World Journal of Fish and Marine Sciences 5 (4): 414-420, 2013
ISSN 2078-4589

DOI: 10.5829/idosi.wjfms.2013.05.04.7417

The Effect of Different Pre-Fried Temperatures on Physical and Chemical Characteristics of Silver Carp Fish (*Hypophthalmichthys molitrix*) Nuggets

Seyed Mahdi Ojagh, Bahareh Shabanpour and Aniseh Jamshidi

Department of Fisheries,
Gorgan University of Agricultural Sciences and Natural Resources, Gorgan, Golestan, Iran

Abstract: In present study the effect of different pre-frying temperatures in sunflower oil on physical and chemical characteristics of silver carp fish nuggets (*Hypophthalmichthys molitrix*) were studied. After prepared, the fish nuggets were pre-fried in sunflower oil heated to 150, 170 and 190°C. The measurements included: the proximate composition (protein, moisture, fat and ash), physical experiments (product yield, shrinkage and adhesion of coating), pH, water holding capacity (WHC), color measurement and sensory evaluation. The obtained results showed no significant differences in protein, fat, ash and sensory evaluation in different pre-frying temperature (p□0.05). Pre-fried silver carp fish nuggets in 170°C showed higher amount of moisture, pH, WHC, product yield, shrinkage and adhesion of coating in comparison pre-fried nuggets in 150 and 190°C (p□0.05). Increasing the pre-frying temperature caused decrease lightness (L*) and increase redness (a*) and yellowness (b*) (p□0.05). According to the obtained results, pre-fried fish nuggets in 170°C showed the best result in physical and chemical characteristics of silver carp fish nuggets.

Key words: Fish Nuggets · Pre-Frying Temperature · Silver Carp · Sunflower Oil

INTRODUCTION

Increasing population and industrialization of cities tend to growing of tendency to ready to ate products. The products are manufactured from fish meat according to its nutritional value have a special place among the ready to ate products [1]. Such as these products can be cited fish burgers, fish fingers, fish sausages and fish nuggets. The fish nugget is product which is made from mixing mince or surimi with additives and flavored compounds. After molding the prepared mix, that is respectively has undergone battered and breaded and after pre-fried and freezied it is packaged and preserved in -20°C [2].

In general deep fat frying is a cooking method where fat is used as a heat transfer medium that is produced foods with unique characteristics in terms of taste, texture and appearance [3]. During this process, complex operations could occur involving numerous chemical and physical changes such as starch gelatinization, protein denaturation, moisture evaporates and forming coating [4]. During the frying process, both mobility and transmission of temperature and fat displacement and material transfer also occurs. Usually with increasing frying time, oil absorption rate are also increased, but there is no linear relationship between them (no linear trend) [5].

The amount of oil absorption depends on the factors such as oil quality, frying time, oil and food temperature, shape, porosity and composition of the food and particular the initial water content, as well as the weight-surface relationship [6]. Frying temperature and duration of process can be directly effects [5]. The effect of oil temperature on the quality and oil absorption in deep fried products have been reported [3, 4]. In general, products that fried at a temperature of 175°C to 190°C have a good crispiness properties.

The type of oil used for frying products is an effective on oil absorption and fatty acid composition [5, 7]. For this reason use a high quality oil for frying is important. Today the most commonly oil used for deep fried products is sunflower oil, therefore this was selected for present study. This oil was known in the societies and is easily available in the markets.

Corresponding Author: Aniseh Jamshidi, Department of Fisheries, Gorgan University of Agricultural Sciences and Natural Resources, Gorgan, Golestan, Iran.

Silver carp (*Hypophthalmichthys molitrix*) belongs to the Chinese carps, as a freshwater fish species cultured in polyculture system. Due to its easy cultivation, fast growth rate and high feed effciency ratio for increased consumption silver carp in hold house and industry. Thus, the aim of this study investigated different pre-frying temperatures on chemical and physical properties of silver carp fish nuggets.

MATERIALS AND METHODS

Sample preparation: Fresh silver carp (*Hypophthalmichthys molitrix*) in weight of 1150-1200 g was bought from a local market and after covering with chunked ice transferred to the laboratory fisheries of Gorgan University of Agricultural Sciences and Natural Resources. After washing the fish were beheaded, gutted, washed and filleted by hand. The flesh achieved was 47.5%. The fillets were minced with a meat mincer, using a 3 mm diameter holes plate. The amount of 87% of fish mince were homogenized with ingredients including 5% wheat flour, 5% onion 1.5% salt, 1% garlic powder and 0.5% seasonings (including 0.2% cinnamon, 0.2% turmeric and 0.1% red pepper) in a meat blender. The dough of fish nuggets were divided into equal three groups for pre-frying in different temperatures. The dough of different samples were filled in round mould and then battered and breaded with bread crumbs (□20 mesh) respectively The batter formulation was utilized according to the Chen *et al*. [8] formula which consisted of 55 percent wheat flour, 30 percent cornstarch, 10 percent gluten, 2 percent leavening and 3 percent salt that were mixed with water at 10°C in ratios of 1:1/5 (water to solid ratio). Breadcrumb was purchased from an Iranian Amoon Co, Ltd.

The battered and breaded silver carp fish nuggets were pre-deep-fried in sunflower oil (for frying, Oiyla-Iran) for 30 second at 150, 170 and 190°C temperatures (Moulinex Toucan Automatic fryer, Portugal) and after each batch of frying, the internal pan of the fryer was washed and dried. The fryer temperature measured by external calibrated thermometer equipped with probe that immersed in the deep oils of fryer. After the pre-fried sample of fish nuggets being allowed to cool in room temperature, it was packaged in Ziploc bags and stored at -20°C for seven days. The analysis was performed after thawing the fish nuggets at a time for 1 hour at room temperature.

Proximate Composition: Fat, moisture, crude protein and ash of fish nuggets were determined by standard procedures of Association of Oficial Analytical Chemists [9].

The pH Measurement: The pH measurement was carried out using a pH Lat Stirrer Metrohm model 728 pH meter. Fish nugget (5g) was homogenized thoroughly with 45 ml of distilled water and the homogenate was subjected to pH determination in a room temperature according to the method of Das *et al*. [10].

Determination of Water Holding Capacity (WHC): Each minced battered and breading nugget samples (5g) weighted onto two layers of Whatman No. 1 filter paper and were placed at the bottom of the 50 ml centrifuge tubes. The tube was then being centrifuged 1500 rpm for 5 min according to the method of Das *et al*. [10]. Immediately, after centrifugation, the minced samples were reweighed and the amount of expressible water was calculated as:

$$EW (\%) = (W1-W2) / W1 \times 100$$

EW = Expressible water
W1 = Initial weight
W2 = Final weight

The expressible water is inversely related to the water holding capacity (WHC). The highest percent of water extracted means the lowest WHC.

Product Yield: The weight of each fish nuggets was recorded before and after frying. The product yield was calculated and expressed as percentage according to the following formula [10]:

$$A (\%) = (W_F / W_P) \times 100$$

A = Products yield (%)
W_F = Weight of frying fish nugget
W_P = Weight of pre-frying fish nugget

Shrinkage: The diameter and thickness of each par-fried and frying fish nuggets were recorded and the shrinkage of the products was calculated as [11]:

$$A\ (\%) = [(T_P - T_F) + (D_P - D_F)] / (D_P + T_P) \times 100$$

A = Shrinkage (%)
T_P = Pre-frying fish nuggets thickness
T_F = Frying fish nuggets thickness
D_P = Pre-frying fish nuggets diameter
D_F = Frying fish nuggets diameter

Adhesion of Coating: Frying samples were cut in half transversally with a scalpel and photographs were taken with an Olympus E-1500 camera (SONY, DSC-T77). Percentage of coating that remains adhered to the substrate (CRA) was calculated as:

$$CRA\ (\%) = (P / T) \times 100$$

P = Pixels corresponding to the perimeter of the substrate where coating is adhered
T = Pixels corresponding to the total perimeter of the substrate

High CRA values would indicate good adhesion properties in the final battered and cooked product. The measurements were carried out with the help of Analysis AUTO software (Soft Imaging Systems GmbH, Mu nster, Germany). At least 15 cooked nuggets were measured for each sample [12].

Color Measurements: Samples color with six replication was measured with a Lovibond (Lovibond CAM-system, England 500). The parameters determined were L* is an approximate of lightness between black and white within the range 0-100, redness (+a*) or greenness (-a*) and yellowness (+b*) or blueness (-b*) [13].

Sensory Evaluation: The sensory evaluation of rainbow trout fillets was carried out according Das *et al*. [10] by seven trained panelists. The fish fillets were deep-fried in sunflower oil at 180°C for 2 minutes. The panelists were scored for color, flavor, odor, mouth feel, texture and overall acceptability on an 8-point hedonic scale sensory evaluation (1: dislike extremely to 8: like extremely).

Statistical Analysis: The statistical analysis of the data was performed through using one-way analysis of variance (ANOVA). The results were processed by SPSS 18.0 analysis. Test of significant differences between groups was determined by Kruskal-Wallis for sensory quality and Duncan's multiple range test calculated at p□0.05 for other experiments. The graphs were plotted in Excel software.

RESULTS

The amount of moisture, fat, protein and ash contents of different samples are shown in Table 1. Amount of fat, protein and ash showed no significant difference between treatments (p□0.05), whereas the amount of moisture showed significant difference (p□0.05). The pre-fried silver carp fish nuggets in 170°C was show higher amount of moisture in comparison with pre-fried nuggets in 150 and 190°C.

The water holding capacity (WHC) and pH amount showed significant difference among the patterns (p□0.05) (Fig. 1). The highest amount of WHC showed in pre-fried nuggets in 150°C. The pre-fried nuggets in 190°C displayed the lowest amounts of pH and WHC among the other patterns.

The results of physical characteristics including product yield, shrinkage and adhesion of coating showed that the pre-frying nuggets in different temperature had significant differences among the treatments (p□0.05) (Fig. 2). The amount of product yield in pre-fried nuggets in 150°C was higher than pre-fried nuggets in 170 and 190°C. The nuggets that pre-fried in 170°C showed the higher amount of shrinkage and adhesion of coating in comparison with the pre-fried nuggets in 150 and 190°C (p□0.05).

Fig. 3 shows the results of color measurement in silver carp fish nuggets pre-fried in different temperature. The nuggets pre-fried in different temperature showed significant differences in terms of lightness (L*), redness (a*) and yellowness (b*) among the treated samples (p□0.05). The highest lightness was observed in pre-fried nuggets in 150 and 170°C, whereas the pre-fired nuggets in 190°C showed the lowest lightness (p□0.05). The highest to the lowest amount of redness and yellowness showed in pre-fried nuggets in 190°C, 170°C and 150°C respectively (190°C, 170°C, 150°C).

The hedonic score for color, flavor, odor, mouth feel, texture and overall acceptability of silver carp fish nuggets did not show any significant differences among all the patterns (p□0.05) (Table 2).

DISCUSSION

The pre-frying silver carp nuggets at different temperatures had no significant effect on the amounts of fat, protein and ash. In terms of moisture content, pre-fried nuggets at 170°C showed higher moisture content in comparison with pre-fried nuggets at 150 and 190°C temperatures (Table 1). Probably formed hard coating on surface of product and this protective effect as a

Table 1: Moisture, fat, protein and ash content in silver carp fish nuggets pre-fried in different temperature

Treatments	Moisture	Fat	Protein	Ash
Pre-fried nuggets in150 °C	65.9±0.52[b]	9.33±0.33[a]	16.55±0.26[a]	5.58±0.25[a]
Pre-fried nuggets in170 °C	67.41±0.22[a]	9.67±0.33[a]	15.66±0.2[a]	5.95±0.18[a]
Pre-fried nuggets in190 °C	65.43±0.21[b]	10.47±0.93[a]	15.91±0.52[a]	6.27±0.24[a]

Mean values with different superscripts at the same column are significantly different among samples (P<0.05).

Table 2: Sensory evaluation of silver carp fish nuggets pre-fried in different temperature

Sensory index	Pre-fried nuggets in 150°C	Pre-fried nuggets in 190°C	Pre-fried nuggets in 190°C
Color	5.87±0.29[a]	5.87±0.29[a]	6.75±0.41[a]
Flavor	5.37±0.53[a]	6.12±0.48[a]	5.62±53[a]
Odor	5.87±0.4[a]	5.62±0.56[a]	5.5±0.6[a]
Mouth feel	6.87±0.29[a]	6.62±0.26[a]	6.75±0.45[a]
Texture	5.37±0.6[a]	5.75±0.41[a]	5.37±0.68[a]
Overall acceptability	5.75±0.49[a]	6±0.38[a]	5.75±0.56[a]

Mean values with different superscripts at the same row are significantly different among samples at first time (P<0.05).

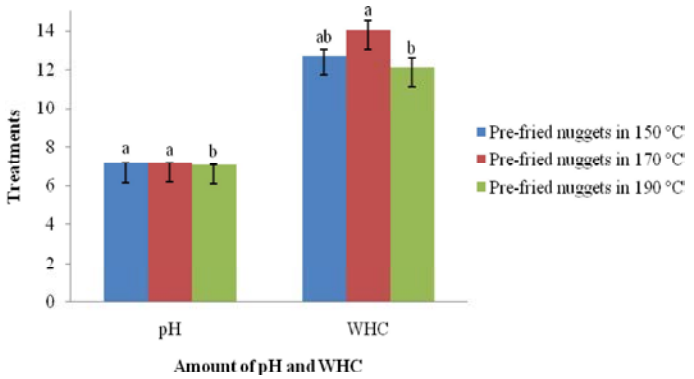

Fig. 1: Changes in amount of pH and WHC in silver carp fish nuggets pre-fried in different temperature. Bars Represent Standard Deviation from Triplicate Determinations

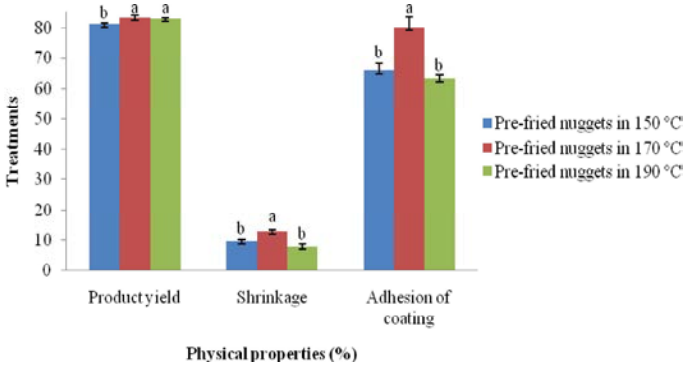

Fig. 2: Changes in amount of product yield, shrinkage and adhesion of coating in silver carp fish nuggets pre-fried in different temperature. Bars Represent Standard Deviation from Triplicate Determinations

barrier to reduce moisture and increases oil, we did not show significant differences in fat, protein and ash during pre-frying at different temperatures. Guillaumin [14] also stated that frying temperature between 150 to 180°C has no significant effect on oil uptake in food stuff. Obtained results In the study has been done by Bunger [15], that examined the effect of frying on the nutritional value of food, was the same with present study. Bunger [15] stated that the frying process caused to maintain a 96 to 10 percent of protein in fish fillets and on the rate of protein digestion was not significantly different.

In the present study, The mobility of material and exit of moisture during the frying process, caused decrease the moisture content. But pre-frying the fish nuggets at 170°C formed stronger coating and showed higher

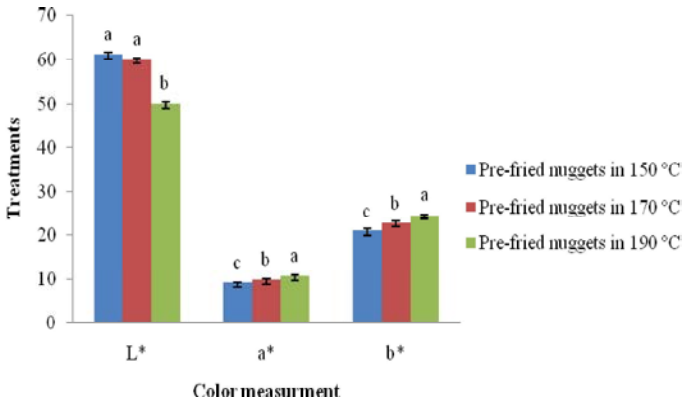

Fig. 3: Color measurement in silver carp fish nuggets pre-fried in different temperature. Bars Represent Standard Deviation from Triplicate Determinations

content moisture in comparison with fish nuggets pre-fried at 150 and 190°C. Moyano *et al*. [16] stated increase the frying temperature made harder and more durable coating, that could be increased the resistance of products against of mobility the materials and improved a surface diffusivity. In the present study increased frying temperature until 170°C caused retain more moisture but, increased higher frying temperature showed negative effect on retain the moisture.

Amount of moisture after pre-frying the battered and breaded is affected by the water holding capacity. Pre-fried fish nuggets at 170°C showed the higher water holding capacity. Moderate temperatures of 170°C was also retains more moisture and increases the water holding capacity. Das *et al*. [10] with studied on shelf life of meat nuggets in the freezer storage expressed, that protein-protein and protein-water interactions could affected the water holding capacity of meat and meat products.

In pre-fried nugget at 190°C, the amount of pH was higher than pre-fried nuggets in 150 and 170°C. In general, increase the pH take placed in resulted of proteolytic bacterial and autolytic enzymes processes in meat during storage and decreased the pH due to an increase the amount of ammonia and amines in result of thermal effects during the frying process [17]. Because short-term storage, in this study bacterial or enzymatic processes, that lead to a change of the pH value, not occurred. On the other hand, different pre-frying temperatures, had a significant effect on the pH value. Researches Tokur *et al*. [18] and Nguyen [19] that showed no change in the pH value was opposite with obtained results of the pH value in the present study.

The percent of coating adhesion is one of critical characteristic of battered and breaded products. Adhesion is the chemical and physical bonding of the battered and breading material with the food substrate [20]. The results showed that the rate of coating adhesion increased in pre-fried nuggets in 170 °C. Factors which affect the adhesion of coating are properties and attributes of the food substrate [20], the cooking method [12] and the batter ingredients [21].

In a study that conducted on the role of hydrocolloids in fried foods, Varela and Fiszman [2] expressed there is a direct relationship between the adhesion of the coating and product yield, whereas with increase in coating adhesion, product yield also increased. Similar results were obtained in the present study so that the highest product yield observed in pre-fried nugget at 170 and 190°C. In study was done by Bunger [15] the effect of frying on the nutritive value of food, results indicated that various methods of cooking mackerel fillets had no significant effect on product yield. That result is opposite with the obtained result in the present study.

With increasing temperature, the amount of shrinkage increased and the pre-fried fish nuggets in 170°C showed the highest amount of shrinkage. The shrinkage occurs due to loss of moisture and protein denaturation in resulted heat frying process. In the study was done by Bras and Costa [22] on the salted and deride fish fillets results showed the amount of shrinkage increased and amount of moisture and water holding capacity decreased. Obtained results in this study is contrast with Varela and Fiszman [2] and Bras and Costa [22], that showed significant difference in the amount of shrinkage and not significant difference was found in the water holding capacity and moisture.

One of the most important parameters that affect the marketability of coated products is the final color of these products. The crust color of fried fish nugget affects consumers' purchasing [8]. The pre-frying process

caused decrease of lightness and the increase of the amount of redness and yellowness in all the patterns of fish nuggets (Fig. 3). The reduce of lightness and increase of redness and yellowness were due to Millard`s reaction and sugar Caramelization at higher temperature of frying treatment [12]. According to Sanz *et al*. [23] development of color during frying process is one of the main factors that will help consumers to choose the right time to frying the final product, so that the ideal final color for such products is light-golden color. Chen *et al*. [8] with added HPMC to the battered and breaded mackerel nuggets observed reduce lightness and increase redness that was consistent with the results obtained in this study.

Despite having different pre-frying temperatures in the samples, no significant difference was observed in terms of sensory and organoleptic evaluation. Tokur *et al*. [18] reported that unwashed fish fingers had more nutritional value, but the panelists preferred washed fish fingers due to desirable flavor. Sensory evaluation in terms of color, flavor, odor, mouth feel, texture and overall acceptability did not show any significant differences among treatments. However study of Garcia *et al*. [24] demonstrated that there were no differences in sensory evaluation between samples uncoated and coated with MC and sorbitol samples fried potato strips and dough disc.

REFERENCES

1. Venugopal, V., 2006. Seafood Processing. CRC Press, pp: 485.
2. Varela, P. and S.M. Fiszman, 2011. Hydrocolloids in fried foods. A review. Journal of Food Hydrocolloids, 25: 1801-1812.
3. Mallema, M., 2003. Mechanism and reduction of fat uptake in deep-fat fried foods. Journal of Trends in Food Science and Technology, 14: 364-373.
4. Dana, D. and S. Saguy, 2006. Review: Mechanism of oil uptake during deep-fat frying and the surfactant effect-theory and myth. Journal of Advances in Colloid and Interface Science, 128-130: 267-272.
5. Kita, A., G. Lisinska and G. Golubowska, 2007. The effects of oils and frying temperatures on the texture and fat content of potato crisps. Journal of Food Chemistry, 102: 1-5.
6. Fiszman, S.M. and A. Salvador, 2003. Recent development in coating batters. Journal of Food Science and Technology, 14: 399-407.
7. Moradi, Y., J. Baker, Y. Che Man and S. Kharidah, 2009. Effects of pre-drying on quality of fries breaded black pomfret (*Parastromateus niger*) fillet. Journal of Fisheries and Aquatic Science, 4(5): 254-206.
8. Chen, C.H., P. Li, W. Hu, M. Lan, M. Chen and H. Chen, 2008. Using HPMC to improve crust crispness in microwave-reheated battered mackerel nuggets: water barrier effect of HPMC. Journal of Food Hydrocolloids, 22: 1334-1344.
9. AOAC International, 1990. In: P. Cunniff, (Ed.), Official methods of analysis of AOAC international (16^{th} ed.). Gaithersburg, MD, USA: AOAC International.
10. Das, K.A., A.S.R. Anjaneyulu, Y.P. Gadekar, R.P. Singh and H. Pragati, 2008. Effect of full-fat soy paste and textured soy granules on quality and shelf-life of goat meat nuggets in frozen storage. Journal of Meat Science, 80: 607-614.
11. Modi, V.K., N.M. Sachindra, P. Nagegowda, N.S. Mehendrakar and D.N. Rao, 2007. Quality changes during the storage of dehydrated chicken kebab mix. International Journal of Food Science and Technology, 42: 827-835.
12. Albert, A., P. Varela, A. Salvador and S.M. Fiszman, 2009. Improvement of crunchiness of battered fish nuggets. Journal of Eru Food Research Technology, 228: 923-930.
13. Fagan, J.D., T.R. Gormley and M.U. Mhuircheartaigh, 2003. Effect of freeze-chilling, in comparison with fresh, chilling and freezing, on some quality parameters of raw whiting, mackerel and salmon portions. Journal of Lebensm.-Wiss. u. Technology, 36: 647-655.
14. Guillaumin, R., 1988. Kinetics of fat penetration in food. In: G. Varela, A.E. Bender and I.D. Morton, (Eds.), Frying of food: Principles, changes, new approaches (pp: 82-89). Chichester: Ellis Horwood Ltd.
15. Bunger, A., P. Moyano and V. Rioseco, 2003. Nacl soaking treatment for Improving the quality of the French-fried potatoes. Food Research International, 36: 161-166.
16. Moyano, P.C., V.K. Rioseco and P.A. Gonzalez, 2002. Kinetics of crust color change during deep-fat frying of impregnated fresh fries. Journal of Food Engineer, 45: 149-255.
17. Kilinccerker, O., I.S. Dogan and E. Kucukoner, 2009. Effect of edible coating on the quality of frozen fish fillets. Journal of Lebensm-Wiss Technology, 42: 868-873.

18. Tokur, B., S. Ozkutuk, E. Atici, G. Ozyurt and C. Ozyurt, 2006. Chemical and sensory quality changes of fish fingers, made from mirror carp (*Cyprinus carpio*) (Linnaeus, 1758), during frozen storage (-18°C). Journal of Food Chemistry, 99: 335-341.
19. Nguyen, B.E., 2009. Effects of methylcellulose on the quality and shelf-life of deep-fat fried and oven baked chicken nuggets. Master Thesis, Faculty of Food Science, Texas Tech University, Texas.
20. Suderman, D.R., 1983. Use of batters and breadings on food products: a review. In: D.R. Suderman and F.E. Cunningham, (Eds), Batter and Breading Technology. Westport, Connecticut: Avi Publishing Co.
21. Primo-Martin, C., T. Sanz, D.W. Steringa, A. Salvador, S.M. Fiszman and T.V. Vliet, 2010. Performance of cellulose derivatives in deep-fried battered snacks: Oil barrier and crispy properties. Journal of Food Hydrocolloids, 12: 1-7.
22. Bras, A. and R. Costa, 2010. Influence of brine salting prior to pickle salting in the manufacturing of various salted-dried fish species. Journal of Food Engineering, 100: 490-495.
23. Sanz, T., A. Salvador and S.M. Fiszman, 2004. Effect of concentration and temperature on properties of methylcellulose-added batters application to battered, fried seafood. Journal of Food Hydrocolloids, 18: 127-131.
24. Garcia, M.A., C. Ferrero, N. Bertola, M. Martino and N. Zaritzky, 2002. Edible coatings from cellulose derivatives to reduce oil uptake in fried products. Journal of Innovative Food Science and Emerging Technologies, 3: 391-397.