Short Paper

The Effects of Repeated Freeze-thaw Cycles on Torrymeter Readings of Carp Fillets

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Several morphological and biochemical methods to differentiate frozen-thawed fish from the unfrozen have been reported on so far.¹⁻⁴⁾ An electrical method using the Torrymeter, an instrument which measures the freshness of fish, has also been reported for the differentiation between frozen-thawed and unfrozen fish.^{5,6)} Torrymeter readings (TMR) fall markedly when fillets of fresh yellowtail have been once frozen and subsequently thawed.⁶⁾ We will report here about the effects of repeated freeze-thaw cycles on TMR of carp fillets.

Twelve live carp *Cyprinus carpio*, weighing 830–850 g each, were purchased from a local market and filleted immediately after being decapitated. One fillet was taken from each fish; 4 fillets were collected and used for an ice storage experiment. During the ice storage the fillets were subjected to 0, 2, and 3 cycles of freeze-thaw. All procedures for preparing the fillets, storage in ice, and freezing at -20°C were the same as described previously.⁶⁾ The procedure to thaw the frozen fillets was also the same except for the period in ice-water (24 h). A measurement of TMR was made in the same manner as described in our previous paper.⁶⁾

Fig. 1 shows changes in TMR of fillets which had undergone 0 to 3 freeze-thaw cycle(s) during storage in ice. The average TMR for very fresh fillets before storage was approximately 12. TMR of fillets without any freeze-thaw cycles decreased very slowly; the decrement was as low as approximately 1.0 unit after 15 days. Fillets which had been subjected to repeated freeze-thaw cycles exhibited a decrease in TMR by ca. 3 units for the first cycle, followed by ca. 2 units each for the second and third cycles. Little decrease was observed in subsequent periods of ice storage. The decrement of 2–3 units in carp fillets, however, was much smaller than that of yellowtail fillets (ca. 11 units) stored under the same conditions.⁶⁾ The great difference in the decrement between the two different fish species might be attributed to the difference in the dielectric property of surface layers on fish bodies. The decrease in TMR, which was produced even by a single freeze-thaw cycle, can thus be utilized to differentiate frozen-thawed fish fillets from unfrozen ones. It was suspected that the fillets underwent the decrease in TMR during the period even when they were placed in ice-water. However, fillets that were placed in ice-water for about one day after having been stored for 0, 2, and 8 day(s) in ice did not show any measurable decrease in TMR (data not shown). This evidence

Fig. 1. Changes in TMR of carp fillets subjected to, 0 to 3 freeze-thaw cycle(s) during ice storage. Vertical bars represent standard deviations. Samples were frozen at -20°C for 18 h at the time as indicated by arrows. Solid and dashed lines represent TMR of samples stored in ice and in ice-water, respectively. $\circ$, 0 freeze-thaw cycle; $\triangle$, 2 freeze-thaw cycles; $\blacktriangle$, 3 freeze-thaw cycles.

suggests little decrease of TMR at ice-water temperature in the thawing process. The 5–7 unit decrease caused by the repeated freeze-thaw cycle strongly suggests that Torrymeters can be applied to determine how many times the cycle was repeated during ice storage of carp fillets.

During the ice storage with no freeze-thaw cycle, the TMR of carp fillets fell extremely slowly over 15 days (Fig. 1) when compared with that of yellowtail fillets.⁶⁾ Therefore, Torrymeters are almost useless for measuring the freshness of carp fillets stored in ice. The freshness of carp fillets stored in ice for 15 days was appreciably low when observed organoleptically. In this connection, Uchiyama *et al.*⁷⁾ reported that a freshness index K value of carp flesh exceeded 20% as early as 8 days after the beginning of ice storage.

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