dehydration in solution with sugar beet molasses. Activity water of the fresh fish meat was 0.944 ± 0.007. The results obtained in the process after the 5 hours of osmotic dehydration were varying from 0.850 ± 0.023 to 0.846 ± 0.023 in all three hypertonic solutions. Bacterial count was reduced from 6 log CFU•g^{-1} to 3 log CFU•g^{-1} is considered as microbiological limit for good fish meat quality.

***Key words**: Osmotic dehydration, Fish, Chemical and microbiological profile.*

1. Introduction

Fish meat is very important because of its unique composition and hence considered quality food for human consumption (Izci [1]). Fish is a perishable food which needs processing and preservation. Salting of fish is essentially an osmotic dehydration process (Oladele *et al.* [2]). Knowing the effect of osmosis and the need for free water microorganisms, it is possible to conserve any foodstuffs by using any of the high osmotic pressure (Bem *et al.* [3]; Škrinjar *et al.* [4]).

Main disadvantages of the convective drying are high energy consumption and loss of the thermo labile components of food. Osmotic dehydration is a water removal process, which is based on soaking foods (fruit, vegetable, meat and fish) in a hypertonic solution. Water removal in liquid form, usage of mild temperatures and osmotic solution reusing are main advantages of osmotic dehydration process in comparison with other drying treatments (Della Rosa *et al.* [5]; Torreggiani *et al.* [6]; Koprivica *et al.* [7]).

According to (Rastogi *et al.* [8]) osmotic dehydration is becoming popular as pre-treatment in the processing of foods specifically because of the advantages of energy savings (occurs without a change in physical state of water) (Tortoe *et al.* [9]).

Moreover, the presence of another solution besides salt, such as sucrose and/or sugar beet molasses maintained a high potential for achieving high dry matter content, or significant loss of water. At the same time large quantities of salt impregnation in muscle tissue, are interfered by the presence of sucrose. Sucrose has the "barrier effect", forming a layer on the periphery of the product which is caused by difference in the transport of water and solutes in meat. The barrier effect is stronger if a high molecular weight sugar is being used (Santchurn *et al.* [10]).

Recent research has shown that use of sugar beet molasses as hypertonic solution improves osmotic dehydration processes (Della Rosa *et al.* [5]). Sugar beet molasses is an excellent medium for osmotic dehydration, primarily due to the high dry matter (80%) and specific nutrient content: solids (around 80%), 51% saccharose, 1% rafinose, 0.25% glucose and fructose, 5% proteins, 6% betaine, 1.5% nucleosides, purine and pyramidine bases, organic acids and bases, which subsequently results in high osmotic pressure of the solution (Mišljenović *et al.* [11]). From nutrient point of view, an important advantage of sugar beet molasses, as hypertonic solution, is enrichment of the food material in minerals and vitamins, which penetrate from molasses to the meat tissue (Filipović *et al.* [12]).

The gibel carp *Carassius gibelio* is one of the dominant species in stagnant and slow-running waters and may change the flow of nutrients in the entire ecosystem (Paulovits *et al.* [13]). Generally, *Carassius gibelio* is only freshly consumed. There are not many processing techniques except smoking (Izci [1]).

In literature, although there is a lot of information about osmotic dehydration of plant material, but there is a little information available about osmotic dehydration of meat and none about osmotic dehydration of meat in molasses (Filipović *et al.* [12]). The objective of this research was to examine the influence of three different osmotic solutions at one temperature on the efficiency of osmotic dehydration process, nutritional value and microbiological profile of the fresh fish meat.

2. Materials and Methods

Sample preparation

Carassius gibelio samples were purchased in a local market in Novi Sad (Serbia) and stored at 4 ^0C until use.

Prior to the treatment, all working areas and tools were thoroughly washed, cleaned and disinfected with pharmaceutical ethanol (70 vol.%).The fish meat was cut into cubes, dimension of nearly 1 x 1cm, using a sharp knife.

Dry matter content of the fresh and treated samples was determined by drying at 105 ^{0}C for 24 h in a heat chamber (Instrumentaria Sutjeska, Serbia) until constant weight after which they were minced and powdered for further analysis.

Osmotic solutions

For the preparation of osmotic solutions were used commercially available sodium chloride and sucrose, and sugar beet molasses from sugar factory Pećinci, Serbia. Then, the samples were immersed in hypertonic solution R_1 (sugar beet molasses), solution R_2 (NaCl + sucrose) and solution R_3 (NaCl + sucrose+ sugar beet molasses in the ratio 1 : 1).

The ratio of raw material and hypertonic solution was 1 : 5, and the immersion time of 5 hours. Osmotic dehydration was carried out at atmospheric pressure and temperature of 20 ^{0}C. After the treatment, samples were taken out from osmotic solutions to be lightly washed with water and gently blotted with absorbent paper to remove excessive water.

Analytical procedures

The analytical measurements were carried out in accordance to (AOAC [14]).

Water activity (*aw*) of the osmotic ally dehydrated samples was measured using a water activity measurement device (TESTO 650, Germany) with an accuracy of ± 0.001 at 25 ^{0}C.

Determination of the total number of bacteria, *Escherichia coli*, coagulase positive staphylococci and sulphite reducing clostridia was done by the (SRPS EN ISO 4833 [15]; SRPS ISO 16649-2 [16]; SRPS EN ISO 6888-1 [17]; SRPS ISO 15213 [18]).

3. Results and Discussion

Microbiological analysis of the fresh and dehydrated fish meat is presented in Table 1. Osmotic dehydration fish in all three solutions was shown to be effective in reduction on number microorganisms. The total number of bacteria was reduced from 6 log CFU•g^{-1} to 3 log CFU•g^{-1} is considered as microbiological limit for good fish meat quality. The reductions of the numbers of total number of microorganisms, dehydrated samples in solution 1 an solution 3in comparison to the initial number in the fish meat were 3 log CFU•g^{-1}, while in the solution was of the order solution 2 were 5 log CFU•g^{-1}.

Table 1. Microbiological analysis of the fresh and dehydrated fish meat (average numbers)

Parameter	Fresh fish meat	Fish meat dehydrated in R_1	Fish meat dehydrated in R_2	Fish meat dehydrated in R_3
Total number of bacteria, CFU•g	1.6×10^6	7.0×10^3	1.9×10^5	7.0×10^3
Escherichia coli, CFU•g	< 10	< 10	< 10	<10
Coagulase positive staphylococci, CFU•g	< 100	< 100	< 100	< 100
Sulphite reducing clostridia, CFU•g	< 10	< 10	< 10	< 10

The average aw values and standard deviation of the fresh and dehydrated fish meat in three solutions are shown in Table 2. Activity water of the fresh fish meat was 0.944 ± 0.01 the results obtained in the process after the 5 hours of osmotic dehydration were varying from 0.850 ± 0.02 to 0.846 ± 0.02 in all three hypertonic solutions. It is obvious that process of osmotic dehydration lowered the activity water values of the meat.

Low activity water achieved by osmotic dehydration in sugar beet molasses (solution 3), which was confirmed by the highest reduction of the total number of microorganism. Result of these studies on nutrient and mineral components in the samples of fish, depending on the type of used solution during osmotic dehydration process are given in Table 3.

Real evaluation of osmotic dehydration treatment impact on nutritional improvement could be noticed through influence of three solutions on the chemical and nutritional characteristics of fresh fish. Values of protein content of the fresh fish meat was 57.67 ± 1.07%, and the results of the protein content obtained in the process of osmotic dehydration were varying from to 42.47 ± 1.90% in solution 1 to 60.03 ± 0.57% in solution 3. The highest content of protein 60.03 % was reached during osmotic dehydration with sugar beet molasses, which helped to preserve the most important nutritional component of the meat.

The sucrose contents increased while fat decreased significantly in all three solutions. The effect of solution 1 and solution 2 resulted in significant increase of salt content. Aqueous binary solutions of sodium chloride are commonly used in osmotic dehydration or fish salting. Sodium chloride has a strong effect in reducing water activity, but it causes at the same time considerable changes in the protein properties; in terms of osmotic process kinetics, it has limited capacity to reduce moisture content and thus increase weight loss of the product (Medina-Vivanco *et al.* [19]).

Contrarily, sucrose solutions produce a stronger reduction of moisture content during osmotic dehydration of foods. This behavior is more important in osmotic dehydration of meats because sucrose is not a compound normally present in animal tissues, and thus the sucrose permeability of muscle cells could be very low (Medina-Vivanco *et al.* [19]).

Influence of beet molasses to the chemical composition could be noticed that amount of tracked minerals was approximately 2 times increased, while Hg amount was 2 times reduced.

Osmotic dehydration of fish meat in sugar beet molasses (solution 3) lead to significant increase of K, C, P, Na, Mg and Hg content was approximately 2 times increased, while Hg amount was 2 times decreased during dehydration in solution with sugar beet molasses.

Table 2. Average water activity (aw) values and standard deviation of the fresh and dehydrated fish meat

Parameter	Fresh fish meat	Fish meat dehydrated in R_1	Fish meat dehydrated in R_2	Fish meat dehydrated in R_3
a_w	0.944 ± 0.01	0.848 ± 0.04	0.850 ± 0.02	0.846 ± 0.02

Table 3. Average values and standard deviations of chemical composition of the dehydrated fish meat

Parameter	Fresh fish meat	Fish meat dehydrated in R_1	Fish meat dehydrated in R_2	Fish meat dehydrated in R_3
Dry matter content, %	97.50 ±1.87	98.31 ± 0.71	98.29 ± 1.05	98.33 ± 0.83
Protein content, %	57.67 ±1.07	42.47± 1.90	58.64 ± 1.10	60.03 ± 0.57
Fat content, %	22.72 ±0.45	11.08 ± 0.90	17.66 ± 1.05	14.58 ± 0.45
Sugar content, %	0.67 ± 0.30	18.52 ± 0.40	17.57 ± 0.90	17.17 ± 0.60
Chloride content, %	1.18 ± 0.35	24.94 ± 0.20	13.47 ± 0.30	3.54 ± 0.25
Mineral content,g•kg^{-1}				
Ca	16.58 ± 9.50	10.84 ±7.71	14.44 ± 4.05	15.60 ± 8.83
Na	6.72 ± 11.07	21.80 ± 18.50	17.64 ± 17.10	1.08 ± 10.57
Mg	0.77 ± 14.45	0.94 ± 11.05	0.70 ± 4.89	0.94 ± 8.81
Ca	16.58 ± 25.00	10.84 ± 14.45	14.44 ± 12.50	15.60 ± 22.10
Fe	0.26 ± 1.12	0.28 ± 1.16	0.16 ± 1.16	0.30 ± 0.53
Hg,mg•kg^{-1}	0.11 ± 0.28	0.07 ± 0.43	0.07 ± 0.62	0.08 ± 0.26
Cd	< 0.1	< 0.1	< 0.1	< 0.1
Pb	< 0.5	< 0.5	< 0.5	< 0.5

From the Table 3 it could be noticed after five hours of immersion content of K and Na increased in fish dehydration in solution 2 and content of Na, Mg and P in fish dehydration in solution 1.

4. Conclusions

- On the basis of presented results it can be concluded that all three solutions are satisfying osmotic mediums. While, the best results considering the achieved using solution 3 as osmotic agent.

- Real evaluation of osmotic dehydration treatment impact on nutritional improvement could be noticed through influence of beet molasses composition on the chemical and nutritional characteristics of fresh fish meat.

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