PJN
ISSN 1680-5194

PAKISTAN JOURNAL OF NUTRITION

ANSInet
308 Lasani Town, Sargodha Road, Faisalabad - Pakistan
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Pakistan Journal of Nutrition 7 (1): 57-61, 2008
ISSN 1680-5194

Osmotic Dehydration of Catfish (*Hemisynodontis membranaceus*): Effect of Temperature and Time

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Abstract: The effects of varying temperature and time on osmotic dehydration of Catfish (*Hemisynodontis membranaceus*) were studied. Catfish steaks (9×3×2cm) were osmotically dehydrated in 2.5M brine solution at 30°, 35° and 40°C for 24h and the following parameters: Salt Content/Salt Gain (SC/SG), Water Loss (WL), Weight Reduction (WR), Moisture Content (MC), Water Activity (a_w) and salt to water ratio (S/W) were determined on dry matter basis at 1, 2, 4, 6 and 24h. Increase in temperature from 30°C to 40°C increased salt gain only within the first 2h of osmosis while water loss increased throughout the 24h with increase in temperature. Increase in temperature had no effect on weight reduction until after 6h when the increase became obvious. The samples were not significantly different from control in colour, texture, flavour and overall acceptability at $p \leq 0.05$.

Key words: Catfish, osmotic dehydration, salt gain, water loss, salting, fish steaks

Introduction

Fish is a perishable food which needs processing and preservation. It is well known and documented that a large percentage of the fish caught in the developing countries are lost through poor handling. James (1986) estimated 4.2 million tones while Esser (1991) estimated 3 million tones as annual global fish post-harvest losses. Dada and Gnanados (1983) documented 50%, Tobor (1984), 30-50% and Essuman (1992), 20-30% as post-harvest fish losses in Nigeria. Abiodun (2002) estimated fish loss in Kainji Lake area to worth 256,008 naira in 1996 and 163,604 naira in 2001. Therefore, there is need for improved processing and preservation techniques. The common fish processing and preservation methods in Nigeria are smoking, salting and sun drying.

Salting of fish is essentially an osmotic dehydration process. Osmotic dehydration is a common processing method for fruits and vegetables to obtain several kinds of products as minimally processed or intermediate moisture products or as a pre-treatment in air drying or freezing (Lerici *et al*., 1985; Collignan and Raoult-Wack, 1994). It is known to produce high quality products, requires lower energy, reduces flavour loss and tissue damage (Raoult-Wack, 1994; Panagiotou *et al*., 1998; Ooizumi *et al*., 2000; Chiralt *et al*., 2001; Mujaffar and Sankat, 2005). Osmotic dehydration has been used for fruits (Chiralt *et al*., 2001), vegetables (Ozen *et al*., 2002), meat (Favetto *et al*., 1981a,b) and fish (Lupin *et al*., 1981; Berhimpon *et al*., 1990; Iseya *et al*., 2000; Mujaffar and Sankat, 2005).

Catfish (*Hemisynodontis membranaceus*) belongs to the Mochokidae family. It is in abundance in rivers Niger and Benue of Nigeria where it is known locally as "Kurungu". It has a good keeping quality of several hours and serves as a source of income for the fisher folks around the rivers most especially Lake Kainji. Despite the economic importance, there is lack of information on the osmotic dehydration of this fish. This work therefore aimed at studying the mass transfer kinetics during osmotic dehydration of catfish (*Hemisynodontis membranaceus*) with respect to different temperature and time and also determining the acceptability of the dehydrated fish.

Materials and Methods

Sample preparation: Catfish (Hemisynodontis membranaceus) were obtained fresh from a local supplier in New Bussa, Niger State, Nigeria. The fish were immediately gutted, cleaned and kept in a freezer overnight. The fish were cut manually with knife into steaks (9×3×2cm) and then weighed to determine the amount of salt (sodium chloride) solution to be used. The fish to solution ratio was 1: 20 to avoid dilution and subsequent reduction in the driving force of the solution. The fish steaks were immersed in 2.5M (molar) salt solutions in water bath preset at 30°, 35° and 40°C for 24h without agitation. Higher temperatures were not used because fish develops cooked flavour at higher temperatures. Before analysis, the fish steaks were drained and mopped with serviette paper to remove excess water. The fish in each bath was analyzed for

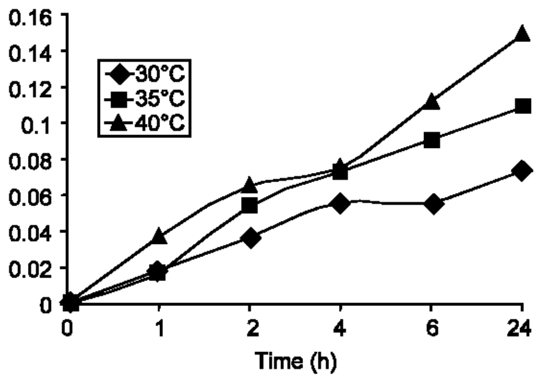

Fig. 1: Effect of brine temperature on Water Loss (WL) of *Hemisynodontis membranaceus* steaks immersed in 2.5M brine

moisture content, salt content/salt gain, weight reduction, moisture loss, water activity and salt to water ratio at 1, 2, 4, 6 and 24h. Each run was in duplicate.

Analytical methods and calculations: For all the calculations, moisture and salt content data were expressed on a non-salt dry matter basis. Non-salt dry matter was calculated as described by Favetto *et al.* (1981a,b) and Berhimpon *et al.* (1990). Favetto *et al.* (1981a,b) stated that non-solute dry matter is a measure of the true dry matter of the sample.

Non-salt dry matter = Sample weight (g)-water (g)-absorbed salt (g)

Determination of moisture content: Moisture content was determined by oven drying method. Five grams of the fish sample was oven dried at 105°C for 24h. Moisture content was expressed on a non-salt dry weight basis (g H_2O gDM^{-1}) (Mujaffar and Sankat, 2005).

$$MC = \frac{(H_2O)_t}{DM}$$

Where MC = moisture content
$(H_2O)_t$ = moisture content at time t
DM = Non-salt dry matter

Determination of salt content/salt gain: The salt (sodium chloride) content of the fish sample was determined titrimetrically using silver nitrate solution as described by Kirk and Sawyer (1991). Five grams of the fish sample was dried and ashed at 550°C. The ash was washed with limited quantity of water and 1 mL of 5% potassium dichlorate solution added. The mixture was then titrated with 0.1M silver nitrate solution.

Determination of Water Loss: The Water Loss (WL) which represents the total amount of moisture loss by the fish steaks from the beginning of the process up to that sampling interval was calculated as described by Mujaffar and Sankat (2005). It was also expressed on a non-salt dry matter basis (g H_2O g DM^{-1}) using the formula

$$WL = \frac{(H_2O)_o-(H_2O)_t}{DM}$$

Where $(H_2O)_o$ = Moisture content at the beginning of the experiment

Determination of weight reduction: The weight of the fish steaks was determined using a weighing balance (Ohaus model). Weight Reduction (WR) was calculated as the change from the original fresh weight (FW_t-FW_o) and expressed on an initial non-salt dry matter basis (gg DM^{-1}) as described by Mujaffar and Sankat (2005).

Determination of water activity: The water activity (a_w) of the osmosed fish steaks was calculated using Lupin *et al.* (1981) relation described for moist salted fish

a_w = 1.002-0.042m
Where m = molality of salt in fish

Salt to Water Ratio: Salt to water ratio (S/W) was calculated as Salt Content (SC) divided by Moisture Content (MC) of the sample (Mujaffar and Sankat, 2005)

$$S/W = \frac{SC}{MC}$$

Sensory evaluation: The osmotically dehydrated fish samples were subjected to sensory evaluation tests using a 10 man panel comprising students of the Department of Food Technology, Federal College of Freshwater Fisheries Technology, New Bussa. Nine point hedonic scale with 1 = dislike extremely; 5 = neither like nor dislike and 9 = like extremely was used for the assessment and the results were subjected to ANOVA. The degree of likeness was determined using Tukey's test (Snedecor, 1956).

Results and Discussion

The effects of increase in both brine temperature and time on the Water Loss (WL) of fish steaks are as shown in Fig. 1. There was a significant increase ($p \leq 0.05$) in water loss throughout the 24h dehydration period. Water loss increased with increase in temperature and time reaching 0.074, 0.109 and 0.149g H_2O g DM^{-1} for fish dehydrated at 30°, 35° and 40°C respectively after 24h. An increase in WL with increase in temperature has been reported by many authors (Kaymak-Ertekin and Sultanoglu, 2000; Sereno *et al.*, 2001). The higher the brine temperature, the greater the water loss.

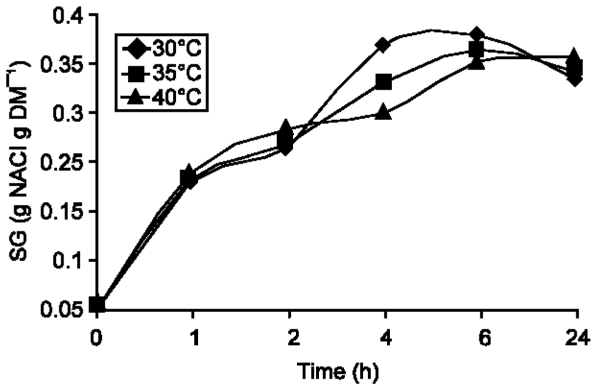

Fig. 2: Effect of brine temperature on Salt Gain (SG) of *Hemisynodontis membranaceus* steaks immersed in 2.5M brine

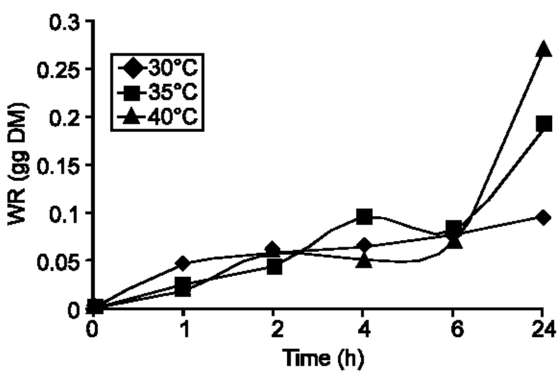

Fig. 3: Effect of brine temperature on the Weight Reduction (WR) of *Hemisynodontis membranaceus* steaks immersed in 2.5M brine

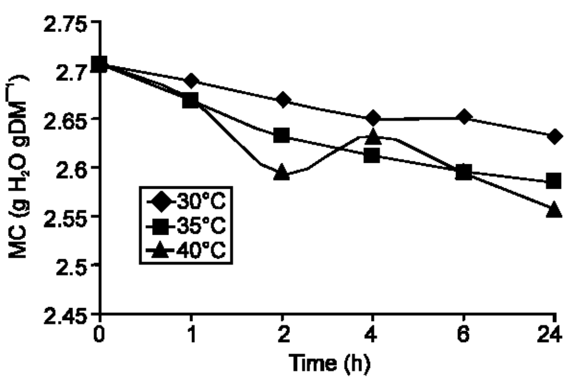

Fig. 4: Effect of brine temperature on Moisture Content (MC) of *Hemisynodontis membranaceus* steaks immersed in 2.5M brine

From Fig. 2, there was a noticeable increase in salt content of the fish steaks up till 6h reaching 0.37, 0.35 and 0.334g H_2O g DM^{-1} for fish dehydrated at 30°, 35° and 40°C respectively. The salt content was not

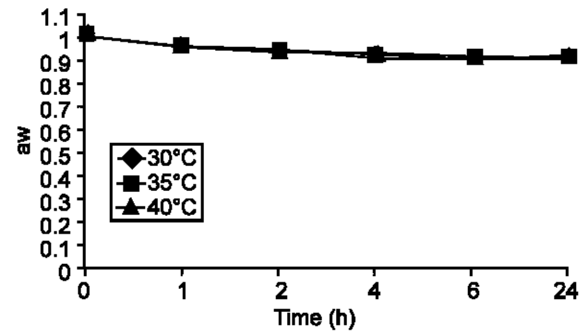

Fig. 5: Effect of brine temperature on water activity (aw) of *Hemisynodontis membranaceus* steaks immersed in 2.5M brine

significantly ($p \leq 0.05$) affected by brine temperature but by immersion time. The fish steaks dehydrated at 40°C had the highest salt content (0.342g H_2O g DM^{-1}) while fish steaks dehydrated at 30°C had the least salt content (0.311g H_2O g DM^{-1}). Salt gain which represents the amount of salt absorbed by the steaks from the beginning of the process to the sampling time is equivalent to salt content. The salt gain was generally small. This can be attributed to the high fat content of the fish. Low-fat fish take up salt faster than high-fat fish. An increase in WL without a corresponding increase in SG with increase in temperature from 20-40°C has been reported (Mujaffar and Sankat, 2005).

Fig. 3 shows the effects of brine temperature and time on the Weight Reduction (WR) of *Hemisynodontis membranaceus* steaks. Weight reduction was not significantly ($p \leq 0.05$) affected by brine temperature and immersion time. The WR had no regular pattern but an increase was obvious for fish steaks dehydrated at 35 and 40°C after 6h of dehydration. The WR values for the fish steaks dehydrated at 30°, 35° and 40°C after 24h averaged 0.096, 0.190 and 0.271g gDM^{-1} respectively. According to Ooizumi *et al.* (2003), weight reduction is a function of temperature, time and concentration of osmotic solution.

All steaks showed a decrease in Moisture Content (MC) which was gradual throughout the 24h of dehydration (Fig. 4). The MC was affected significantly ($p \leq 0.05$) by both immersion time and brine temperature. The higher the temperature, the lower the moisture content. The initial moisture values averaged 2.70g H_2O g DM^{-1} while the final values were 2.63, 2.58 and 2.56 g H_2O g DM^{-1} for fish steaks dehydrated at 30°, 35° and 40°C respectively. A similar result was reported for shark slabs dehydrated at 20°, 30°, 40° and 50°C (Mujaffar and Sankat, 2005).

From Fig. 5, brine temperature has no significant effect ($p \leq 0.05$) on water activity (a_w) of the fish steaks. The a_w reduced from approximately 0.99 to 0.915, 0.912 and 0.906 for fish dehydrated at 30°, 35° and 40°C respectively. The high a_w might be attributed to the low

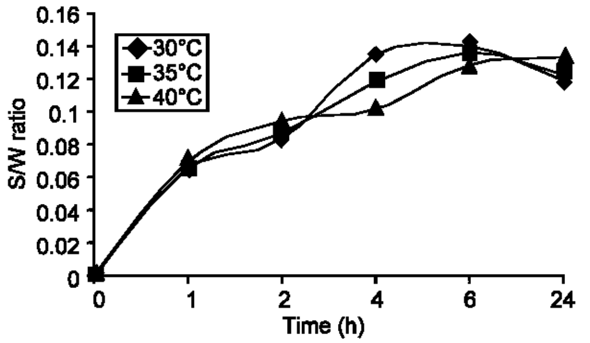

Fig. 6: Effect of brine temperature on salt-water ratio (S/W) of *Hemisynodontis membranaceus* steaks immersed in 2.5M brine

Table 1: Sensory evaluation result of fresh and osmotically dehydrated fish at 2.5M salt solution at 30°C, 35°C and 40°C for 24 hours

	Samples			
Attributes	A	B	C	D
Colour	7.6a	7.4a	7.7a	6.6a
Taste	7.8a	8.0a	6.6b	6.3b
Texture	7.9a	7.8a	7.5a	7.3a
Flavour	7.4a	7.8a	7.3a	7.1a
Overall Acceptability	7.9a	8.1a	7.6a	7.6a

Samples with different alphabets across the row are significantly different at $p \leq 0.05$, A = Fresh (Non-salted) fish, B = Fish salted at 2.5M salt solution at 30°C , C = Fish salted at 2.5M salt solution at 35°C, D = Fish salted at 2.5M salt solution at 40°C

salt content in the fish. A significant decrease in water activity of up to 0.76 was reported by Berhimpon *et al.* (1990) for salted yellowtail dehydrated in saturated brine. From Fig. 6, the salt to water ratio (S/W) was averaged 0.118. 0.122 and 0.133 for fish dehydrated at 30°, 35° and 40°C respectively. It was observed that the moisture contents of the fish steaks were higher than the salt contents, therefore S/W of less than 1.00. Although the S/W increased with increase in both temperature and time, the increase followed no regular pattern.

Quality changes: From the sensory evaluation results (Table 1), both the control and osmotically dehydrated fish steaks were not significantly ($p \leq 0.05$) different in colour, texture, flavour and overall acceptability but were significantly different in taste. Fish steaks dehydrated at 30°C was rated highest in taste while fish dehydrated at 40°C was rated least. Also, at 40°C, there was discoloration and little shrinkage. A higher temperature from 40°C has been found to increase salt uptake but results in discoloration of apple dices (Ponting *et al.*, 1966) and discoloration and shrinkage of fish flesh (Mujaffar and Sankat, 2005). It is therefore safer to osmodehydrate fish at a temperature of not more than 35°C.

Conclusion: The osmotic dehydration of *Synodontis membranaceus* steaks at different temperature and time is possible. Increase in temperature and time affected significantly ($p \leq 0.05$) the moisture content and water loss while weight reduction, salt gain, salt to water ratio and water activity of the fish steaks were not significantly affected by the increase. Only the taste of the fish was affected significantly ($p \leq 0.05$) by both temperature and time. Fish steaks dehydrated at 30°C was rated highest while the fish dehydrated at 40°C was rated lowest.

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