World Journal of Fish and Marine Sciences 5 (4): 398-404, 2013
ISSN 2078-4589

DOI: 10.5829/idosi.wjfms.2013.05.04.7387

Quality Characteristics of Fried Rainbow Trout (*Oncorhynchus mykiss*) Fillets Coated with Different Hydrocolloids Edible Films

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Abstract: This study evaluates the effects of edible films of xanthan, carrageenan, alginate, soy protein isolate and hydroxypropyl methylcellulose gums on the quality of fried rainbow trout (*Oncorhynchus mykiss*) fillets. The immersed samples of fish fillets in solution of gums and fried were compared with the control with uncoated and fried fish fillets. The effects of different hydrocolloid edible films on viscosity, amount of batter pick-up, color, water retention and reduction of oil uptake were significant ($p < 0.05$) whereas no significant effect on sensory evaluation was observed ($p < 0.05$). Among the hydrocolloid samples, fish fillets coated with xanthan and HPMC showed the highest viscosity and batter pick-up, the coated fillets with carrageenan and HPMC indicated the highest content of moisture and the coated fillets with HPMC showed the least amount of fat ($p < 0.05$). The results indicated that all of the edible films were effective in retaining the quality characteristics of treated fish fillets and showed better performance than the control.

Key words: Fried Fish Fillet · Hydrocolloids Edible Film · Carrageenan · Xanthan · Rainbow Trout

INTRODUCTION

Edible coatings from hydrocolloids (proteins or polysaccharides), lipids (fatty acids, acylglycerols or waxes) and composite films can prolong the shelf life of foods by functioning as solute, gas and vapor barriers [1]. Coating preserves and enhances food quality; and is usually applied in liquid form (by dipping, falling film or spraying on the food item) [2]. Among the hydrocolloids, hydrophilic polymers such as alginate, carrageenan and xanthan gum are extensively used as film-forming solutions to control and preserve the texture, flavor and shelf life of foods as well as good oxygen barriers and can provide protection against lipid oxidation [2-3]. Cellulose derivatives such as MC and HPMC have good film-forming properties and their reversible thermal gelation capability in aqueous systems is widely utilized to reduce oil absorption during the frying foods [4-6]. Chicken balls coated with HPMC edible film showed a reduction in oil absorption as well as an increase in moisture retention [7]. Xanthan gum is a microbial polysaccharide that is obtained from the bacteria *Xanthomonas campestris* by aerobic fermentation and has a wide application in the food industry as a high pseudoplastic flow behavior and stability over wide ranges of pH, temperature and salt concentration. Carrageenan is a water soluble polysaccharide that is produced from red seaweeds (*Rhodophyceae*) and is used in the food for its water binding, thickening and gelling properties [8]. The Carrageenan coating was used for mackerel fillets by dipping into aqueous carrageenan solutions (10g/kg) prior to freezing and the shelf-life increased to 5 months, whereas uncoated controls were unacceptable after 3 months. Alginate is obtained from brown seaweeds (*Phyophyceae*) [9].

Soy protein isolate is used as a functional food ingredient because it possesses desirable functional properties such as emulsification, gelation, fat absorption and water binding [10].

However, deep-fat frying is a method of food processing that is widely used. One problem associated with fried food consumption is the considerable amount of oil absorbed during the frying operation [11-13]. High oil content leads to the high incidence of diseases such as obesity, high cholesterol levels or high blood pressure and as a result is a cause of concern for fried food consumption. The amount of oil absorption depends on the factors such as oil quality, frying time, oil

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and food temperature, shape, porosity and composition of the food and especially the initial water content, as well as the weight-surface relationship [14]. Upon addition of the food to the hot oil, with rise of the surface temperature of the food, the water at the surface immediately starts boiling and the explosive evaporation can lead to the formation of large pores [11, 15]. The reason of fat uptake is that the vapor leaves voids for the fat to enter later. Hydrocolloids are generally used in seafood for this application to bind with added water, increase yield and improve the eating quality of the final products. Ingredients that enable form or increase the water holding capacity may increase fragility and tenderness texture of the fried products and reduce oil uptake. Many reports have focused on alternative effects of different coatings on seafood such as fish fillets, squid rings, mackerel nuggets, hake nuggets and other products [13-16-17]. However, there are almost no studies on effects of coating of hydrocolloids on fish fillets, increase of the water holding capacity and reduction of oil uptake. The aim of this study is to investigate the effects of different hydrocolloid coatings on the quality of fried rainbow trout fillets.

MATERIALS AND METHODS

Fish Sample Preparation: Rainbow trout were supplied alive in a local market with an average weight of 450±25 g and were transferred to the fish processing laboratory of Fishery Department at Gorgan University of Agricultural Sciences and Natural Resources. After washing, the fish were beheaded, gutted and after being washed again were filleted by hand. The flesh achieved was 40 %. Two fillets were obtained from each fish after beheading and deboning.

Preparation of Coating Solutions and Treatment of Fish Fillets: In operation of coating five different coated hydrocolloids were used, three hydrophilic polymers: 1) alginate, 2) carrageenan and 3) xanthan gum; a cellulose derivative: 4) hydroxypropyl methylcellulose and a protein matter: 5) Soy protein isolate, fish fillets without coating were used as control. All coating solutions were provided with 1% (W/V) of each matter in distilled water. To achieve complete dispersion of coating solutions, the solutions were stirred at moderate temperature (15-25°C) with a kitchen stirrer. Fillet samples were randomly assigned into six treatment lots containing of one control (uncoated) and five lots treated with different coating solutions. The fillets were dipped in the coating solutions for 1 minute and were drained for 30 s. The fillet samples were then kept at chilled temperature (4±1°C) for 4 hours and after that were packaged in Ziploc bags and stored at -20°C for 7 days. For analysis triplicate fish samples from each lot were taken randomly and fried at 180°C for 5 minutes without thawing.

Viscosity: The flow properties of different coating solutions were studied using a Viscometer (BROOKFIELD, model LVDV-II+PPRO, U.S.A) with spindle No 6 and speed circulate of spindle 100 rpm at time 20 second and 20°C temperature.

Coating Pick-Up: Rainbow trout fillets coating pick-up before cooking was calculated using Chen *et al.* [17] as:

Batter pick-up (%) = [(coated fish –fish)/ (coated fish)] ×100

Moisture and Fat Analysis: Moisture and fat content of samples were analyzed by the method of AOAC [18]. The 10g of samples were dried in an oven at 105°C until constant weights were achieved and moisture content was calculate. Samples were then extracted using a Soxhlet extraction (416 SE, Gerhardt, Germany) with petroleum ether for 2.30 hour to determine fat content.

Water Holding Capacity: The expressible water is inversely related to the water holding capacity (WHC) and lowest percent of water extracted means the highest WHC. For measuring expressible water of the fish fillets According to Das *et al.* [19], about 5 g cooked sample weighted onto two layers of Whatman No. 1 filter paper. The samples were placed at the 50 ml centrifuge tubes and centrifuged at 1500 rpm for 5 min. Then the meat sample were re-weighted and the amount of expressible water was calculated as:

Expressible water: initial weight – final weight / initial weight × 100

Product Yield: The weight of each coated fish fillets was recorded before and after deep fat frying. The product yield was calculated and expressed as percentage by weight of frying fish fillets/weight of raw fish fillets×100 [19].

Color Measurements: Samples color with three 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*). Chroma, Hue angle, Whiteness and Red index were calculated from the parameters by the following equations [20]:

$$H^*_{ab} = \text{Arctan}\ (b^*/a^*)$$
$$C^*_{ab} = [(a^*)^2 + (b^*)^2]^{1/2}$$

Sensory Evaluation: The sensory evaluation of rainbow trout fillets was carried out according Das *et al*. [19] 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, odor, flavor, texture and general 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 Duncan's multiple range test calculated at $p < 0.05$. Non-parametric Kruskal-Wallis tests for analysis of sensory data (for multiple group comparisons) and Mann-Whitney (for comparison with other groups) were used. The graphs were plotted in Excel software.

RESULTS

The viscosity of different coatings of solutions showed a significant difference among different treatments ($p < 0.05$) (Table 1). The solutions of gums had different apparent viscosities and could have contributed to the observed differences in the batter pick-up. The highest viscosity and batter pick-up was observed in xanthan and HPMC treatments ($p < 0.05$).

Fig. 1 shows the moisture and fat contents obtained from fish trout fillets coated with different gums after frying step. Carrageenan and HPMC treatments showed the highest and control and xanthan treatments showed the lowest amount of moisture (p?0.05). After frying, the oil content was tested and found to be lower in fillets that had been coated with HPMC. The effectiveness of using gums as a moisture and fat barrier in comparison with the control can be clearly seen.

Water holding capacity (WHC) is inversely associated with the percent water expressed by centrifugation [19]. Water holding capacity among the fillets coated with different gums and control treatments didn't show any significant difference (Table 2), except in fillets coated with alginate gum that the water holding capacity had decreased (increase expressible water) ($p < 0.05$).

The product yield content was not comparable between control and treated fillets except in the xanthan gum treatments (Table, 2). The yield in fillets coated with xanthan gum was significantly lower than control and other treated fillets.

Table 3 shows the results of color measurement in fish trout fillets coated with different gums. The coats of different gums showed significant differences in terms of lightness (L*), redness (a*) and yellowness (b*), Hue and Chroma between the treated samples ($p < 0.05$).

Table 1: Viscosity and batter pick-up content in fish trout fillet coated with different gums

Patterns	Viscosity	Batter pick-up
Xanthan	1320±95.04[a]	19.45±2.11[a]
Carrageenan	106.67±3.33[c]	7.75±0.3b[c]
Alginate	136.67±3.33[c]	10.83±0.99[b]
Soy protein isolate	40±0[c]	5.73±0.53[c]
HPMC	893.33±5.77[b]	17.51±1.32[a]

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

Table 2: Water holding capacity and product yield content in fish trout fillet coated with different gums

Pattern	WHC	Product yield
Control	12.65±1.8[b]	50.83±1.39[a]
Xanthan	13.28±0.45[b]	41.96±4.34[b]
Carrageenan	13.67±0.83[b]	52.64±1.71[a]
Alginate	17.04±0.99[a]	56.52±2.4[a]
Soy protein isolate	12.9±0.77[b]	51.05±1.9[a]
HPMC	14.37±0.72[ab]	55.38±1.68[a]

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

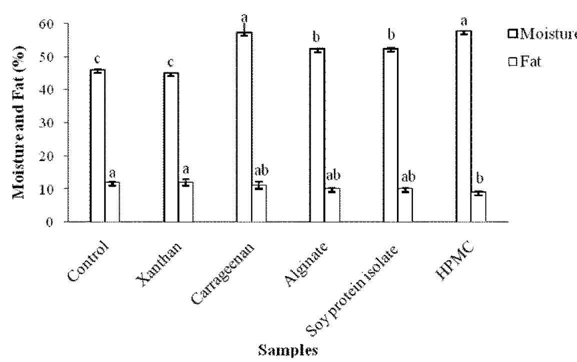

Fig. 1: Moisture and fat content in fish trout fillet coated with different gums

Mean values with different superscripts are significantly different among different samples (P<0.05).

Table 3: Color measurement in fish trout fillet coated with different gums

Patterns	L*	a*	b*	Hue	Chroma
Control	55.41±1.16b[c]	9.36±0.30[a]	12.76±0.31[a]	0.94±0.02[a]	15.83±0.35[a]
Xanthan	58.73±0.93[ab]	7.98±0.17[d]	11.31±0.25[b]	0.96±0.01[a]	13.85±0.25[c]
Carrageenan	53.78±1.24[c]	9.09±0.28[ab]	11.57±0.21[b]	0.91±0.01[a]	14.72±0.30[b]
Alginate	61.66±0.76[a]	7.97±0.12[d]	9.09±0.21[c]	0.85±0.01[b]	12.10±0.16[d]
Soy protein isolate	57.53±1.11[b]	8.64±0.19[bc]	11.11±0.36[b]	0.91±0.02[a]	14.10±0.27[bc]
HPMC	62.00±1.38[a]	8.38±0.12[cd]	9.54±0.44[c]	0.85±0.02[b]	12.73±0.32[d]

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

Table 4: Sensory evaluation in fish trout fillet coated with different gums

Pattern	Color	Odor	Juiciness	Texture	Overall acceptability
Control	6±0.53[a]	7±0.58[a]	5.71±0.78[a]	6.28±0.42[a]	5.86±0.67[a]
Xanthan	6.71±0.47[a]	6.28±0.42[a]	4.86±0.51[a]	6.28±0.47[a]	5±0.49[a]
Carrageenan	6.86±0.67[a]	6.14±0.4[a]	4.57±0.43[a]	6.43±0.68[a]	5.57±0.57[a]
Alginate	6.86±0.34[a]	6.14±0.55[a]	4.71±0.64[a]	6.86±0.46[a]	5.14±0.51[a]
Soy protein isolate	6.86±0.26[a]	6.14±0.7[a]	4.71±0.86[a]	6±0.62[a]	5.28±0.61[a]

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

The highest lightness was observed in alginate and HPMC samples, whereas control and carrageenan samples showed the lowest lightness ($p < 0.05$).

Statistical analysis of sensory evaluation in terms of color, odor, juiciness, texture and overall acceptability did not show any significant differences among treatments of trout fillets and the sensory parameters measured did not show significant differences ($p < 0.05$) (Table 4).

DISCUSSION

The increase of viscosity can be various based on the hydrocolloid type and its concentration that is used. The batter pick-up is an important index in the food industry, as it can affect the final food quality and products yield [21]. The amount of batter pick-up can influence on the yield and the quality of the final product [14-16]. The Xanthan gum can form a solution having a low-shear viscosity and high elastic thermoreversible gel that the temperature, addition of salt and pH can not affect this viscosity [10]. In other hand using of HPMC leads to the increase of viscosity and thereby enhancing the adherence properties [13]. Alginate and carrageenan coatings because of high moisture of gelatinous form a gel with weak viscosity and are more used as protection against lipid oxidation in food stuff [2]. HPMC is formed gels which melt on heating, whereas alginate is formed gels that on addition of polyvalent ions (usually calcium).

After frying, the oil content was tested and found to be lower in fillets that had been coated with HPMC. Among the different ingredients that had been proved to reduce the amount of oil absorbed by fried food, cellulose and its derivatives were of considerable interest. HPMC coating reduced oil absorption in both the surface layer [22] and core region [23-24] of chicken nuggets and other fried battered products in comparison with uncoated products [12]. The film-forming properties and unique thermal gelation ability described for HPMC had also been used successfully to reduce oil absorption that because of sufficient dehydration of the polymer occurred, causing polymer-to-polymer interactions to create an oil barrier. Annapure *et al.* [25] had evaluated the different contents of hydrocolloids (0.25-2%) for reducing oil uptake in *sev* (a fried product prepared from chickpea flour) and the results showed that their effectiveness decreased in the following order: gum Arabic< carrageenan< gum karaya< guar gum and that xanthan gum, gum tragacanth and locust bean gum were not effective (<10% reduction in oil content).

The hydrocolloid gums (i.e. alginate, carrageenan, pectin or xanthan gum) are used as film-forming solutions and gelling agents or thickeners and emulsifiers in composite films [26]. These gums are highly hydrophilic and as a result they present only a limited barrier to moisture, whereas they are good oxygen barrier and can be used against lipid oxidation [2]. About alginate we can tell that because of high moisture of gelatinous, the produced films have a little value for controlling inter-phase migration; and as a result the fillets coated with alginate show moderate moisture and fat after deep frying.

A major factor determining the amount of water evaporation and oil absorbed by the fried products is the food microstructure [27]. Changes of moisture and fat in cooked products depend on the changes of concentration of the water evaporation and fat uptake. Akesowan [28] stated that the soy protein isolate had the ability of water and fat binding and increasing yield, but in this study samples coated with soy protein isolate only in amount of water showed a better performance than the control samples but in the fat amount and yield of products were similar to the control.

The lowest percent of water extracted from the treated fillet means the highest WHC. Hydrophilic hydrocolloid coatings can be use as water binders which minimize the water loss [2]. The protein-protein and protein-water interactions are responsible for influencing on water holding capacity in meat and meat products. In fillets treated with alginate, water molecules interacted weakly with protein in fillets compared to tight protein-water interaction in control and other treated fillets [29].

Demirci *et al.* [8] stated that the cooking losses decreased with gum addition. In this study the cooking yield of samples were similar to control due to more water binding during cooking. The coated xanthan absorbed higher water in performance of preparing coating solutions and when the fillets were exposed to frying temperatures, due to rapid water evaporates from the xanthan coating, the amount of product yield decreased.

Color is one of the most important parameters used in assessing the quality of the fish and its products. The reduction of the amount of moisture can lead to the decrease of lightness and value changes of lightness and yellowness have a direct relationship with the proportional of the amount of moisture [30]. In this study alginate and HPMC samples had the higher amount of moisture, thus they showed the highest lightness to the other samples. The results of color measurement are also influenced by the deep-fat frying process. The frying process increases the amount of redness and decreases the yellowness and lightness of fish fillets. In general, no significant difference was found in terms of redness and yellowness values between samples that were coated with different gums.

Sensory evaluation in terms of color, odor, juiciness, texture and overall acceptability did not show any significant differences among treatments. Bajaj *et al.* [31] stated that with adding xanthan gum to *sev* dough, they did not observe any significant effects on the hardness or crispness of the fried *sev*. In preparing the film coatings, the added gums are in a very low concentration (0.5-2%), thus with adding a small percentage of them to the final product, they will not affect the final product taste. However study of Garcia *et al.* [32] 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 whereas study of Nguyen [33] indicated that MC chicken nuggets had coarser and crispier texture and also tasted better than the controls.

CONCLUSION

The effects of different hydrocolloid edible films on viscosity, amount of batter pick-up, color, water retention and reduction of oil uptake were significant ($p < 0.05$) whereas no significant effect on sensory evaluation was observed ($p < 0.05$). Among the hydrocolloid samples, fish fillets coated with xanthan and HPMC showed the highest viscosity and batter pick-up, the coated fillets with carrageenan and HPMC indicated the highest content of moisture and the coated fillets with HPMC showed the least amount of fat ($p < 0.05$). The results indicated that all of the edible films were effective in retaining the quality characteristics of treated fish fillets and showed better performance than the control.

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