DOI: http://dx.doi.org/10.1590/1678-457X.0102

Effects of gutting process on the shelf life of cultured meagre (*Argyrosomus regius* ASSO, 1801) stored at 4 ± 1 °C

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Abstract

The aim of this study was to determine chemical, nutritional and microbiological evaluation of whole or gutted meagre stored at 4 ± 1 °C. Whole ungutted (Group A), eviscerated (Group B), beheaded-eviscerated fish (Group C) and fillets (Group D) groups were created for this study. According to fatty acid analysis, it was determined that meagre is rich in PUFA content and the n3/n6 ratio is within the ideal limits. In all 4 groups, obtained from fillets values were the highest in general, quality parameters were found within acceptable limits. Psychrophilic and mesophilic aerobic bacteria counts exceeded the standards for fillet groups on 7th days of storage. According to microbiological analysis, ungutted, beheaded, eviscerated samples were not exceeded limit values on 9th day. In conclusion, whole or gutted (headed and eviscerated) storage of meagre is found to be more advantageous compared to fillets for storage at 4 ± 1 °C.

Keywords: cultured meagre; quality; gutting process; cold storage; fatty acid.

Practical Application: The effect of gutting process of shelf life of fish.

1 Introductıon

Meagre (*Argyrosomus regius*) has high aquacultural potential due to significant growth rate. Although rather known in local markets, farmed meagre fish have increasing popularity in markets due to its attractive attributes like large size, good processing yield, low fat content, excellent taste and firm texture (Monfort, 2010). Today, meagre is produced in several countries in the Mediterranean basin, including Turkey where meagre farming has been practised since 2005. Originally an occasional catch of Mediterranean coasts of Turkey, meagre is now commonly found in markets and wholesalers.

There are different studies about meagre. Ribeiro et al. (2013) performed a study about efffect of grape dietay fibre on storage stability of innovative functional seafood products (sausages) made from meagre. According to Grigorakis et al. (2011) reared meagre has distincly different qualities from most other reared Mediterranean fish and include very low total fat content and high polar lipids content. García Mesa et al. (2014) studied the juvenile meagre and stated that meagre offered good indices of lipid quality for human consumption. Information on quality, body composition and shelf life of meagre stored in cold conditions is available in literature (Poli et al., 2003; Nunes et al., 2003, Hernández et al., 2009, Genç et al., 2013, Sáez et al., 2014). Most of the studies deal with the quality and shelf life of meagre fillets on ice and/or in cold storage, but little information is available regarding effects of gutting process on the shelf life of meagre. The present study includes a comparative quality evaluation of whole, beheaded, eviscerated and filleted meagre stored in cold storage (4 ± 1 °C) conditions in terms of chemical and microbiological changes. Furthermore, shelf life estimates of all meagre groups and fatty acid content changes during storage period are presented.

2 Materials and methods

2.1 Preparation of fish samples

Fresh meagre (*Argyrosomus regius*) were obtained from sea cages in a farm in Western Turkey (Kuzey Deniz Ürünleri Company in İzmir). Fresh fish in polystyrene boxes with ice were transported to the laboratory within 8 h. A total of 30 kg fish were used for the experiment. The mean values and standard deviations of the weight and length of the fish were 674.3 ± 68.35 g and 42.17 ± 1.41 cm, respectively. After washing, fish were divided into four lots; whole ungutted (Group A), eviscerated (B), beheaded–eviscerated fish (C) and fillets (D). Each group was stored in individual polystyrene boxes without ice at 4 ± 1 °C. Quality control analyses were done in triplicate on days 1, 3, 5, 7 and 9.

2.2 Proximate composition

Moisture content was analysed with an automatic moisture analyzer (AND MX-50), crude protein content according to Kjeldahl method (Nx6,25) (Association of Official Analytical Chemists, 2000), lipid contents by Bligh & Dyer (1959)'s method and crude ash content according to Association of Official Analytical Chemists (2002) were done.

Received 10 Dec., 2015
Accepted 05 Apr., 2016
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2.3 Fatty acid analysis

Fatty acid methyl esters were extracted by transmethylation of small addition of n-heptane to lipids, using the method described by Ichihara et al. (1996). 4 mL of 2M KOH was added to extracted 10 mg lipid samples with 2 ml of heptane. Afterwards, the mixture was stirred with a vortex at room temperature for 2 minutes and centrifuged at 4000rpm for 10 minutes and heptane layer is removed for GC analysis. Fatty acid methyl esters were separated by gas chromatography (Perkin Elmer Clarus 500, USA) equipped with a flame ionization detector and a fused silica capillary SGE column (30 m x 0.32 mm, ID.BP20 0.25 µm, USA). The oven temperature was 140 °C, held 5 min, raised to 200 °C at a rate of 1 °C /min, while the injector and detector temperature were set at 220 °C and 280 °C, respectively. Sample size was 2 µL. The carrier gas was checked at 16 psi and the split rate was 1:100. Fatty acids were identified by comparing retention times of FAME with standard 37 component FAME mixture (Supelco). Gas chromatography (GC) analyses were performed in two replicates. Results were calculated in the GC area % as mean values and ± standard deviation.

2.4 Chemical analysis

The pH was measured a method by (Varlık et al., 1993). Thiobarbituric acid (TBA, mg MDA/kg) value was determined by the method of Erkan & Özden (2008). 2 g homogenised sample was put in 50ml centrifuge tube and then 5% (w/v) TCA (trichloroaceticacid - Riedel-de Haen 27242) and 100 µL BHT (butylated hydroxytoluene) were added, homogenised with homogenizer (Heidolph Diax 900, Germany). Mixture was filtered through a Whatman No 1 filter paper. 1 mL of a 0.01- M aqueous solution of 2-TBA reagent (malondialdehyde bis-diethyl acetal, Merck 805797) and 5 mL of filtrate were mixed. The tubes were kept for 40 minute in 95 °C water bath (WB 22 Memmert, Germany). After cooling process, the absorbance of coloured solution was read at by Spectrophotometer (T80+UV/VIS Spectrometer, PG Instruments. TBA values were given as mg MDA/kg. Total volatile basic nitrogen (TVB-N, mg/100g) value was estimated by the Antonacopoulos & Vyncke (1989). 10g fish muscle was homogenised with 90ml percloric acid (6%) by homogenizer (Heidolph Diax 900, Germany). Homogenised sample was filtered with Whatman No 1 filter paper. NaOH (20%) was added to filtrated solution and distilled with distilation unit (Velp Scientifica UDK 142, Europa). Finally, the distillate was titrated with HCI (0.01N). Trimethylamine (TMA-N, mg/100g) analysis were done by the Association of Official Analytical Chemists (1998) methods.

2.5 Microbiological analysis

Samples (10 g) were aseptically placed into sterile Stomacher bags containing 90ml of peptone water (Merck, Darmstadt, Germany) and homegenized for 60 sec with a Stomacher (BagMikser 400, France). From this dilution, other decimal dilutions were prepared and plated on appropriate media. For the enumeration of mesofilic aerobic (MAB) and psychrophilic aerobic bacteria (PAB), PCA (Merck, Darmstadt, Germany) was incubated at 30 °C for 48 h (International Organization for Standardization, 2003) and at 6.5 °C for 10 days (International Organization for Standardization, 2001) respectively. MRS agar was used for lactic acid bacteria (LAB). After the second layer was solidified, broth was added to the petri dish and allowed to incubate for 5 days at 25 °C (American Public Health Association, 1974). For hydrogen sulfide (H_2S) producing bacteria, iron agar was prepared. Petri dishes were then incubated at 25 °C for 48 h and black colonies were counted as H_2S-producing bacteria (Erkan & Özden, 2006). The validation tests were performed necessary for bacteria.

2.6 Statistical analysis

For statistical analysis, the results indicated was recorded as mean ± standard deviation. Two-way analysis of variance (two-way ANOVA) was carried out to determine treatment and the effect of storage time. Tukey-HSD multiple comparisons test was used for multiple comparison of difference between averages. All statistic analyses were performed using SPSS 16.0 package program (Esteves, 2011).

3 Results and discussion

3.1 Proximate composition

The proximate composition of meagre was 77.26 ± 1.01% moisture, 16.95 ± 0.84% crude protein, 2.58 ± 0.12% crude fat and 1.38 ± 0.12% crude ash. The chemical composition of meagre is similar to the findings of Hernández et al. (2009) (76.3% moisture, 19.8% protein, 2.49% fat, and 1.26% ash). With records of even lesser amount of fat content (Grigorakis et al., 2011), compared to other farmed fish such as sea bass (Poli et al., 2003) the meagre fish have a very low fat content, which is of interest by the consumer (Hernández et al., 2009).

3.2. Fatty acids

Tables 1-4 show the fatty acid contents found in meagre during storage period. From a total of 23 fatty acids determined, 9 were saturated and 14 were unsaturated fatty acids. The percentages of saturated fatty acids were lower than those of unsaturated fatty acids over the 9 day storage period in all groups. Fish lipids are particularly rich in polyunsaturated fatty acids (PUFA). The predominant *n*-3 fatty acids in marine fish are eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA) (Sağlık et al., 2003; Özogul et al., 2007).

According to Hernández et al. (2009), the highest fatty acid rates in meagre belong to polyunsaturated fatty acids (PUFA) followed by saturated (SFA) and monounsaturated fatty acids (MUFA) at each sampling day. The fatty acid composition in the present study is highly similar (Tables 1, 2, 3). Highest quantity among all saturated fatty acids belonged to palmitic acid (Table 1), being a dominant fatty acid ranging between 11.8 to 21.6% (Nunes et al., 2003). In general, insignificant differences were observed among the groups in terms of total fatty acid content and gutting didn't alter these results. At the beginning of the storage, the total amount of n3 and n6, n3/n6 ratio and n9 rate were 15.24 ± 0.3%, 15.17 ± 0.09%, 1 ± 0.01, and 20.89 ± 0.04%, respectively. EPA/DHA ratio was 13.25 ± 0.57%. These values showed little change in relation to the time. Insignificant ($P > 0.05$)

changes were observed in all groups, depending on the storage (Table 4). Meagre is rich in PUFA and decosahexaenoic acid (DHA) content (Table 3). Results of clinical and epidemiological research suggest that EPA and DHA, found only in fish and seafoods, have extremely beneficial properties for the prevention of' human coronary artery disease. Therefore, when fish is suggested as a means of improving health, both fat content and the PUFA composition must be considered (Osman et al., 2001).

Table 1. Changes of saturated fatty acids (SFA) of meagre during storage at 4 ± 1 °C (%).

Days	Groups				
		14:0	16:0	18:0	Σ SFA
1	A	3.27 ± 0.19^{aA}	17.06 ± 0.28^{aA}	4.61 ± 0.44^{aA}	26.38 ± 0.02^{abA}
	B	3.27 ± 0.19^{aA}	17.06 ± 0.28^{aA}	4.61 ± 0.44^{aA}	26.38 ± 0.02^{abA}
	C	3.27 ± 0.19^{aA}	17.06 ± 0.28^{aA}	4.61 ± 0.44^{aA}	26.38 ± 0.02^{aA}
	D	3.27 ± 0.19^{aA}	17.06 ± 0.28^{aA}	4.61 ± 0.44^{aA}	26.38 ± 0.02^{abA}
3	A	2.67 ± 0.07^{aA}	15.67 ± 0.56^{bB}	5.66 ± 0.19^{aA}	25.92 ± 0.16^{abB}
	B	3.88 ± 0.37^{aA}	17.36 ± 0.20^{aA}	4.36 ± 0.12^{aA}	27.10 ± 0.25^{abA}
	C	2.89 ± 0.47^{aA}	16.07 ± 0.17^{aB}	5.16 ± 0.83^{aA}	25.47 ± 0.21^{aB}
	D	3.29 ± 0.13^{aA}	16.54 ± 0.01^{aAB}	4.25 ± 0.07^{aA}	25.58 ± 0.17^{bB}
5	A	3.16 ± 0.29^{aA}	16.24 ± 0.14^{abA}	4.68 ± 0.28^{aA}	25.72 ± 0.14^{bA}
	B	2.86 ± 0.22^{aA}	16.15 ± 0.45^{aA}	4.34 ± 0.15^{aA}	24.85 ± 0.53^{bA}
	C	3.16 ± 0.43^{aA}	17.39 ± 0.66^{aA}	4.02 ± 0.66^{aA}	25.97 ± 0.76^{aA}
	D	3.02 ± 0.28^{aA}	16.54 ± 0.31^{aA}	4.82 ± 0.16^{aA}	25.80 ± 0.35^{bA}
7	A	3.20 ± 0.19^{aA}	17.4 ± 0.42^{aA}	4.65 ± 0.30^{aA}	26.87 ± 0.44^{aA}
	B	3.51 ± 0.45^{aA}	18.30 ± 1.13^{aA}	4.14 ± 0.98^{aA}	27.42 ± 0.74^{aA}
	C	3.32 ± 0.13^{aA}	17.5 ± 0.57^{aA}	4.32 ± 0.68^{aA}	26.75 ± 0.18^{aA}
	D	3.19 ± 0.38^{aA}	16.6 ± 0.50^{aA}	4.53 ± 0.60^{aA}	25.85 ± 0.50^{bA}
9	A	3.22 ± 0.04^{aAB}	16.95 ± 0.06^{abA}	4.81 ± 0.07^{aB}	26.28 ± 0.28^{abA}
	B	3.37 ± 0.17^{aA}	16.4 ± 0.67^{aA}	4.60 ± 0.14^{aB}	25.94 ± 0.98^{abA}
	C	2.89 ± 0.06^{aB}	16.56 ± 0.05^{aA}	4.90 ± 0.03^{aAB}	25.65 ± 0.13^{aA}
	D	3.18 ± 0.03^{aAB}	17.47 ± 0.11^{aA}	5.21 ± 0.07^{aA}	27.48 ± 0.04^{aA}

The fatty acids 12:0,17:0,20:0, 23:0 and 24:0 present in percentage less than 1% were considered for statistical calculation, but not given in the table for brevity. In same column means with different letters are significantly different ($P < 0.05$). Capital letters indicate differences between the groups. Lower case letters indicate differences between the days. A: whole ungutted, B: eviscerated fish, C: beheaded/eviscerated fish, D: fillets.

Table 2. Changes of mono unsaturated fatty acids (MUFA) of meagre during storage at 4 ± 1°C (%).

Days	Groups				
		16:1	18:1n9cis	18:1n7	Σ MUFA
1	A	4.23 ± 0.29^{aA}	20.84 ± 0.03^{aA}	2.72 ± 0.08^{bA}	28.42 ± 0.39^{aA}
	B	4.23 ± 0.29^{aA}	20.84 ± 0.03^{aA}	2.72 ± 0.08^{abA}	28.42 ± 0.39^{aA}
	C	4.23 ± 0.29^{aA}	20.84 ± 0.03^{aA}	2.72 ± 0.08^{aA}	28.42 ± 0.39^{aA}
	D	4.23 ± 0.29^{abA}	20.84 ± 0.03^{aA}	2.72 ± 0.08^{bcA}	28.42 ± 0.39^{aA}
3	A	3.17 ± 0.36^{bB}	19.11 ± 0.42^{bA}	2.80 ± 0.20^{abA}	25.66 ± 0.62^{bB}
	B	4.29 ± 0.12^{aAB}	18.29 ± 1.00^{bA}	2.46 ± 0.13^{bA}	25.67 ± 0.95^{bB}
	C	3.70 ± 0.50^{aAB}	21.17 ± 0.91^{aA}	2.74 ± 0.16^{aA}	28.17 ± 0.25^{aAB}
	D	4.59 ± 0.05^{aA}	20.58 ± 0.39^{aA}	2.50 ± 0.07^{cA}	28.32 ± 0.47^{aA}
5	A	4.10^{aA}	20.92 ± 0.24^{aA}	2.62 ± 0.25^{bA}	28.25 ± 0.59^{aA}
	B	3.91 ± 0.02^{aA}	20.86 ± 0.16^{aA}	2.49 ± 0.14^{bA}	27.90 ± 0.43^{aA}
	C	4.50 ± 0.48^{aA}	20.26 ± 0.04^{aA}	2.58 ± 0.03^{aA}	28.01 ± 0.47^{aA}
	D	4.04 ± 0.19^{abA}	21.57 ± 0.62^{aA}	3.02 ± 0.15^{abA}	28.92 ± 0.6^{aA}
7	A	4.31 ± 0.05^{aA}	20.61 ± 0.31^{aA}	3.42 ± 0.11^{aA}	29.04 ± 0.21^{aA}
	B	4.23 ± 0.55^{aA}	20.84 ± 0.03^{aA}	2.45 ± 0.21^{bB}	28.22 ± 0.42^{aA}
	C	4.52 ± 0.03^{aA}	20.25 ± 0.35^{aA}	2.53 ± 0.24^{aB}	27.92 ± 0.53^{aA}
	D	4.22 ± 0.11^{abA}	20.47 ± 0.21^{aA}	2.71 ± 0.01^{bcB}	27.97 ± 0.34^{aA}
9	A	3.94 ± 0.08^{abA}	21 ± 0.12^{aAB}	2.53 ± 0.03^{bB}	28.16 ± 0.24^{aAB}
	B	3.86 ± 0.11^{aA}	20.13 ± 0.09^{aC}	3.07 ± 0.04^{aA}	27.86 ± 0.21^{aB}
	C	3.77 ± 0.03^{aA}	21.24 ± 0.03^{aA}	3.04 ± 0.04^{aA}	28.68 ± 0.01^{aA}
	D	3.66 ± 0.29^{bA}	20.74 ± 0.05^{aB}	3.07 ± 0.03^{aA}	28.11 ± 0.21^{aAB}

The fatty acids 14:1, 17:1cis and 22:1n9 present in percentage less than 1% were considered for statistical calculation, but not given in the table for brevity. In same column means with different letters are significantly different ($P < 0.05$). Capital letters indicate differences between the groups. Lower case letters indicate differences between the days. A: whole ungutted, B: eviscerated fish, C: beheaded/eviscerated fish, D: fillets.

The n3/n6 ratio was within the ideal limits, except for group A and B at day 3. The n3/n6 ratios in all samples were in the range of 0.80 to 1.39. The n3/n6 ratio of 1:1-1:5 has been suggested for a healty human diet (Osman et al., 2001).

3.3 pH, TBA, TVB-N, TMA-N analyse results

There were increases in TBA, TVB-N and TMA values during storage period (Table 5). Although neutrality of pH of live fish is stated to be terminated by acidification due to anaerobic

Table 3. Changes of poly unsaturated fatty acids (PUFA) of meagre during storage at 4 ± 1 °C (%).

Days	Groups					
		18:2n6cis	18:3n3	20:5n3	22:6n3	Σ PUFA
1	A	14.64 ± 0.08^{bA}	1.98 ± 0.18^{aA}	1.43 ± 0.13^{aA}	11.83 ± 0.70^{bA}	31.29 ± 0.40^{cA}
	B	14.64 ± 0.08^{bA}	1.98 ± 0.18^{aA}	1.43 ± 0.13^{cA}	11.83 ± 0.70^{aA}	31.29 ± 0.40^{abA}
	C	14.64 ± 0.08^{cA}	1.98 ± 0.18^{aA}	1.43 ± 0.13^{aA}	11.83 ± 0.70^{aA}	31.29 ± 0.40^{abA}
	D	14.64 ± 0.08^{abA}	1.98 ± 0.18^{aA}	1.43 ± 0.13^{aA}	11.83 ± 0.70^{aA}	31.29 ± 0.40^{aA}
3	A	13.47 ± 0.95^{bBC}	1.47 ± 0.19^{aA}	1.93 ± 0.16^{aB}	15.73 ± 0.30^{aA}	34.32 ± 0.62^{aA}
	B	12.44 ± 0.22^{dC}	1.47 ± 0.27^{aA}	4.94 ± 0.42^{aA}	11.62 ± 1.39^{aB}	31.73 ± 0.62^{aB}
	C	15.65 ± 0.27^{bAB}	0.67 ± 0.14^{bB}	1.60 ± 0.17^{aB}	11.24 ± 0.49^{aB}	30.45 ± 0.08^{bB}
	D	16.04 ± 0.44^{aA}	0.83 ± 0.05^{bAB}	1.92 ± 0.31^{aB}	11.34 ± 0.77^{aB}	31.53 ± 0.08^{aB}
5	A	14.74 ± 0.19^{bA}	1.85 ± 0.09^{aA}	1.72 ± 0.19^{aA}	12.81 ± 0.48^{bA}	32.50 ± 0.43^{bcA}
	B	15.60 ± 0.24^{aA}	0.72 ± 0.02^{bB}	1.59 ± 0.07^{bcA}	12.65 ± 0.26^{aA}	31.94 ± 0.12^{aAB}
	C	16.08 ± 0.14^{abA}	0.75 ± 0.06^{bB}	1.56 ± 0.41^{aA}	11.01 ± 0.22^{aA}	30.73 ± 0.18^{bB}
	D	15.01 ± 0.69^{abA}	0.72 ± 0.06^{bB}	1.45 ± 0.01^{aA}	12.02 ± 1.13^{aA}	30.60 ± 0.54^{aB}
7	A	16.66 ± 0.19^{aA}	2.04 ± 0.16^{aA}	1.39 ± 0.17^{aA}	11.65 ± 0.14^{bA}	33.12 ± 0.40^{abA}
	B	15.48 ± 0.21^{aB}	0.74 ± 0.12^{bB}	1.53 ± 0.26^{bcA}	11.92 ± 0.01^{aA}	31.03 ± 0.67^{abAB}
	C	16.76 ± 0.15^{aA}	0.74 ± 0.07^{bB}	1.64 ± 0.03^{aA}	11.94 ± 0.01^{aA}	32.42 ± 0.40^{aAB}
	D	14.74 ± 0.18^{abB}	0.57 ± 0.13^{bB}	1.42 ± 0.21^{aA}	12.09 ± 0.65^{aA}	30.06 ± 0.83^{aB}
9	A	14.60 ± 0.07^{bB}	1.89 ± 0.09^{aA}	1.72 ± 0.04^{aB}	11.76 ± 0.09^{bBC}	31.41 ± 0.26^{bcA}
	B	13.60 ± 0.21^{cC}	0.62 ± 0.09^{bB}	2.44 ± 0.07^{bA}	11.67 ± 0.15^{aC}	29.71 ± 0.48^{bB}
	C	15.70 ± 0.41^{bA}	0.73 ± 0.02^{bB}	1.36 ± 0.07^{aC}	12.22 ± 0.17^{aAB}	31.26 ± 0.58^{abAB}
	D	14.35 ± 0.05^{bBC}	0.69 ± 0.02^{bB}	1.61 ± 0.04^{aBC}	12.51 ± 0.03^{aA}	30.50 ± 0.02^{aAB}

The fatty acids 20:2,20:3,20:4 and 22:2 present in percentage less than 1% were considered for statistical calculation, but not given in the table for brevity. In same column means with different letters are significantly different (P < 0.05). Capital letters indicate differences between the groups. Lower case letters indicate differences between the days. A: whole ungutted, B: eviscerated fish, C: beheaded/eviscerated fish, D: fillets.

Table 4. Changes of total n3, n6, n3/n6, n9 and EPA+DHA fatty acids (PUFA) of meagre during storage at 4 ± 1 °C (%).

Days	Groups					
		Σ n3	Σ n6	Σ n3/n6	Σ n9	Σ EPA+DHA
1	A	15.24 ± 0.39^{bA}	15.17 ± 0.09^{bA}	1 ± 0.01^{bA}	20.89 ± 0.04^{aA}	13.25 ± 0.57^{bA}
	B	15.24 ± 0.39^{bA}	15.17 ± 0.09^{bA}	1 ± 0.01^{bcA}	20.89 ± 0.04^{aA}	13.25 ± 0.57^{bA}
	C	15.24 ± 0.39^{aA}	15.17 ± 0.09^{bA}	1 ± 0.01^{aA}	20.89 ± 0.04^{aA}	13.25 ± 0.57^{aA}
	D	15.24 ± 0.39^{aA}	15.17 ± 0.09^{abA}	1 ± 0.01^{aA}	20.89 ± 0.04^{aA}	13.25 ± 0.57^{aA}
3	A	19.14 ± 0.27^{aA}	14.03 ± 0.98^{bBC}	1.37 ± 0.11^{aA}	19.15 ± 0.42^{bA}	17.67 ± 0.46^{aA}
	B	18.04 ± 0.69^{aA}	12.94 ± 0.11^{dC}	1.39 ± 0.06^{aA}	18.33 ± 1.01^{bA}	16.56 ± 0.96^{aA}
	C	13.51 ± 0.18^{bcB}	16.14 ± 0.33^{abAB}	0.84 ± 0.03^{bB}	21.21 ± 0.91^{aA}	12.84 ± 0.33^{aB}
	D	14.09 ± 0.40^{aB}	16.61 ± 0.43^{aA}	0.85 ± 0.04^{aB}	20.62 ± 0.38^{aA}	13.26 ± 0.46^{aB}
5	A	16.39 ± 0.19^{bA}	15.27 ± 0.21^{bA}	1.07 ± 0.01^{bA}	20.96 ± 0.24^{aA}	14.53 ± 0.28^{bA}
	B	14.97 ± 0.32^{bAB}	16.16 ± 0.22^{aA}	0.92 ± 0.03^{bcAB}	20.91 ± 0.18^{aA}	14.24 ± 0.34^{bA}
	C	13.33 ± 0.25^{cB}	16.63 ± 0.09^{aA}	0.80 ± 0.01^{bB}	20.30 ± 0.03^{aA}	12.58 ± 0.19^{aA}
	D	14.20 ± 1.06^{aAB}	15.52 ± 0.68^{abA}	0.92 ± 0.11a^{AB}	21.32 ± 0.62^{aA}	13.48 ± 1.13^{aA}
7	A	15.09 ± 0.48^{bA}	17.22 ± 0.14^{aA}	0.87 ± 0.03^{bAB}	20.66 ± 0.31^{aA}	13.04 ± 0.31^{bA}
	B	14.19 ± 0.40^{bA}	16.06 ± 0.21^{aB}	0.88 ± 0.01^{cAB}	20.90 ± 0.02^{aA}	13.45 ± 0.28^{bA}
	C	14.33 ± 0.11^{abA}	17.28 ± 0.23^{aA}	0.83 ± 0.01^{bB}	20.30 ± 0.34^{aA}	13.59 ± 0.04^{aA}
	D	14.08 ± 0.57^{aA}	15.21 ± 0.19^{abC}	0.93 ± 0.02^{aA}	20.52 ± 0.21^{aA}	13.51 ± 0.45^{aA}
9	A	15.37 ± 0.24^{bA}	15.19 ± 0.04^{bAB}	1.01 ± 0.01^{bA}	21.07 ± 0.09^{aB}	13.48 ± 0.14^{bB}
	B	14.73 ± 0.32^{bAB}	14.23 ± 0.12^{cB}	1.03 ± 0.01^{bA}	20.16 ± 0.06^{abD}	14.11 ± 0.23^{bA}
	C	14.32 ± 0.07^{abB}	16.16 ± 0.47^{abA}	0.88 ± 0.02^{bB}	21.31^{aA}	13.59 ± 0.09^{aAB}
	D	14.82 ± 0.11^{aAB}	14.89 ± 0.12^{bB}	0.99 ± 0.01^{aA}	20.81 ± 0.03^{aC}	14.13 ± 0.08^{aA}

The fatty acids 22:1n9 present in percentage less than 1% were considered for statistical calculation, but not given in the table for brevity. In same column means with different letters are significantly different (P < 0.05). Capital letters indicate differences between the groups. Lower case letters indicate differences between the days. A: whole ungutted, B: eviscerated fish, C: beheaded/eviscerated fish, D: fillets.

Table 5. Changes of some quality parameters of meagre during storage at 4 ± 1 °C.

Days	Groups	pH	TBA(mgMDA/kg)	TVB-N(mg/100g)	TMA-N (mg/100g)
1	A	6.52 ± 0.16^{Aab}	0.16 ± 0.04^{Ab}	15.46 ± 0.53^{Ac}	0.58 ± 0.06^{Ab}
	B	6.52 ± 0.16^{Aa}	0.16 ± 0.04^{Ab}	15.46 ± 0.53^{Ab}	0.58 ± 0.06^{Ac}
	C	6.52 ± 0.16^{Aa}	0.16 ± 0.04^{Ac}	15.46 ± 0.53^{Ac}	0.58 ± 0.06^{Ac}
	D	6.52 ± 0.16^{Aa}	0.16 ± 0.04^{Ac}	15.46 ± 0.53^{Ad}	0.58 ± 0.06^{Ac}
3	A	6.66 ± 0.01^{Aa}	0.14 ± 0.05^{Bb}	15.79 ± 0.52^{Abc}	0.73 ± 0.19^{Bb}
	B	6.37 ± 0.02^{Ba}	0.11 ± 0.02^{Bb}	15.54 ± 0.39^{Ab}	0.78 ± 0.05^{Bc}
	C	6.37 ± 0.02^{Bab}	0.11 ± 0.06^{Bc}	14.87 ± 1.33^{Ac}	0.96 ± 0.05^{Bc}
	D	6.37 ± 0.03^{Bab}	0.67 ± 0.03^{Ab}	14.99 ± 0.76^{Ad}	1.52 ± 0.16^{Ac}
5	A	6.42 ± 0.01^{Abc}	0.14 ± 0.07^{Bb}	17.47 ± 1.14^{Bbc}	0.94 ± 0.30^{Cb}
	B	6.43 ± 0.05^{Aa}	0.38 ± 0.24^{Bb}	19.16 ± 0.87^{ABa}	1.93 ± 0.14^{Bb}
	C	6.28 ± 0.04^{Bb}	0.43 ± 0.06^{ABb}	18.57 ± 0.38^{ABb}	1.67 ± 0.30^{Bb}
	D	6.26 ± 0.03^{Bb}	0.80 ± 0.16^{Ab}	19.99 ± 0.29^{Ac}	2.86 ± 0.12^{Ab}
7	A	6.29 ± 0.02^{Cc}	0.34 ± 0.13^{Bb}	18.65 ± 1.97^{Bab}	2.72 ± 0.3^{Ba}
	B	6.50 ± 0.01^{Aa}	0.41 ± 0.04^{Bb}	19.07 ± 0.77^{ABa}	2.34 ± 0.08^{Ba}
	C	6.45 ± 0.02^{ABab}	0.40 ± 0.05^{Bb}	18.82 ± 1.24^{Bb}	2.86 ± 0.23^{Ba}
	D	6.44 ± 0.02^{Bab}	1.08 ± 0.35^{Ab}	22.60 ± 1.27^{Ab}	5.64 ± 0.40^{Aa}
9	A	6.36 ± 0.03^{Bbc}	0.96 ± 0.19^{Ba}	21.42 ± 0.76^{Ba}	2.84 ± 0.24^{Ba}
	B	6.38 ± 0.02^{ABa}	0.73 ± 0.05^{Ba}	22.09 ± 2.19^{ABa}	2.46 ± 0.28^{Ba}
	C	6.40 ± 0.02^{ABab}	0.63 ± 0.09^{Ba}	22.09 ± 0.58^{ABa}	3.05 ± 0.17^{Ba}
	D	6.49 ± 0.07^{Aa}	2.32 ± 0.17^{Aa}	25.12 ± 0.53^{Aa}	6.31 ± 0.93^{Aa}

In same column means with different letters are significantly different ($P < 0.05$). Capital letters indicate differences between the groups. Lower case letters indicate differences between the days. A: whole ungutted, B: eviscerated fish, C: beheaded/eviscerated fish, D: fillets. TBA: Thiobarbituric acid, MDA: Malondialdehyde, TVB-N: Total volatile basic nitrogen, TMA: Trimethylamine

fermentation of glycogen (Huss,1995) and post mortem pH can vary from 6.0 to 7.1 acccording to season and species, pH values were nearly neutral in all groups. Thiobarbituric acid (TBA) value is the most widely used indicator for measurement of lipid degredation degree (Nishimoto et al., 1985). As stated by Connel (1995), 1-2 mg MDA/kg fish muscle are related with the development of questionable flavours and odours. Since TBA is secondary lipid oxidation product, it leads to undesirable taste and odor. TBA values were in the range of 0.11 ± 0.02 (3rd day of storage, Group B) to 2.32 ± 0.17mg MDA/100g (9th day of storage, Group D). The highest increase was observed in fillets (group D). Gutting process may affect rancidity levels in meagre because of exposure of the lipid to atmospheric oxygen. In this study, an increase in TBA values was observed in all groups during storage time. Similar results were reported for *Dicentrarchus labrax* (Papadopoulos et al., 2003), for *Scomber japonicus* (Goulas & Kontominas,2005), for *A.regius* (Hernández et al., 2009). Varlık et al. (1993) stated that TBA should be less than 3mg MDA/Kg in very good material, shouldn't be more than 5 mg MDA/Kg in a good material. So, TBA values did not exceed the limit values.

Total Volatile Basic Nitrogen (TVB-N) values were in the range of 15.46 ± 0.53 and 25.12 ± 0.53mg/100g (Table 5). Generally, changes of TVB-N values of all groups were found significant ($P < 0.05$) depending on the time. TVB-N is one of the parameters used for determining of seafood quality. The acceptable limit value was <30-35mg TVBN/100g muscle for cold water fish stored in ice (Connel, 1995). TVB-N values did not exceed the limit values. Similar results were found in another study for the same species (Hernández et al., 2009).

TMA value ranged from 0.58 ± 0.06mg/100g (All groups in 1st day) to 6.31 ± 0.93 mg/100g (group D in 9th day) (Table 5). Significant differences were observed in all groups among the storage days. TMA-N is produced by shredding of the TMAO compounds as a result of enzymatic activity of the bacteria in seafish (Dalgaard, 1995). Varlık et al. (1993) stated that TMA-N values between 1 mg N/100g and 8 mg N/100g TMA in seafood can be appropriate for consumption. The quality of meagre was within the limits of overall consumption criteria. Similar results have been demonstrared for sea bass (Papadopoulos et al., 2003) and sardine (Erkan & Özden, 2008). In this study, TMA-N values of filleted samples (group D) were always higher than those of ungutted samples (Group A) during the storage time. Similarly, low TMA-N values have been reported for ungutted fresh fish (Papadopoulos et al., 2003).

3.4 Microbiological analyse results

Counts in all bacterial groups were increased during the storage. Initial MAB count were found as 0.93 ± 0.04 log cfu/g and then increased during storage period. This increase is statistically significant ($P < 0.05$). There were significant differences between storage days and the groups. MAB counts reached at 6.54 ± 0.04, 6.84 ± 0.06 ve 6.86 ± 0.01 log cfu/g at the end of storage period for groups A, B and C, respectively (Table 6). According to food safety standards 7 log cfu/g of MAB is considered the upper limit for fresh fish (International Commission on Microbiological Specifications for Foods, 1986). In present study MAB counts exceeded on 7th days of storage at group D (fillets) (8.03 ± 0.01 log cfu g^{-1}), but the other gutted

meagre samples didn't reached the limit values on 9th days of storage. The effect of gutting on some quality characteristics of sea bass stored in ice was researched by Papadopoulos et al. (2003) and they found a longer shelf life in ungutted samples.

In the present study, significant differences ($P < 0.05$) for LAB were found among the groups. A rapid increase in fillets was observed after 3 days of storage and reached 4.49 ± 0.02 log cfu/g on day 9 (Table 7). Stamatis and Arkoudelos (2007), reported that initial populations of LAB were 1.8 log cfu/g, while a count of more than 7 log cfu/g did not exceed in all different packing conditions for filleted *S. pilchardus* at 3°C. H_2S bacteria which is important by spoilage process was reported as 1.89 ± 0.20 log cfu/g for fresh meagre samples and showed increases after storing. According to gutting process, it increased to 5.54 (A), 6.51 (B), 5.49 (C) and 7.51 log cfu/g (D) on 9 days of storage (Table 8). The differences between gutting treatments were statistically significant ($P < 0.05$). Initial PAB counts were 1.19 ± 0.10 log cfu/g and during storage period it increased significantly ($P < 0.05$) (Table 9). PAB counts of D groups reached to 7.23 ± 0.07 log cfu/g and exceeded the legal limits of aerobic plate counts (7 log cfu/g) (International Commission on Microbiological Specifications for Foods, 1986). Papadopoulos et al. (2003) reported that shelf life of whole ungutted sea bass stored in ice were found longer than gutted sea bass. Taliadourrou et al. (2003). reported that total viable counts for whole ungutted sea bass were always lower than those for filleted sea bass samples and shelf-life of samples was determined as 8-9 days for filleted and 12-13 days for whole ungutted fish. These findings are in agreement with our results.

Table 6. Changes of mesophilic aerobic bacteria of meagre during storage at 4 ± 1 °C. (log cfu g^{-1}).

Days	A	B	C	D
0	0.93 ± 0.04^{d}	0.93 ± 0.04^{d}	0.93 ± 0.04^{e}	0.93 ± 0.04^{e}
3	3.54 ± 0.06^{cC}	3.76 ± 0.02^{cBC}	4.08 ± 0.08^{dA}	3.96 ± 0.08^{dAB}
5	5.79 ± 0.07^{bB}	5.76 ± 0.12^{bB}	5.53 ± 0.05^{cB}	6.52 ± 0.06^{cA}
7	6.60 ± 0.15^{aB}	6.60 ± 0.05^{aB}	6.49 ± 0.02^{bB}	8.03 ± 0.01^{bA}
9	6.54 ± 0.04^{aC}	6.84 ± 0.06^{aB}	6.86 ± 0.001^{aB}	8.55 ± 0.001^{aA}

In same column means with different lower case letters are significantly different ($P < 0.05$). In same line means with different upper case letters are significantly different ($P < 0.05$). A: whole ungutted, B: eviscerated fish, C: beheaded/eviscerated fish, D: fillets.

Table 7. Changes of H_2S bacteria of meagre during storage at 4 ± 1 °C. (log cfu g^{-1}).

Days	A	B	C	D
0	1.89 ± 0.20^{c}	1.89 ± 0.20^{c}	1.89 ± 0.20^{d}	1.89 ± 0.20^{c}
3	1.56 ± 0.09^{cB}	1.16 ± 0.06^{dC}	1.45 ± 0.05^{cB}	5.21 ± 0.01^{bA}
5	4.76 ± 0.05^{bB}	5.51 ± 0.05^{bA}	4.84 ± 0.03^{bB}	4.90 ± 0.02^{bB}
7	5.69 ± 0.01^{aB}	5.49 ± 0.02^{bC}	5.54 ± 0.01^{aC}	7.64 ± 0.05^{aA}
9	5.54 ± 0.02^{aC}	6.51 ± 0.05^{aB}	5.49 ± 0.02^{aC}	7.51 ± 0.05^{aA}

In same column means with different lower case letters are significantly different ($P < 0.05$). In same line means with different upper case letters are significantly different ($P < 0.05$). A: whole ungutted, B: eviscerated fish , C: beheaded/eviscerated fish, D: fillets.

Table 8. Changes of lactic acid bacteria of meagre during storage at 4 ± 1 °C. (log cfu g^{-1}).

Days	A	B	C	D
0	0.60 ± 0.16^{c}	0.60 ± 0.16^{c}	0.60 ± 0.16^{b}	0.60 ± 0.16^{d}
3	1.38 ± 0.03^{bB}	1.38 ± 0.03^{bB}	1.38 ± 0.03^{aB}	2.18 ± 0.07^{cA}
5	1.61 ± 0.16^{bA}	1.49 ± 0.02^{bA}	1.54 ± 0.05^{aA}	1.49 ± 0.02^{bA}
7	3.54 ± 0.01^{aB}	1.49 ± 0.02^{bC}	1.61 ± 0.10^{aC}	4.54 ± 0.03^{aA}
9	1.79 ± 0.11^{bC}	3.66 ± 0.03^{aB}	1.31 ± 0.01^{aD}	4.49 ± 0.02^{aA}

In same column means with different lower case letters are significantly different ($P < 0.05$). In same line means with different upper case letters are significantly different ($P < 0.05$). A: whole ungutted, B: eviscerated fish, C: beheaded/eviscerated fish, D: fillets.

Table 9. Changes of psychrophilic aerobic bacteria of meagre during storage at 4 ± 1 °C. (log cfu g^{-1}).

Days	A	B	C	D
0	1.19 ± 0.10^{d}	1.19 ± 0.10^{d}	1.19 ± 0.10^{d}	1.19 ± 0.10^{e}
3	3.70 ± 0.06^{cC}	3.89 ± 0.08^{cC}	4.13 ± 0.02^{cB}	6.06 ± 0.01^{dA}
5	6.04 ± 0.06^{bB}	5.87 ± 0.001^{bC}	5.81 ± 0.02^{bC}	6.59 ± 0.02^{cA}
7	6.80 ± 0.001^{aB}	6.59 ± 0.01^{aD}	6.65 ± 0.02^{aC}	8.23 ± 0.02^{aA}
9	6.82 ± 0.02^{aB}	6.62 ± 0.01^{aC}	6.66 ± 0.01^{aC}	7.23 ± 0.07^{bA}

In same column means with different lower case letters are significantly different ($P < 0.05$). In same line means with different upper case letters are significantly different ($P < 0.05$). A: whole ungutted, B: eviscerated fish, C: beheaded/eviscerated fish, D: fillets.

4 Conclusion

According to fatty acid analyse results, it was determined that meagre is rich in unsaturated fatty acid contents and has ideal n3/n6 ratio. As a result of all analyses in the current study, A marked change was observed in all groups throughout the storage. In this study, the cutting of head did not have any effect on quality of fish. Chemical quality parameters did not exceed the acceptable limits thgroughout the storage period. At the end of the study, no significant differences were found between treatments except for fillets groups. Results of this study showed that ungutted, beheaded, eviscerated samples were not exceeded limit values on 9th day but fillet group exceeded on 7th. Thus, it can be said that storing meagre as whole or gutted (headed and eviscerated) is more advantageous compared to fillets under refrigerator conditions.

Acknowledgements

This work has been carried out with the financial support of Suleyman Demirel University within the Research Project (2628-M-10).

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