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Comparison of effects of slurry ice and flake ice pretreatments on the quality of aquacultured sea bream (*Sparus aurata*) and sea bass (*Dicentrarchus labrax*) stored at 4 °C

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Abstract

Slurry ice, a biphasic system consisting of small particles of spherical ice immersed in seawater at subzero temperature, was evaluated as a new chilled method for whole sea bream (*Sparus aurata*) and sea bass (*Dicentrarchus labrax*). Two types of different chilling methods were used for two species in this study; slurry ice-treated sea bream (Group A), slurry ice-treated sea bass (Group B), flake-ice treated sea bream (Group C) and flake ice-treated sea bass (Group D). The effects of this system on the quality and shelf life of these two species were evaluated. Mesophilic counts for sea bass exceeded 7 log cfu/g, which is considered the maximum level for acceptability for freshwater and marine fish after 13 days for Groups C, D and 15 days for Groups A, B. At day 13, TVB-N values of Groups C, D reached the legal limits (35 mg/100 g set for TVB-N) for consumption. According to the results of sensory analyses, up to day 13, all the Groups were determined as 'acceptable' but, on day 15, the Groups A, B, C, D were no longer acceptable. Using slurry ice pretreatment for 2 h before the storage period presumably caused the deleterious effect on appearance as well as salt and water uptake. According to the results of chemical and microbiological analyses, use of slurry ice pretreatment for 2 h extended the shelf life of sea bream and sea bass stored at 4 °C for only two days longer than did use of flake ice.

Keywords: Sea bass; Sea bream; Chilled storage; Slurry ice; Quality control; Shelf-life

1. Introduction

Stowage in chilled sea water offers the following advantages over stowage in ice; the catch is cooled more rapidly, less effort is required to stow and unload it, and there is less likelihood of fish being crushed or losing weight. In addition, sea water can be safely lowered to a temperature of about −1 °C without freezing the fish contained in it (Kelman, 1977).

Chilled sea water, slurry ice, also known as fluid ice, slush ice, liquid ice or flow ice, offers a promising technique for preservation and consists of an ice–water suspension at a subzero temperature (Huidobro, Mendes, & Nunes, 2001). Two main features of slurry ice are its faster chilling rate, deriving from its higher heat-exchange capacity, and the reduced physical damage caused to seafood products by its microscopic spherical particles, as compared with flake ice (Rodriguez et al., 2003). The overall covering of the fish surface by the slurry ice mixture also protects the fish from the action of oxygen. The versatility of the slurry ice technique should also be noted; slurry ice can be pumped, thereby improving hygienic handling, and may be combined with other agents, such as ozone, to achieve an antiseptic surface effect, or melanosis inhibitors, to prevent browning reactions in shellfish (Huidobro, Lopez-Caballero, & Mendes, 2002). However, as well as its theoretical advantages, the practical advantages derived from use of slurry ice for the storage of marine species are clear. This method causes the fish to absorb water without reducing quality (Gregersen, 2001). Disadvantages of the

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method which preclude its general adoption are as follows; some species, herring for example, keep as well or a little better than in ice for 3–4 days, but thereafter spoil more quickly, and some species take up unacceptable amounts of water and salt when kept in sea water. Other species, capelin for example, are reported to keep better in ice, even during the first few days. For these reasons the method is usually confined to short term storage of particular species that are caught in large quantities within a short time, for example herring, mackerel, sprats and blue whiting (Kelman, 1977).

Sea bream and sea bass both have white flesh, mild tastes and low fat contents (Body, Green, & LePors, 1992). These attributes have made these species popular and highly-valued around the world. In Turkey, increasing production of these species, as aquaculture products, has raised the importance of keeping them in good quality. Therefore, in the present work the effects of flake and slurry ice pretreatment on the quality of aquacultured sea bream and sea bass stored at 4 °C were evaluated.

2. Materials and methods

2.1. Materials

Aquacultured fresh sea bream (*Sparus* aurata) and sea bass (*Dicentrarchus labrax*) average weight and length (300–350 g and 200–250 mm), cultivated in net cages, were used as materials.

2.2. Slurry ice and flake ice system used

A slurry ice prototype (FLO-ICE, Kinarca SAU, Vigo, Spain) was used in the present work. The composition of the slurry ice binary mixture was 40% ice and 60% water, prepared from filtered seawater (salinity: 3.3%). The temperature of the slurry ice mixture was −1.5 °C. Flake ice was prepared with an Icematic F100 Compact device (CASTELMAC SPA, Castelfranco, Italy). The fish were placed in either slurry or flake ice (at a fish:ice ratio of 1:1) for 2 h before being stored at 4 °C in air.

2.3. Fish material, processing and sampling

After the fish were taken from the net cages, they were put into tanks for 2 h on board in which two different chilling methods for two species were used: slurry ice for packaged sea bream (Group A), slurry ice for packaged sea bass (Group B), flake ice for packaged sea bream (Group C) and flake ice for packaged sea bass (Group D). After the pretreatments were applied for 2 h, the fish samples were put into boxes without ice and stored at 4 °C. For each chilling treatment, three different batches were used and studied separately over the whole experimental period. Samples were taken from each batch on days 1, 5, 8, 13, 15. All analyses were performed in triplicate.

2.4. Chemical analyses

Total volatile base nitrogen (TVB-N) was determined according to the method of Vyncke (1996). The pH value was recorded using a pH meter (HANNA model Microprocessor), the glass electrode being applied directly to the fish flesh. The TMA-N method was that proposed by AOAC (1995). Thiobarbituric acid reactive material (TBA, mg malonaldehyde/kg) was determined by using the method of Tarladgis, Watts, Younathan, and Dugan (1960).

2.5. Microbiological analyses

Samples of 10 g of fish muscle were dissected aseptically from chilled sea bream and sea bass specimens, mixed with 90 ml of 0.1% peptone water (Difco, 0118-17-0), and homogenised in a stomacher (IUL Instruments, Spain) for 1 min. In all cases, serial dilutions from the microbial extracts were prepared in 0.1% peptone water. Total viable mesophilic and psychrophilic bacterial counts were determined by the pour plate method, as described by Harrigan and McCance (1976) using plate count agar (Difco, 0479-17). The inoculated plates were incubated at 30 °C for 24–48 h and 5 °C for 72 h for total viable mesophilic counts and psychrophilic counts, respectively.

2.6. Colour measurement

2.6.1. Instrument

The colour measurement on fish samples trials was carried out with the spectral colour meter, Spectropen® (Dr. Lange, Dusseldorf, Germany). This is a colorimeter operating the spectral method described in DIN 5033, using the 45/0° circular viewing geometry, i.e. the sample is illuminated with polychromatic light encircling it at an angle of 45°, with the optical unit observing the reflected light from a horizontal angle (0°) towards the sample surface. Spektro-pen® is a genuine grating colorimeter, measuring the visible spectral range (400–700 nm) at intervals of 10 nm. A 10° standard observer and D65 illuminant were used (light source: polychromatic with tungsten lamp). The PC-software "spectral-QC" allows state-of-the-art data processing. Before measuring each lot, the colorimeter was calibrated against a white standard (LZM 224).

2.6.2. Measurement

Sea bream and sea bass were homogenised by using a homogenizer (IKA-WERKE, DI 25 basic, Germany). The colour was measured on homogenates prepared from fish. The homogenate was placed in plastic Petri dishes and the colour measurement was repeated 10 times. In the CIELab system L^* denotes lightness on a 0–100 scale from black to white; a^*, (+) red or (−) green; and b^*, (+) yellow or (−) blue (Schubring, 2002).

2.7. Sensory analyses

The sensory assessment of fish was conducted using the Tasmanian Food Research Unit (TFRU) method, (Alasarvar et al., 2001) (Tasmanian Food Research Unit, Hobart). The panel normally consisted of at least five of six regular contributors, each of whom was trained in fish quality assessment. Each contributor was given up to four simple descriptors, scoring demerit points from 0 to a maximum of 3, where 0 represented best quality and any higher score indicated poorer quality (see Table 1 below). The scores for the separate characteristics were summed to give an overall sensory score. This system gave score of zero (or near zero) for very fresh fish while increasingly larger totals resulted as fish deteriorated. Minor variations in scoring individual attributes, therefore, had little influence on the overall score. Also, the original TFRU scheme was modified and scores were developed to reject the changes in cultured sea bream and sea bass according to the panelists' perceptions during the storage period.

2.8. Statistical analysis

Results are presented as means ± SD (n: 3 or 4). Differences between means were analysed by one-way analysis of variance (ANOVA), followed by Tukey's and Duncan's tests, using SPSS 9. 05.

Table 1
Modified Tasmanian Food Research Unit (TFRU) sensory assessment scheme for cultured sea bream and sea bass (Alasalvar et al., 2001)

Parameters being assessed	Demerit points[a]			
	0	1	2	3
Appearance	Very bright	Bright	Slightly dull	Dull
Skin	Firm or elastic	Soft		
Slime	Absent	Slightly slimy	Slimy	Very slimy
Stiffness	Pre-rigor	Rigor	Post-rigor	
Eyes				
Clarity	Clear	Slightly cloudy	Cloudy	
Shape	Normal	Flat sunken	Sunken or swollen	
Iris	Visible	Slightly visible	Not visible	
Blood	No blood	Slightly bloody	Bloody	Very bloody
Gills				
Colour[b]	Dark red	Red	Brown	Dark brown or grey
Mucus	Absent	Slight	Moderate	Excessive or sticky
Smell	Neutral	Fishy	Stale	Spoilt
Belly				
Discoloration	White iridescent	Some yellowish	Yellow	Excessive yellow
Firmness	Firm	Soft	Sunken	Burst
Vent				
Condition	Normal	Slight break and darkening	Excessive	
Smell	Fresh	Neutral	Fishy	Spoilt

3. Results and discussion

3.1. Chemical analysis

Increases in pH indicate the accumulation of alkaline compounds, such as ammonia compounds and TMA, mainly derived from microbial action (Hebard, Flick, & Martin, 1982). The pH of live fish muscle is close to the value 7.0. However post-mortem pH can vary from 6.0 to 7.1, depending on season, species and other factors (Simeonidou, Govaris, & Vareltzis, 1998). In our work regarding pH no statistically significant differences ($p < 0.05$) were determined between Groups A, B, C and Group D at the end of the storage period. pH values of Groups A, B, C, D were 6.53, 6.53, 6.53, 6.58 at the beginning and 6.80, 6.80, 6,80, 6.82 at the end of the storage period (15 days), respectively (Table 2).

The concentration of TVB-N in freshly caught fish is typically between 5 and 20 mg N 100 g^{-1}, whereas levels of 30–35 N 100 g^{-1} flesh are generally regarded as the limit of acceptability for ice-stored cold water fish (Connell, 1995; Huss, 1988). The TVB-N values of Groups A, B, C, D were 17.9, 17.4, 19.2, 18.4 mg N 100 g^{-1} at the beginning and 29.1, 29.3, 36.0, 38.6 mg N 100 g^{-1} at the end of the storage period (13 days), respectively. According to the results of TVB-N, statistically significant differences ($p < 0.05$) existed between Groups A, B and Groups C, D on day 13; no statistically significant difference was determined ($p > 0.05$) between Group A and Group B (Table 2). According to time of storage, there were significant differences in TVB-N and pH values of four groups ($p < 0.05$). At day 13, TVB-N values of Group C and Group D reached the legal limits (35 mg/100 g) set for TVB-N for consumption (Directive 95/149/EEC). Papadopoulos, Chouliara, Badeka, Savvaidis, and Kontominas (2003) determined the effect of gutting on microbiological, chemical, and sensory properties of aqua-cultured sea bass (*Dicentrarchus labrax*) stored in ice. Results of this study were very similar to our findings because of the increasing of TVB-N and pH value according to time of storage. In another report, pH value of European hake stored in slurry ice and flake ice increased from 6.67, 6.67 to 6.8 and 7.4 (day 15), respectively (Rodriguez, Losada, Auborg, & Barros-Velazquez, 2004). Similar small increases have also been reported for turbot (Pineiro, Vazquez, Perez-Diz, Gallardo, & Auborg, 2003; Rodriguez et al., 2003) and horse mackerel (Losada et al., 2003).

Lipid oxidation is a major quality problem. It leads to the development of off-odours and off-flavours in edible oils and fat-containing foods, called oxidative rancidity (Ashie, Smith, & Simpson, 1996). The TBA values of Groups A, B, C, D were 0.51, 0.49, 0.65, 1.73 mg malonaldehyde/kg at the beginning and 2.19, 1.94, 3.00, 3.20 mg malonaldehyde/kg at the end of the storage period (15

Table 2
TVB-N and pH changes of sea bream and sea bass during storage period

Days	Analyses	Group A	Group B	Group C	Group D
t_1	TVB-N	17.9 ± 0.51^{a}	17.4 ± 0.5^{a}	19.2 ± 0.51^{b}	18.4 ± 0.55^{b}
	pH	6.53 ± 0.02^{a}	6.53 ± 0.02^{a}	6.53 ± 0.005^{a}	6.58 ± 0.01^{a}
t_5	TVB-N	20.6 ± 0.62^{a}	19.6 ± 0.62^{a}	22.2 ± 0.21^{b}	22.6 ± 0.62^{b}
	pH	6.55 ± 0.01^{a}	6.55 ± 0.01^{a}	6.59 ± 0.05^{a}	6.59 ± 0.02^{a}
t_8	TVB-N	23.1 ± 0.23a	23.0 ± 0.00^{a}	28.2 ± 0.22^{b}	30.6 ± 0.62^{b}
	pH	6.60 ± 0.03^{a}	6.58 ± 0.05^{a}	6.60 ± 0.05^{a}	6.62 ± 0.04^{a}
t_{13}	TVB-N	$29.14 \pm 0.62^{a,b}$	29.3 ± 0.62^{a}	36.0 ± 0.00^{b}	38.6 ± 0.5^{b}
	pH	6.65 ± 0.05^{a}	6.60 ± 0.05^{a}	6.71 ± 0.03^{a}	6.72 ± 0.03^{a}
t_{15}	TVB-N	35.1 ± 0.5^{a}	36.0 ± 0.00^{a}	–	–
	pH	6.80 ± 0.006^{a}	6.80 ± 0.02^{a}	6.80 ± 0.02^{a}	6.82 ± 0.02^{a}

days), respectively. The concentration of TBA in good quality frozen and chilled fish or fish stored on ice is typically between 5 and 8 mg malonaldehyde/kg whereas levels of 8 mg malonaldehyde/kg flesh are generally regarded as the limit of acceptability for most species (Schormüller, 1968). The data obtained in the present study suggest that TBA values of all group were within the very good quality limits (Table 3).

The TMA-N comes from the reduction of trimethylamine oxide (TMAO) by bacterial activity. It is used to confirm that the fish is spoiled and unfit for human consumption. In fresh fish, the TMA value is about 1 mg/100 g; in spoiled samples it is above 8 mg/100 g (FAO, 1986). The TMA-N values of Groups A, B, C, D were 0.62, 0.72, 0.98, 1.33 mg/100 g at the beginning and 2.50, 2.55, 4.30, 4.33 mg/100 g at the end of the storage period (15 days), respectively.

3.2. Microbiological analyses

One way ANOVA was initially carried out considering total viable and psycrophilic bacteria counts as dependent variables, and time as the factor. Post hoc analyses were selected and the Tukey test was implemented. The total viable mesophilic and psychrophilic bacterial counts increased throughout the storage period. Statistically significant ($p < 0.05$) differences were observed between the groups for mesophilic and psycrophilic bacterial counts according to time of storage. Initial mesophilic and psychrophilic viable counts of Groups A, B, C, D were 2.03, 2.14, 3.40, 3.43 log cfu/g for mesophilic and 2.27, 2.33, 2.95, 3.09 log cfu/g for psychrophilic viable counts, respectively (day 1). For the groups of A, B, C, D, mesophilic counts reached 7.12, 7.04, 8.00, 8.29 log cfu/g and psychrophilic counts reached 7.28, 7.33, 8.39, 8.46 log cfu/g, respectively, after 15 days (Table 4). Mesophilic counts for sea bream and sea bass exceeded 7 log cfu/g, which is considered the maximum level for acceptability of freshwater and marine fish (ICMSF, 1978) after 13 days for Groups C, D and 15 days for Groups A, B.

The initial and final microbiological results of fresh sea bass stored in ice were found to be similar to those reported in the literature for fish stored aerobically and under modified atmosphere (Dalgaard, 1995; Drosinos & Nychas, 1996; Gram & Huss, 1996; Koutsoumanis & Nychas, 2000). Studies so far have concentrated on chemical and sensory changes rather than microbiological associated changes with Mediterranean fish species stored in ice and slurry ice (Alasalvar et al., 2001; Cakli, Kilinc, Cadun, Dinçer, & Tolasa, 2006a; Cakli, Kilinc, Cadun, & Tolasa, 2006c; Cakli, Kilinc, Dincer, & Tolasa, 2006b; Campos, Rodriguez, Losada, Aubourg, & Barros-Velazquez, 2004;

Table 3
TMA-N and TBA changes of sea bream and sea bass during storage period

Days	Analyses	Group A	Group B	Group C	Group D
t_1	TMAN mg/100 g	0.62 ± 0.11^{a}	0.72 ± 0.09^{a}	$0.98 \pm 0.02^{a,b}$	1.33 ± 0.55^{b}
	TBA mg malonaldehyde/kg	0.51 ± 0.00^{a}	0.49 ± 0.04^{a}	0.65 ± 0.04^{b}	1.73 ± 0.06^{b}
t_5	TMA-N mg/100 g	0.93 ± 0.14^{a}	0.90 ± 0.45^{a}	1.98 ± 0.15^{b}	2.02 ± 0.00^{b}
	TBA mg malonaldehyde/kg	1.22 ± 0.40^{a}	1.50 ± 0.01^{a}	2.01 ± 0.66^{b}	2.24 ± 0.44^{b}
t_8	TMA-N mg/100 g	1.00 ± 0.08a	0.92 ± 0.10^{a}	2.99 ± 0.02^{b}	2.91 ± 0.43^{b}
	TBA mg malonaldehyde/kg	1.52 ± 0.03^{a}	1.77 ± 0.12^{a}	2.16 ± 0.05^{b}	2.58 ± 0.18^{b}
t_{13}	TMA-N mg/100 g	1.43 ± 0.05^{a}	1.52 ± 0.19^{a}	3.57 ± 0.03^{b}	3.60 ± 0.21^{b}
	TBA mg malonaldehyde/kg	1.95 ± 0.27^{a}	1.84 ± 0.20^{a}	2.25 ± 0.22^{b}	3.29 ± 0.13^{b}
t_{15}	TMA-N mg/100 g	2.50 ± 0.5^{a}	2.55 ± 0.00^{a}	4.30 ± 0.00^{b}	4.33 ± 0.21^{b}
	TBA mg malonaldehyde/kg	2.19 ± 0.00^{a}	1.94 ± 0.26^{a}	3.00 ± 0.02^{b}	3.20 ± 0.02^{b}

Table 4
Microbiological quality changes of sea bream and sea bass during storage period

Days	Analysis	Group A	Group B	Group C	Group D
t_1	log TVC/g	2.03 ± 0.00^{a}	2.14 ± 0.06^{a}	3.40 ± 0.07^{b}	3.43 ± 0.09^{b}
	log PBC/g	2.27 ± 0.05^{a}	2.30 ± 0.00^{a}	2.95 ± 0.15^{b}	3.09 ± 0.30^{b}
t_5	log TVC/g	3.86 ± 0.08^{a}	3.92 ± 0.08^{a}	$4.21 \pm 0.18^{a,b}$	4.34 ± 0.26^{b}
	log PBC/g	4.00 ± 0.18^{a}	4.06 ± 0.10^{a}	4.38 ± 0.01^{b}	4.36 ± 0.22^{b}
t_8	log TVC/g	4.83 ± 0.09^{a}	4.87 ± 0.02^{a}	5.29 ± 0.01^{b}	5.39 ± 0.09^{b}
	log PBC/g	5.00 ± 0.06^{a}	5.05 ± 0.05^{a}	5.89 ± 0.04^{b}	5.98 ± 0.02^{b}
t_{13}	log TVC/g	6.24 ± 0.24^{a}	6.31 ± 0.18^{a}	7.68 ± 0.04^{b}	7.70 ± 0.04^{b}
	log PBC/g	6.35 ± 0.06^{a}	6.48 ± 0.03^{a}	7.98 ± 0.08^{b}	7.92 ± 0.05^{b}
t_{15}	log TVC/g	7.51 ± 0.19^{a}	7.64 ± 0.12^{a}	8.32 ± 0.10^{b}	8.39 ± 0.11^{b}
	log PBC/g	7.82 ± 0.17^{a}	7.93 ± 0.04^{a}	8.59 ± 0.19^{b}	8.66 ± 0.03^{b}

Table 5
Colour changes of sea bream and sea bass during storage period

Days	Colour measurement	Group A	Group B	Group C	Group D
t_1	L	53.85 ± 2.1^{a}	52.45 ± 2.4^{a}	50.28 ± 2.0^{b}	50.88 ± 2.6^{b}
	a^*	-1.5 ± 0.1^{a}	-1.6 ± 0.1^{a}	-1.7 ± 0.1^{a}	-1.6 ± 0.1^{a}
	b^*	8.00 ± 0.3^{a}	8.60 ± 0.8^{a}	9.1 ± 0.9^{a}	9.00 ± 0.5^{a}
t_5	L	54.00 ± 1.8^{a}	55.08 ± 0.6^{a}	56.00 ± 2.2^{b}	56.86 ± 1.08^{b}
	a^*	-1.5 ± 0.1^{a}	-1.5 ± 0.1^{a}	-1.6 ± 0.1^{a}	-1.6 ± 0.1^{a}
	b^*	9 ± 0.3^{a}	9 ± 0.3^{a}	9.3 ± 0.4^{a}	8.6 ± 0.2^{a}
t_8	L	57.63 ± 2.9^{a}	58.12 ± 2.5^{a}	56.29 ± 1.8^{b}	56.30 ± 1.4^{b}
	a^*	-1.6 ± 0.1^{a}	-1.3 ± 0.3^{b}	-1.6 ± 0.09^{a}	-1.7 ± 0.09^{a}
	b^*	9.20 ± 0.9^{a}	9.1 ± 1^{a}	9.3 ± 0.4^{a}	9.3 ± 0.5^{a}
t_{13}	L	64.09 ± 3.9^{a}	65.81 ± 3.2^{a}	60.04 ± 2.3^{b}	61.24 ± 1.0^{b}
	a^*	-1.6 ± 0.6^{a}	-1.6 ± 0.2^{a}	$-1.7 \pm 0.1a$	-1.8 ± 0.2^{a}
	b^*	9.50 ± 1.6^{a}	9.40 ± 1.6^{a}	$10 \pm 0.8^{a,b}$	11.7 ± 0.9^{b}
t_{15}	L	66.51 ± 2.0^{a}	68.54 ± 3.4^{a}	61.1 ± 2.6^{b}	62.31 ± 1.4^{b}
	a^*	-1.6 ± 0.3^{a}	-1.7 ± 0.1^{a}	-1.8 ± 0.2^{a}	-1.9 ± 0.3^{a}
	b^*	9.8 ± 0.9^{a}	9.9 ± 0.9^{a}	11.3 ± 1^{b}	12.0 ± 0.7^{b}

Kyrana, Lougovois, & Valsamis, 1997; Simeonidou et al., 1998; Rodriguez et al., 2003).

3.3. Colour measurement

Colour measurements of seabream and sea bass are shown in Table 5 and 6. At the beginning of the storage period, L^* values of Groups A, B, C, D were 53.85, 52.45, 50.28 and 50.88, respectively. L^* values of Groups A, B, C, D increased to 66.51, 68.54, 61.1, 62.31 at the end of the storage period (day 15). Similar results were reported with increasing L^* values during a storage period in ice (Cakli et al., 2006a, 2006b, 2006c). A values of Groups A, B, C, D changed from −1.5, −1.6, −1.7, −1.6 to −1.6, −1.7, −1.8, −1.9; b values of Groups A, B, C, D increased from 8, 8.6, 9.1, 9 to 9.8, 9.9, 11.3, 12.0 at the end of the storage period (15th day).

3.4. Sensory analyses

For the determination of the sensory quality of sea bream and sea bass, the modified Tasmanian Food Research Unit (TFRU) method was used. Fish samples were served to the panellists to evaluate the sensory attributes (appearance, colour, firmness, smell) of the samples by using the TFRU test of Alasalvar et al. (2001). According to the TFRU test, a total score of sensory attributes of '0' indicated fresh quality, '1' indicated neutral, '2' indicated fishy, '3' indicated spoilt. According to the results of sensory analyses, on day 13; all the Groups were of 'fishy' quality at the '2' point but, on day 15, Groups A, B, C, D were spoilt at the '3' point.

4. Conclusions

Two different group chilling methods for two species were used in this study: slurry ice-treated sea bream (Group A), slurry ice-treated sea bass (Group B); flake ice-treated sea bream (Group C) and flake ice-treated sea bass (Group D). The effects of flake and slurry ice pretreatment on the quality of aquacultured sea bream and sea bass stored at 4 °C were evaluated. Mesophilic counts for sea bream and sea bass exceeded 7 log cfu/g (which is considered the maximum level for acceptability

for freshwater and marine fish) after 13 days for Groups C, D and 15 days for Groups A, B. At day 13, TVB-N values of Groups C, D reached the legal limits (35 mg/100 g) set for TVB-N for human consumption. According to the results of sensory analyses, up to day 13, all the Groups were 'acceptable' but, on day 15, the Groups A, B, C, D were no longer acceptable. The main negative aspect, related to quality loss, in the slurry ice group, corresponded to the appearance of eyes and gills. Using slurry ice pretreatment for 2 h before the storage period presumably caused the deleterious effect on appearance as well as salt and water uptake. According to the results of chemical and microbiological analyses, slurry ice pretreatment for 2 h extended the shelf life of sea bream and sea bass stored at 4 °C for only two days longer than did flake ice.

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