Eur Food Res Technol (2001) 212:408–412 © Springer-Verlag 2001

ORIGINAL PAPER

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Washing effect on the quality index method (QIM) developed for raw gilthead seabream (*Sparus aurata*)

Received: 14 April 2000 / Revised version: 5 June 2000

Abstract The effect produced on the evolution of the quality index by washing gilthead seabream (*Sparus aurata*) with tap water during storage and whether it affects other fish quality parameters such as the K value, the microbial load and sensory evaluation of cooked fillets is examined. The results indicate that washing reduced the demerit points assigned when the raw gilthead seabream was evaluated with the QIM. The maximum allowable score for this species was not reached in the washed fish even when the storage period set on the basis of both sensory and microbiological considerations was exceeded. Washing caused no significant differences with respect to unwashed fish in the evolution of the K value or in the sensory evaluation of the cooked fillets. On the other hand, washing delayed the limit of microbiological acceptability.

Keywords Sensory evaluation · QIM · Gilthead seabream · Washing

Introduction

Fresh fish is a highly perishable product, and therefore it is essential for commercialization to be able to estimate accurately its freshness. Many research laboratories working on fish quality in the European Union are engaged in projects, one of whose aims is to develop indices that are simple to apply and easy to use in industrial processes and commercialization and which will assess the freshness of fish or fish products during storage. Over the last few decades, sensory evaluation has come to be viewed as a highly useful tool for determining the consumer acceptability of fish, and researchers have therefore been working to improve sensory methods of measuring fish quality. The quality index method (QIM) has been introduced and widely studied as an alternative to other commonly used traditional sensory methods [1–4]. This method permits quick and easy evaluation of fish and fish products. Developed specifically for each species, the method evaluates characteristic defects in the spoilage pattern of each species, to which a demerit point system is allocated, the sum of demerit points being the score. When the fish is inspected, the sensory score or quality index is the sum of the demerit points awarded to each parameter considered. Parameters are selected so that evolution of the index correlates linearly with time in iced storage up to the end of the product's shelf life, thus providing a means of predicting the shelf life.

Gilthead seabream (*Sparus aurata*) is now one of the most widely farmed species in the Mediterranean countries with a total production in Europe of 47,800 tonnes in 1999 [5]. In Spain production has increased considerably, from 127 tonnes in 1985 to 8500 tonnes in 1999 [6, 7].

Some points of sale specializing in fish occasionally wash the fish with tap water before it is placed on display counters. This practice could affect some of the parameters included in the QIM developed for gilthead seabream, and therefore preliminary assays were carried out to study the effect of washing with tap water [8, 9]. At the outset no differences were found in the quality indexes of washed and unwashed batches, but the index for the washed batch scored lower as storage progressed. This preliminary study did not investigate whether the changes observed in the quality index reflected changes in the microbial flora, in the sensory parameters of the cooked fillets, or in other biochemical indexes considered to be indicative of quality or spoilage.

The aim of this study was to determine whether the differences observed in evolution of the quality index for gilthead seabream when it is washed are accompanied with sensory differences in the cooked fillets, or to

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early changes in fish muscle such as degradation of ATP and derivatives and/or in the microbial load.

Materials and methods

Fish source

A total of 40 kg of immature gilthead seabream (*Sparus aurata*), fasted for 48 h, were obtained from a Spanish fish farm (CUPIMAR, San Fernando, Cádiz, Spain) in June 1999, and killed by immersion in an ice slurry. Immediately after death the fish were packed in expanded polystyrene boxes with perforated bottoms, covered by a perforated plastic film with ice flakes on top, sealed and freighted to the laboratory in refrigerated trucks. At the laboratory the fish were kept in boxes with ice in cold stores at 2 ± 10 °C. In the control (unwashed) lot, ice was added to the boxes as required. In the washed lot, the fish was daily washed with tap water, then stored again in the same conditions as the unwashed lot. The mean and standard deviations of the weight and length of the fish studied were 261.73 g (±27.55) and 21.13 cm (±1.03).

Analyses performed

Proximate analyses: moisture, crude protein and ash [10] and crude fat [11] were measured in quadruplicate. pH was determined at room temperature on homogenates of dorsal muscle in distilled water (1/10 w/w) [12].

For sensory evaluation the quality index method previously developed for raw gilthead seabream was used [8, 9]. The method considers parameters relating to surface appearance, elasticity of the muscle, odor, eyes and gills, as this species is largely sold as chilled whole fish. A quality test of the cooked fillets was conducted in parallel with the sensory evaluation of raw fish. The fish were filleted and skinned by hand and packed in heating-resistant bags (WIPAK/GRYSPEERT model PAE 110 K FP; permeability to oxygen 30 ml/m^2/24 h measured at 23 °C/75% RH, distributed by ILPRA Systems España, S.L., Mataró, Spain). The fillets were cooked for 10 min at 100 °C using a saturated steam oven (Rational Combi-Master CM6, Groβbküchentechnik GmbH, Landsberg a. Lech, Germany). The panel members were asked to evaluate juiciness, toughness, adhesiveness, flavor, odor, and color. Structured scales (0 to 10; 0: minimum – 10: maximum) were used in all cases.

Adenosine 5′-triphosphate (ATP) and its breakdown products were periodically extracted with 0.6 M perchloric acid according to Ryder [13] from the dorsal muscle of three individuals and stored at –80 °C until analyzed. Immediately before analysis the extracts were thawed and passed through 0.22 μm Nylon filters (Micro Filtration Systems; MSF, Inc., Pleasanton, CA, USA). Aliquots of 20 μL were injected on a LKB HPLC (LKB, Bromma, Sweden) system equipped with a Model 2152 controller, a Model 2150 pump, and a Model 2151 variable-wavelength detector set at 254 nm. Determinations of ATP, adenosine 5′-diphosphate (ADP), adenosine 5′-monophosphate (AMP), inosine (Ino) and hypoxantine (Hx) were performed on a Waters Bondapak C-18 radial compression column (Millipore Corporation, Milford, MA, USA) using 0.04 M KH_2PO_4/0.06 M K_2HPO_4 buffer pumped at 1 mL × min^{-1}. Run time was 20 min. External calibration was used with standards obtained from Sigma (Sigma Chemical Company, St. Louis, MO, USA). The means of six measurements were calculated. Amounts of ATP and breakdown products were expressed as μmol/g wet weight flesh. K value was calculated as a percentage of the ratio between Ino + Hx to all ATP-related products [14].

For microbiological analysis 10 g of muscle with skin from different parts of at least 5 individuals from each lot were taken aseptically in a vertical laminar-flow cabinet (Telstar mod. AV 30/70, Madrid, Spain) and placed in a sterile plastic bag (Sterilin, Stone, Staffordshire, UK) with 90 ml of buffered peptone water (Oxoid, Basingstoke, UK). After 1 min in a Stomacher blender (model Colwoth 400, Seward, London, UK), dilutions were made in the same diluent to determine the total viable count on plate count agar (PCA, Oxoid, Basingstoke, UK) after 72 h of incubation at 30 °C. Microbiological counts were expressed as log cfu/g of sample. Microbiological analyses were performed in duplicate.

Statistical treatment

The significance of the variables studied was assessed by an F-test. A time-dependent linear regression analysis was performed for the results obtained for QIM and K value (Statgraphics Program: Graphic Software System Inc., Rockville, MD, USA).

Results and discussion

The mean and standard deviations in proximate composition were: crude protein 22.31 ± 1.72%; crude fat 5.28 ± 0.87%; moisture 71.83 ± 0.96%; ash 1.27 ± 0.07. Although some differences in pH values between unwashed and washed lots were found, no clear trend was observed in the evolution of the pH (Fig. 1). In both cases the pH measured up to 16th days of ice storage was in the range found previously for this species and season [15].

Fig. 2 shows the sensory evaluation of the washed and unwashed lots of raw gilthead seabream using the specific QIM developed for this species. No significant differences were found in the quality index up to 11 days of chilled storage. From then until the end of the experimental storage period the control lot scored significantly higher than the washed lot. The evolution of the quality index up to 16 days storage was linear in both lots ($y = 0.8294x$, $R^2 = 0.9904$ in the unwashed lot; $y = 0.7228x$, $R^2 = 0.9713$ in the washed lot). The washed

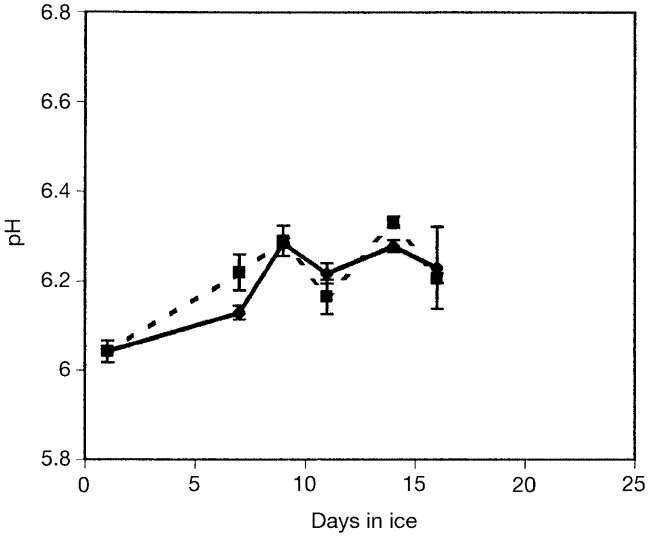

Fig. 1 pH of dorsal muscle homogenates in distilled water for raw chilled gilthead seabream unwashed (–) and daily washed with tap water (- -)

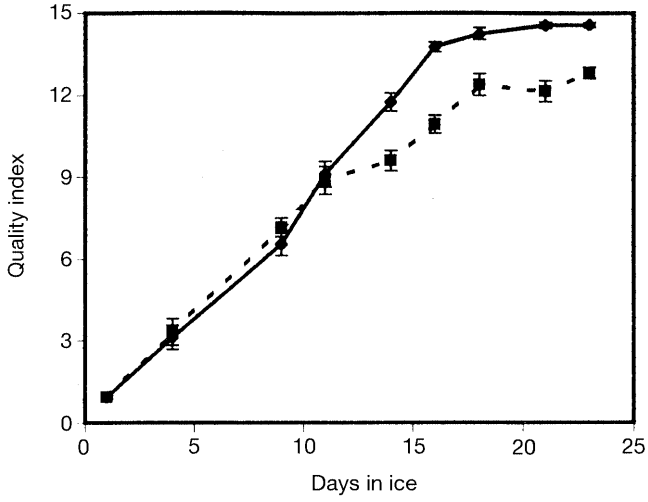

Fig. 2 Quality index applied to raw chilled gilthead seabream unwashed (–) and daily washed with tap water (- -)

lot failed to reach the maximum demerit score even when storage was prolonged to 23 days.

The individual scores of the QIM parameters during storage in ice are shown in Fig. 3. The only parameters for which the differences between the unwashed and the washed lot were significant were slime and fishy odor (Table 1). In a preliminary study on the effect of washing on evolution of the QIM [8, 9], moreover, the washed lot scored lower than the unwashed in odor of gills, which could account for the differences in scores for the two lots. These differences between the washed and the unwashed lots were smaller and occurred later in the present study than in the preliminary one.

No significant time-dependent differences were found between the two lots in the sensory evaluation of the cooked fillets (Fig. 4) for any of the parameters considered. This indicates that washing of gilthead seabream with tap water did not alter the sensory charac-

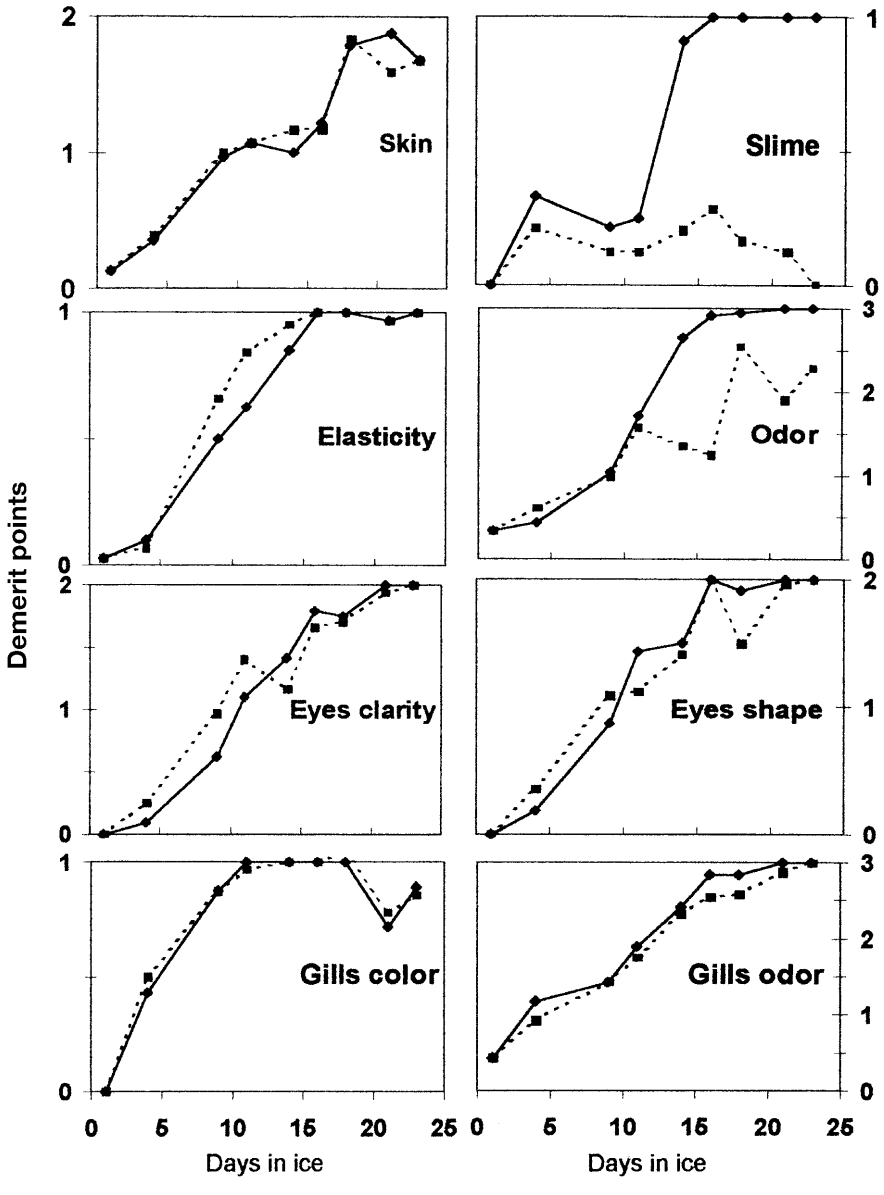

Fig. 3 Evolution of the different parameters included in the quality index applied to raw chilled gilthead seabream unwashed (–) and daily washed with tap water (- -)

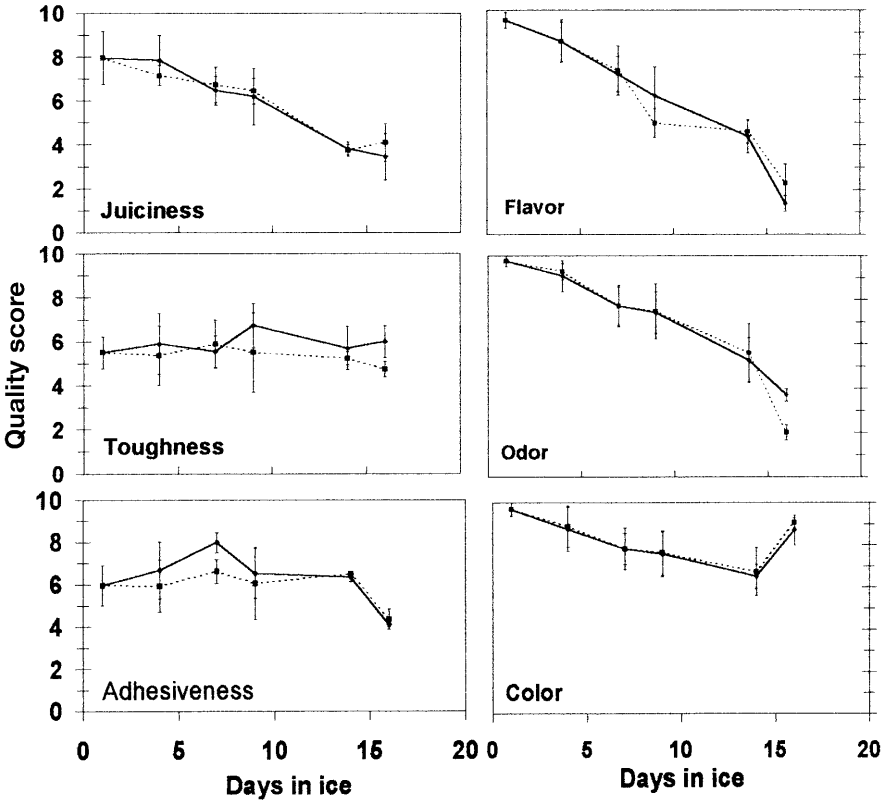

Fig. 4 Sensory quality scores for different parameters of cooked fillets of chilled gilthead seabream unwashed (–) and daily washed with tap water (- -)

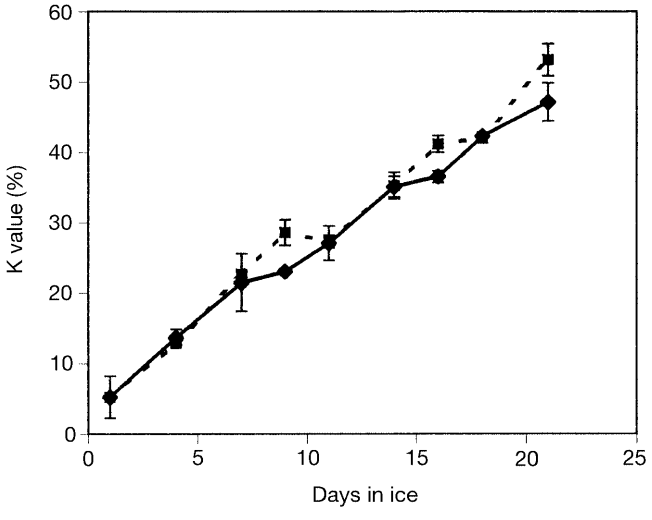

Fig. 5 K value (%) of chilled gilthead seabream unwashed (–) and daily washed with tap water (- -)

teristics of the cooked fillets. In both lots the changes occurring during storage were noticeable in flavor, odor, and juiciness. Flavor and odor were the determining parameters for rejection by the tasting panel after 15 days in chilled storage.

The evolution of the K value (Fig. 5) was highly linear throughout storage in both lots ($y=2.0496x+4.9535$, $R^2=0.9913$ in the unwashed lot; $y=2.2426x+4.6403$, $R^2=0.9787$ in the washed lot). No

Table 1 *F*-test for the different parameters included in the quality index method between the unwashed and washed lots of gilthead seabream during chilled storage[a]

Days in ice	1	4	9	11	14	16	18	21	23
Skin	–	–	–	–	–	–	–	–	–
Slime	–	–	–	–	***	***	***	***	***
Elasticity	–	–	–	–	–	–	–	–	–
Odor	–	–	–	–	***	***	–	***	***
Eyes clarity	–	–	–	–	–	–	–	–	–
Eyes shape	–	–	–	–	–	–	–	–	–
Gills color	–	–	–	–	–	–	–	–	–
Gills odor	–	–	–	–	–	–	–	–	–

[a] *** significant at $p<0.05$; – not significant

significant differences between the unwashed and washed lots were found, although the regression slope was slightly steeper for the washed lot than for the unwashed lot [confidence intervals: (1.8782, 2.2211) and (1.9472, 2.5380) for unwashed and washed lots respectively]. No significant differences between the K values of the unwashed lot and the K values previously obtained for this species were found [16, 17].

The initial total microorganism counts (Fig. 6) were 4 log cfu/g of muscle, which is within the known range for this species and farming area [15 and unpublished data]. Microbial growth in the unwashed lot at around 15 days of storage was >7 log cfu/g, which is considered the limit for microbiological acceptability [18]. The counts were significantly lower in the washed lot than

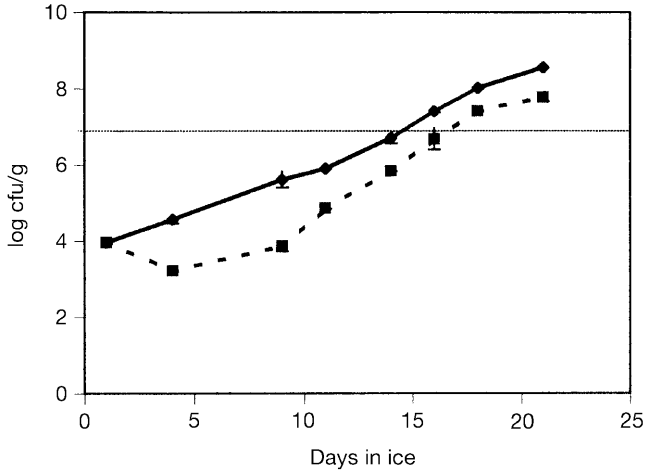

Fig. 6 Microbiological charge (log CFU/g) of chilled gilthead seabream unwashed (–) and daily washed with tap water (- -). Microbiological limit was set at 7 log cfu/g

in the unwashed lot, reaching >7 log cfu/g at around 17 days of storage. These differences could have been due to removal by washing of the slime and hence of the microorganisms in the slime [19].

Washing reduced the demerit points assigned to raw gilthead seabream applying the QIM to the extent that in the washed lots, the maximum score allotted to this species was not reached even after the storage period set for sensory and microbiological assay had been far exceeded. Washing of gilthead seabream with tap water produced no significant differences with respect to unwashed sample in the evolution of K value, which is considered to be one of the best biochemical indicators for determining loss of fish freshness. Again, washing did not alter the sensory evaluation of the cooked fillets; the unwashed and washed lots reached the rejection point on the basis of low scores for flavor, odor and juiciness around 15 days of storage in ice. Washing did, however, delay the limit of microbiological acceptability to day 17.

Application of the QIM developed specifically for gilthead seabream to fish that has been washed or subjected to prolonged post-mortem treatments in fresh water can therefore be misleading where this index is used for predictive purposes, as it may indicate a longer shelf life than other sensory, chemical, or microbiological indicators.

Acknowledgements This study was supported by the EU FAIR CT 97–3127 (FAQUWEL) and the Spanish ALI99–1262-CE projects.

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