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Original research paper

COMPARATIVE INVESTIGATION OF FISH *(Carassius gibelio)* TREATED BY OSMOTIC DEHYDRATION IN MOLASSES AT DIFFERENT TEMPERATURES

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ABSTRACT: Different working temperatures were tested in order to confirm their effects on the quality of fish after osmotic dehydration. Microbiological profile and chemical content in fish were investigated, before and after osmotic treatment in sugar beet molasses solutions. Based on results it was concluded that molasses as hypertonic solution had great influence on the quality of the final product. The fat content decreased by 1.5% in sugar beet molasses solution at different temperatures (20 °C and 50 °C). The average percentages of fish sugar showed a significant increase during osmotic dehydration at the two temperatures. Osmotic dehydration treatment had great impact on nutritional improvement of fish meat, especially on the mineral composition. Results indicated that the process of osmotic dehydration with sugar beet molasses is hygienically safe. Using sugar beet molasses as an alternative medium in osmotic dehydration opens new opportunities for innovation in dehydrated products.

Key words: *osmotic dehydration, fish, sugar beet molasses*

INTRODUCTION

One of the potential preservation techniques in production of products with low water content and improved nutritional, sensorial and functional properties is osmotic treatment. Osmotic dehydration, also called “dehydration-impregnation by soaking” (Raoult-Wack et al., 1991), is widely employed to remove water from pieces of meat by immersing them in a relatively concentrated aqueous solution of sugar and/or salt without any phase change. This process is mainly used for the partial removal of water, but it also leads to the penetration of solute into the product and the leaching of some natural solutes (sugars, minerals, etc.) from the product into the soaking solution. The main advantages of osmotic treatment are water removal in liquid form, usage of mild temperatures, reuse of the osmotic solution, improvement of the texture and color, no chemical pretreatment, energy efficiency, providing a stable and quality product (Della Rosa and Giroux, 2001; Pezo et al., 2013). Investigations on the effect of the process of osmotic dehydration of pork meat in molasses on micro-biological profile have shown that intermediate, osmo-dehydrated products had reduced number of present microorganisms, improved microbiological profile, and it was adequate food material for the final technological procedures of production (Filipović et al., 2012; Nićetin et al., 2012).

Sugar beet molasses can be used as osmotic agent due to high content of solids and liquid aggregate state (Filipčev et al., 2008). Sugar beet molasses is an excellent medium for osmotic dehydration, primarily due to the high solid content (around 80%) and specific nutrient content: 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., 2008). 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., 2012). In molasses, calcium, potassium and iron are present in substantial amounts although their contents vary over wide ranges (Šimurina et al., 2012). It is especially important to note that minerals in molasses are dissolved and that potassium is dominant with a share of 75% (by weight) of total cations (Šušić et al., 1989).

Temperature is one of the most important variables affecting the kinetic of mass transfer during osmotic dehydration. Rahman and Lamb (1990) have noted that at high temperatures, solute does not diffuse readily through the cell membrane as well as water, and the osmotic balance is achieved primarily through flow of water from the cells, which leads to a reduced solution in the dehydrated material. Higher temperature reduces the viscosity of the osmotic medium, allowing faster water loss and higher mass transfer (Tortoe, 2010).

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., 1998). Fish meat is very important because of its unique composition and hence considered quality food for human consumption. Generally, *C. gibelio* is only freshly consumed. There are not many processing techniques except smoking (Izci, 2010).

The aim of the study presented in this paper was to examine the influence of sugar beet molasses solution at two different temperatures on nutritional composition and microbiological profile of the fresh fish meat.

MATERIAL AND METHODS

Sample and osmotic solution preparation

Carassius gibelio samples were purchased at a local market in Novi Sad (Serbia) and stored at 4 °*C* until use. Prior to the treatment, all working areas and tools were thoroughly washed, cleaned and disinfected with pharmaceutical ethanol (70% v/v).The fish meat was cut into cubes, dimensions of about 1x1x1 cm, using a sharp knife.

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

For the preparation of osmotic solution, commercially available sugar beet molasses from sugar factory Pećinci, Serbia, was used and its chemical composition is shown in Table 1. Chemical analyses of sugar beet molasses were performed according to AOAC methods (AOAC, 1984). Mineral content of molasses was determined by atomic absorption spectrometry with an atomic spectrometer “Varian”, model “Spectra 10”. Molasses used in the experiment was diluted to 80% of solids content.

Osmotic dehydratation treatment

The fish meat cubes were immersed in hypertonic solution (sugar beet molasses). The ratio of raw material and hypertonic solution was 1:5, and the immersion time lasted for 5 hours. Osmotic dehydration was carried out at atmospheric pressure and two temperatures of 20 °C and 50 °C. Osmotic dehydration is conducted in a thermostat. After the treatment, the samples were taken out from osmotic solutions to be lightly washed with water and gently blotted with absorbent paper to remove excessive water.

Table 1.
Chemical composition and characteristics of sugar beet molasses

Composition	
Total solids,%	87.04
Protein,%	10.38
Sugar,%	52.32
Ca, g/kg	4.80
K, g/kg	22.11
Na, g/kg	3.18
Mg, g/kg	0.26
Fe, g/kg	0.10

Analytical procedures

Chemical analyses of fresh and dehydrated fish were performed according to AOAC methods (AOAC, 2000). Water activity (*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. Determination of the total number of bacteria, *Escherichia coli*, coagulase positive staphylococci and sulphite reducing clostridia was done according to SRPS EN ISO 4833 (2008); SRPS ISO 16649-2 (2008); SRPS EN ISO 6888-1 (2003); SRPS ISO 15213 (2003). All analyses were performed in triplicates and results presented as mean values.

Statistical analysis

Analysis of variance and Duncan's multiple range tests were performed using the software package Statistica 10 for Windows, Stat Soft, Tulsa, Oklahoma, USA, 2009. Differences were considered significant at $p < 0.05$.

RESULTS AND DISCUSSION

The average a_w values and standard deviations of the fresh and dehydrated fish meat in sugar beet molasses are shown in Table 2. Increasing temperature from 20 °C to 50 °C led to the intensification of mass transfer between fish tissue and sugar beet molasses and a reduction in tissue a_w values. The a_w levels reached in fish after the process of osmotic dehydration at both working temperatures were smaller than the limiting value for a_w growth of most microorganisms (Huang and Nip, 2001; Feiner, 2006), which indicates a positive effect of the osmotic treatment on the microbial profile of dehydrated fish.

Results of microbial analysis of fresh fish and fish treated by osmotic dehydration showed the absence of pathogenic bacteria, which indicated a good quality of fish meat. Tracking the change in the counts of the total bacteria can indicate the level of hygiene of the process. From Figure 1, the reduction of total number of bacteria in the fish dehydrated at both temperatures in comparison to the fresh fish can be observed. This result is due to the inhibitory effect caused by reduced a_w value of the dehydrated fish meat and is in agreement with findings of Chabbouh et al. (2011). Also, the process temperature had a significant impact on the reduction of the total count of microorganisms in the samples. Results indicate that the process of osmotic dehydration of fish in sugar beet molasses is hygienically safe.

In our study, increasing trends were observed for Na, Mg and Fe contents during the osmotic dehydration of fish at the two temperatures. The iron increase in dehydrated fish meat was very significant, since it is known that the iron absorption from meat usually spans between 15-20%. Molasses provides very low level of iron, but it becomes increasingly soluble with an increase in temperature (Valclavik et al., 2007). This implies the significant improvement in the nutritional profile of meat as food (Higgs, 2000). The temperatures did not significantly influence the change in potassium content during osmotic dehydration. Although sugar beet molasses is rich in potassium, the viscosity of molasses falls at a given temperature.

With respect to viscosity behavior of molasses, K^+ ions raise the viscosity, while Ca^{2+} lowers it (Olbrich, 1963). The content of Ca was greater in the samples treated

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

Sample	a_w/20 ºC	a_w/50 ºC
Fresh fish	0.944±0,007^a	0.944±0,007^a
Fish dehydrated in sugar beet molasses	0.846±0,023^b	0.833±0,009^c

Results are given as mean ± standard deviation (n = 3); a,b,c - data followed by different letters indicate statistical difference (p<0.05)

Table 3.
Chemical and mineral composition of fresh and osmotic dehydrated fish in sugar beet molasses

Parameter	Fresh fish	Dehydrated fish in sugar beet molasses (t=20 °C)	Dehydrated fish in sugar beet molasses (t=50 °C)
Total solids,%	97.55^a ± 0.19	98.52^b ± 0.59	98.33^b ± 0.02
Protein,% DM	57.59^a ± 0.29	60.16^b ± 0.31	50.40^c ± 0.47
Fat,% DM	22.64^a ± 0.41	14.50^b ± 0.22	14.58^b ± 0.14
Sugar,% DM	0.66^a ± 0.04	17.53^b ± 0.66	22.01^c ± 0.20
Ca, g/kg DM	16.42^{ab} ± 0.62	15.50^a ± 0.30	17.43^b ± 0.18
K, g/kg DM	17.02^a ± 0.84	16.24^a ± 0.08	16.70^a ± 0.31
Na, g/kg DM	6.71^a ± 0.27	7.08^b ± 0.12	7.61^b ± 0.25
Mg, g/kg DM	0.77^a ± 0.02	0.91^b ± 0.02	1.50^c ± 0.01
Fe, g/kg DM	0.26^a ± 0.01	0.30^b ± 0.01	0.55^c ± 0.06
Hg, mg/kg DM	0.02^a ± 0.02	0.01^b ± 0.01	0.01^b ± 0.01

Results are given as mean ± standard deviation (n = 3); DM - dry matter basis

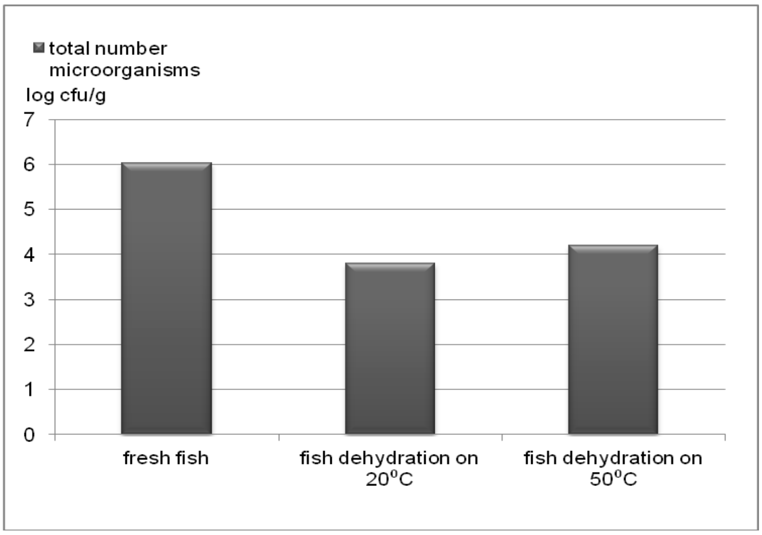

Figure1. The dynamics of change of total number microorganisms content in fish meat during osmotic treatment

at higher temperature (50 °C).Osmotic dehydration of fish in sugar beet molasses at both temperatures significantly affected the content of mercury in muscle tissue by decreasing half of its initial content.

CONCLUSIONS

Based on the results of analyses carried out at two working temperatures, it can be concluded that sugar beet molasses exhibited certain advances when applied as a hypertonic solution in the process of osmotic dehydration of fish. The microbiological profile of dehydrated fish at two temperatures confirmed that osmotic dehydration is a microbiologically safe process. Osmotic dehydration treatment had a great impact on the nutritional improvement of fish meat, especially its mineral composition. Osmotic dehydration in sugar beet molasses can be used as a pretreatment for many processes in order to improve the functional properties of fish, without a significant decrease in nutritive value of the product.

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КОМПАРАТИВНО ИСПИТИВАЊЕ РИБЕ (*Carassius gibelio*) ОСМОТСКОМ ДЕХИДРАТАЦИЈОМ У МЕЛАСИ НА РАЗЛИЧИТИМ ТЕМПЕРАТУРАМА

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Сажетак: Тестиране су различите радне температуре у циљу утврђивања њиховог утицаја на квалитет рибе након процеса осмотског сушења у раствору меласе шећерне репе. Анализиран је микробиолошки профил и нутритивни састав рибе, пре и после процеса осмотског сушења у раствору меласе шећерне репе. На основу добијених резултата, закључено је да је употреба хипертоничног раствора меласе имала велики утицај на квалитет финалног производа. Садржај масти смањен је око 1.5% у дехидрираној риби на температурама 20 °C и 50 °C. Средње вредности садржаја шећера значајно су повећане током осмотске дехидратације рибе на две температуре. Третман осмотске дехидратације имао је велики утицај на нутритивно побољшање меса рибе, посебно на минерални састав. Добијени резултати указују на то да је процес осмотске дехидратације са меласом шећерне репе хигијенски безбедан. Коришћење меласе шећерне репе, као алтернативног медијума за процес осмотске дехидратације, отвара нове могућности за иновације у дехидратацији производа.

Кључне речи: *осмотска дехидратација, риба, меласа шећерне репе*

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