Detecting the specific parameters that affect the maturation of farmed sea bass (*Dicentrarchus labrax*) fillets stored in sunflower oil

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Abstract In this study, it was aimed to detect the specific parameters that effect the maturation of farmed sea bass fillets stored in sunflower oil. Sea bass fillets were taken into the pickling solution (2.5% acetic acid and 11% sodium chloride) at 4 °C(±1). Fish meat in each group was analysed for the following parameters; pH, moisture%, acetic acid% and NaCl% in the maturation pickling solution and in sunflower oil. At the end of the 90 days storage, there were not any negative situations about the fish in terms of the scientific approach. It was detected that the skinless samples had the less NaCl and acidity values but scaly and scaleless samples had the higher values. Main reasons are: for the scaly and scaleless samples, the skin acted as a barrier in the pickling solution or oil and for scaly samples, scales depart from the skin and defeat the passing of NaCl and acid to the meat. When evaluating this study results, the fillet group samples which contain more salt and acetic acid are thought to be more appropriate for marinating in terms of shelf-life and quality.

Keywords *Dicentrarchus labrax* · Sea bass · Marinade · Maturation affect · Cold storage

Introduction

In the Mediterranean countries and Turkey, aquaculture is focused on sea bass (*Dicentrarchus labrax*) and sea bream

(*Sparus aurata*), these countries provide 90% of world production. In Turkey total sea bass production was 41.900 tons in 2007. Traditionally, sea bass has been used almost exclusively for fresh consumption, but the high current volume of production and low prices mean that sea bass can be industrialized to obtain other processed products (Anonymous 2007; Fuentes et al. 2008). Quality changes in fish muscle depend upon endogenous enzymes, microbial contamination, and post-catch handling. The rate of quality loss depends on the fish species and the storage condition (Chotimarkorn 2011).

The traditional seafood preservation methods are effective in controlling microbial activity from the point of safety, but have adverse organoleptic and textural properties. The current demand for ‘natural’ foods necessitates new approaches to seafood preservation (Siriskar Dipty et al. 2011).

Recently, in Italy, marination technology is also spreading to some reared fish, like gilthead sea bream and sea bass (Giufrida et al. 2007). Generally anchovy are commercially used for marinated fish production, but the usage of sea bass is not common in Turkey and in the other countries. However, little literature regarding the usage of sea bass in marinating is available. Fish marinades incorporating vinegar have been popular in Mediterranean countries since antiquity, but their consumption has historically been limited to the fishing season. Marinades are fish products consisting of fresh, frozen or salted fish or portions of fish processed by treatment with edible acids and salt and put in brines, sauces, creams or oils. Marinating preserves fish by means of sodium chloride and acetic acid solutions (Ozden 2005). Today, however, anchovies marinated in vinegar are also manufactured in factories, making them available to consumers year round (Pons-Sa’nchez-Cascado et al. 2005). Marinated fish has a limited shelf life. The shelf-life

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depends largely on storage temperature, acid and NaCl value and also on the type of bacteria associated with the marinated fish. In general, the shelf life and safety of none thermally treated marinated seafood is due to the used kinds of organic acid, the NaCl concentration and the final pH value. It is well known that a pH 4.5 is enough to guarantee a high long, despite, in some cases; the products have a strong acidic taste due to the low pH value (Giuffrida et al. 2007; Duyar and Eke 2009). Marination increases ionic strength and decreases pH, not only preventing micro-organism growth but also involving changes in taste and in the textural and structural properties of fish (Pons-Sa'nchez-Cascado et al. 2005). Varlık et al. (1993) studied the effect of temperature on the penetration of vinegar/salt during the marination process. Gun et al. (1994) determined the maturation time for rainbow trout marination. Poligne and Collignan (2000) investigated the quality and stability of the end product of anchovy marinated using acetic and gluconic acids.

The aim of this study is to investigate whether the different sea bass fillets (scaly fillet, scaleless fillet and skinless fillet) kinds are appropriate for marinating or not and to detect the effective parameters for storage in oil.

Material and methods

Fish

Aquacultured fresh sea bass, *Dicentrarchus labrax* (average weight and length: 300–350 g and 230–250 mm) was cultivated in net cages in Turkish fish farm (Kılıç Fisheries Co., Muğla) and harvested during the period of October 2007. A total of 50 kg fish were obtained by immersing in flaked ice-cold water, packed with flaked ice (2:1, fish: ice) into polystyrene boxes provided with holes for drainage and transported to the laboratory (whole as scaly and scaleless) within 18 h of harvesting.

Marination process

All the fish were beheaded, eviscerated, washed thoroughly of blood, and filleted. Before starting this study, preliminary experiments with marination solutions in different concentrations were performed in order to determine the valid taste (total 6 experiments). After the taste tests, it was decided that the best taste was obtained with 2.5% acetic acid (v/v) and 11% NaCl (w/v). The marinating process was achieved by immersing the fish into solutions containing acetic acid and NaCl for 72 h. Fillets were separated into three groups as scaly fillet, scaleless fillet, and skinless fillet. Fillets were taken into the sunflower oil in glass jars at 4 °C (± 1). About

2.5 kg samples were placed in each of nine different glass jars (diameter: 21 cm, h: 34 cm, approximately 7 L capacity) were prepared and added to the jars, covering the fish completely with the oil. Fish were classified as 1.5/1: pickling solution & oil ratio/fish (v/w).

Storage and analyse periods

For 3 months (0, 1st, 2nd, 3rd, 4, 5, 6, 7, 14, 21, 28, 42, 56, 70 and 90th days), fish meat in each group was analysed for following parameters; pH, moisture, acetic acid and NaCl. Reagents of analytical grade and deionised water were used throughout the experiments. Before every analysis, four fish fillets from every jar were randomly taken and all the fish were pooled. Then the fish flesh were homogenised using a kitchen blender. In this study, all analysis were done and carried out as 4 parallels.

pH measurement

Sea bass fillets homogenised using a food processor. Samples were prepared according to Manthey et al. (1988) by blending 5 g of the homogenate with 5 mL distilled water for 1 min at room temperature in an Ultra-Turrax (IKA T 25 Basic, Staufen, Germany). pH was monitored using a WTW-pH-meter (Ina Lab Level 1 model, Germany).

Moisture content

Moisture content was determined by 5 g of minced fish at 105 °C for 24 h to constant weight (AOAC 1990).

Analyses of salt in fish flesh

NaCl content in fish muscle was determined by the volumetric method of AOAC (1990). The NaCl content was calculated as percentage of the sample.

Analyses of acidity in fish flesh

Acidity was determined as acetic acid according to the method given by Karl (1994). The method was based on titration using NaOH and phenolphthalein as an indicator.

Statistical analysis

The results of analyses are reported as means $\pm$ standard deviation (SD). One way ANOVA test followed by the least significant difference test (LSD) in the statistical software program SPSS11 were used to evaluate any significant difference ($p < 0.05$).

Results and discussion

The changes in pH values during the storage period of sea bass fillets within pickling solution (3th days) and sunflower oil (90 days) are summarized in Fig. 1. pH values of raw sea

Fig. 1 Chemical changes in scaly, scaleless and skinless seabass fillets during storage(+4°C) ($n=3$)

bass were 6.35 ± 0.01 . At the end of the pickling process (at 3th days), at the beginning of the oil process (4th days) and at the end of the storage period in oil (90 days), pH values of scaly, scaleless and skinless fillets were 4.16 ± 0.02 , 3.99 ± 0.01 , 3.95 ± 0.02 ; 4.28 ± 0.01 , 4.11 ± 0.02 , 3.95 ± 0.00 and 4.32 ± 0.00 , 4.17 ± 0.00 , 4.13 ± 0.00 , respectively.

A significant difference was not observed ($p > 0.05$) in pH value, among the average values of scaly, scaleless and skinless sample group during the oil storage period. It was observed that pH value of sea bass fillets increased a little bit from the time it was put into the oil to the end of the storage. It was determined that during the storage period the lowest pH value was observed in skinless samples and the highest one was observed in scaly samples.

The changes in moisture contents during the storage period of sea bass fillets within pickling solution (3th days) and sunflower oil (90 days) are summarized in Fig. 1. Moisture contents of raw sea bass were $74.27\% \pm 0.84$. At the end of the pickling process (at 3th days), at the beginning of the oil process (4th days) and at the end of the storage period in oil (90 days), moisture contents of scaly, scaleless and skinless fillets were $70.37\% \pm 0.35$, $69.31\% \pm 1.20$, $71.34\% \pm 0.41$; $65.28\% \pm 0.58$, $66.22\% \pm 1.07$, $64.90\% \pm 0.44$ and $64.24\% \pm 0.88$, $64.16\% \pm 0.58$, $63.05\% \pm 0.67$, respectively.

In this study, moisture content of brined fillets was less than that of raw fillets. In pickling solution decreased ($p < 0.05$) moisture content in all fillets. In the first day that the fillets were taken into oil (4th day), the moisture levels fell rapidly and in the coming days of storage this slowly increasing and decreasing change at the level of moisture went on. There was not a significant ($p > 0.05$) change in moisture value between the average values of scaly, scaleless and skinless sample group during the oil storage period. During the oil storage period of sea bass fillets, the lowest moisture value was observed in skinless sea bass, the highest value on the other side, was observed in scaleless sea bass. It has been thought that the main reason for different moisture value between scaleless and scaly fillets is that the scale is covering the whole fish meat in time.

The changes in acetic acid values during the storage period of sea bass fillets within pickling solution (3th days) and sunflower oil (90 days) are summarized in Fig. 1. Acetic acid values of raw sea bass were $0.36\% \pm 0.04$. At the end of the pickling process (at 3th days), at the beginning of the oil process (4th days) and at the end of the storage period in oil (90 days), acetic acid values of scaly, scaleless and skinless fillets were $1.36\% \pm 0.01$, $1.32\% \pm 0.07$, $1.14\% \pm 0.05$; $1.20\% \pm 0.04$, $1.37\% \pm 0.04$, $1.29\% \pm 0.06$ and $1.49\% \pm 0.01$, $1.42\% \pm 0.01$, $1.31\% \pm 0.06$, respectively.

When the results of acetic acid values were checked there was not an important difference among the average values of scaly, scaleless and skinless sample groups ($p > 0.05$). During the oil storage time acetic acid

level of scaly, scaleless samples was observed to be higher than skinless ones.

The changes in NaCl values during the storage period of sea bass fillets within pickling solution (3th days) and sunflower oil (90 days) are summarized in Fig. 1. NaCl values of raw sea bass were $1.21\% \pm 0.32$. At the end of the pickling process (at 3th days), at the beginning of the oil process (4th days) and at the end of the storage period in oil (90 days), NaCl values of scaly, scaleless and skinless fillets were $4.34\% \pm 0.21$, $5.53\% \pm 0.11$, $4.51\% \pm 0.12$; $4.47\% \pm 0.08$, $4.31\% \pm 0.09$, $4.42\% \pm 0.06$ and $4.82\% \pm 0.03$, $4.69\% \pm 0.02$, $4.31\% \pm 0.09$, respectively.

When the results of NaCl values were checked, there was not an important difference among the average values of scaly, scaleless and skinless sample groups during the oil storage period ($p > 0.05$). After the fillets were put in to the oil, little decrease was seen in salt value, after that increases/decreases occurred in a balanced way. During the storage time, the lowest salt value came out in skinless samples.

The shelf life of a product in refrigerated conditions (2–4 °C) can be extended to several months by decontaminating the product during processing in solution, while decreasing its pH (4.0) and/or its water activity (Karl 1994). Giuffrida et al. (2007) concluded that the Aw in marinated sea bass reached a mean value of 0.987 after 3 days and decreased to 0.972 after 35 days of storage. Fish salting leads to a reduction in moisture. Nketsia-Tabiri and Sefa-Dedeh (1995) declared that salting time was an important processing variable influencing product moisture content. Ozden (2005) reported that the moisture contents (fresh anchovy, 69.76%; fresh trout, 76.23%) were reduced in marinated fish at the end of storage period of 120 d (anchovy, 66.75%; trout, 74.02%). In an other study, in the raw cod fillets (*Gadus morhua*) has been observed 81.8% water. During brining, the water content decreased. The water content decreased as 57.6–58.4% during storage (Thorarinsdottir et al. 2004). Birkeland et al. (2005) has worked the effects of different brine concentrations (10, 16.5 and 25.5%), brining temperatures (3.5 and 17.5 °C), the presence of skin or not on the fillets, and brining time (1, 2, 3, 4, and 7 d) were investigated on the weight gain (%) and final salt content (%) of herring (*Clupea harengus*). A significant ($p < 0.001$) high weight gain of the fillets was observed at the lowest brining temperature (3.5 °C) compared to the highest temperature (17.5 °C), independently of brine concentration and brining time. Increased brine concentration and skinning of the fillets caused the weight gain to significantly decrease ($p < 0.001$) and increase ($p < 0.001$), respectively. After 1 d of brining, the weight gain was in the range of 10% to 12% for both brining temperatures, and at the lowest temperature, the weight gain increased significantly ($p < 0.001$) as a function of brining time. It is concluded that the weight gain in herring fillets brined according to the present commercial

practice is significantly affected by temperature, brine concentration, brining time, and the presence or absence of skin on the fillets and that the weight gain may be of high magnitude.

The pH in fresh fish flesh is often between 6 and 6.5. Marinades have a low pH due to acetic acid content. During the storage period pH value increased according to storage time. Marinades have a low pH due to acetic acid content. During the storage of marinades, lactic acid bacteria can grow and cause the amino acids to degrade. Thus, the formation of carbon dioxide and other decarboxylation products is observed. These products bind acetic acid and the pH of marinade rises (Gokoglu et al. 2004; Duyar and Eke 2009). For marinating studies, the pH value is assessed 4.5 or lower as limit degree. In our study, we have never met a degree under this limit for any of the three fillet groups. Aksu et al. (1997) determined that pH values of anchovy marinated with 2% and 4% and stored at 4 °C from 4.25 and 4.18 to 4.53 and 4.31, respectively. It was also reported that pH value in anchovy marinated 4% acetic acid changed from 3.89 to 3.95 during the storage of 8 months. Duyar and Eke (2009) reported that pH values in raw anchovy and bonito flesh were found 6.04 - 4.59 and 6.18 - 4.21, respectively at the end of storage period. pH levels of marinated anchovy and bonito decrease from 5.39 and 4.59 to 5.51-4.21 respectively at the end of storage period. Similar pH values have been reported for marinated sea bass. The pH values, after an initial drastic decrease to under 4.5, fluctuated from 4.4 to 4.9 (Giuffrida et al. 2007). Poligne and Collignan (2000) established that the pH values of anchovies pickled with acetic acid increased from 3.9-4.21 after 20 d of storage and then remained permanent until the end of storage. These values were very similar to our findings on the increase of pH level during storage.

The intake and distribution of salt in the fish fillets depend on several factors such as the method used, species, muscle thickness, brine concentration, brining time and ratio between fish and salt. It is generally accepted that salt migration by diffusion plays an important role in salting, and two main fluxes occur; the uptake of NaCl in the muscle and the loss of water from the muscle tissue (Jittinandana et al. 2002). The preservative effect of salt has been recognised according to a decrease in water activity, less availability to microbial attack, and enhancement of functional properties, leading to an increase of the shelf-life time (Aubourg and Ugliano 2002). Ozden (2005) have observed the salt concentration in marinated anchovy and trout were 5.3 and 5.1% respectively. Similar salt (5.9%) contents have been reported by Gun et al. (1994) in marinated rainbow trout. Wang et al. (1998) reported that it took 24 h for the centre of a thin slice (4–5 mm) of Atlantic salmon to reach at least 90% of its equilibrium salt concentration. Poligne and Collignan (2000) declared that the salt content of anchovies

decreased by 0.1 and 0.3 g/100 g after 30 d of storage and then remained constant until the end of the storage period. Yanar et al. (2005) indicated that the tilapia brined in the 5%, 10%, 15% brines and unsalted tilapia contained 2.09%, 4.17%, 6.26% and 0.95% salt in the water-phase portion of the smoked tilapia, respectively. In other study, in the raw cod (*G.morhua*) fillets has been observed 0.4% salt. During brining, the salt content of the fillets increased (Toyohara et al. 1999). Higher brine concentration caused ($p<0.05$) dehydration of the fillets, due to the difference in solute concentration between the brine solution and inherent muscle water; water migrated from fish muscle to the high brine solution (Jittinandana et al. 2002). Bligh and Duclos-Rendell (1986) claimed that released brine by a vacuum filter-press increased as salt concentration increased from 5 to 28% (w/w) in minced cod. Lautenschlager (1985) revealed that diffusion of salt ions through a meat slice was a very slow process and a function of time. Diffusion occurs until sodium chloride concentration of fish and brine has equilibrated.

In vinegar curing, both firmness and cohesiveness increased in the early stages, with concomitant increase in water content, decrease in NaCl, and lowering of pH (Wang et al. 1998). The activity of organic acid and the values of pH and Aw should guarantee the growth inhibition of *L. monocytogenes* during refrigerated storage, also in the case of persistence of a few cells after the marinating process (Gokoglu 2003). When the concentration of the acids was higher than 1% the meat was felt to be sour (Aktaş and Kaya 2001). Ozden (2005) have observed acetic acid concentration in marinated anchovy and trout were 2.2% and 2.1% respectively. Similar acetic acid (1.8%) values have been reported by Gun et al. (1994) in marinated rainbow trout. Cardinal et al. (2001) determined a salt uptake of 3.2–4% wet weight for weak fish and 2.2–3.4% for fatter fish. Acidity as acetic acid has been determined to investigate the diffusion of acetic acid into the sardine tissue. According to acidity results, acetic acid concentration in sardine tissue was prepared with 4% acetic acid increased until 8 h and then remained constant, whereas acetic acid continued to increase up to 16 h in the samples prepared with 2% acetic acid (Gokoglu 2003).

At the end of the 90 days storage period, there were not any negative situations about the fish in terms of the scientific approach. It was detected that the skinless samples had the less NaCl and acidity values but scaly and scaleless samples had the higher values. Main reasons are: for the scaly and scaleless samples, the skin acted as a barrier in the pickling solution or oil and for scaly samples, scales depart from the skin and defeat the passing of NaCl and acid to the meat. When evaluating this study results, the fillet group samples which contain more salt and acetic acid are thought to be more appropriate for marinating in terms of shelf-life

and quality. To those people or companies who want to make sea bass marinating, we advise them that: three kinds of fillet groups are appropriate for marinating process and scaleless fillets give better results in marinating process when compared with other scaly and skinless fillets in terms of economic conditions, shelf life and hygiene.

References

- Aksu H, Erkan N, Colak H, Varlık C, Gokoğlu N, Ugur M (1997) Some changes in anchovy marinades during production in different acid-salt concentrations and determination of shelf life. *YYU Veteriner Fakültesi Dergisi* 8(2):86–89
- Aktaş N, Kaya M (2001) The influence of marinating with weak organic acids and salts on the intramuscular connective tissue and sensory properties of beef. *Eur Food Res Technol* 213:88–94
- Anonymous (2007) Fisheries Statistics. State Institute of Statistics. Prime Ministry Republic of Turkey, Ankara
- AOAC (1990) Official Methods of Analysis (13th Ed.) Association of Official Analytical Chemists. Washington, D.C.
- Aubourg SP, Ugliano M (2002) Effect of brine pre-treatment on lipid stability of frozen horse mackerel (*Trachurus trachurus*). *Eur Food Res Technol* 215:91–95
- Birkeland S, Sivertsvik M, Nielsen HH, Skåra T (2005) Effects of brining conditions on weight gain in herring fillets. *J Food Sci* 70 (7):418–424
- Bligh EG, Duclos-Rendell R (1986) Chemical and physical characteristics of lightly salted minced cod (*Gadus morhua*). *J Food Sci* 51 (1):76–78
- Cardinal M, Knockaert C, Torrisen OJ, Sigurgisladottir S, Mørkøre T, Thomassen M, Vallet JL (2001) Relation of smoking parameters to the yield, colour and sensory quality of smoked Atlantic salmon (*S. salar*). *Food Res Int* 34:537–550
- Chotimarkorn C (2011) Quality changes of anchovy (*Stolephorus heterolobus*) under refrigerated storage of different practical industrial methods in Thailand. *J Food Sci Technol*. doi:10.1007/s13197-011-0505-y
- Duyar H, Eke E (2009) Production and quality determination of marinade from different fish species. *J Anim Vet Adv* 8(2):270–275
- Fuentes JM, Barat I, Fernández-Segovia JAS (2008) Study of sea bass salting process: Kinetic and thermodynamic control. *Food Control* 19:757–763
- Giuffrida A, Ziino G, Orlando G, Panebianco A (2007) Hygienic Evaluation of Marinated Sea Bass and Challenge Test for *Listeria monocytogenes*. *Vet Res Commun* 31(1):369–371
- Gokoglu N (2003) Changes in biogenic amines during maturation of sardine *Sardina pilchardus* marinade. *Fisheries Sci* 69:823–829
- Gokoglu N, Cengiz E, Yerlikaya E (2004) Determination of the shelf life of marinated sardine (*Sardina pilchardus*) stored at 4 °C. *Food Control* 15:1–4
- Gun H, Gokoglu N, Varlık C (1994) Alabalık (*Onchorhynchus mykiss*) marinatında olgunlaşma süresinin belirlenmesi. *Istanbul Univeristesi Su Ürünleri Fakültesi Dergisi* 1(2):137–144
- Jittinandana S, Kenney PB, Slider SD, Kiser RA (2002) Effect of brine concentration and brining time on quality of smoked rainbow trout fillets. *J Food Sci* 67(6):2095–2099
- Karl H (1994) Überlegungen zur berechnung der salz-und sauregehalte im fischgewebewasser von marinierten fischereierzeugnissen. *Infischw* 41(1):47–59
- Lautenschlager R (1985) Diffusion of sodium chloride and sodium nitrite in raw meat model systems. In: Proceeding of the 41st Int.

- Cong. Meat Sci. Tech. August 20–25, 1985. Vol.2, San Antonio. Illinois: American meat Science Association pp.507–508
- Manthey M, Karnop G, Rehbein H (1988) Quality changes of European catfish from warm-water aquaculture during storage ice. *Int J Food Sci Tech* 23:1–9
- Nketsia-Tabiri J, Sefa-Dedeh S (1995) Optimization of process, conditions and quality of salted dried tilapia (*Oreochromis niloticus*) using response surface methodology. *J Sci Food Agric* 69(1):117–127
- Ozden O (2005) Changes in amino acid and fatty acid composition during shelf-life of marinated fish. *J Sci Food Agric* 85 (12):2015–2020
- Poligne I, Collignan A (2000) Quick marination of anchovies (*Engraulis encrasicolus*) using acetic and gluconic acids. Quality and stability of the end product. *Lebensm Wiss Technol* 33:202–209
- Pons-Sa'nchez-Cascado S, Vidal-Carou MC, Marine-Font A, Veciana-Nogue's MT (2005) Influence of the freshness grade of raw fish on the formation of volatile and biogenic amines during the manufacture and storage of vinegar-marinated anchovies. *J Agric Food Chem* 53:8586–8592
- Siriskar Dipty A, Khedkar GD, Lior D (2011) Production of salted and pressed anchovies (*stolephorus* sp.) and it's quality evaluation during storage. *J Food Sci Technol*. doi:10.1007/s13197-011-0450-9
- Thorarinsdottir KA, Arason S, Bogason SG, Kristbergsson K (2004) The effects of various salt concentrations during brine curing of cod (*Gadus morhua*). *Int J Food Sci Tech* 39:79–89
- Toyohara M, Murata M, Ando M, Kubota S, Sakaguchi M, Toyohara H (1999) Texture changes associated with insolubilization of sarco-plasmic proteins during salt-vinegar curing of fish. *J Food Sci* 64 (5):804–807
- Varlık C, Gökoğlu N, Gün H (1993) Marinat üretiminde sıcaklığın sirke/tuz geçişi üzerine etkisi. *Gıda* 18:223–228
- Wang D, Correia LR, Tang J (1998) Modelling salt diffusion in Atlantic salmon muscle. *Can Agr Eng* 40:29–33
- Yanar Y, Çelik M, Akamca E (2005) Effects of brine concentration on shelf-life of hot smoked tilapia. (*Oreochromis niloticus*) stored at 4 °C. *Food Chem* 97(2):244–247