

## FOOD SCIENCE AND NUTRITION

### Effects of scale and skin on chemical and sensory quality of marinated sea bass filets (*Dicentrarchus labrax*, L. 1758) in sunflower oil during storage at 4°C

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#### Abstract

In this study, the effects of descaling and skin removal on chemical changes and sensory attributes of marinated sea bass filets (*Dicentrarchus labrax*) in sunflower oil stored at 4°C were investigated. In terms of overall acceptability, although skinless sea bass fillets reached consumable limit values at the 70th day, scaly and descaled samples did not reach limits even at the end of the 90-day storage. During 90-day storage, (Total Volatile Basic Nitrogen) TVB-N and (Trimethylamine–nitrogen) TMA-N values of sea bass fillets were found to be below consumable limits. Thiobarbituric acid (TBA) value reached the consumable limit of 8 mg malonaldehyde/kg at the 56th day for skinned fillets and at the 70th day for descaled fillets. Scaly fillets did not reach the TBA limit during 90-day storage time. According to obtained results, scaly and descaling sea bass fillets were found to be more appropriate for marination in terms of brightness, juiciness, tenderness, acid and salt transition and hygiene. It was detected that descaling has some disadvantages on texture (acid and salt transition) and hygiene of fish. Comparing the scaly and descaled fillets, it was found that scales effect the brightness of brine solution and also cause undesirable colour changes as the scales stick to the fish skin.

**Key words:** Sea bass, *Dicentrarchus labrax*, Marinade, Storage, Quality changes

#### Introduction

Marinating process is one of the oldest methods of conservation of fish and it is popular in Europe. Fatty fish like sardines, mackerel, herring, and anchovies, as well as several kinds of crustaceans and bivalves are usually used. The term “marinades” or “marinated fish” is used to define fish products which consists of fresh, frozen or salted fish or portions of fish processed by treatment with an edible organic acid, usually acetic acid, and salt and put into brines, sauces or oil (Duyar and Eke, 2008). Due to the increasing consumer demand for fresh refrigerated foods with prolonged shelf-life, many researches have focused on preservation techniques to control bacterial growth for safety purposes or for extending the shelf-life of the food (Sallam, 2007). Marination, a food-preservation technique, is based on treatment

of muscle with solutions containing salt, spices, lemon juice, etc. and provides high sensory acceptability to a variety of meat products (Ozogul et al., 2009).

Marination is also used to tenderise or to change taste, textural and structural properties of raw material. Marinades stored at cooler temperatures (4–6°C) keep a long time such as four months. Marinades are semi-preserves; the preserving principal is the combination of acetic acid and salt. (Gokoglu et al., 2004; Sallam et al., 2007; Duyar and Eke, 2009). Salt and acetic acid uptake depends on many factors including species, muscle type, fish size, fillet thickness, weight, composition (lipid content and distribution), physiological state, salting method, brine concentration, duration of salting step, and fish-to-salt ratio, ambient temperature, freezing and thawing (Gallart-Jornet et al., 2007). The marinating process has many positive effects on the palatability and shelf-life of meat and seafood products. The main aims of marinating are to tenderize and enhance the flavour, safety and shelf-life of meat products owing to inhibition of microbial growth (Björkroth, 2005; Ozogul et al., 2008).

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Anchovies are generally used for marination fish production; however, use of some reared fish, like gilthead seabream (*Sparus aurata*) and sea bass (*Dicentrarchus labrax*) has been recently proposed. Recently, in Italy, marination technology is also spreading to some reared fish, like gilthead seabream and sea bass (Giuffrida et al., 2007). Aquaculture of sea bass has major economic importance in Turkey and many European countries. Sea bass is one of the most widely farmed species with a total production of 105.900 tons in Europe in 2008 (FAO, 2008).

This study was aimed to determine the effects of scale, descaling and skinning on chemical changes and sensory attributes of marinated sea bass (*Dicentrarchus labrax*) in sunflower oil during storage at 4°C.

## Materials and Methods

### Materials

A total of 50 kg, aquacultured sea bass samples (*Dicentrarchus labrax*) in the Egean Sea coast were harvested by Kılıç Fisheries Holding (Mugla, TURKEY) and ice-chilled within 18h. Fish sample used in this study were degutted manually by the workers in the fish processing plant and were transported to the laboratory in polystyrene boxes with flaked ice within 90 minutes of purchasing. The mean weight of fish was  $330 \pm 10$  g.

### Methods

Samples were divided into three lots. First lot of 18 kg sea bass was just filleted with no other treatment. Second lot of 18 kg was first descaled then filleted. Remaining lot of 14 kg was skinned and then filleted. Then, all three lots of fillets were dipped in an ice-water solution (1:4 v/v) for 60 minutes to provide physical cleaning and temperature stability of the fish samples. Then marinating solution composed of 2.5% acetic acid and 11% sodium chloride was added to fillets put in 5000 mL glass jars with the lids. Jars filled with sea bass fillets and marinating solution at a weight ratio of 1.5:1 were stored in a refrigerator at  $+4 (\pm 1) ^\circ\text{C}$  for marinating. Marinating and brining processes were completed after 72 h. Fish samples were removed from the solutions and put into glass jars, filled with sunflower oil. During storage in oil, samples from all three groups were analysed at the first day 0 and the following days after 7, 14, 21, 28, 42, 56, 70, 90 days of the marinating.

### Sensory analysis

Sensory analysis of marinated fillets was evaluated by 6 experienced panellists and the results were given as described by Sallam et al.

(2007). Three representative fish samples were individually presented to each panellist. The judges were not informed about the experimental approach. Panellists were asked to evaluate the overall acceptability with regard to fish-like appearance, colour, texture, odour, rancidity, juiciness, tenderness, sour taste, salty taste and flavour-aftertaste. An eight-point hedonic scoring scale, with 8 = extremely intense/juicy/tender, 7 = very intense/juicy/tender, 6 = moderately intense/juicy/tender, 5 = slightly intense/juicy/tender, 4 = slightly bland/dry/tough, 3 = moderately bland/dry/tough, 2 = very bland/dry/tough, 1 = extremely bland/dry/tough, was employed for odour and flavour intensity, juiciness, and tenderness, respectively, while a nine-point hedonic scale, ranging from extremely acceptable (9) to extremely unacceptable (1) was utilized for evaluation of the appearance. Sea bass samples receiving overall scores of more than 4 were considered acceptable, while a score between 3 and 4 was considered the borderline of acceptability. The parameters were tested throughout the storage period of 90 days.

### Determination of quality changes

pH, Total Volatile Basic Nitrogen (TVB-N), Trimethylamine Nitrogen (TMA-N) and Tiobarbituric Acid (TBA) analyses were performed three times for each group of samples. The pH value was determined by dipping a pH electrode into homogenates of filleted muscle in distilledwater (1/1) (Manthey et al., 1988). All measurements were performed at room temperature using pH-meter (WTW Inolab, Weilheim, Germany). TVB-N was used as indices for the quality of fresh fillets of sea bass and determined according to the Antonocopoulos (1973). Volatile bases were separated by steam distillation of homogenized samples, collected in 0.1 N HCl and titrated back with 0.1 N NaOH. TMA-N, which is produced by the decomposition of TMAO by bacteria or enzymatic reaction, is a spoilage indicator for fresh fish. TMA-N amount of the homogenized samples were determined according to the Schormüller (1968). Samples were extracted with trichloroacetic acid. Bases in the extract were fixed with formaldehyde and after adding picric acid, the absorbance was measured at 410 nm. TBA was used as an indicator of lipid oxidation and calculated according to the Tarladgis et al. (1960). HCl were added to the fish samples and processed at condenser. TBA solution prepared with 90% glacial acetic acid was added to the distilled solution and was left in a water bath. The

absorbance was determined by a spectrophotometer at 538 nm. For chemical analysis, 6 fillets were used for each replicate.

#### Determination of proximate composition

Crude protein content was calculated by converting the nitrogen content determined by the Kjeldahl method ( $6.25 \times N$ ) AOAC (1998). Lipid was determined by using the method described by AOAC (1998).

#### Statistical analyses

SPSS 14 for Windows was used to test the differences between mean values of the different analysed parameters. Differences between means were analyzed by one-way analysis of variance (ANOVA) followed by the Tukey multiple comparison test, when a significant difference was detected between the days of storage ( $P < 0.05$ ).

#### Results and Discussion

There were significant increases especially for crude fat, TMA-N and TBA values and also there were considerable decreases in overall acceptability, pH and TVB-N values after marination (Table 1). No significant change was detected in crude protein values.

As shown in Table 2, when sensory score changes of marinated seabass fillets under refrigerator conditions were examined, it was seen that panellists found the scaly fillet group more fit and the skinned fillet group less fit in terms of appearance, color, rancidity, juiciness, acetic acid rancidity and salinity. Also, descaled fillet group was found to be more fit and the skinned group was found to be less fit in terms of odour, texture, softness, taste and flavour. It was detected that according to average acceptability assessment, skinned samples reached consumable limit value at

day 70 where scaly and descaled samples still could not at day 90. Only for appearance, descaled samples were detected to be under limit values at day 90, skinned samples were detected to be under limit values at day 70; for colour, texture and softness assessment, skinned group was detected to be under limit values at day 70; for rancidity, scaly and descaled samples at day 70, skinned samples were detected to be under limit values at day 56; for acetic acid rancidity and salinity skinned samples were detected to be under limit values at day 56. A similar sensory analysis results has been reported by Baygar et al. (2002) for marinated sea bass. It was concluded that TBA values depending on the level of fatty oxidation and sensory evaluation determined the shelf life of marinated anchovies under vacuum and MAP conditions during storage at  $2 \pm 2^\circ\text{C}$  (Gunsen et al., 2011). It was reported that there was a correlation between the TBA value and sensory evaluation in many researches (Ramanathan and Das, 1992).

#### Protein and lipid contents

In our study, it was determined that as the crude fat content of fresh sea bass increased with the marination and storage in sunflower oil (Figure 1). We suggest that salt amount of the marination solution cause that artificial increase of crude fat. Although there was not an important change in crude fat contents of groups during oil storage, there were little decreases for all three group samples during the oil storage. A similar proximate composition (72.10% moisture, 19.87% protein, 4.84% fat, 1.54% ash) has been reported by Arık et al. (2002) for marinated fish.

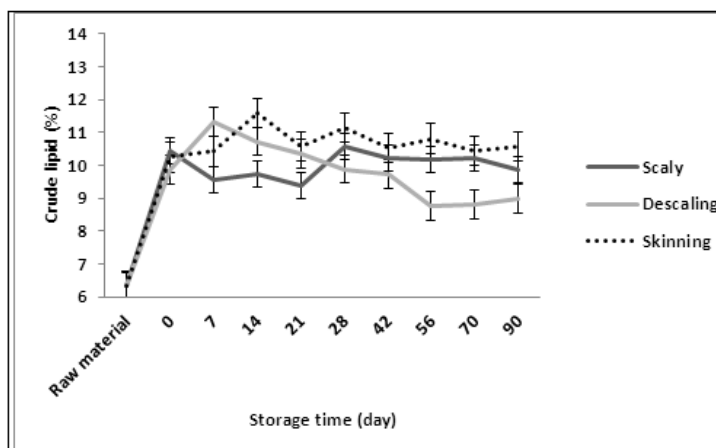
Table 1. Sensory scores and chemical analyses results of raw seabass and marinated seabass in sunflower oil during stored at  $4 \pm 1^\circ\text{C}$ .

Product		Overall acceptability*	Crude protein	Crude lipid	pH	TVB-N	TMA-N	TBA
Raw sea bass		$8.40 \pm 0.23^a$	$20.18 \pm 0.19^a$	$6.34 \pm 0.19^a$	$6.35 \pm 0.02^a$	$16.89 \pm 1.45^a$	$2.86 \pm 0.1^a$	$0.30 \pm 0.01^a$
Marinated sea bass (After 90-day)	Scaly	$6.66 \pm 0.32^b$	$19.15 \pm 0.35^b$	$9.87 \pm 0.23^b$	$4.32 \pm 0.04^b$	$9.82 \pm 0.87^b$	$3.21 \pm 0.12^b$	$7.83 \pm 0.06^b$
	Descaling	$6.75 \pm 0.17^b$	$19.04 \pm 0.21^b$	$8.98 \pm 0.46^c$	$4.17 \pm 0.01^b$	$9.62 \pm 0.43^b$	$2.91 \pm 0.09^a$	$8.50 \pm 0.10^c$
	Skinning	$4.90 \pm 0.10^c$	$19.93 \pm 0.11^a$	$10.57 \pm 1.10^d$	$4.13 \pm 0.01^b$	$10.83 \pm 0.70^c$	$3.03 \pm 0.21^a$	$9.68 \pm 0.03^d$

Data is expressed as mean  $\pm$  standard deviation of three determinations. Mean with different letters within the row are significantly different ( $P < 0.05$ ), [(n=3), \*(n=6)].

Table 2. Sensory scores of sea bass filets marinated in sunflower oil during stored at  $4\pm1^\circ\text{C}$ .

Sensory parameters	Sample type	Storage time (day)								
		0	7	14	21	28	42	56	70	90
Appearance	Scaly	6.73	7.37	7.22	7.24	7.28	7.09	6.52	5.76	5.37
	Descaled	7.22	7.11	7.18	7.09	7.03	6.54	6.12	5.52	4.65
	Skinned	6.55	6.84	6.70	6.56	6.42	5.25	5.28	4.72	4.03
Colour	Scaly	7.28	7.19	6.94	6.92	6.89	6.65	6.78	6.17	5.42
	Descaled	7.00	7.27	7.11	7.08	7.02	6.87	6.02	5.66	5.09
	Skinned	7.08	6.58	6.25	6.12	5.89	5.67	5.35	4.78	4.52
Odour	Scaly	7.12	7.34	7.17	7.09	7.21	6.06	5.95	5.57	5.34
	Descaled	7.00	7.15	7.02	7.13	7.23	6.24	6.06	5.61	5.94
	Skinned	6.85	7.09	7.01	6.87	6.74	5.91	5.66	5.52	5.21
Texture	Scaly	7.50	6.97	6.88	7.04	7.01	7.14	6.96	6.75	6.61
	Descaled	7.43	7.05	7.13	6.91	6.93	6.78	6.81	6.88	6.79
	Skinned	7.13	7.09	7.01	7.11	6.87	6.56	6.41	6.35	6.44
Rancidity	Scaly	7.13	7.12	6.55	6.72	5.87	5.60	5.45	4.87	4.35
	Descaled	7.02	7.11	6.38	6.05	5.75	5.65	5.02	4.32	3.92
	Skinned	6.03	5.83	5.45	5.36	5.12	5.24	4.55	3.84	-
Juiciness	Scaly	7.12	6.80	6.54	6.41	5.87	5.52	5.44	5.67	5.32
	Descaled	7.31	6.74	6.31	6.07	6.21	5.89	6.11	5.63	5.28
	Skinned	7.13	6.58	6.20	6.03	5.56	5.72	5.12	5.45	5.07
Tenderness	Scaly	7.16	6.78	6.43	6.25	6.12	6.29	5.89	5.67	5.42
	Descaled	7.00	6.97	6.85	6.56	6.63	6.45	6.27	6.03	5.88
	Skinned	7.07	6.24	5.78	5.55	5.63	5.21	5.07	4.56	4.72
Sour taste	Scaly	7.52	6.65	6.39	6.25	5.87	5.43	5.75	5.68	5.32
	Descaled	7.42	5.56	6.71	6.48	6.24	6.03	5.78	5.56	5.11
	Skinned	6.45	6.12	5.95	5.62	5.55	5.30	4.42	4.17	-
Salty taste	Scaly	7.08	6.67	6.45	6.21	5.88	5.67	5.19	5.32	5.58
	Descaled	7.41	6.94	6.56	6.34	6.12	5.85	5.61	5.42	5.54
	Skinned	7.04	6.34	6.01	5.76	5.23	5.21	4.74	4.25	-
Flavour and after taste	Scaly	7.07	6.45	6.66	6.54	6.27	6.63	6.32	6.13	5.78
	Descaled	7.44	7.47	7.34	7.02	6.89	6.56	6.61	6.34	6.03
	Skinned	7.25	6.35	6.25	6.14	5.78	5.82	5.43	5.21	-
Overall acceptability	Scaly	7.25	7.07	7.03	6.95	6.92	6.67	6.74	6.81	6.66
	Descaled	7.34	7.22	7.12	7.05	7.09	7.11	6.99	6.83	6.75
	Skinned	6.88	7.18	7.07	6.55	6.72	5.62	5.34	4.90	-

Figure 1. Changes in crude fat value of marinated seabass in sunflower oil during stored at  $4\pm1^\circ\text{C}$  (Values are mean  $\pm$  SD (n=3)).

Such as the crude fat content, crude protein content also showed an artificial increase during the beginning of oil storage. The protein content decreased during the oil storage and again reached its initial value (Figure 2). Erkan ve Özden (2007) determined crude protein level as %  $20.35 \pm 0.41$  for sea bass. This protein results are consistent with initial values in our study.

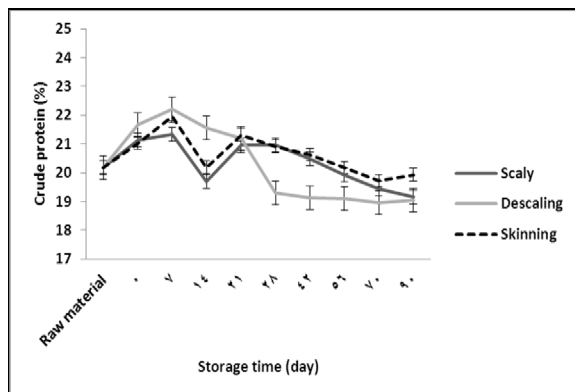


Figure 2. Changes in crude protein value of marinated seabass in sunflower oil during stored at  $4 \pm 1^\circ\text{C}$  (Values are mean  $\pm$  SD (n=3)).

### pH value

An important intrinsic factor related to fish flesh is the very high post-mortem pH ( $>6.0$ ). Most fish contain only very little carbohydrate ( $<0.5\%$ ) in the muscle tissue and only small amounts of lactic acid are produced post-mortem (Sallam et al., 2007). pH value in raw fish flesh was 6.35. During marination process, scaly, descaling and skinning pH values dropped down to 4.32, 4.17 and 4.13, respectively. There was a significant difference ( $p < 0.05$ ) in pH value between samples in sunflower oil. Lower pH values were found skinning samples in sunflower oil (Figure 3). Gokoglu et al. (2004) reported insignificant changes in pH levels of marinated fish.

### TVB-N analysis results

TVB-N value is a quality index for unprocessed fishery products indicative of fish spoilage as a result of metabolic activity of fish spoilage bacteria and endogenous enzymes action (Gunsen et al., 2011). In marine fish, TVB-N values of 15-20 mg N/100 g show good quality, whereas TVB-N values of 50 mg N/100 g show poor quality (Connell, 1980). However, upper levels from TVB-N values

of 28 mg N/100 g have been reported as “unacceptable” in processed fish, according to the Turkish Manual of Seafood Quality Control Limits (Anon., 2008). There was a significant change in TVB-N value of all three groups during marination then an increase occurred after storage in oil (Figure 4). Although the highest TVB-N value was seen for skinned samples, all groups were under the consumable limit. TVB-N value is useful in assessing the degree of fish deterioration than in evaluating the changes occurring during the first stages of storage (Gokoglu et al., 2009), Ludorf and Meyer (1973) suggested levels of 30–35 mg TVB-N/100 g as the upper limit of acceptable freshness. The samples did not reach such limit value throughout storage.

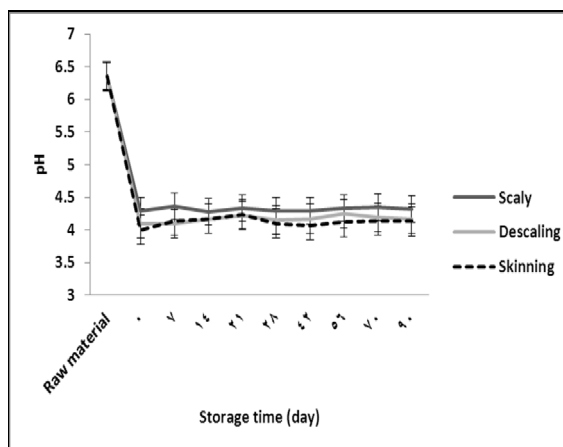


Figure 3. Changes in pH value of marinated seabass in sunflower oil during stored at  $4 \pm 1^\circ\text{C}$  (Values are mean  $\pm$  SD (n=3)).

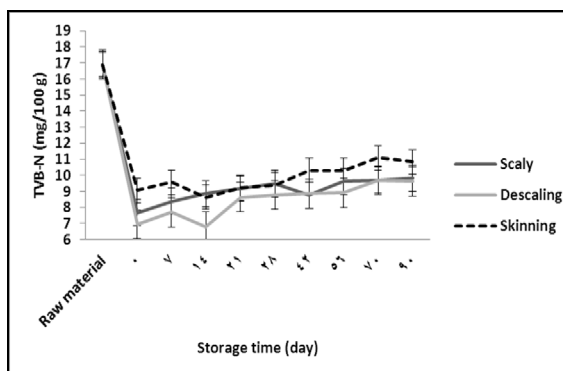


Figure 4. Changes in TVB-N (mg/100g) value of marinated seabass in sunflower oil during stored at  $4 \pm 1^\circ\text{C}$  (Values are mean  $\pm$  SD (n=3)).

### TMA-N analysis results

TMA-N is also used as an index of quality for assessing the state of freshness of fish and considered as a valuable tool in the evaluation of the quality of fish. At the first 7 days of oil storage, there was an important increase at TMA-N value of all groups and after the decrease at 14<sup>th</sup> day, it proceeded as a slight increase (Figure 5). Higher TMA-N values were found skinning samples. A TMA-N value of 5–10mg/100 g sample was reported as the limit for acceptability of fish (Sikorski et al., 1989). All TMA-N levels for samples in marination conditions of the present study were below the limit level. Similar results were reported in the previous researches (Dokuzlu, 2000; Gokoglu et al., 2004).

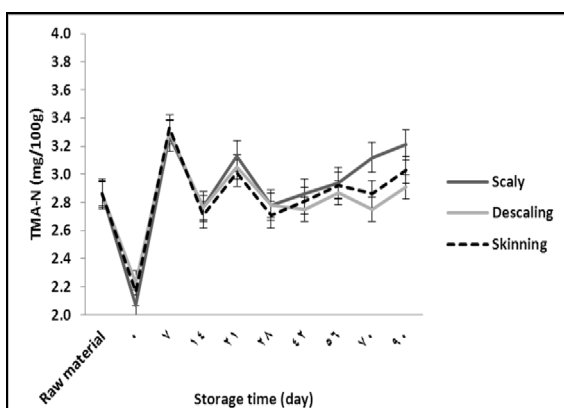


Figure 5. Changes in TMA-N (mg/100g) value of marinated seabass in sunflower oil during stored at  $4\pm 1^\circ\text{C}$  (Values are mean  $\pm$  SD (n=3)).

### TBA analysis results

The initial TBA value of raw fish was found as  $0.30 \pm 0.01$ . At the end of the 90 days storage period, the TBA values recorded for marinated scaly, descaled and skinned fillets were 7.82, 8.50 and 9.68 mg malonaldehyde/kg fish, respectively. The acceptable TBA limit value of 8 mg malonaldehyde/kg fish muscle was reached on days 70 and 56 for both the marinated skinned fillets and descaled, respectively (Figure 6). Sallam et al., (2007) found the raw TBA value of pacific saury (*Cololabis saira*) which they marinated in different acid solutions to be 0.37 mg MA/kg and emphasized that marinades were of good quality although no steady increase had happened during the 90 days of storage period. Baygar et al. (2012) reported after the marinating process, the TBA values recorded for marinated scaly, descaled and skinned fillets were 4.25, 5.74 and 5.95 mg malonaldehyde/kg fish, respectively. Olgunoglu

(2007) found out that the TBA value of anchovy (*Engraulis encrasicolus*) marinades at the beginning of storage period was  $1.16 \text{ mg MA kg}^{-1}$  and it steadily increased and reached  $4.20 \text{ mg MA kg}^{-1}$  at the end of the 7 months of storage period. Varlik et al. (2007) and Kaya et al. (2010) maintained that the TBA number should not be  $<3$  in a very good material and it should not be  $>5$  in a good material.

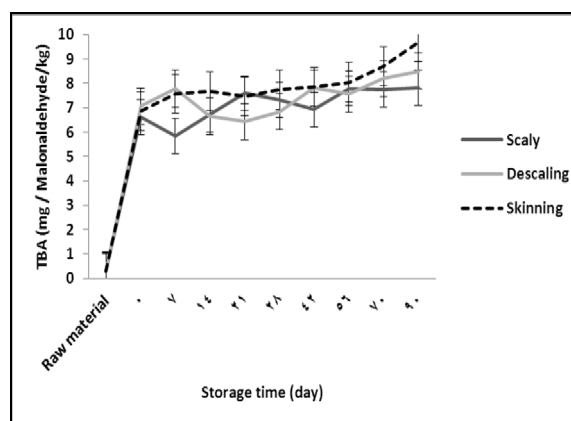


Figure 6. Changes in TBA (Mg malonaldehyde/kg) value of marinated seabass in sunflower oil during stored at  $4\pm 1^\circ\text{C}$  (Values are mean  $\pm$  SD (n=3)).

### Conclusion

After storage in oil for 90 days, scaly and descaled fillets were found to be more suitable than skinned fillets for marinating and oil storage. Skin and scales effect relatively the acid and salt transition, especially at tail parts of thin fish flesh during storage in brine solution and oil. Variability in acid and salt taste in different parts of skinned fillets was not approved by panellists during the oil storage. Likewise changes at juiciness, tenderness and texture of skinned fillets were less acceptable than other samples. These problems of skinned samples affected the overall acceptability and TBA value so 70 days was determined as the maximum storage time of skinned fillets. Both of the scaly or descaled sea bass fillets are suggested to those companies who will do sea bass marination. Also, when scaly fillets will be used for marination, it is advised to clean the scales carefully before taking the fillets into oil.

### References

- Anonymous, 2008. Regulation for changing in turkish manual of seafood quality control limits. Turkish Republic Formal Paper, 21<sup>st</sup> of September, 2008, No. 27004.
- Antonocopoulos, N. 1973. Fische und fischerzeugnisse. In: W. Ludorff and V. Meyer (Eds.). pp.

- 224–225. Bestimmung Des Fluchtigen Basenstickstoofs Berlin: Verlag Paul Parey.
- AOAC. 1998. Association of official analytical chemists (AOAC) official methods of analysis of the AOAC international (16<sup>th</sup> edition). Gaithersburg, MD, USA.
- Arik, F., F. Fiedler, M. V. Lukowicz, B. Sperner and A. Stolle. 2002. Untersuchungen zur haltbarkeit von be- und verarbeiteten susswasserfischen. Arch Lebensmittelhyg, 52:34–39.
- Baygar, T., Y. Alparslan and M. Kaplan. 2012. Determination of changes in chemical and sensory quality of sea bass marinades stored at +4 (±1)°C in marinating solution. CyTA-J. Food 10(3):196-200.
- Bjorkroth, J. 2005. Microbiological ecology of marinated meat products. Meat Sci. 70:477-480.
- Connell, J. J. 1980. Marinades. Control of fish quality (2<sup>nd</sup> Edition), Scotland: Torry Research Station, Aberdeen, 102-105.
- Dokuzlu, C. 2000. Shelf-life of the marinated local anchovies. Uludag University. J. Fac. Vet. Med 19:45–49.
- Duyar, H. A. and E. Eke. 2009. Production and quality determination of marinade from different fish species. J. Anim. Vet. Adv. 8(2):270-275.
- Erkan, N. and O. Ozden. 2007. Proximate composition and mineral contents in aqua cultured sea bass (*Dicentrarchus labrax*), sea bream (*Sparus aurata*) analyzed by ICP-MS. Food Chem. 102:721-725.
- FAO. 2008. FAO fisheries department, fishery information, data and statistics unit. Fishstat plus: Universal software for fishery statistical time series. Aquaculture production: for 2007-2008. ([Http://Www.Globefish.Org/Seabass-And-Seabream-Market-Reports.html](http://www.globefish.org/Seabass-And-Seabream-Market-Reports.html))
- Gallart-Jornet, J., M. Barat, T. Rustad, U. Erikson, I. Escriche and P. Fito. 2007. A comparative study of brine salting of atlantic cod (*gadus morhua*) and atlantic salmon (*Salmo salar*). J. Food Eng. 79:261-270.
- Guaffrida, A., G. Ziino, G. Orlando and A. Panebianco. 2007. Hygienic evaluation of marinated sea bass and challenge test for *Listeria monocytogenes*. Vet. Res. Commun. 31:369–371.
- Gokoglu, N., E. Cengiz and P. Yerlikaya. 2004. Determination of the shelf life of marinated sardine (*sardina pilchardus*) stored at 48°C. Food Cont. 15:1–4.
- Gokoglu, N., O. K. Topuz and P. Yerlikaya. 2009. Effects of pomegranate sauce on quality of marinated anchovy during refrigerated storage. LWT-Food Sci. Technol. 42:113–118.
- Gunsen, U., A. Ozcan and A. Aydın. 2011. Determination of some quality criteria of cold stored marinated anchovy under vacuum and modified atmosphere conditions. Turk. J. Fisher. Aqu. Sci. 11:233-242.
- Kaya, G. K., B. G. Busra and O. Basturk. 2010. The investigation of quality changes in marinades obtained from frozen african catfish (*Clarias gariepinus*, b., 1822). J. Food Technol. 8(4):200-203.
- Ludorf, W. and V. Meyer. 1973. Fische und fischereierzeugnisse. Hamburg-Berlin: Paul Parey Verlag.
- Manthey, M., G. Karnop and H. Rehbein. 1988. Quality changes of european catfish from warm-water aquaculture during storage ice. Int. J. Food Sci. Technol. 23:1–9.
- Olgunoglu, I. 2007. Sensory chemical and microbiological changes of marinated anchovy (*Engraulis engrasicholus* l., 1758). Phd Thesis (pp.70-71), University of Cukurova, Institute of Basic and Applied Sciences, Adana.
- Ozogul, Y., E. Kuley and F. Ozogul. 2009. Quality changes of marinated tench (*tinca tinca*) during refrigerated storage. Food Sci. Techn. Int. 15:513-521.
- Ozogul, Y., F. Ozogul, A. I. Olgunoglu and E. Kuley. 2008. Bacteriological and biochemical assessment of marinating cephalopods, crustaceans and gastropoda during 24 weeks of storage. Int. J. Food Sci. Technol. 59:465–476.
- Ramanathan, L. and N. P. Das. 1992. Studies on the control of lipid oxidation in ground fish by some polyphenolic naturel products. J. Agri. Food Chem. 40:17-21.
- Sallam, K. I. 2007. Antimicrobial and antioxidant effects of sodium acetate, sodium lactate and

- sodium citrate in refrigerated sliced salmon. Food Cont. 18:566-575.
- Sallam, K. I., A. M. Ahmed, M. M. Elgazzar and E. A. Eldaly. 2007. Chemical quality and sensory attributes of marinated pacific saury (*Cololabis saira*) during vacuum-packaged storage at 4°C. Food Chem. 102:1061-1070.
- Schormuller, J. 1968. Handbuch der lebensmittel chemie (Band III/2), Pp. 1482–1537, New York: Springer-Verlag.
- Sikorski, Z. E., A. Kolakowska and J. R. Burt. 1989. Post harvest biochemical and microbial changes. seafood: resources, nutritional composition and preservation. Boca Raton, Florida: Crc Press Inc.
- Tarladgis, B. G., B. M. Watts and M. T. A. Younathan. 1960. A distillation method for the quantitative determination of malonaldehyde in rancid foods. J. Am. Oil Chem. Soc. 37:44–48.
- Varlık, C., N. Erkan and O. Ozden. 2007. Basic quality control of seafood. Istanbul University, Istanbul, p. 202.