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Effect of delayed icing on quality changes of iced rainbow trout (*Onchorynchus mykiss*)

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Abstract

The effect of delayed icing on quality deterioration of rainbow trout (*Onchorynchus mykiss*) iced 0, 4 and 8 h after catch was assessed by chemical, microbiological and sensory methods. Total volatile basic nitrogen (TVB-N), free fatty acids (FFA), peroxide value (PV) and thiobarbituric acid (TBA) values increased during the pre-icing duration. Delayed icing led to significant increased ($p < 0.05$) in total viable counts (TVC) throughout the period of storage. This study showed that sensory analysis of rainbow trout correlated well with microbiological analysis. Results of this study according microbiological and sensory data indicated that the shelf-life of rainbow trout stored in ice immediately after catch was approximately 9–11 days, while delay in icing for 4 and 8 h shortened the shelf-life was around 5–7 and 1–3 days, respectively.

Keywords: Rainbow trout; Delayed icing; Quality; Shelf life

1. Introduction

Fish freshness is the most important and fundamental single criterion for judging the quality of fish and fishery products (Rodríguez-Jérez, Hernández-Herrero, & Roig-Sagués, 2004). The loss of freshness, and therefore of quality, depends on many factors, including the fish species, handling conditions and storage temperature. Fatty fish species, such as rainbow trout (*Onchorynchus mykiss*) (Venugopal & Shahidi, 1996) are particularly sensitive to an oxidative changes during storage, and quality deterioration of this species is primarily caused by microorganisms and lipid oxidation (Gram, Wedell-Neergaard, & Huss, 1990). Time passed after catch and the temperature "history" of fish is considered to be the key factor determining the final quality characteristics of a fish product (Ólafsdóttire et al., 2004). Rainbow trout is mainly stored and transferred in ice (Rezaei et al., 2007), but in some cases because of lack of ice, fish may spend several hours at ambient temperature, before icing. High ambient temperatures and long pre-icing periods may accelerate the deterioration of fish quality. In a previous study, the shelf-life of headed and gutted rainbow trout (*Salmo gairdneri*) was evaluated by Dawood, Roy, and Williams (1986) over a 14-day storage period in ice. The results indicated that when fish had been held at high ambient temperatures of 30 °C for 6 h before icing, there was a rapid deterioration in quality as shown by a linear increase in hypoxanthine values. However, there is limited information on the quality changes as a result of delays in icing that occur in rainbow trout. The objectives of this study were to investigate the effect of delayed icing on the quality deterioration of rainbow trout stored in ice, by using chemical, microbiological and sensory assessment.

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2. Materials and methods

2.1. Sample preparation and storage conditions

Fifty-four freshwater rainbow trout (11 months old with average weight and length 300 g and 280 mm, respectively) were purchased from a local aquaculture farm located at Noshahr, in North of Iran. The fish were fed fish meal-based diet purchased from Chineh Company (Tehran, Iran). Fish samples were harvested in April 2006, and divided into three lots (18 fishes in each lot). One lot was immediately iced after catch, and the remaining two lots after holding at ambient temperature (18–20 °C) for 4 and 8 h were iced in boxes (3 ± 1 °C) with outlet for water drainage. The fish to ice ratio was approximately 1:3 and the melted ice was replaced daily, as required, to maintain the ratio. At each sampling time (0, 4, 8, 12, 16 and 20 days), three randomly chosen fish were removed from ice and their raw sensory attributes determined. Then, we performed sampling microbial test. The fishes were skinned aseptically and minced/mixed and homogenized for the chemical analyses. Data were obtained using three different fish which were homogenized for each sampling. Sampling in triplicate was continued over a 20-day storage period.

2.2. Chemical analysis

The TVB-N content of rainbow trout was determined according to the method of Goudlas and Kontaminas (2005) and expressed as mg TVB-N/100 g rainbow trout flesh. FFA analysis, expressed as % of oleic acid was done by the Egan, Kirk, and Sawyer (1997). PV, expressed as meq of peroxide oxygen/kg fat, was determined according to the Egan et al. (1997) method. The thiobarbituric acid (TBA) (mg malondialdehyde/kg fish flesh) was determined according to the Kirk and Sawyer (1991) method.

2.3. Microbiological analysis

Samples of rainbow trout fish stored under the three different storage conditions were taken to estimate TVC. Ten grammes of fish muscle were dissected aseptically from the dorsal, ventral and tail area, followed by blending with 90 ml of Ringer solution and then stomached for 3 min. Further decimal dilutions were made up to 10^{-4} and then 0.1 ml of each dilution was pipetted onto the surface of plate count agar (PCA, Merck) plates, in triplicate. They were then incubated for 48 h at 30 °C.

2.4. Sensory analysis

For sensory analysis, triplicate samples, from each of the three different lots, were taken at regular intervals. Sensory analysis was assessed according to the guidelines presented in Table 1 (Lin & Morrissey, 1994). Four categories were ranked; 0 = excellent; 1 = good; 2 = acceptable; >2 = reject. Sensory assessment included the evaluation of the following parameters: texture, general appearance, gill odor, gill appearance and eyes. Each assessment was carried out by a minimum of four trained persons.

2.5. Statistical analysis

Data for the different parameters were analysed using one-way ANOVA method ($p < 0.05$). Comparison of means was performed using a least-significant difference (LSD) test.

3. Results and discussion

3.1. Chemical assessment

The changes in TVB-N, FFA, PV, and TBA for rainbow trout stored on ice after 0, 4 and 8 h delay before icing are shown in Figs. 1–4.

TVB-N is produced from degradation of proteins and non-protein nitrogenous compounds, mainly as a result of microbial activity (Connell, 1975). In this study, TVB-N concentration was significantly increased ($p < 0.05$) by holding fish samples at ambient temperature for 8 h on days 0 and 16 (Fig. 1). The rate of accumulation of TVB-N during storage of fish on ice was also higher in samples

Table 1
Descriptive sensory evaluation definitions and descriptors

Texture	General appearance	Gill odor	Gill appearance	Eyes	Score
Flesh is firm and resilient and springs back immediately when released	Good overall appearance, skin lustrous and shiny, no fading	Characteristic of species, fresh	Bright red, little mucus	Clear, bright convex eyes	0
Reasonably firm some loss of resiliency, thumb indentation slowly fills out	Good overall appearance, very slight bleaching of skin	Neutral. Total absence of odor characteristic odor no longer detectable but off-odors have not developed	Red, some mucus	Slightly sunken or some what dull	1
Moderately firm, thumb indentations may remain in flesh	Some loss of metallic luster, some bleaching	Slight to moderate sour odor	Pinkish red to brownish, some mucus	Dull and/or cloudy	2
Excessively soft flesh	Bloom gone from skin, color faded and bleached	Very sour, strong, or putrid	Brown, may be covered with mucus	Very dull, sunken and cloudy	3

Source: Lin and Morrissey (1994).

iced after 4 or 8 h, compared to those iced immediately. Since, TVB-N is produced mainly by bacterial decomposition of fish flesh, the higher level of TVC of samples iced after 4 or 8 h throughout the period of storage in ice could account for the higher TVB-N values of rainbow trout. Similar results were reported for other fish such as sardines (Ababouch et al., 1996) and Nile perch (Karungi, Byaruhanga, & Muyonga, 2004). However, the level of 30–35 mg TVB-N/100 g flesh is considered the limit of acceptability for ice-stored cold water fish (Connell, 1995; Huss, 1988). In the present study, the TVB-N level showed fluctuations during storage, indicating that TVB-N could not be a good indicator of rainbow trout quality, as also proposed by Dawood et al. (1986), Chytiri, Chouliara, Savvaidis, and Kontominas (2004) for rainbow trout and Özogul et al. (2006) for wild turbot.

Lipid hydrolysis occurred along the storage of rainbow trout in three different lots in ice. In the present study, the release of FFA in samples stored at ambient temperature for 4 or 8 h showed significant increase ($p < 0.05$) on days 12 and 16 (Fig. 2). It seems therefore that lipid hydrolysis is more rapid at the high ambient temperature than during storage on ice (Karungi et al., 2004). Since, the release of FFA content increased with time, as found in this study, it is reported that there is a relation ship between FFA release and loss of freshness (Barassi, Pècora, Roldán, & Trucco, 1987; Özogul, Ozyurt, Özogul, kuley, & Polat, 2005).

Primary lipid oxidation was evaluated by means of the PV. In this study, PV values were not significantly affected ($p > 0.05$) by holding fish samples at ambient temperature for up to 8 h (Fig. 3). However, the PV values were

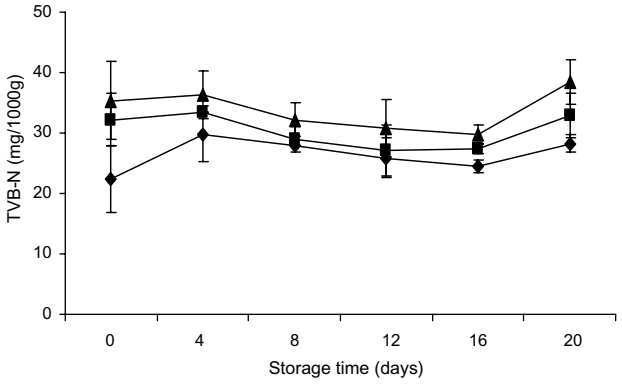

Fig. 1. Changes in TVB-N in rainbow trout samples stored on ice after 0 (♦), 4 (■), 8 (▲), h delay before icing. Each point shown is the mean value ± SD of three determinations.

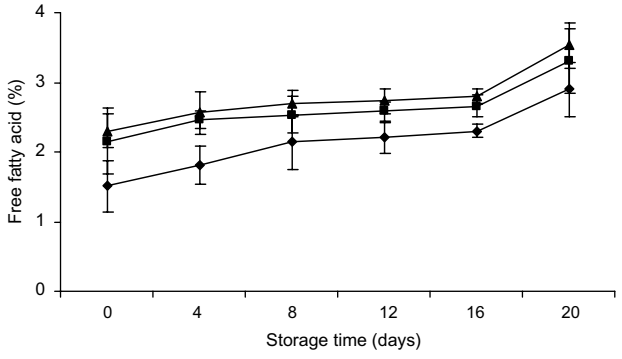

Fig. 2. Changes in free fatty acid value (FFA) in rainbow trout samples stored on ice after 0 (♦), 4 (■), 8 (▲), h delay before icing. Each point shown is the mean value ± SD of three determinations.

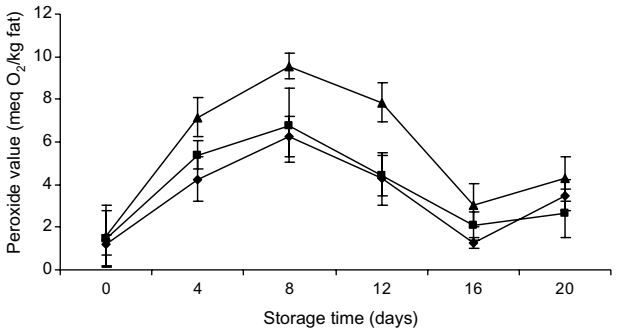

Fig. 3. Changes in peroxide value (PV) in rainbow trout samples stored on ice after 0 (♦), 4 (■), 8 (▲), h delay before icing. Each point shown is the mean value ± SD of three determinations.

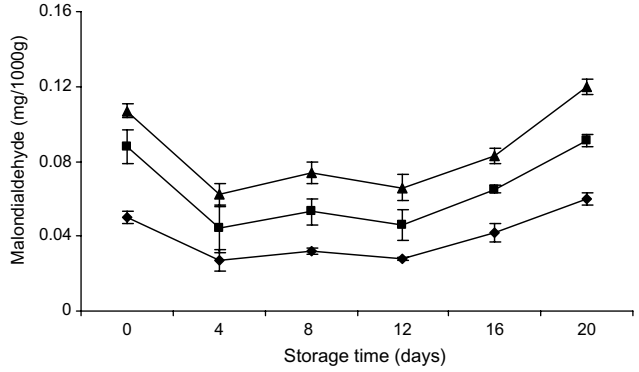

Fig. 4. Changes in thiobarbituric acid (TBA) in rainbow trout samples stored on ice after 0 (♦), 4 (■), 8 (▲), h delay before icing. Each point shown is the mean value ± SD of three determinations.

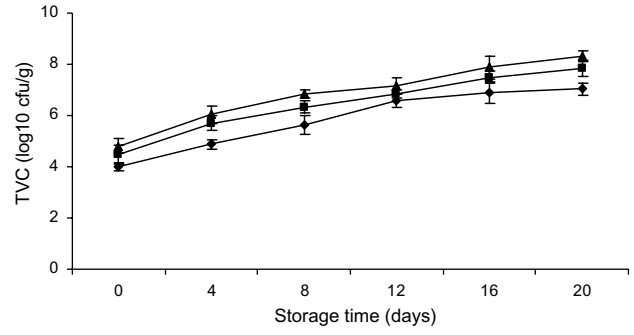

Fig. 5. Changes in total viable count (TVC) in rainbow trout samples stored on ice after 0 (♦), 4 (■),8 (▲), h delay before icing. Each point shown is the mean value ± SD of three determinations.

Table 2
Comparative sensory acceptability of rainbow trout batches

	0 h delay before icing (days of storage)						4 h delay before icing (days of storage)						8 h delay before icing (days of storage)					
	0	4	8	12	16	20	0	4	8	12	16	20	0	4	8	12	16	20
Texture	0	0	1	1.67	2.67	3	0	1	1.67	2.33	2.67	3	0.66	1.33	2.33	2.67	3	3
General appearance	0	0	0.67	1.33	2.33	3	0	0.67	1.33	2	2.67	3	0.33	1	2	2.33	3	3
Gill appearance	0	0.33	1.33	2	2.67	3	0.33	1	2	2.67	3	3	0.67	1.67	2.67	3	3	3
Gill odor	0	0.67	1.67	2.33	3	3	0.66	1.33	2.33	3	3	3	1	2.33	2.67	3	3	3
Eye color	0	0.33	1.33	2	2.67	3	0.33	1	1.67	2.33	3	3	0.67	1.33	2.33	3	3	3

Each value represents the mean of four samples.
Scoring was: 0 = Excellent; 1 = Good; 2 = Acceptable; >2 = Reject.

comparatively low in samples stored in ice immediately after catch than those kept at ambient temperature for 4 or 8 h before icing.

TBA is a widely used indicator for the assessment of degree of secondary lipid oxidation (Nishimoto, Suwetja, & Miki, 1985). TBA values were found to be quite low for the three different lots, however, the values of TBA for rainbow trout samples iced after 4 or 8 h were significantly higher ($p < 0.05$) than samples iced immediately throughout the storage period (Fig. 4). Auburg (1993) reported that TBA values may not give actual rates of lipid oxidation since malondialdehyde can interact with other components of fish such as nucleosides, nucleic acid, proteins, amino acids of phospholipids and other aldehydes which are end-products of lipid oxidation.

3.2. Microbiological assessment

Delay of 4 or 8 h before icing led to significant increase ($p < 0.05$) in total viable counts (TVC) over the period of storage, this indicating a more quickly growth of this microbial group at ambient temperature (Fig. 5). Similar results reported for Nile perch (Karungi et al., 2004) and for sardines (Ababouch et al., 1996). Initial total viable counts of rainbow trout iced 0, 4 and 8 h after catch were 4.0, 4.48 and 4.81 log cfu g^{-1}, respectively (day 0). Total viable counts for rainbow trout iced immediately exceeded 6.58 log cfu g^{-1} (day 12) and for samples iced after 4 and 8 h exceeded 6.34 log cfu g^{-1} (day 8) and 6.03 log cfu g^{-1} (day 4), respectively. If 10^6 microorganisms/g are considered the TVC limit of acceptability (Özogul et al., 2005), the shelf-life of rainbow trout stored in ice immediately after catch was approximately 9–11 days, while delay in icing for 4 and 8 h shortened the shelf-life was around 5–7 and 1–3 days, respectively.

3.3. Sensory assessment

Table 2 shows the results of the sensory analysis of the rainbow trout stored on ice after delay icing for various time intervals. According to the results of the sensory analysis, the rainbow trout samples iced immediately, maintained excellent to good quality up to day 4 of storage. After this time, quality decreased, and by day 12 the samples was no longer acceptable. The main aspect related to quality loss was the gill odor. In contrast with these results, the excellent to good sensory quality of samples kept at ambient temperature for 4 h and the good sensory quality for samples iced after 8 h, were maintained only up to day 0, such rainbow trout samples being rejected on days 8 and 4, respectively. In the case of samples iced after 4 h, only gill odor was the limiting factor of acceptability, but for samples iced after 8 h, texture, eyes, gill odor and appearance were the limiting factors of acceptability. Sensory evaluation indicated that the fish iced immediately after catch deteriorated at a slower rate than the fish iced after 4 and 8 h holding at ambient temperature. This results indicated that sensory analysis of rainbow trout correlated well with microbiological analysis.

4. Conclusion

The storage of rainbow trout in ice immediately after catch allowed a remarkably good maintenance of chemical, microbiological and sensory quality; involving an extension of its shelf-life as compared with samples iced 4 and 8 h after catch. Based on microbiological and sensorial data, the shelf-life of rainbow trout stored in ice immediately after catch was approximately 9–11 days, while delay in icing for 4 and 8 h shortened the shelf-life was around 5–7 and 1–3 days, respectively. It is therefore recommended that fish be iced immediately after capture in order to slow down the mechanisms involved in quality loss.

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