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The Sensory Quality of Pearl Mullet (*Chalcalburnus tarichi*) Fillets Coated with Different Coating Materials

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Abstract

The effects of gluten:zein (30:70, 50:50, 70:30) as first coating, guar gum (0.2, 0.4, 0.6%) as second coating and wheat flour:corn flour (30:70, 50:50, 70:30) as a last coating on the sensory qualities of pearl mullet fillets were determined using response surface methodology. The increasing amount of gluten in the first coating increased L and whiteness values and decreased a values. Colour, appearance, and a values decreased with increased guar gum in the second coating. Increasing wheat flour in the last coating decreased b, colour and overall acceptability values. The differences in the amount of coating materials were not found to be significant (P>0.05) on odour, flavour and texture values.

Keywords: Pearl mullet, fillet, coating, sensory quality.

Farklı Kaplama Materyalleri ile Kaplanan İnci Kefali (*Chalcalburnus tarichi*) Filetolarının Duyusal Kalitesi

Özet

İnci kefali filetolarının duyusal kalitesi üzerinde yanıt yüzeyi metodolojisi kullanılarak, ilk kaplama olan gluten:zein (30:70, 50:50, 70:30)'nin, ikinci kaplama olan guar gamı (0,2, 0,4, 0,6%)'nın ve son kaplama olan buğday unu:mısır unu (30:70, 50:50, 70:30)'nun etkileri belirlendi. İlk kaplamada gluten miktarının artışı whiteness ve L değerlerini artırırken, a değerlerini düşürmüştür. Renk, görünüm ve a değerleri, ikinci kaplamada guar gamının artışı ile birlikte düşmüştür. Son kaplamada ise buğday unu miktarının artması b değerlerini, renk ve kabul edilebilirlik değerlerini düşürmüştür. Koku, lezzet ve tekstür değerleri üzerinde kaplama materyallerinin miktarlarının farklılığı önemli (P>0,05) bulunmamıştır.

Anahtar Kelimeler: İnci kefali, fileto, kaplama, duyusal kalite.

Introduction

Flesh of fish is extremely perishable, which needs processing to increase shelf life. There is increased interest in using edible coatings from polysaccharide and protein for industrial application (Gennadios *et al.*, 1997; Kilincceker and Kucukoner, 2007). Improvements in texture, colour, flavour and nutritional value are some of the advantages of edible coatings (Sanz *et al.*, 2004; Kilincceker *et al.*, 2009). Moreover, they are effective oil, moisture and oxygen barriers to protect fried products from the loss of critical factors determining the acceptability of the finished products (Mallikarjunan *et al.*, 1997; Lee and Inglet, 2007). A number of coating materials have been tested, and flour is a major ingredient among them (Kilincceker and Kucukoner, 2007; Yusnita *et al.*, 2007). In particular, its gluten content plays an important role in the quality of deep fat fried product (Yusnita *et al.*, 2007). Moreover, the hydrocolloids, such as methyl cellulose and gums, were used either as part of the coating ingredients or in the form of a film layer (Kilincceker *et al.*, 2009; Maskat *et al.*, 2005). Gums affect viscosity of batter, which is a key characteristic for the quality of coating (Fiszman and Salvador, 2003). Adhesion performances of coating materials are related to viscosity of their solutions (Kilincceker *et al.*, 2009). Gluten, zein, wheat and corn proteins are important in terms of functionality. They can contribute to gel properties which help to barrier formation on coated food surface (Fiszman and Salvador, 2003; Kilincceker *et al.*, 2009).

The coating process affects the sensory characteristics of the fried foods, which enhances consumer interest in them because of their crispy, crackly and brown crust with the tender and juicy inside (Baixauli *et al.,* 2003; Lee and Inglet, 2007). Kilincceker *et al.* (2009) reported that the sensory quality of the coated fillets was more desirable than that of the non-coated fillets.

One of the major characteristics of coated fried foods is colour, since it influences consumer acceptability. The colour of coating samples changes with frying to redness, yellowness, etc. which depends upon the characteristics of coating materials (Kulp and Loewe, 1990; Dyson, 1992). Powder mixtures were important in food and pigment industries. It is necessary to investigate how the process and the colour of these mixtures affect colour quality of the products (Zhu *et al.*, 2009). Colour measurement systems, such as Hunter system measured reflected and transmitted colour of food products. Using instrumental systems provides objective and quantifiable colour measurements.

To evaluate the performance of three coating layers and the interactions between their materials, the effects of gluten, zein, guar gum, corn flour and wheat flour were studied on the sensory quality of fish fillets and were examined using the Box-Behnken design of response surface methodology.

Materials and Methods

The fresh fish (*Chalcalburnus tarichi*) were obtained from local markets, and stored at 2±1°C until use. Zein was purchased from Sunar Corn Products Co. (Adana, Turkey); guar gum, from Dairy Gold Co. (Ireland); and gluten, from Kurtsan Co. (Istanbul, Turkey). Corn and wheat flours were obtained from the local grocery shops. Hydrogenated palm olein margarine was used as the frying medium (Paksoy Co., Adana, Turkey), and it was stored at room temperature in a dark environment.

Coating Process

The coating process of fish fillets was performed in three stages, involving a first coating, a second coating and a last coating. The first coating material was prepared from gluten and zein. Different combinations of gluten and zein were used, as indicated in Table 1. The second coating material was prepared from different concentrations of guar gum in water (Table 1). The last coating material was prepared from wheat flour, corn flour, 1% onion powder, 1% garlic powder, 1% maltodextrin and 2% salt. While different combinations of Weat flour:Corn flour (WF:CF) were used in the last coating (Table 1), the amounts of other ingredients in the last coating were remained constant for all treatments.

In the first step, fish fillets were dusted with the first coating materials. In the next step, the fish fillets were dipped in the second coating materials and allowed to drain for 5 min. Finally, they were breaded with the last coating materials. After the coating process, the fish fillets were fried at 180°C for 20 s and then cooled to room temperature.

Colour Analysis

The colour of the fried coated samples was measured according to CIELAB systems as L (lightness), a (redness) and b (yellowness) values, as described by Dogan (2006). The Hunter whiteness values of samples were obtained by substituting the values of L, a and b into the following equation (Sathivel, 2005):

$$\text{Whiteness} = 100 - [(100 - L)^2 + a^2 + b^2]^{1/2}$$

Sensory Analysis

Five semi-trained judges assessed the sensory properties using a hedonic scale for the appearance, colour, odour, flavour and texture for acceptability.

Table 1. Box-Behnken design of three independent variables

	Codified levels			Actual levels		
Run order	X_1	X_2	X_3	Gluten:Zein	Guar	WF:CF
1	-1	-1	0	30:70	0.2	50:50
2	-1	1	0	30:70	0.6	50:50
3	1	-1	0	70:30	0.2	50:50
4	1	1	0	70:30	0.6	50:50
5	0	-1	-1	50:50	0.2	30:70
6	0	-1	1	50:50	0.2	70:30
7	0	1	-1	50:50	0.6	30:70
8	0	1	1	50:50	0.6	70:30
9	-1	0	-1	30:70	0.4	30:70
10	1	0	-1	70:30	0.4	30:70
11	-1	0	1	30:70	0.4	70:30
12	1	0	1	70:30	0.4	70:30
13	0	0	0	50:50	0.4	50:50
14	0	0	0	50:50	0.4	50:50
15	0	0	0	50:50	0.4	50:50

The average score of these parameters was deemed the overall acceptability. The different values in the scale indicated the following reactions: 1: extremely dislike, 2: dislike very much, 3: moderately dislike, 4: slightly dislike, 5: neutral, 6: slightly like, 7: moderately like, 8: like very much, 9: extremely like (Gökalp *et al*., 1999).

Statistical Analysis

The experimental design and statistical analysis were performed using Jump Software (SAS Institute Inc.). The experiments were based on a Box-Behnken design. A total of 15 combinations including 3 replicates of the centre point were carried out in random order. The codified and actual levels are given in Table 1. The variables were coded according to the following equation:

$$X_i = (x_i - \overline{x_i}) / \Delta x_i$$

where X_i is the coded value of an independent variable, x_i is the real value of an independent variable, $\overline{x_i}$ is the real value of an independent variable at the centre point, and Δx_i is the step change. The variance for each factor assessed was partitioned into linear, quadratic and interactive components and was represented using a second order polynomial equation. The equation is

$$Y = \beta_0 + \sum_{i=1}^{k} \beta_i x_i + \sum_{i=1}^{k} \beta_{ii} x_{ii}^2 + \sum_{\substack{i=1 \\ i<j}}^{k} \sum_{j=1}^{k} \beta_{ij} x_i x_j$$

where Y is the estimated response, β_0, β_i, β_{ii} and β_{ij} are constant coefficients, and k is the number of factor variables. x_i, x_{ii} and $x_i x_j$ represent the linear, quadratic and interactive effects of the independent variables, respectively.

Results and Discussion

The results of analysis of variance indicating L, a, b and whiteness values are summarised in Table 2. The linear effects of the first coating (gluten:zein) were found to be significant ($P<0.05$) for L, a and whiteness values. In addition, the linear effect of the second coating (guar gum solution) and the last coating (WF:CF) were found to be significant ($P<0.05$) for the a and b values, respectively. When the amount of gluten was increased in the gluten:zein combinations of the first coating, L and whiteness values increased, and a values decreased (Figure 1, 2, 3). This effect might be attributed to colour pigments of zein. The second coating was colourless because of transparent structure of guar gum. The positive effect of zein on colour was because of the greater content of red pigment compared to the gluten (Kilincceker *et al.*, 2009). The increasing amount of guar gum in the second coating decreased the a values (Figure 2). This effect might be caused by guar gum film formation on the first coating, and by the interactions of guar gum and wheat flour. The effects of the first and second coatings were not found to be significant for b values ($P>0.05$). However, the increasing amount of wheat flour in the last coating significantly ($P<0.05$) decreased b values (Figure 4). This was expected because of decreasing corn flour in last coating. Baixauli *et al.* (2002) reported that addition of corn flour to the coating increased yellow colour. Yeyinli and Köse (2008) reported that corn flour addition increased b value of breading. As a result of the colour analysis, it may be stated that higher levels of gluten in first coating, guar gum in second coating and wheat flour in last coating caused discolouration of coated fish fillets. Sathivel (2005) reported that the effects of coating with egg albumen, soy protein concentrate, pink salmon protein, arrowtooth flounder protein and chitosan on a, b and whiteness values of cooked pink salmon fillets were not significant.

Table 2. Analysis of variance of the effects of edible coatings on L, a, b and whiteness values of coated fish fillets

Sources of Variation	DF	L values $R^2 = 82$ F-value	a values $R^2 = 86$ F-value	b values $R^2 = 76$ F-value	Whiteness $R^2 = 83$ F-value
X_1 (Gluten:Zein)	1	13.330*	13.480*	3.702	13.209*
X_2 (Guar gum)	1	0.546	9.691*	0.721	0.431
X_3 (WF:CF)	1	0.264	4.353	7.663*	1.821
X_1*X_2	1	0.496	1.192	0.803	0.326
X_1*X_3	1	0.171	0.071	0.362	0.030
X_2*X_3	1	1.611	1.432	0.023	1.822
X_1*X_1	1	0.281	1.462	0.986	0.081
X_2*X_2	1	0.982	0.000	0.992	0.919
X_3*X_3	1	5.704	0.068	0.699	5.974
C. total	14				

*: $P<0.05$ significance level, WF: Wheat flour, CF: Corn flour, DF: Degrees of Freedom, X_1, X_2 and X_3: linear effects of independent variables, X_1*X_1, X_2*X_2 and X_3*X_3: quadratic effects of independent variables, X_1*X_2, X_1*X_3 and X_2*X_3: interaction effects of independent variables.

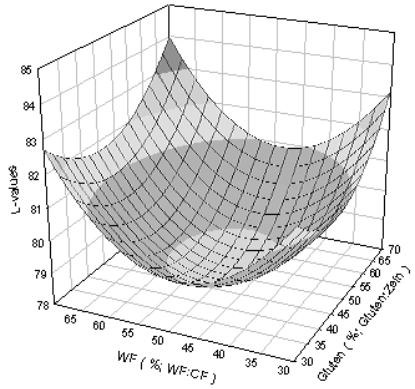

Figure 1. Three dimensional plots of the effects of edible coatings of fish fillets for L values.

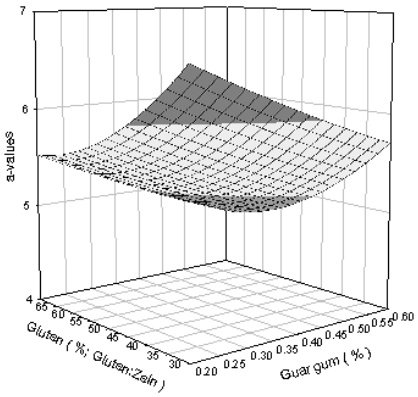

Figure 2. Three dimensional plots of the effects of edible coatings of fish fillets for a values.

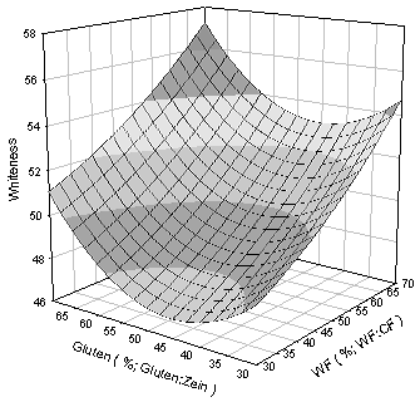

Figure 3. Three dimensional plots of the effects of edible coatings of fish fillets for whiteness values.

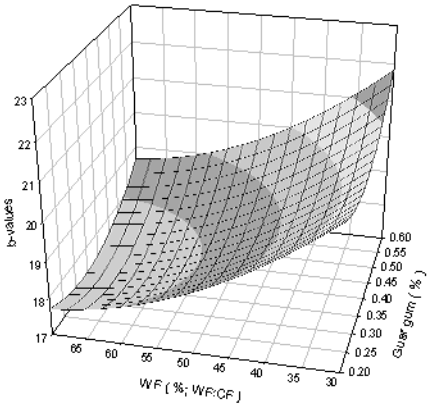

Figure 4. Three dimensional plots of the effects of edible coatings of fish fillets for b values.

As shown in Table 3, second and, particularly, last coatings were found to have significant effects on the sensory quality of fish fillets. Increasing guar gum in the second coating or wheat flour in the last coating (WF:CF) decreased the appearance, colour and overall acceptability values of fish fillets (Figure 5, 6, 7). Moreover, guar gum had a significant ($P<0.05$) quadratic effect on overall acceptability (Table 3), with the observation that higher levels of guar gum decreased overall acceptability (Figure 7). Chidanandaiah *et al.* (2009) reported that sodium alginate coating improved the sensory quality of beef meat patties on refrigerated storage.

The effects of changes in the amount of coating materials were not found to be significant ($P>0.05$) on odour, flavour and texture values. The effects of zein and corn flour on sensory quality can be attributed to their colour pigments. Zein and corn flour can be used at certain levels with gluten and wheat flour, respectively. Ilter *et al.* (2008) reported that zein was an effective coating material in pre-dusting application of turkey buttocks. Kilincceker *et al.* (2009) reported that the coated fish fillets were much more preferred than uncoated ones. They also reported that the gluten in the first coating and corn flour with wheat flour in the last coating had significant advantages. Kılınççeker and Kurt (2010) reported that corn flour with chickpea flour increased colour scores of coated chicken nuggets.

The effects of edible coatings on sensory quality of fish fillets are also expressed mathematically in Table 4. These predicted model equations are useful for understanding the significance of edible coatings and the interactions between studied factors. Hence, the performance of many levels of these coating materials in the studied range of factor levels can be evaluated using predicted model equations for the studied parameters.

Conclusion

In general, each coating layer improved sensory quality. However, the effects of the first coating materials were not found to be significant by panellists. The results indicated that the levels of guar gum can be decreased to lower levels in the second

Table 3. Analysis of variance of the effects of edible coatings on sensory parameters of coated fish fillets

Sources of Variation	DF	Appearance $R^2 = 84$ F-value	Colour $R^2 = 87$ F-value	Odour $R^2 = 60$ F-value	Flavour $R^2 = 64$ F-value	Texture $R^2 = 76$ F-value	Overall acceptability $R^2 = 92$ F-value
X_1 (Gluten:Zein)	1	0.609	2.390	1.210	0.654	0.168	0.147
X_2 (Guar gum)	1	6.678*	8.913*	0.268	0.517	3.394	10.628*
X_3 (WF:CF)	1	11.983*	19.578**	0.507	0.396	5.070	30.322**
X_1*X_2	1	0.171	0.023	0.536	0.404	0.754	1.537
X_1*X_3	1	0.076	0.051	1.415	0.258	0.084	0.024
X_2*X_3	1	0.119	0.000	1.206	3.633	2.095	3.316
X_1*X_1	1	1.244	0.507	0.234	0.106	0.054	0.042
X_2*X_2	1	2.563	2.735	0.698	0.200	1.807	7.485*
X_3*X_3	1	2.563	1.004	1.409	2.784	2.632	5.587
C. total	14						

**: $p<0.01$ significance level, *: $p<0.05$ significance level, WF: Wheat flour, CF: Corn flour, DF: Degrees of Freedom, X_1, X_2 and X_3: linear effects of independent variables, X_1*X_1, X_2*X_2 and X_3*X_3: quadratic effects of independent variables, X_1*X_2, X_1*X_3 and X_2*X_3: interaction effects of independent variables.

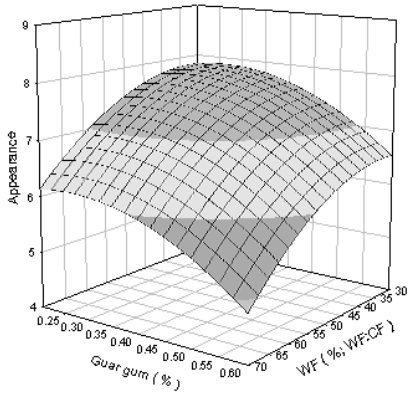

Figure 5. Three dimensional plots of the effects of edible coatings of fish fillets for appearance values.

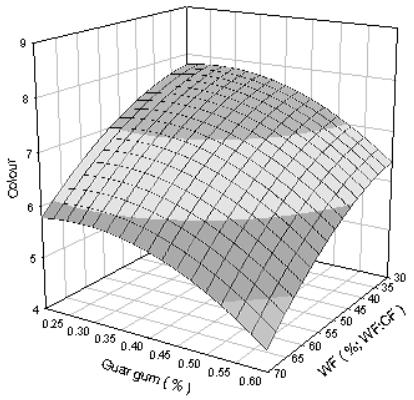

Figure 6. Three dimensional plots of the effects of edible coatings of fish fillets for colour values.

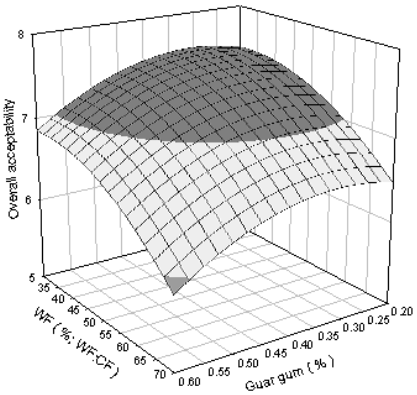

Figure 7. Three dimensional plots of the effects of edible coatings of fish fillets for overall acceptability values.

coating. However, zein and corn flour need to be used in a 1:1 ratio or less with gluten and wheat flour, respectively.

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Table 4. Predicted model equations for the effects of edible coatings (X_1; Gluten:Zein , X_2; Guar gum and X_3; WF:CF) on sensory quality of fish fillets

Parameters	Equations
L	$Y = 51.48 + 3.905X_1 + 0.79X_2 + 0.55X_3 + 0.835X_1^2 + 1.56X_2^2 + 3.76X_3^2 + 1.065X_1X_2 - 0.625X_1X_3 - 1.92X_2X_3$
a	$Y = 5.253 - 0.559X_1 - 0.474X_2 - 0.318X_3 + 0.271X_1^2 + 0.001X_2^2 + 0.058X_3^2 - 0.235X_1X_2 - 0.058X_1X_3 - 0.258X_2X_3$
b	$Y = 17.563 + 1.063X_1 + 0.469X_2 - 1.529X_3 + 0.807X_1^2 + 0.81X_2^2 + 0.68X_3^2 + 0.7X_1X_2 - 0.47X_1X_3 - 0.118X_2X_3$
Whitness	$Y = 48.097 + 3.175X_1 + 0.574X_2 + 1.179X_3 + 0.365X_1^2 + 1.233X_2^2 + 3.143X_3^2 + 0.705X_1X_2 - 0.215X_1X_3 - 1.668X_2X_3$
Appearance	$Y = 7.333 - 0.2X_1 - 0.663X_2 - 0.888X_3 + 0.421X_1^2 - 0.6042X_2^2 - 0.6041X_3^2 + 0.15X_1X_2 - 0.1X_1X_3 + 0.125X_2X_3$
Colour	$Y = 7.267 - 0.363X_1 - 0.7X_2 - 1.038X_3 - 0.246X_1^2 - 0.571X_2^2 - 0.346X_3^2 + 0.05X_1X_2 + 0.075X_1X_3 + 1.421e^{-14}X_2X_3$
Odour	$Y = 7.2 + 0.213X_1 - 0.1X_2 - 0.138X_3 + 0.138X_1^2 - 0.238X_2^2 + 0.338X_3^2 + 0.2X_1X_2 - 0.325X_1X_3 - 0.3X_2X_3$
Favour	$Y = 7.467 + 0.225X_1 + 0.2X_2 - 0.175X_3 - 0.133X_1^2 - 0.183X_2^2 + 0.683X_3^2 + 0.25X_1X_2 + 0.2X_1X_3 - 0.75X_2X_3$
Texture	$Y = 7.733 - 0.05X_1 - 0.225X_2 - 0.275X_3 - 0.042X_1^2 - 0.242X_2^2 - 0.292X_3^2 + 0.15X_1X_2 + 0.05X_1X_3 - 0.25X_2X_3$
Overall acceptability	$Y = 7.4 - 0.035X_1 - 0.298X_2 - 0.503X_3 - 0.028X_1^2 - 0.368X_2^2 - 0.318X_3^2 + 0.16X_1X_2 - 0.02X_1X_3 - 0.235X_2X_3$

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