The K Value As A Freshness Index For Tropical Food Fish And Its Application As A Quality Control Tool During Fish Storage And Distribution

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Abstract

The K value, expressed as

$$\text{K value } \% = \frac{\text{HxR + Hx}}{\text{ATP + ADP + AMP + IMP + HxR + Hx}} \times 100$$

is a good index for estimating the enzymatic freshness of fish.

The changes in K value of various species of tropical food fishes during ice-storage had been studied. It was found that these warm water fishes deteriorate slowly under ice-storage preservation. A study was made on the K value changes of three species of fish (*Polynemus* sp., *Rastrelliger kanagurta* and *Pampus argenteus*) in a supermarket distribution chain. Most sets of data showed changes of quality; from the point of supply until the morning after an overnight stay on display shelves. The results support a conclusion that the shelflife limit of fresh tropical food fish, based on sensory evaluation, was, when handled well, between 12 to 28 days ice-storage depending on species, with the K value ranging from 24 - 37%.

Introduction

When a fish dies, the adenosine triphosphate (ATP) is broken down by enzymes into other compounds as follows:

$$\text{ATP} \xrightarrow{\text{Tpase}} \text{ADP} \xrightarrow{\text{myokinase}} \text{AMP} \xrightarrow{\text{deaminase}} \text{IMP} \xrightarrow[\text{phosphatase}]{\text{alkaline}} \text{HxR}$$

$$\text{HxR} \xrightarrow[\text{phospharylase}]{\text{nucleoside}} \text{Hx} \xrightarrow[\text{oxidase}]{\text{xanthine}} \text{UA}$$

where ATP = adenosine triphosphate
ADP = adenosine diphosphate
AMP = adenosine monophosphate
IMP = inosine monophosphate
HxR = inosine
Hx = hypoxanthine
UA = uric acid

Presently, two K value determination methods are adopted by our laboratory, viz the anion exchange chromatography method and the oxygen-electrode method using the Freshness Meter (Model KV 101, Oriental Co.) (Low *et al* , 1989).

The objective of this study was to examine the endogenous changes of tropical food fishes during ice-storage as well as during distribution. As the freshness of fish changes enzymatically before significant bacterial activity begins, the K value was considered a suitable index for quality changes.

Twelve tropical food fish species - *Lates calcarifer* (seabass), *Epinephalus tauvina* (greasy grouper), *E. bleekeri* (Bleeker's grouper), *Lutjanus*

Note: This paper was presented at the Seminar by Mrs Tan.

johnni (golden snapper), *L. argentimaculatus* (mangrove snapper), and *Pampus chinensis* (Chinese pomfret) purchased live from aquaculture farms and *Scomberomorus commerson* (Spanish mackerel), *Thunnus tonggol* (tonggol), *Saurida tumbil* (lizardfish), *Rastrelliger kanagurta* (Indian mackerel), *P. chinensis* (Chinese pomfret) and *P. argenteus* (silver pomfret) purchased fresh from wholesale/retail markets were studied under ice-storage.

The K value changes of fish in a commercial retail cold-chain distribution system was monitored.

Changes In The K Value Of Tropical Food Fish Under Ice-Storage

Method And Materials

Six species of fish were purchased live from aquaculture farms for study of K value changes under ice-storage. Upon arrival, they were immediately killed by immersion in ice-cold water. They were ice-stored with proportion of fish to ice of 2:1. Regular physical examinations for changes were made on days of sampling. For each species, three fishes were sampled for K value per storage day. An interval of three to four days was allowed for each lot of sampling. Monitoring of K value continued until gills emitted a strong putrid odour and to the point at which body muscle turned soft and non-resilient. Overall acceptability was based on organoleptic assessment of steamed samples.

The K values of fresh fishes purchased from wholesale/retail markets were also studied under similar ice-storage conditions.

The K values were determined by the anion exchange chromatography method (Hasegawa, 1987).

Results And Discussion

In all the fish species studied, a gradual increase in K value during ice storage (Figs. 1 and 2) was observed.

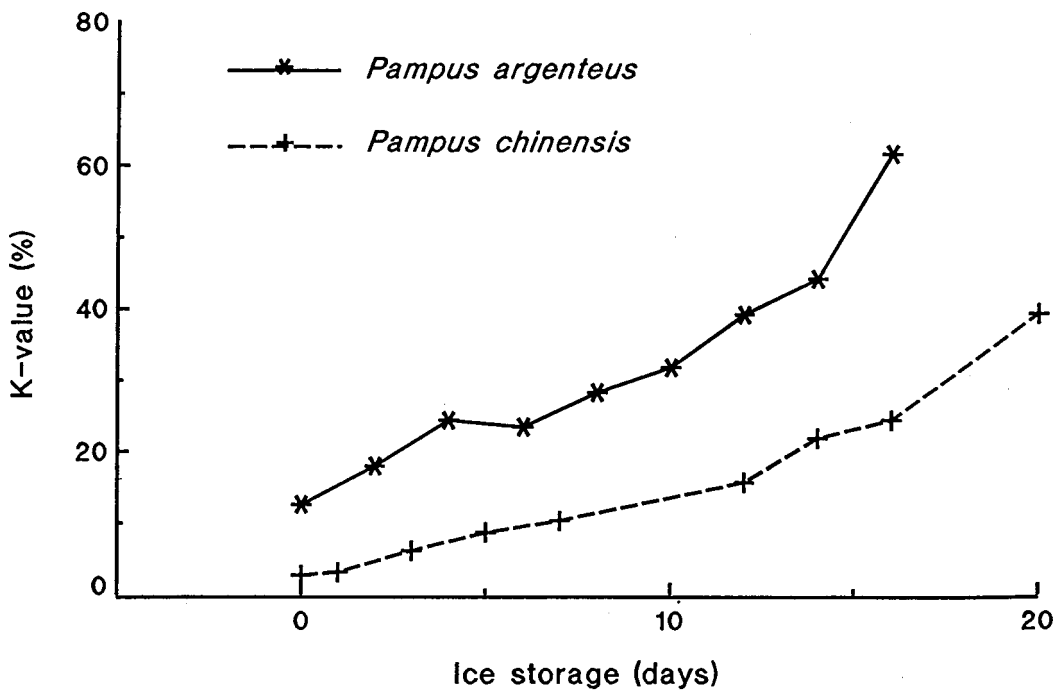

Fig. 1. Changes in freshness (K value) of promfrets during ice storage.

The muscle proteins stability as well as the late initiation of bacterial propagation contributed greatly to maintaining the freshness of the fish during ice-storage.

Referring to Tables 1 and 2, it was found that sensory evaluation acceptability of fishes varied according to species from 12 to 28 days ice-storage with the K value range of 24% to 37% respectively.

Most of the fishes from the wholesale/retail markets had K values between 12 to 25% on arrival. The lizardfish, being of better initial quality (12.9%), could be ice-stored for 6 days before reaching 20% K value.

Case Study : Monitoring Changes In K Value Of Fishes During Retail Distribution

Method

A local supermarket chain was selected for this study. The company operated a central processing plant where the fish were prepared and packed for distribution to the retail stores. Three retail outlets were selected for inclusion in this study.

Generally, fishes were delivered to the central processing plant in the morning (8.00am). These were re-chilled, washed, processed and packed into styrofoam trays for subsequent distribution in the afternoon (1.00pm) by refrigerated trucks. The pre-packed fish were placed on the display shelves at the retail outlets (-4 to 8°C) for sale.

In this study, the temperature of the fish was measured at the central processing plant, and at various points in the distribution outlets. Fish samples were taken for K value determination at the central processing plant, upon arrival at outlets and after one day at the display shelves.

Fig. 3 shows the operational flowchart of the distribution, and the data collection points.

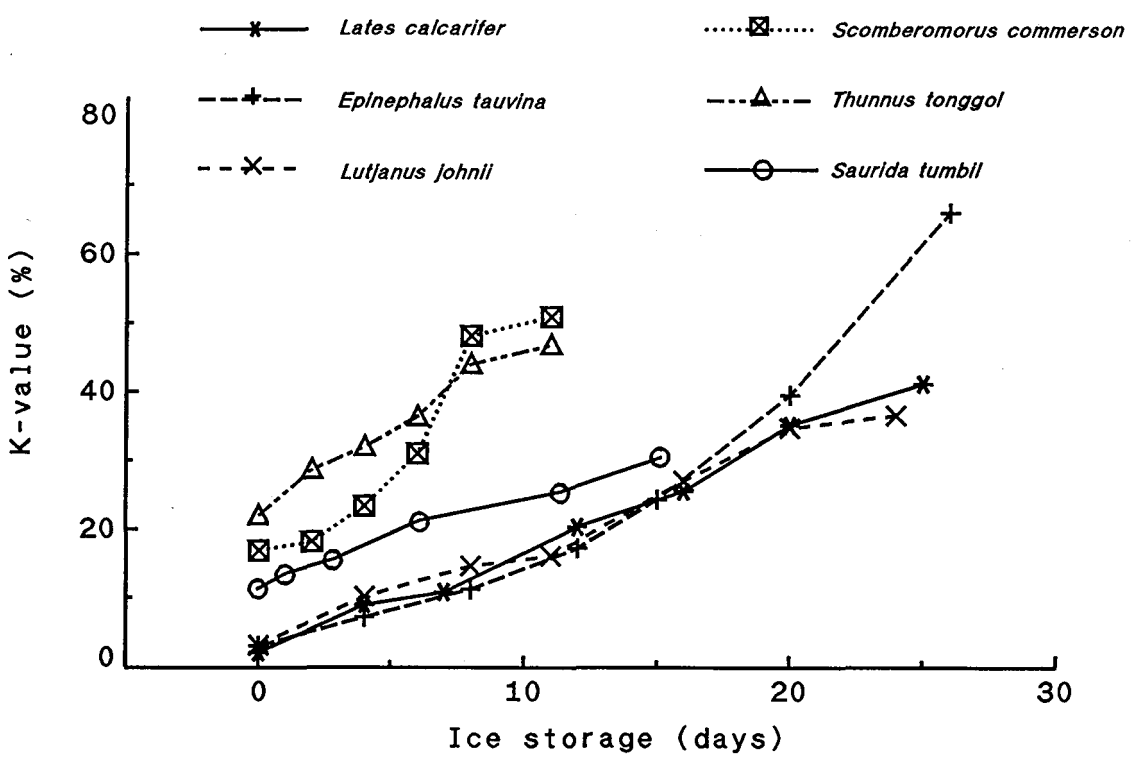

Fig. 2. Changes in freshness (K value) of tropical fishes during ice storage.

Table 1. Changes in K value, VB-N, TMA and sensoric properties of grouper (body length : 34.5 cm, bodyweight : 1 kg) during storage.

Days of Storage	K Value (%)	VB-N (mgN/100g)	TMA-N (mgN/100g)	Eye	Gill	Appearance	Flesh (raw)
0	4.4	8.2	ND	transparent, not sunken.	red, no slime, no smell (seaweedy).	dark brown, no smell, no slime.	white colour (normal), no smell, rubbery texture.
3	5.9	13.2	0.3	milky white, not sunken.	pale red, slightly slimy, smells but not bad smell.	(rigor mortis), no smell, no slime.	slightly yellowish, slightly softer, no smell.
7	12.0	11.6	0.2	-do-	dark red, sticky mucus, very slightly fishy smell.	(post rigor) no smell, no slime.	white with yellowish tint, no smell, very soft texture. Skin: no smell.
11	18.1	17.3	0.3	-do-	dark red, sticky mucus, strong fishy (bad) smell.	very slight smell, slimy.	slightly reddish tint, no smell, very soft. Skin: no smell.
15	26.7	11.8	0.5	cloudy/milky white, sunken.	dark red, very slimy.	normal colour, slightly fishy smell, slightly slimy.	yellowish tint, no/very slight fishy smell, soft. Skin: no/very slight fishy smell.
18	37.1	12.1	2.6	milky-white with reddish colour, sunken.	dark red; very slimy, spoiled smell.	normal colour, fishy smell, slime.	greyish tint, very slight fishy smell, soft and sticky. Skin: slight fishy smell.
21	34.0	16.9	4.4	-do-	reddish brown colour, slimy, spoiled smell.	normal colour, spoiled smell, slime.	white with yellowish tint, moderate fishy smell (very slightly), very soft, sticky structure. Skin: fishy smell but not rancid.
24	42.3	18.3	6.5	-do-	-do-	-do-	white with yellowish tint, slight fishy smell, very soft texture. Skin: surface: spoiled smell, not rancid; meat: slightly fishy smell.

Table 2. Iced storage characteristics of various fishes.

Fish type	Scientific name	Acceptability limit (days)	K value (%)
Indian mackerel	*Rastrelliger kanagurta*	5	28.7
White pomfret	*Pampus argenteus*	12	29.9
Chinese pomfret	*Pampus chinensis*	16	24.4
Seabass	*Lates calcarifer*	14	27.9
Grouper	*Epinephelus bleekeri*	24	37.4
Grouper	*Epinephelus tauvina*	28	28.2

The oxygen-electrode based Freshness Meter was used during this study.

Results And Discussion

On the whole, all fishes arrived between 10 min of each other around 8.00 am. The smaller fishes were generally well-iced whereas the larger fishes such as *Polynemus* sp. were moderately iced. Body temperatures of smaller fishes monitored were well below 10°C whereas that of the larger fishes were around 15°C . The preparation room's temperature was kept low at around 16°C.

All fishes, after saline washing, were around 2°C and 7 to 9°C after sampling for K value measurements. The time lapse for samples left in the chiller room (2°C) before distribution was 2 hr, when sampling was also completed.

Time taken from Center to Outlet 1 was 28 min, to Outlet 2 was 56 min and Outlet 3 was 86 min on the average.

Referring to Table 3, there was negligible differences in K value amongst most samples.

The prompt handling of fishes between the warehouse and the outlets had helped maintain their quality at their best. The quality of fish delivered to the supermarket, however, was not always the best. Other than the threadfin which showed constant excellence of quality, a mixed supply of good and lower quality small fishes was noted. In particular, though initial physical appearance of silver pomfrets may appear good for the majority, yet K value had been found to be high on the average.

Freshness Breakdown Trend In Tropical Food Fish

Ng *et al* (1983) found that in grouper and white pomfret, most muscular proteins, particularly myofibrillar and sarcoplasmic proteins, were of very stable condition throughout ice-storage. This further supports the observations of Uchiyama *et al* (1978) that tropical fish has muscular protein stability. That is, most tropical food fishes degrade in freshness very gradually when well-iced and handled. VB-N data remains reasonably stable in most fish studied whereas the TMA-N remains low for about 14 days before it starts showing signs of increase. As the degradation of fish freshness is a biochemical reaction influenced by body temperature changes; a fish subjected to a larger temperature fall is more likely to retain better freshness than one which experiences a smaller change in temperature.

Conclusion

The K value is a suitable freshness indicator for tropical food fishes.

The long shelflife of tropical food fish could be attributed to the stability of its muscular proteins, the larger fall in temperature during ice-storage and the low bacterial activity present.

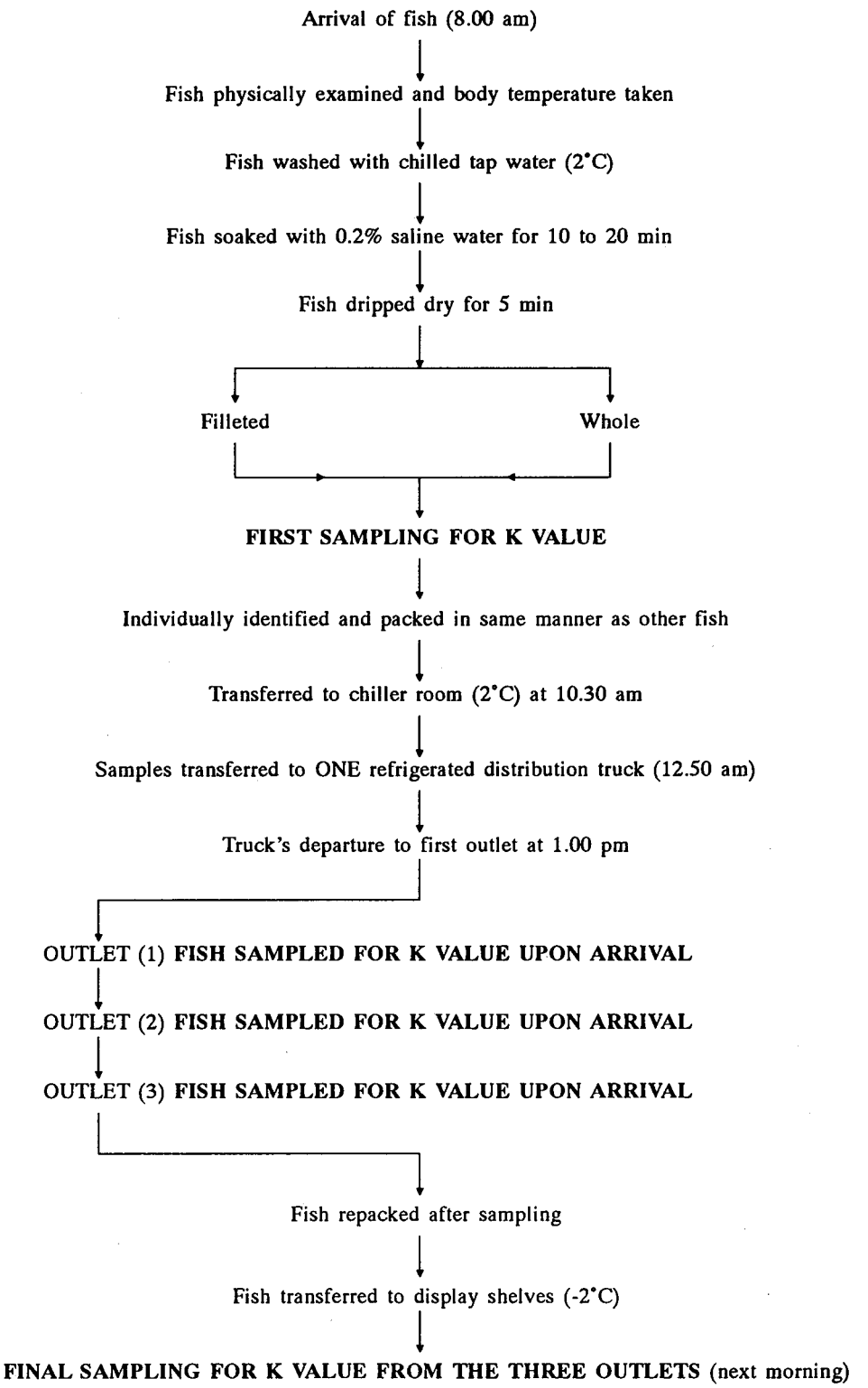

Fig. 3. Fish quality monitoring in a retail distributor and its outlets.

Table 3. Changes in K value (%) of fish in a major distribution chain and its outlets.

OUTLET	THREADFIN			INDIAN MACKEREL			SILVER POMFRET		
	A	B	C	A	B	C	A	B	C
1	9.2	13.7	15.2	12.3	14.8	14.4	52.8	50.5	48.3
	9.0	12.1	12.0	5.6	9.4	11.7	68.2	68.3	62.8
	9.8	14.0	10.8	14.6	15.5	21.1	57.7	54.0	54.1
	12.6	13.6	12.1	13.2	15.7	17.9	32.0	30.0	33.6
2	14.8	17.1	13.8	7.1	9.8	14.7	30.7	26.6	24.4
	13.2	14.9	12.6	20.1	20.7	25.4	45.9	37.5	33.7
	12.3	14.4	13.3	12.7	14.0	21.3	39.7	33.1	40.2
	11.8	14.4	12.8	7.1	10.0	17.7	51.6	49.4	48.2
3	13.5	14.9	17.4	6.5	11.6	13.6	38.8	35.4	40.8
	12.4	11.2	12.7	10.7	14.6	15.2	62.3	64.0	60.6
	13.1	13.2	14.1	19.8	22.3	22.8	51.5	47.8	49.1
	14.0	15.0	15.2	16.9	19.7	19.9	50.6	49.5	52.2

A - all samples taken simultaneoulsy at main distribution center in the morning.
B - samples taken at three outlets, upon arrival in the afternoon.
C - overnight samples in display shelves, taken on next morning.

The K value increase in all ice-stored samples were gradual and varied according to species. Species such as the groupers were more hardy than others and were still acceptable as steamed samples when K value ranged from 28 to 37% (24 to 28 days ice-storage). Others, like the seabass, mangrove snappers, golden snappers and pomfrets, were organoptically acceptable till around 30% K value (18 days ice-storage).

Acknowledgement

The authors are grateful to Mr Hooi Kok Kuang, Chief of MFRD and Dr Katsutoshi Miwa, Deputy Chief of MFRD for permission to publish this paper as well as to Mr M Yamagata and Ms Low Lai Kim for their guidance and help.

Hasegawa, H. 1987. Laboratory manual on analytical methods and procedures for fish and fish products. SEAFDEC/MFRD, Singapore, 137 pp.

Low, L. K., Teo, P. H. and Choo, S. E. 1989. Suitability of the Freshness Meter KV-101 for routine laboratory use. Singapore Journal of Primary Industries, 17(2) : 121-127.

Ng Cher Siang, Chin Yew Ning, *et al.* 1983. Changes in quality of white pomfret, Chinese pomfret and grouper during ice-storage. Bulletin of the Japanese Society of Scientific Fisheries, 49(5): 769-775.

Uchiyama, H. 1978. Analytical methods for estimating freshness of fish. SEAFDEC/TD, Bangkok.

Discussion

Asked about the procedure used to determine the acceptability limit, Mrs Tan replied that it was based on a panel assessment of steamed samples.

It was noted that the study showed good correlation between the K value and TMA-N. Mrs Tan agreed that as TMA-N is related to bacteria activity, this may not be suitable for frozen fish since the K value will increase faster than TMA-N increase in the frozen state. It was further noted that in the western countries, the hypoxanthine was quantified instead of the K-value. A query was then raised as to whether data to compare these two parameters were available. Mrs Tan replied that as some fishes have high levels of hypoxanthine, it is more accurate to use K value instead of hypoxanthine.

Mrs Tan was asked whether the analysis of K value by ion exchange was feasible when large numbers of samples need to be analysed, and whether the commercial freshness meter was accurate. She replied that the freshness meter was the faster method, and that previous studies had shown that the K values obtained had high correlation coefficient with the data obtained by the ion-change method.