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Comparison of the Color Properties of Farmed and Wild Gilthead Sea Bream Fillets (Sparus aurata) Stored in Ice for 14 Days

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Abstract
Changes in color properties of farmed and wild gilthead sea bream (*Sparus aurata*) fillets during iced storage were investigated. Values of L*, a*, b*, Chroma (C^*_{ab}), Hue (H_{ab}) Redness index (a*/b*) were observed during 14 days. At the end of the storage period increases were observed in the L* values for both groups due to protein denaturation of fillets in iced storage. Redness index (a*/b*) and hue values were better criteria than C^*_{ab} value for observing the color changes of fillets.
Keywords: Color, Gilthead sea bream, *Sparus aurata*, Fillets, Iced storage

1. Introduction
In recent years, the aquaculture sector has contributed to human nutrition, providing fish with high nutrient quality at low prices. In addition, farmed fish meet the expectations the increasing demand for fish proteins and indirectly protect natural stocks from further exploitation (Lenas *et al*., 2011). Thus, many fish farmers on the coasts waters have gradually expanded their annual production (Alasalvar *et al*., 2002).

Gilthead sea bream (*Sparus aurata*) is an economically important for industrial and coastal fisheries and the major marine fish aquaculture species in Mediterranean countries. The leading producer countries of gilthead sea bream are Greece, Turkey, Spain, and Italy (Bubić *et al*., 2014). For this reason, gilthead sea bream (*S. aurata*) farming contributes significantly to the production of this widely consumed fish species. The demand for gilthead sea bream has increased significantly over the past decade; the investigation of quality changes during storage continues to be of major interest to industries, retailers and consumers (Simat *et al.*, 2012).

Freshness and spoilage are the most important criteria to determine the overall quality of food products. Organoleptic evaluation is the most commonly used method for quality assessment of raw fish. The other majority of data from literature which compare quality of fish deals with chemical composition, nutritional value. Results reported by some authors indicate that there are differences in the organoleptic characteristics between farmed and wild fish, however in some studies these differences have not been detected. In general, cultured fish have been reported to have a softer texture and milder flavour than wild fish (Fuentes *et al*. 2010; Simat *et al.*, 2012). There are not enough studies who try to compare the color properties of wild and farmed fish. In fact, the color properties of fish meat are one of the most important quality parameters used to evaluate the quality of fisheries products. Color loss can be observed in fish which are capture in nature until they reach the consumer. If the color does not give a positive impact to the consumer, it is regarded as a negative feature no matter how good the taste, aroma, nutritional elements, amount etc. are (Olgunoglu, 2013). Therefore this study focused on to compare the color properties of wild and farmed sea gilthead bream during storage in ice for 14 days.

2. Material and methods
Fish Samples
In this this study 12 sea gilthead bream from two origins (farmed and wild) were used, 6 fish from each origin. These fish were purchased from the local market in the coast of Mediterranean Sea of Turkey/Adana in February 2016. Immediately after purchasing, fish were placed in plastic bags over a layer of ice in a cooler and transported to the laboratory. The fish were eviscerated, filleted and skins were removed manually, after arriving in the laboratory. The average weight of farmed gilthead bream was 284±25g, wild gilthead bream was 206±34g.
Color Measurement
Color measurements were taken immediately after filleting the samples (to prevent color degradation as a result of light and oxygen). Then, the samples were kept in ice for 14 days. The ice to fish fillets ratio was maintained throughout the study.

The color was measured on surface of the muscle. Prior to each color measurement the instrument was standardized according to the instruction manual. Color readings were taken in L*, a*, b* color space (CIELAB color space, D65 standard illumination) and repeated 3 times using a colorimeter (Konica Minolta Chroma Meter Model CR-410) with 50-mm-diameter measurement area. In the CIELAB or CIE L*a*b* system, L*defines lightness (or luminosity) on a 0–100 scale from black to white; a* denotes the redness when (+) or green when (-) or grey when zero; b* denotes the yellowness when (+) or blueness when (-) or grey when zero. There is no specific numerical limit for a* and b* (Balev *et al*.,2011; Marencic *et. al*., 2011; Valente *et al*., 2011).

Chroma (C*ab) refers to the saturation or intensitiy of a color and is expressed by the equation, Cab=

$(a^{*2}+b^{*2})^{1/2}$ (Pavlidis *et al*., 2006).

Hue (H_{ab}) is determined by the dominant wave length and is the name of a color as found in its pure state in the spectrum and expressed by the equation H°ab= Arctan (b*/a*) (Pavlidis *et al*., 2006; Rahmanifarah *et al*., 2011).

The redness index (a*/b*) of fish meat was determined as described by Chaijan *et al*., (2004) and HassabAlla *et al*., (2009).

Data analysis

Differences between wild and farmed samples were analysed statistically by t-test at a 0.05 significance level. For comparison of means, one-way analysis of variance (ANOVA) was used. Statistical analysis was performed using the SPSS 15.0 for Windows. The mean values were obtained from 3 experiments and reported as X±SD (Simat *et al*., 2012).

3. Results and Discussion

Agiular *et al.,* (2008) and Higuera *et al*., (2009) reported that the initial colour of fishing products changed during the storage in ice affecting the quality. At the same time, determines the acceptance of the product by the consumer.

The the redness index (a*/b*) of farmed and wild gilthead sea bream fillets is given Fig. 1 and the L*, a*, b*, C*ab and hue angle values are given in Table 1.

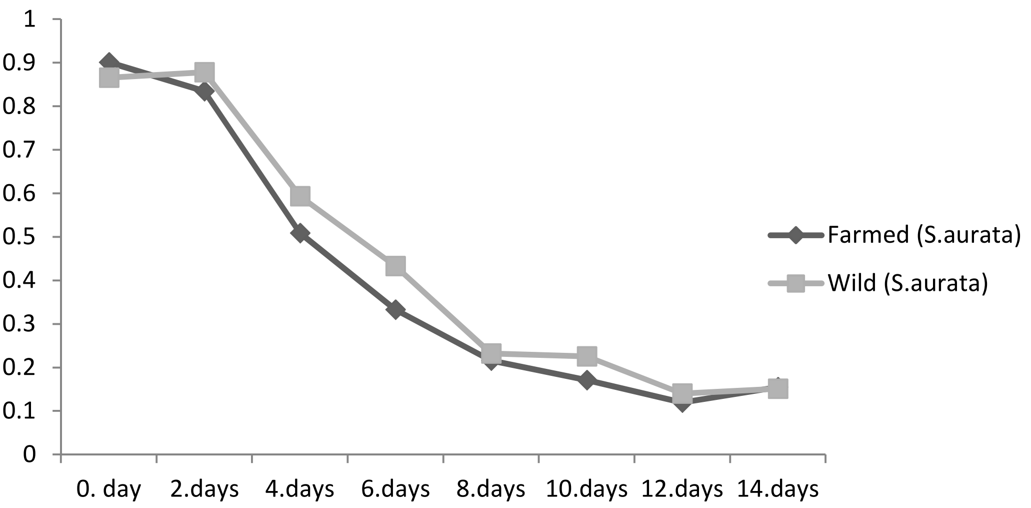

Fig. 1.

As seen in Table 1, at the beginning of study, significant differences were not observed in all color measurements between farmed and wild gilthead sea bream except L* value ($p>0.05$). Results showed an increase (from black to white) in L* value and the initial values were lowest (for farmed as 62.20±4.63 and for wild as 56.71±3.54). The highest L* values were observed as 66.61±3.73 and 62.97±2.15 on 14th day of storage for farmed and wild gilthead sea bream, respectively. The analysis of variance (ANOVA) pointed to significant difference ($p < 0.05$) for L values' measurement. In a study on determination of color characterization some economical freshwater fish species fillets during iced storage for 24 days, Olgunoglu (2013) reported that L* value is higher at the end of the storage time in comparison with the initial values. Nakamura *et al*., (2011) reported that L* value can reach its maximum in protein denaturations. In another research HassabAlla et al., (2009) reported that the increase in L* value of fish meat is due to hydrolrolysis of muscle protein or aggregation of myofibrillar proteins during storage.

In the present study, in both groups, a decrease was observed for a* value while an increase was observed in b* value during the storage period ($p < 0.05$). When the Fig. 1 is examined a decrease was also observed in redness index (a*/b* ratio) for both groups. Boulianne and King (1998) reported that there is a positive correlation between total pigment concentration and a* value. The decrease in the redness index is associated with the darkening of meat, resulting from the formation of metmyoglobine.

At the same time it was reported that color parameters (L*a*b*) are also correlated to the fat content of the muscle (Bjerkeng, 2000). Chaijan *et al*., (2005) reported that during the iced storage, the redness index (a*/b* ratio) of sardine (*Sardinella gibbosa*) and mackerel (*Rastrelliger kanagurta*) muscles decrease when the storage time increase. Olgunoglu (2013) reported a decrease in a*/b* ratio during iced storage period of economical freshwater fish species fillets due to the myoglobine protein that can dissolve in water. Our results are in agreement with the results reported on value of L*, a* and b* measurement.

A constant increase or decrease was not observed in terms of chroma (C^*_{ab}) values ($p<0.05$), while hue (H^*_{ab}) values tended to be high towards the last days of storage time ($p>0.05$). The change in chroma ranged from 6.87-

9.09 for farmed sea bream fillets, 5.76-7.61 for wild gilthead sea bream fillets repectively.

The change in hue (H_{ab}) value ranged between 0.83-1.27 for farmed sea bream fillets, 0.84-1.35 for wild gilthead sea bream fillets. In both groups, the lowest hue values were observed at day 0, and highest were on 10th days.

The results of the present study indicated that the L* value of each sample increased due to protein denaturation of fillets in iced storage. Redness index (a*/b*) and hue values were better criteria than C^*_{ab} value for observing the color changes of fillets.

Table 1. Color measurements in farmed and wild gilthead sea bream (*S. aurata*) fillets

Days	Species	L*	a*	b*	C^*_{ab}	H_{ab} (radians)
0.day	**Farmed** *S. aurata*	62.20±4.63^a	4.90±1.58^a	5.43±1.86^a	7.38±2.22^a	0.83±0.14^a
	Wild *S. aurata*	56.71±3.54^b	4.55±1.64^a	5.25±2.07^a	7.05±2.34^a	0.84±0.18^a
2. days	**Farmed** *S. aurata*	58.68±5.16^a	5.71±2.41^a	6.84±1.60^a	9.09±2.26^a	0.89±0.20^a
	Wild *S. aurata*	56.57±3.52^a	4.95±1.64^a	5.64±1.40^a	7.61±1.66^a	0.86±1.18^a
4.days	**Farmed** *S. aurata*	62.62±4.64^a	3.31±1.82^a	6.51±1.66^a	7.47±1.89^a	1.12±0.22^a
	Wild *S. aurata*	60.21±2.97^a	2.96±1.14^a	4.99±1.54^b	5.92±1.46^b	1.02±0.21^a
6.days	**Farmed** *S. aurata*	63.03±5.26^a	2.15±1.28^a	6.47±2.11^a	6.87±2.28^a	1.26±0.14^a
	Wild *S. aurata*	60.51±3.11^a	2.25±1.14^a	5.20±1.15^a	5.76±1.18^a	1.16±0.19^a
8. days	**Farmed** *S. aurata*	64.64±4.81^a	1.71±1.16^a	7.95±1.91^a	8.20±2.01^a	1.11±0.81^a
	Wild *S. aurata*	60.24±11.45^b	1.14±0.97^a	4.93±1.16^b	5.13±1.24^b	1.22±0.57^a
10. days	**Farmed** *S. aurata*	64.17±4.83^a	1.41±1.02^a	8.25±2.13^a	8.42±2.15^a	1.27±0.61^a
	Wild *S. aurata*	59.00±3.03^b	1.28±0.86^a	5.69±1.10^b	5.89±1.09^b	1.35±0.14^a
12. days	**Farmed** *S. aurata*	65.33±4.39^a	1.01±1.03^a	8.49±2.53^a	8.60±2.58^a	0.95±1.09^a
	Wild *S. aurata*	60.95±2.38^b	1.34±1.11^a	6.01±1.33^b	6.25±1.35^b	0.96±0.98^a
14. days	**Farmed** *S. aurata*	66.61±3.73^a	1.28±0.90^a	8.29±2.33^a	8.42±2.17^a	1.16±0.83^a
	Wild *S. aurata*	62.97±2.15^b	1.03±0.91^a	6.85±1.50^a	6.99±1.51^a	1.03±0.97^a

Within each column, different superscripts show differences between mean values ($p < 0.05$).

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