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Microbiological profile of fish dehydrated in two different osmotic solutions

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Abstract. Fish is a substantial source of animal protein in human nutrition, but high water activity (a_w) value and moisture content of fish tissue are favourable to the growth of microorganisms. To extend its shelf life, fish needs to be processed. Dehydration of foods by osmosis involves the contact of the material with a concentrated aqueous solution. The aim of this research is to examine the influence of two different hypertonic mediums (sugar beet molasses and ternary solution) on the

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microbiological profile of fish (*Carassius gibelio*) after the process of osmotic dehydration. The process was carried out in laboratory jars under atmospheric pressure at a constant solution temperature of 20 °C for 5 hours. The sample to solution ratio was 1:5 (w/w) to neglect the changes of solution concentration during the process. In every 15 minutes, the fish samples were manually stirred. Both osmotic solutions have proved to be efficient in reducing a_w and the moisture content of samples providing quality and safe fish semi-product.

1 Introduction

Preservation of fish meat by drying involves a decrease in water content in order to reduce or inhibit microbiological growth (*Tsironiand & Taoukis*, 2014). Using osmotic dehydration to remove water from fish tissue reduces a_w, while the nutritional, sensorial and functional properties of food are improved (*Byrne et al.*, 2001; *Lee & Lim*, 2011. The osmotic dehydration process has many advantages in comparison to other drying methods such as water removal in liquid form, usage of mild temperatures, reduction of drying time, osmotic solution reusing, improvement of texture, flavour and colour, no chemical pretreatment and energy efficiency (*Ćurčić et al.*, 2013). The most important part of the osmotic treatment is the immersion into concentrated solutions of different salts and sugars and their combinations (*Agustinelli et al.*, 2013). For the osmotic dehydration of fish, usually binary (sodium chloride, sucrose) or ternary (salt-sucrose, salt-corn syrup) aqueous solutions are used as hypertonic mediums (*Oladele et al.*, 2008). According to a recent research, sugar beet molasses as a hypertonic solution improves the dehydration process primarily because of high dry matter content and specific nutrient composition (*Koprivica et al.*, 2013), and it can be successfully used for the osmotic dehydration of fruits, vegetables (*Mišljenović et al.*, 2011) and meat (*Filipović et al.*, 2012). Sugar beet molasses has a complex chemical composition (approximately 51% sucrose, 1% raffinose, 0.25% glucose and fructose, 5% proteins, 6% betaine, 1.5% nucleosides, purine and pyramidine bases, organic acids and bases) and the high content of solids (around 80%) provide high osmotic pressure in the solution; therefore, molasses appears to be an excellent osmotic medium (*Pezo et al.*, 2013).

The goal of this research was to examine the efficiency of the osmotic dehydration process, comparing the influence of two different osmotic mediums on water removal and on the microbiological profile of fish meat.

2 Materials and method

Experimental circumstances

The osmotic dehydration was carried out in laboratory jars under atmospheric pressure at a constant solution temperature of 20 °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 (1×1 cm) using kitchen slicer and scissors. Hypertonic solution 1, sugar beet molasses, was obtained from the sugar factory Pećinci, Serbia with an initial dry matter content of 85.04% w/w; hypertonic solution 2, ternary aqueous solution (TAS) of sodium chloride and sucrose, was made from commercial sucrose and NaCl in the quantity of 1,200 and 350 g/kg of distilled water, respectively. After preparation, samples were measured and immersed in hypertonic solutions for 5 hours. The 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. In every 15 minutes, the fish samples in the osmotic solutions were stirred to provide a better homogenization of the osmotic solution, considering the amount of diffused water from the samples. After 5 hours, the fish samples were taken out from the solutions, lightly washed with distilled water, gently blotted with paper to remove excess water from the surface and then weighed.

Methods

The dry matter content of the fresh and treated samples was determined by drying the material at 105 °C for 24 hours in a heat chamber (Instrumentaria Sutjeska, Croatia). a_w of the osmotically dehydrated samples was measured using a water activity measurement device (TESTO 650, Germany) with an accuracy of ± 0.001 at 25 °C. The soluble solids content of the molasses solution was measured using Abbe refractometer, Carl Zeis, Jenna, at 20 °C. All analytical measurements were carried out in accordance with AOAC (2000). In order to describe the mass transfer of the osmotic dehydration process, the experimental data for three key process variables are usually used, and these are: the moisture content, the change in the weight and the change in the soluble solids. Using these, the water loss and solid gain values were calculated as described by *Mišljenović et al.* (2012).

The determination of the total number of bacteria, *Escherichia coli*, Sulphite-reducing Clostridia and coagulase-positive Staphylococci was done by the SRPS EN ISO 4833, SRPS ISO 16649-2, ISO 15213 and SRPS EN ISO 6888-1, respectively.

3 Results and discussion

The osmotic dehydration process was studied in terms of common kinetic parameters such as dry matter content (DM), water loss (WL), solid gain (SG) and a_w. In *Table 1*, the changes in DM content in the samples of fish meat after the osmotic dehydration as a function of different type of osmotic solution are shown. The process resulted in higher dry matter content in fish meat samples dehydrated in both osmotic solutions, but a slightly higher value was achieved in samples dehydrated in sugar beet molasses ($58.339 \pm 4.471\%$).

Along with changes in dry matter content, as a consequence of the osmotic dehydration process, changes in water content occurred, causing a great water loss from the fish tissue. Both hypertonic solutions appear to be efficient in the water removal process; however, the higher WL value (0.530 ± 0.003 g/g i.s.w.) was noticed in samples dehydrated in sugar beet molasses. SG value shows the degree of penetration of solids from the hypertonic solution into the fish meat samples. SG, after the osmotic dehydration of fish meat, increased and the lower value of SG parameter was obtained in samples dehydrated in AOS (aqueous osmotic solution) (0.099 ± 0.008 g/g i.s.w.).

Table 1: Average values and standard deviations of kinetic parameters of the dehydrated fish

Kinetic parameter	Fresh fish meat	Fish meat dehydrated in molasses	Fish meat dehydrated in AOS
Dry matter content, %	23.975 ± 1.965	58.339 ± 4.471	52.680 ± 2.256
Water loss*, g/g i.s.	0.000 ± 0.000	0.530 ± 0.003	0.474 ± 0.004
Solid gain*, g/g i.s.	0.000 ± 0.000	0.111 ± 0.003	0.099 ± 0.008
a_w	0.944 ± 0.007	0.845 ± 0.023	0.848 ± 0.036

*mass in grams of WL or SG per mass in grams of initial sample

Table 1 shows the average a_w values and the standard deviation of the fresh and dehydrated fish in sugar beet molasses and in the AOS solution. Fresh

samples of fish before treatment had an average a_w of 0.944 ± 0.007, which is close to the optimum growth level of most microorganisms (*Nićetin et al.*, 2012). After the process of osmotic dehydration, lower a_w values of fish meat samples dehydrated in both osmotic solutions were observed. The obtained a_w values of samples dehydrated in sugar beet molasses and AOS solution were 0.845 ± 0.023 and 0.848 ± 0.036, respectively. Sugar beet molasses was slightly more effective in lowering the a_w of fish samples. It may be concluded that the process of osmotic dehydration ensures a_w values which are within a specified range for fish meat quality and safety, considering that most meat spoilage bacteria do not grow below a_w value of 0.91 (*Vereš*, 1991).

The results of the microbiological analysis of the fresh and dehydrated fish meat are presented in *Table 2*. The total number of bacteria in fresh fish was $6.67 \cdot 10^5 \pm 3.4 \cdot 10^4$ CFU/g. After the osmotic dehydration process, the total number of bacteria in dehydrated samples in sugar beet molasses and AOS were $4.23 \cdot 10^4 \pm 2.6 \cdot 10^3$ and $7.33 \cdot 10^4 \pm 7.6 \cdot 10^3$ CFU/g, respectively. The reductions of the total number of bacteria in dehydrated samples in comparison to the initial total number of bacteria in the fresh fish meat was 93.66% for samples dehydrated in sugar beet molasses and 89.01% for samples dehydrated in AOS. These results prove that the process of osmotic dehydration has an important influence on the reduction of the total number of bacteria in the osmotically treated fish.

Table 2: Microbiological analysis of the fresh and dehydrated fish meat in two osmotic solutions

Hygiene and food safety criteria	Fresh fish meat	Fish meat dehydrated in molasses	Fish meat dehydrated in AOS
Total number of bacteria, CFU/g	$6.6 \cdot 10^5 \pm 3.4 \cdot 10^5$	$4.23 \cdot 10^4 \pm 2.6 \cdot 10^3$	$7.33 \cdot 10^4 \pm 7.6 \cdot 10^3$
Escherichia coli (CFU/g)	0	0	0
Sulphite-reducing Clostridia (CFU/g)	< 10	< 10	< 10
Coagulase-positive Staphylococci (CFU/g)	< 100	< 100	< 100

The number of *Escherichia coli*, coagulase-positive Staphylococci and sulphite-reducing Clostridia in fresh fish meat samples was in accordance with the hygiene production criteria of the Serbian National Regulation (72/2010). There

was no observed increase in the number of these bacteria in the dehydrated fish post-osmotic treatment.

The microbiological profile of dehydrated fish meat samples indicates that the osmotic dehydration is a hygienically safe process. A better reduction of the present microorganisms in fish meat was obtained in the samples dehydrated in sugar beet molasses. Both osmotic solutions have proved to be efficient in reducing the water content and the a_w of samples, providing quality and safe fish semi-product. Sugar beet molasses was proved to be more than a good alternative to the conventional hypertonic solution.

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