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Original paper

FRESHNESS CHANGES OF YELLOWFIN TUNA (*Thunnus albacares*) DURING STORAGE AT LOW TEMPERATURES

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ABSTRACT

Freshness quality is considered as an important factor in determining overall quality of particular fish product items. The degree to which the freshness quality of the items meets the consumer's expectation concerning freshness quality will greatly affect whether the fisheries product item will be purchased again or not. Considering the importance of fish freshness quality, many methods have been proposed to evaluate fish freshness including physical, chemical and sensory methods. The K value is one of the chemical methods widely used , especially in Japan, as a fish freshness index to evaluate the quality change of raw fish. Tuna has been regarded as a palatable and valuable fish species and its freshness is the concern of many researchers.

This study is aimed at investigating the freshness change of yellowfin tuna (*Thunnus albacares*) during storage at low temperatures (10oC, 5oC and 0oC) by measuring the K value of the fish. Observation on the changes of ATP and its related compounds during storage was also carried out.

The result of the study shows that the freshness of yellowfin tuna as measured by K value, changed in different patterns depending on the storage temperatures. The higher the temperature of storage the faster was the decrease in freshness of yellowfin tuna. It was also observed that yellowfin tuna could be eaten raw up to 1 day, 2 days and 4 days storage at temperature of 10º C, 5º C and 0º C, respectively. Storage temperature of 0º C is recommended for its preservation in chilled state. The use of HPLC allows for each of ATP-related compounds to be determined quantitatively.The Ki value is more appropriate for measuring fish freshness obtained more than 24 hours after death.

Key words: Fish freshness, yellowfin tuna, K value, low temperatures

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INTRODUCTION

Fish and fisheries products are considered as perishable food and are susceptible to microbial degradation. Their spoilage is mainly caused by bacterial activity, lipid oxidation, autolysis and hydrolytic enzyme activity. In order to get optimal fish production after catching, handling and preservation of fish play an important role to minimize the spoilage.

Freshness quality is considered as an extremely important factor in determining overall quality of particular fish product item. The freshness quality, including appearance, flavor, odor, and texture of each fish product is, consciously or

unconsciously, determined by each user and depends on each fisheries product item that is being consumed. The degree to which the freshness quality of the items meets the buyer's or user's expectation concerning freshness quality will greatly affect whether the fisheries product item will be purchased again or not.

Considering the importance of fish freshness quality, many methods have been proposed to evaluate fish freshness, including physical, chemical or sensory methods. The chemical method has been considered as an objective method and therefore superior to methods involving sensory evaluation.

Adenine nucleotides occupy more than 90% of the total nucleotide and the main component is adenosine 5'-triphosphate (ATP). Some chemical methods of fish freshness evaluation based on nucleotide degradation have been proposed (Saito et.al.,1959 and Karube et.al., 1984). Among these, the K value is widely used as fish freshness index, especially in Japan to evaluate the quality change of raw fish (Ehira and Uchiyama, 1987). It is generally known that tuna has been regarded as a palatable and valuable fish species and its freshness has become the concern of many researchers. The tuna fish , in the form of a dish called , *sashimi* is eaten raw in Japan, and therefore freshness is one of the priorities for its quality.

The storage of fish at low temperature can prolong its shelf life due to lowering microbial and chemical process. The higher the temperature during storage, the shorter the shelf life of fish. As a general rule, for every 5º C above 0º C that fishes are stored, the storage life in ice is reduced by half. (Clucas and Ward, 1996).

This purpose of this study is to investigate the freshness change of yellowfin tuna (*Thunnus albacares*) during storage at different temperatures by measuring the K value of the sample and by observing the changes of ATP and its related compounds.

MATERIALS AND METHODS

Fish sample

The fish used in this study was yellowfin tuna (*Thunnus albacares*). The fish was purchased as dorsal-sliced fish meat (1000 gram each for 3 different pieces) from retail shops in Shinagawa, Tokyo, Japan and brought to the laboratory on ice in styrofoam boxes. The fish was then stored at different temperatures (0º C, 5º C and 10º C, respectively) for approximately one week.

Chemical Analysis

K value was measured to evaluate the state of fish quality by using a modified method (Ryder, 1985). One gram of fish muscle tissue was homogenized with 8 ml of chilled 10% and 5% perchloric acid (HClO). The homogenate was centrifuged at 2,000×g for 10 min at 5º C and the supernatant was immediately neutralized to pH 6.8 with 1 N and 10N KOH. The neutralized mixture was centrifuged again at 2,000×g for another 10 min and the supernatant was diluted to 20 ml with neutralized HClO and then filtered prior to storage at –46 º C for subsequent analysis.

Separation of ATP-related compounds was achieved on reverse-phase column Asahipak GS-320-HQ (Tokyo-Japan). The mobile phase of 200 mM sodium dihydrogenphosphate dihydrate (NaH2PO3.2H2O) at pH 2.8 was used at a flow rate of 1 mL/min at 30 oC. The eluant was monitored at 258 nm for each ATP-related compound. The concentration of each compound was determined on the base of its peak height. The analysis of K value was carried out in duplicate.

RESULTS AND DISCUSSION

K value is expressed as a percentage of the amount of inosine (HxR) and hypoxanthine (Hx) to the total amount of adenosine 5'-tri-, di-, mono-phosphate (ATP, ADP, AMP), inosine mono-phosphate (ATP, ADP, AMP), inosine mono- (ATP, ADP, AMP), inosine mono-adenosine 5'-tri-, di-, mono-phosphate (ATP, ADP, AMP), inosine mono-phosphate (IMP), HxR and Hx. This value has been commonly used in Japan as one of the indices of freshness to evaluate the quality change of raw fish after catch (Kennish and Kramer, 1987). K value is the most reliable indicator for fish, in particular for those known as *sashimi* (sliced-raw fish eaten by the Japanese). In case the K value is below 20%, it is possible to eat the fish meat in a raw state, while if the K value is above 20% but below 40%, the fish should be cooked before eating. If the K value is above 40%, the fish meat should not be eaten.The equation used to calculate the K value is as follows (Ehira and Uchiyama 1987 and Watanabe, 1993):

$$K\ value\ (\%) = HxR+Hx\ /\ [ATP+ADP+AMP+IMP+HxR+Hx] \times 100$$

The results of HPLC analysis for ATP and its related compounds of yellow fin tuna are listed on Table 1. Based on the results, it can be seen that initial ATP concentration of yellow fin tuna was very low for all storage temperature. It means that the fish used for experiment was on the state of post rigor, which was characterized by the low ATP and high IMP concentration of the fish. Extending storage time resulted in the decrease of IMP concentration and increase in Inosine and Hypoxanthine, which in turn represented spoilage of the fish.

Post mortem change of fish meat can be represented briefly as follows:
Catching $\longrightarrow$ rigor mortis $\longrightarrow$ dissolution of rigor mortis $\longrightarrow$ autolysis $\longrightarrow$ spoilage

Table 1. The Concentration of ATP and Its Related Compounds of Yellowfin tuna (*Thunnus albacares*) Stored at Low Temperatures (10^oC, 5^oC and 0^oC)

Storage Time day)	ATP and Its Related Compounds (μ mole / gram sample)					
10^oC	**ATP**	**ADP**	**AMP**	**IMP**	**HxR**	**Hx**
0	0.1	1.332	0.152	10.71	0.207	0.049
	0.1	0.803	0.179	10.84	0.111	0.050
1	0.1	0.369	0.085	10.33	1.687	0.443
	0.1	0.393	0.071	11.12	1.592	0.493
2	0.1	0.345	0.071	8.521	2.165	1.084
	0.11	0.369	0.004	7.632	2.643	0.788
4	0.1	0.321	0.098	5.345	2.501	0.197
	0.1	0.321	0.071	5.445	2.499	1.430
5	0.1	0.321	0.071	6.026	2.691	3.304
	0.1	0.393	0.058	5.650	2.643	2.317
6	0.11	0.297	0.085	4.352	1.878	5.276
	0.08	0.345	0.071	3.122	2.452	3.895
5^oC	**ATP**	**ADP**	**AMP**	**IMP**	**HxR**	**Hx**
0	0.12	0.353	0.122	10.64	0.509	0.039
	0.1	0.45	0.122	11.44	0.547	0.039
1	0.09	0.45	0.1	10.62	1.350	0.118
	0.11	0.315	0.079	10.02	1.656	0.197
2	0.11	0.411	0.1	10.15	2.458	0.236
	0.12	0.334	0.122	9.824	2.305	0.276
3	0.08	0.45	0.089	9.031	2.726	0.355
	0.1	0.315	0.1	7.855	2.726	0.315
4	0.1	0.296	0.1	7.582	3.452	0.512
	0.1	0.296	0.079	7.363	3.681	0.512
5	0.1	0.315	0.089	6.953	3.910	0.591
	0.11	0.411	0.089	8.183	3.949	0.512
6	0.1	0.353	0.089	6.817	4.063	0.710
	0.11	0.315	0.079	5.832	2.955	1.696
7	0.12	0.334	0.089	6.571	2.496	2.288
	0.07	0.546	0.046	6.817	3.719	1.104
9	0.11	0.296	0.089	3.864	1.961	3.708
	0.1	0.469	0.068	6.379	2.114	2.327
0^oC	**ATP**	**ADP**	**AMP**	**IMP**	**HxR**	**Hx**
0	0.12	0.315	0.1	10.89	0.586	0.039
	0.08	0.296	0.057	10.12	0.586	0.039
1	0.09	0.469	0.1	11.08	1.006	0.039
	0.1	0.334	0.1	9.988	1.044	0.039
2	0.09	0.488	0.089	10.7	1.426	0.078
	0.08	0.527	0.079	10.53	1.617	0.118
3	0.09	0.257	0.079	7.363	1.579	0.157
	0.09	0.296	0.1	7.09	1.388	0.078
4	0.11	0.373	0.1	9.222	2.305	0.276
	0.1	0.315	0.089	8.375	2.076	0.197
5	0.1	0.296	0.089	8.375	2.535	0.315
	0.12	0.353	0.111	9.988	2.649	0.197
6	0.08	0.527	0.079	9.55	2.993	0.236
	0.11	0.353	0.111	9.112	2.993	0.276
7	0.07	0.488	0.046	8.293	3.261	0.355
	0.08	0.392	0.068	8.347	3.108	0.315
9	0.1	0.315	0.068	6.735	3.49	0.512
	0.1	0.411	0.068	7.555	3.91	0.355
10	0.1	0.296	0.089	6.598	3.605	0.394
	0.1	0.296	0.079	6.653	3.643	0.434

Soon after death, the fish will go to pre-rigor state, in which the muscle is soft and pliable and biochemically characterized by a process of decreasing ATP and creatine phosphate as well as an active glycolisis. Following a fall in ATP and creatine phosphate, actin and myosin gradually associate to form inextensible actomyosin that is the onset of rigor mortis. Fish generally exhibit a short rigor mortis period starting from 1 to 6 hours after death depending on numerous factors (Watanabe, 1993). Following the dissolution of rigor mortis, a gradual tenderization of fish meat occurs and complex compounds such as protein, lipid and glycogen degrade into simple compounds, which can be used readily by micro organism. Prolonged storage will result in microbial spoilage.

The changes of K value of yellow fin tuna can be seen on Table 2.The K value of fish stored at 10º C increased relatively faster than that of fish stored at 5º C and 0º C. This indicated that lowering the storage temperature could retard the spoilage of the fish. The initial K value of the fish was relatively low, indicating that the freshness of fish used in this study was good.

Generally ATP, ADP and AMP disappear around 24 hours after death, and usually fish are obtained from the market at least 24 hours after death. Therefore, another freshness indicator of Ki value is proposed and defined as Ki = HxR+Hx / IMP+HxR+Hx x 100 (Okuma et.al (1992). Figure 1 shows the changing of K value and Ki value of yellow fin tuna during storage. The graph clearly shows that the Ki value is higher than the K value, and it seems that the former value is a more accurate indicator of fish obtained more than 24 hours in the market as is the case with the tuna fish used in this study.

Table 2. K value Changes of yellowfin tuna (*Thunnus albacares*) Stored at Low Temperatures (10^oC, 5^oC and 0^oC)

Storage Time (day)	Storage Temperatures (^oC)					
	10^oC		5^oC		0^oC	
	K value (%)	SD	K value (%)	SD	K value (%)	SD
0	1.29	1.09	4.64	0.02	5.39	0.29
1	15.76	0.87	13.25	2.43	8.75	0.82
2	28.08	2.31	19.94	0.08	12.54	1.21
3	N.d	N.d	25.42	1.73	17.23	1.42
4	32.38	10.53	33.89	1.36	20.61	0.33
5	46.18	2.45	35.65	2.82	22.77	2.21
6	61.64	2.86	40.83	2.11	24.61	0.88
7	N.d	N.d	39.71	0.69	28.36	0.77
9			47.65	12.56	35.03	0.89
10					36.23	0.21

N.d: Not detected

Figure 1. Change of K value and Ki value of Yellowfin tuna during Storage at Low Temperature

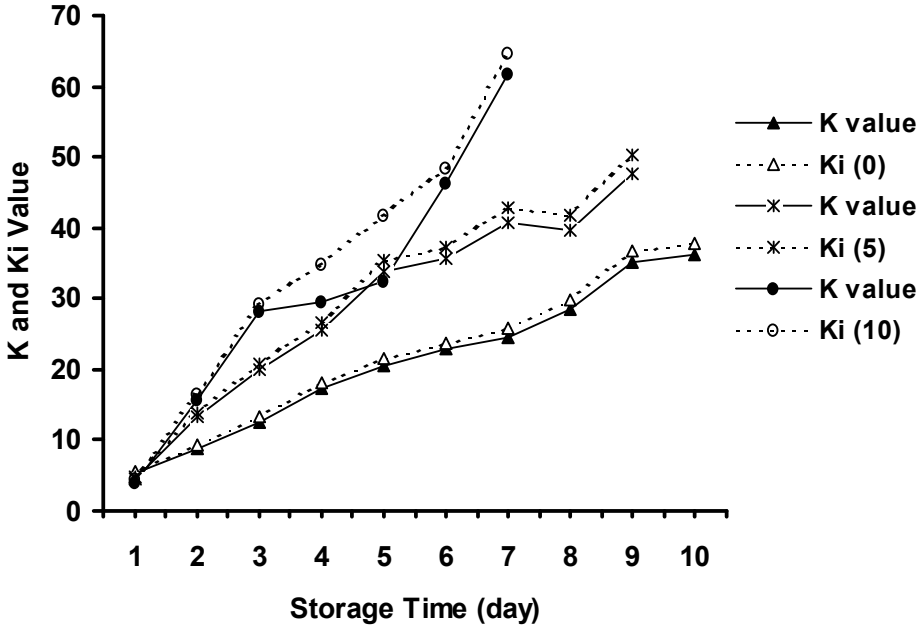

Figure 1: Change of K value and Ki value of Yellowfin tuna during Storage at Low Temperature

CONCLUSION

Based on the results of the study, it may be concluded that the change of freshness in yellow fin tuna during storage depended on storage temperature. The higher the storage temperature, the faster the change in freshness. Ki value is more appropriate than K value for measuring freshness of fish obtained more than 24 hours after death.

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