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Production of breaded kilka (*Clupeonella cultriventris*) using two different batters and determination of chemical, microbial and sensory properties

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Abstract

This study aimed to assess the chemical, microbial and sensory properties in a new product from kilka in mass scale with two different types of batters (simple and tempura batter). Kilka fish were battered in a simple or tempura batters, before being breaded with conventional breading crumbs and pre-fried in sunflower oil at 170°C for 30 sec. The fried samples were then immediately frozen through continuous method at -40°C in a spiral freezer before being packed kept at -18°C. Chemical, microbial and sensory properties were performed on the fried breaded kilka a day after freezing. There was no significant difference in protein, fat and ash contents of raw breaded kilka prepared from tempura and simple batters ($p \geq 0.05$), while there was significant difference in moisture content of raw breaded kilka prepared from two batters ($p<0.05$). There was a significant difference in moisture and fat contents between raw and fried breaded kilka by both tempura and simple batters ($p<0.05$) with lower moisture content and higher fat content seen in fried breaded kilka. To determine the microbiological quality of breaded kilka, total bacteria count (TBC) and total *Colifirms* (TC) and *E. coli* were evaluated. The produced breaded kilka with two types of batters were proper from the hygienic view point. Comparing TC and TBC of breaded kilka products with different batters showed that the breaded kilka with tempura batter is in a better status. There were significant differences in some sensory properties of breaded kilka with simple and tempura batters includes odor, cohesiveness of batter and general acceptability ($p<0.05$). Among all determined characteristics, the breaded kilka with tempura batter had higher scores than the one with simple batter.

Keywords: Breaded kilka, Batter, Tempura, Product quality

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Introduction

The most abundant fishes in the Caspian sea are the small clupeids known as kilka including common kilka (*Clupeonella cultriventris caspia*), anchovy (*Clupeonella engrauliformes*) and large eye kilka (*Clupeonella grimi*)(Svetovidov, 1963). Those are native species of the Caspian Sea and found in all parts of this sea especially in coastal lines. In Iran, the overall annual kilka catch increased from 19610 tones in 2004 to over 25483 tones in 2009 (Fisheries studies and statistic group, 1392). Unfortunately, limited quantity of kilka catch is only consumption by human (4%) because of its small size, easy deterioration, being not practical gutting right away after catching, difficulties in hygienic preservation, packaging, and supply and therefore the rest is used as fish meal for poultry and aquaculture industries (Shabanpour *et al*., 2007; Khoshkhoo *et al.*, 2010). It is noteworthy that clupeids present a few positive qualities such as abundance in the Caspian Sea, low cost, easy scaling without scaling equipments; and therefore, clupeids can be utilized as raw materials in conversion industry.

Kilka can be processed as salted, smoked, pickled, sausages, canned, dried and frozen fish. In Iran, kilka products in market are available in canned, packed in frozen shape and fresh wet fish (Martin, 1994).

The growing tendency to spend less time on food preparation has led to a great demand for time-saving "ready-to-heat" frozen products. Coatings by battering and breading foods are very popular today, and their consumption has increased in recent years (Varela *et al*., 2008).

The main purpose for applying bread and batter coating on fried foods is to produce high-quality products in terms of visual appeal, crispness, low fat content, flavor and favorable consumer satisfaction (Loewe, 1993; Fiszman and Salvador, 2003).

The unit operations in development of coated product are portioning/forming, predusting, battering, breading, flash frying, freezing, packaging, and storage (Venugopal, 2006). Predust usually is a very fine, dry, raw flour material that is sprinkled on the moisty surface of fresh–food substrate before any other coating is applied. Batters are defined as liquid mixture composed of water, flour, starch, and seasonings, into which food products are dipped prior to cooking. Batters are in two types, adhesive and tempura. The traditional adhesive batter (simple batter) is a fluid, basically consisting of flour and water. Tempura batter is the puff-type especial batter. Corn flour is important in tempura batters. Tempura–type batters form a crisp, continuous, uniform layer over the food. The tempuras are used at very high viscosity levels and always contain raising/leavening agents (Venugopal, 2006). Breading was defined as a dry mixture of flour, starch, seasonings, coarse composition, and applied to moisten or battered food products prior to frying (Suderman, 1993). Then they should be pre-fried for a few seconds in order to make the batter coagulate, and

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then they should be frozen. The pre-fried products meet customers where they are cooked again for a few minutes before it is used (Fiszman and Salvador, 2003). Coating is referred as the batter and/or breading adhering to a food product after cooking (Suderman, 1993).

Coating protects the natural juice of foods from the effects of freezing or reheating, thereby ensuring a final product that is tender and juicy on the inside and the same time crisp on the outside (Fiszman and Salvador, 2003). Moisture loss due to dehydration is a common problem during storage of frozen food products. Functionally, coating provides a moisture barrier for the product, helping in reduction of weight loss during frozen storage while reheating before consumption. Coating restricts volatile flavor loss, and foreign odor is picked up by seafood. Battering and breading also reduce oil uptake during deep fat frying and also provides an opportunity to increase the nutritional value of a product through incorporation of nutrients in the coating (Liorca *et al*., 2003; Venugopal, 2006). Battering and breading prevent oxidation and prolonged shelf-life of coated products (Gennadios *et al*., 1997; Joseph, 2003). These advantages offer consumer appeal for the product through improving sensory value of the processed items. The wider use of tempura batter in conjunction with coarse crumbs represents a new coating process for modern processing (Venugopal, 2006).

Batters have become a sophisticated complex system in which the nature of the ingredients is very wide-ranging and interactions between ingredients determine the performance quality of the final product (Fiszman and Salvador, 2003).

There are several studies showing the basic ingredients that contribute better covering characteristics and their effects on properties of final product (Makinson *et al*., 1987; Salvador *et al*., 2002; Baixauli *et al*., 2003; Liorca *et al*., 2003; Chen *et al.*, 2009; Kilincceker *et al*., 2009; Dehghan *et al*., 2010)

Considering abundant resources of kilka in the Caspian Sea, the aim of this study was to produce a new product from kilka with different sensory properties in industrial scale with two different types of batters (simple and tempura batters in order to increase human consumption and evaluation of chemical, microbial and sensory properties.

Materials and methods

Preparation of raw fish

Fresh kilka were bought from special fishing boats with lantern net in Anzali Harbor, (Guilan Province, Iran) and then they were transferred to National Research Seafood Processing Center in CSW tanks with 60% fish, 25% ice and 15% sea water. The fish were immediately deheaded and gutted by two skilled technicians and then rinsed with cold water. Then, the fish were submerged in diluted brine at 4°C for 60 min. The fish were soaked in brine, to give the sufficient time for muscle to absorb a significant amount of salt. Afterwards, the fish were rinsed for 5 min in order to remove the surface salt.

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Batter ingredients and formulations

Simple batter consists of wheat flour (31%), dried egg albumin (7%), pepper (0.3%), salt (0.4%), and 14°C water (61%) (Venugopal, 2006). Tempura batter contained wheat flour (16%), tapioca starch (3%), corn flour (5%), soy flour (5%), (7%), powdered milk (3%), baking powder (2%), sunflower oil (6%), salt (0.4%), pepper (0.3%), lime juice (0.3%), guar gum (1%), and water (51%) (Venugopal, 2006) with 100 ppm thyme and rosemary extracts as natural preservatives. All dry ingredients were mixed at low speed for 1 min in a stainless-steel bowl. Ingredients were further mixed with water for 2 min, and then stored in an ice bath to maintain the low temperature during batter application.

Preparation of breaded kilka

Pre-dusting was performed with wheat flour using automated machinery. Then, the kilka fish were battered in the batters produced with two different formulations, were subjected to batter shower by conveyor and the batter were sprayed by a pump from a tank and then, the fish were breaded with conventional breading crumbs (Solar Company, Iran). In this step, some raw breaded kilka fish were taken to laboratory for chemical and microbial assays. The rest of the samples were flash-fried in sunflower oil (Oila Company, Iran) at 170°C for 30 sec. The fried samples were immediately frozen through continuous method at -40°C in a spiral freezer and then they were packed with polyethylene coating with 20 fish in each pack. The samples were kept frozen. Chemical and microbial assays were performed on the fried breaded kilka fish a day after freezing.

Chemical analysis

The moisture content was determined by using oven at 103˚C (AOAC, 2002). The amount of ash was measured by burning the sample in an electrical furnace at 550˚C (AOAC, 2002). The amount of crude protein was determined by Kjeldahl method (AOAC, 2002) and crude fat was measured using Soxhlet method (AOAC, 2002). All the analyses were carried out in triplicate.

Microbial analysis

To determine the microbiological quality of breaded kilka, total bacteria count (TBC) and total *Colifirms* (TC) and *E. coli* were analyzed. TBC and TC were determined according to the Iranian Institute of Standard and Industrial Studies (8923-1, 2007 and 11166, 2008). *Escherichia coli* most probable Number method (MPN) and Lauryl Sulfate broth as medium were used. Confirmation test was made in Pepton Water and EC broth according to ISO7251 (2005). All the analyses were carried out in triplicate.

Sensory analysis

In order to assess sensory properties, the breaded kilka fish were fried in sunflower oil for 3 min after thawing in ambient temperature. The assessment was performed through Hedonic method using 10 trained panels in standard chambers (ASTM, 1969). The

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panelists scored odor, flavor, texture, crispness, cohesiveness of the batters and general acceptability using a five-point hedonic scale (1, extremely dislike to 5, extremely like). In order to avoid interference of odor and flavor during the assessment, the panelist smelled coffee before odor assessments and they washed their mouth cavities before flavor assessments.

Statistical analysis

Data were analyzed by One-way analysis of variance (ANOVA) using SPSS Software version 15. Chemical quality and sensory properties were analyzed through Duncan Test at 5% confidence level and Mann-Whitney Test at 5% confidence level, respectively.

Results

Proximate composition analysis

The results obtained from chemical analysis of fresh and breaded kilka with simple and tempura batters in two forms of raw and fried are provided in Table 1.

Table 1: Proximate composition (%) of fresh kilka, breaded kilka with simple and tempura batters in two forms of raw and flash fried (g 100g^{-1} of total matter).

Product	Crude protein	Crude fat	Moisture	Crude ash
Fresh kilka	15.50±0.28^{b}	6.5±0.14^{b}	75.00±0.28^{a}	3.00±0.08^{c}
Raw breaded kilka with simple batter	15.95±0.07^{b}	5.60±0. 28^{b}	63.50±0.00^{b}	3.25±0.21^{b}
Fried breaded kilka with simple batter	17.55±0.21^{a}	20.91±0.15^{a}	47.65±0.21^{d}	3.49±0.07^{a}
Raw breaded kilka with tempura batter	15.90±0.56^{b}	5.40±0.42^{b}	60.02±0.03^{c}	3.29±0.00^{b}
Fried breaded kilka with tempura batter	17.65±0.07^{a}	20.4±0.48^{a}	48.45±0.07^{d}	3.55±0.07^{a}

Data is expressed as mean±SD (n=3).

Means within the same column having different superscripts are significantly different at p<0.05.

No significant difference was detected in protein and fat contents between fresh and raw breaded fish (p≥0.05) while there was a significant difference in moisture content (p<0.05). The moisture content of raw breaded kilka decreased compared to fresh fish (p<0.05). Significant difference was detected in moisture content of raw breaded kilka prepared from tempura and simple batters (p<0.05).

The fat content in raw and fried breaded kilka with tempura batter was 5.40% and 20.4%, respectively, and the fat content in raw and fried breaded kilka with simple batter was 5.60% and 20.91%, respectively. The fat content of breaded kilka increased after flash frying (p<0.05) but the moisture of fried breaded kilka decreased significantly after flash frying (p<0.05). There was a significant difference in moisture content between fried breaded kilka by tempura and simple batters (p<0.05). A significant difference was observed in protein content between

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raw and fried breaded kilka (p<0.05) so that protein content in fried breaded kilka was higher than that of raw one. Ash content in raw breaded and fried breaded kilka increased significantly compared to fresh fish (p<0.05).

Microbial analysis

Table 2 presents the microbial contents of fresh kilka and raw and fried breaded kilka produced by two kinds of batters.

Table 2: The microbiological contents of fresh kilka, breaded kilka with simple and tempura batters in two forms of raw and flash fried.

Product	T.B.C (log CFU g^{-1})	T.C (log CFU g^{-1})	*E. Coli* (log CFU g^{-1})
Fresh kilka	3.29 ± 0.12^{c}	3.13 ± 0.23^{b}	1.31 ± 0.17^{a}
Raw breaded kilka with simple batter	5.50 ± 0.23^{a}	3.79 ± 0.19^{a}	1.34 ± 0.22^{a}
Fried breaded kilka with simple batter	2.95 ± 0.09^{d}	1.84 ± 0.18^{c}	0.00 ± 0.00^{b}
Raw breaded kilka with tempura batter	4.65 ± 0.11^{b}	3.69 ± 0.09^{b}	1.27 ± 0.11^{a}
Fried breaded kilka with tempura batter	2.69 ± 0.12^{d}	1.15 ± 0.16^{c}	0.00 ± 0.00^{b}

Data is expressed as mean±SD ($n=3$).
Means within the same column having different superscripts are significantly different at p<0.05.

In the present study, TBC was estimated to be 3.29 log CFU g^{-1} in fresh kilka. Contamination load of the produced breaded kilka with both types of batters increased. TBC in raw breaded kilka produced by simple and tempura batters increased significantly as 5.50 and 4.65 log CFU g^{-1}, respectively (p<0.05). TBC in raw breaded kilka with tempura batter was lower than that of breaded kilka with simple batter (p<0.05). Fried breaded kilka showed lower TBC in comparison with raw breaded kilka (p<0.05).

TC in fresh kilka was 3.13 log CFU g^{-1}. TC in raw breaded kilka increased significantly compared to fresh fish (p<0.05). TC in flash fried breaded kilka reduced significantly in comparison with raw breaded kilka (p<0.05). Content of *E.coli* in fried breaded kilka decreased to zero after flash frying.

Sensory analysis

The sensory quality of breaded kilka with simple and tempura batters was evaluated in terms of odor, taste, texture, crispness, cohesiveness of batter, and general acceptability which are shown in Table 3.

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Table 3: Sensory quality of breaded kilka with simple and tempura batters.

Product	Odor	Taste	Texture	Crispness	Cohesiveness of batter	General acceptability
Fried breaded kilka with simple batter	4.00±0.77b	3.91±0.70a	3.91±0.78a	3.54±0. 69a	3.73±0.90b	3.73±0.65b
Fried breaded kilka with tempura batter	4.73±0.48a	4.27±0.78a	4.18±0.75a	3.81±0.75a	4.54±0.52a	4.64±0.50a

Data is expressed as mean (*n=10*)
Means within the same column having different superscripts are significantly different at $p<0.05$.

The results showed that there were no significant differences in taste, texture, and crispness properties of breaded kilka with simple and tempura batters ($p>0.05$); however, odor, cohesiveness of batter and general acceptability indices showed significant differences between the treatments ($p<0.05$). Among all determined characteristics, the breaded kilka with tempura batter had higher scores than the one with simple batter ($p<0.05$).

Discussion

Chemical analysis

Moisture content of raw breaded kilka decreased during the processing. This deduction was due to the addition of some ingredients like wheat flour and breading materials. Similar results have also been reported by Taşkaya *et al*. (2003) for fish burgers produced from rainbow trout (*Oncorhynchius mykiss*), Ihm *et al*. (1992) for fish burgers produced from sardine, Bochi *et al*. (2008) for fish burgers produced from silver catfish (*Rhamdia quelen*), and Elyasi *et al*. (2010) for fish burgers produced from mince and surimi of common carp.

The significant difference in moisture content of raw breaded kilka prepared from tempura and simple batters can be attributed to higher cohesiveness of the tempura batter and higher percentage of breading crumbs in final coating in breaded kilka by tempura batter.

The fat content of breaded kilka increased after flash frying. Absorbing the frying oil during deep frying increased the fat content of fried breaded kilka. One of the important mechanisms of oil uptakes during deep-fat frying is water replacement. During frying, oil replaces the water that has evaporated. When the food is exposed to frying temperatures, water evaporates rapidly, the outer surface becomes dry and a crust forms. Moisture within the product is converted to steam, creating a positive pressure gradient. Thus steam escapes through cracks, defects, open capillaries and channels in the cellular structure and membranes. As the process progresses, oil adheres to the food, entering into the food through the large pores formed by the frying and evaporation of water (Dana and Saguy, 2006). Here, there is a linear correlation between reduction of moisture and fat uptake (r= -0.80) (Krokida *et al*., 2000). For example, a food with more moisture content would show more oil absorption (Gamble *et al.,* 1987; Mellema, 2003; Dana and Saguy,

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2006). On the other hand, Bouchon *et al*. (2003) suggested that oil uptake and water loss were not synchronous phenomena because in their study only a small amount of oil uptake was found during frying while most of oil absorption was observed at the end of the process. Therefore, water replacement alone could not fully explain the oil absorption in fried food. Several studies have shown that oil absorption occurs mainly during another mechanism 'cooling phase' (Moreira *et al.*, 1997; Dana and Saguy, 2006). During frying, vapor at high moisture content escapes the food and creates the over pressure inside the pore, thus, oil cannot enter the pores. A few seconds after removal from the fryer, fried food is cooled, the water vapor in the crust is condensed, and the internal pressure decreases from over-pressure to under-pressure (Mellema, 2003). As a result, oil adhering to the food surface is absorbed into the pores. Therefore, oil enters the food. This mechanism can possibly explain what occurs in large foods with short frying times. With longer frying time, oil can be mostly absorbed before the food is removed from the fryer (Mellema, 2003). In a nutshell, increased fat and reduced moisture contents in fried breaded Kilka compared to raw breaded Kilka can be attributed to water replacement and cooling-phase effect mechanisms. Consistent results about reduced moisture content and increased fat content in breaded fish product were obtained by Ihm *et al*. (1992), Taskaya *et al*. (2003), Elyasi *et al*. (2010), Yazdan *et al.* (2009), and Moradi *et al*. (2010).

Protein content in fried breaded kilka was higher than that of raw one which can be elucidated by presence of protein compounds in batter such as wheat gluten, egg albumin, and powdered milk protein, and also reducing moisture after frying.

Ash content in raw breaded and fried breaded kilka increased significantly compared to fresh fish, which is due to some ingredients in the using batter (i.e. wheat flour, corn flour, soy flour, and breading crumbs).

In the present study, sum of the moisture, protein, fat, and ash contents were estimated to be 88.3%, 89.60%, 84.60%, and 90.55% in raw breaded kilka with simple batter, fried breaded kilka with simple batter, raw breaded kilka with tempura batter, and fried breaded kilka with tempura batter, respectively. The remaining percentage of the total proximate analyses is mainly belongs to carbohydrate (Tokur *et al*., 2006). In general, fish are considered to have low amounts of carbohydrate in their muscles. Nevertheless, the high amount of carbohydrate in breaded kilka can be due to coating materials such breading crumbs, wheat flour, corn flour, soy flour, and starch. Sayar (2001) reported 15.2% carbohydrates in croquet prepared from whiting fish (*M. merlanguis*). Also, Cakli *et al*. (2005) and Miranda *et al*. (2010) reported increased amount of carbohydrate in fish fingers prepared from different species and in breaded tuna paste, respectively.

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Microbial analysis

In the present study, TBC was estimated to be 3.29 log CFU g^{-1} in fresh kilka, which is lower than the permitted maximum rate (7 log CFU g^{-1}) recommended by ICMSF. Also, National Standard Organization of Iran (No.5625) reported the maximum recommended TBC to be 5 log CFU g^{-1}. Therefore, the kilka introduced to production line in the present study was in a suitable range. Izci *et al*. (2011) and Tokur *et al*. (2006) reported increased TBC in raw fish finger produced from sand smelt and mirror carp, respectively.

TBC in raw breaded kilka produced by simple and tempura batters significantly increased compared with fresh fish. Some products like breaded fish steaks, fish burger, and fish finger have very different microbial load from fresh fish because of additives, extra processes, and exposure to machinery, conveyors, workers' hands, and also environmental contaminations and packaging (Tokur *et al*., 2006).

TBC in raw breaded kilka with tempura batter was lower than breaded kilka with simple batter which is presumably due to antibacterial and antioxidant potentials of thyme and rosemary extracts in tempura batter. Antibacterial effect of thyme and rosemary extracts is due to the presence of hydroxyl groups in their phenolic compounds (Shahidi and Wanasundara, 1992; Del Campo *et al.,* 2000; Karamanoli *et al.,* 2000). Also, antibacterial and antifungal effects of rosemary extract against different gram-positive and negative bacteria have been proved (Del Campo *et al.,* 2000; Whitemore and Naidu, 2000; Benkeblia, 2004; Gachkar *et al.,* 2006). Antibacterial and antioxidant properties of thyme extract have been reported in coated semi fried fillets of mullet fish containing 2.5 and 5 percent thyme (Yasin and Abou-Taleb, 2007).

Fried breaded kilka showed lower TBC in comparison with raw breaded kilka. Lower TBC in fried fish finger compared to raw one after flash frying at 170-180 °C has been observed in several studies (Cakli *et al.,* 2005; Tokur *et al.,* 2006; Elyasi *et al*., 2010; Izci *et al.,* 2011).

According to the standard of ICMSF, the maximum recommended bacterial counts for good quality products and maximum recommended bacterial counts for marginally acceptable quality products of precooked breaded fish are 5×10^5 and 10^7, respectively. Because TBC in fried breaded kilka was lower than 10^3, both breaded kilka products were in high quality.

Like TBC, TC and *E.coli* also showed a declining trend after frying. Decreased TC and *E.coli* in fried fish finger compared to raw one after frying is reported in several studies (Cakli *et al.,* 2005; Elyasi *et al.,* 2010; Izci *et al.,* 2011). After flash frying, the temperature of the frying oil was adequate to kill the all *E.coli*.

The maximum level of coliform bacteria and *E.coli* in flash fried fish fingers has been 10^2 CFU g^{-1} and zero recommended by ISIRI (2006). Therefore, considering the data presented in Table 2, it is confirmed that the produced breaded kilka with

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two types of batters were proper from the hygienic view point. Also, comparing TC and TBC of breaded kilka products with different batters showed that the breaded kilka with tempura batter is in a better status.

Sensory analysis

The results of present study showed that cohesiveness of tempura batter had significant differences in compare with simple batter. One of the most important properties of batter is its cohesiveness. Viscosity of batter affects the pickup and cohesiveness of batter, the handling properties of the battered product, its appearance and final texture (Venugopal, 2006). The main ingredients of tempura batter, such as gums and polysaccharides (wheat flour, corn flour, and starch) can enhance cohesiveness of the batter (Kuntz, 1997; Venugopal, 2006). On the other hand, protein ingredients of the batter (milk powder and egg albumin) can improve water absorption capacity of the flour and thus increase the batter viscosity (Venugopal, 2006). Therefore, with increased viscosity in tempura batter, cohesiveness of the batter increases and the breading crumbs sticks to the surface of the product and creates a uniform layer without pores on the surface of food product. The layer is fixed following frying and earns a more favorable appearance. However, simple batter, which is a blend of flour and water, had lower viscosity and consequently, weaker cohesiveness compared to tempura batter.

The average odor scores in breaded kilka with tempura batter were higher than those in breaded kilka with simple batter. Significant difference in odor of breaded kilka might be due to thyme and rosemary extracts in tempura batter composition.

Although there was no significant difference in texture index between the treatments, texture assessment score was higher in breaded kilka with tempura batter. Tempura batter contains raising agents that produce carbon dioxide in the presence of water and heat, so it expands when fried, developing a spongy structure an improved texture of the product (Venugopal, 2006; Fiszman, 2008).

The most appreciated texture parameter in a fried product is crispness. The breaded kilka with tempura batter was able to get higher score in crispness index. Mohamed *et al*. (1998) observed that the addition of ovalbumin to a batter formulation improved the crispness and color of the fried product as a result of the amino groups present in the proteins that take part in the Maillard reaction. In tempura batter soy flour has shown to be an effective ingredient in enhancing crispness and color (Dogan *et al*., 2005). Modified starch improves adhesion of batter and enhances the crispness of final products (Loewe, 1993; Fiszman and Salvador, 2003).

Although there was no significant difference in crispness between two treatments, the breaded kilka with tempura batter was able to get higher score in crispness index. Corn flour is often used to provide natural yellow color and to increase crispness in coated fried products because it has often

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added to control viscosity since its higher starch level affects the batters ability's to absorb water (Fiszman and Salvador, 2003). Oil added into batter tenderizes the coating and plays an important role in overall favor and mouth–feel (Loewe, 1993). Salt, pepper, thyme and rosemary extracts added in batter system as flavorings create acceptable taste. The gelling ability of hydrocolloids (like guar, cellulose, methylcellulose, and hydroxypropyl methylcellulose) together with their usual hydrophilic nature makes them suitable for reducing oil uptake during frying in battered products (Annapure *et al*., 1999).

Starch and gums are often used together in batter systems to provide proper texture, control moisture, improve overall product quality and reduce costs (Shi and BeMiller, 2002).
The breaded kilka with two simple and tempura batters had significant difference in terms of general acceptability with higher score for the breaded kilka with tempura batter.

Battered products have better flavor, texture, and appearance and the batters play the role of a barrier against reduction of moisture and natural extract in food product during refreezing or reheating (Fiszman and Salvador, 2003). Thus, they are juicy inside and crispy outside. Advantages of the breaded kilka with tempura batter in the present study can be regarded to be more attractive appearance because more cohesiveness of breading crumbs, formation of a crispy and uniform layer on the surface of fish, formation of a lighter and more spongy texture due to released carbon dioxide resulted from use of baking powder in the batter composition, juiciness of inner part of the product, and also more favorable odor of the product due to use of thyme and rosemary extracts.

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