Factors Affecting to Freshness Quality of Selected Tuna Fish Varieties along the Supply Chain

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ABSTRACT

The focus of this study was to detect freshness quality of the selected two tuna varieties "Yellowfintuna – Kelawalla(S) (Thunusalbacares)" and "Frigate tuna- Alagoduwa (S) (Auxisthazard)" along the supply chain. The distribution route was selected based on the Negombo fish landing center up to the 125 km distance and 4.5 hours duration. Mean values of TVB-N were recorded in mg/100g, 52 and 54 for yellowfin tuna and Frigate tuna respectively in Kegalle retail stall. Mean core temperature of the fish flesh was recorded around 10°C for both fishes also in Kegalle. Positive levels of Salmonella was indicated the range 3% to 5% also in package icing and potable water. There is positive relationship between TVB-N value and core temperature. The study revealed that overall acceptability levels of the freshness quality for yellowing tuna 32% and frigate tuna 40% as per the QIM indicator. Poor handing practices, inadequate package icing, poor hygienic practices and cleanliness of the workstations have to be improved and further studies are need to improve quality management along the supply chain.

Keywords: *QIM (Quality Index Method); freshness quality; TVB-N (Total Volatile Basic Nitrogen)*

1. INTRODUCTION

Sri Lanka is an Island located in the Indian Ocean, southeast of India, between 5°55'and 9°51' N latitude, and 79°41' and 81°53' E longitude. It is land area is approximately 65,610 km 2; with a coastline of about 1,620 km (Joseph, 2003). The fisheries industry is contributed to fulfill 60 % of the animal protein requirement of people. Gross Domestic Production level of the country from the fishery is reported as 1.3 in the period 2018-2017. The marine fishery is the highest contributor to fish production in Sri Lanka, which is shared around 85% (Fisheries outlook 2016). Tuna and tuna -like fishery are dominated by offshore or deep-sea fish production (Hasarangi et al., 2012). The tuna fishes in Sri Lanka mainly involve with Yellowfin tuna (Thunnusalbacares), Bigeye tuna (Thunnusobsesus), Skipjack tuna (Katsuwonuspelamis), Kawakawa (Enthynnusaffinis), Frigate tuna (Auxisthazard) and Bullet tuna (Auxisrochei) (Haputhantri and Maldeniya, 2011; Joseph and Dayaratne, 1994). The different type of fishing gears is being used in capturing tuna and tuna-like fish, which belong to high commercial fish varieties in the global market also. The freshness quality of the high portentous food commodity as fish becomes a crucial part of the supply (cold) chain, shown in Figure 01. The maintenance of respective quality standards has to be fulfilled along the supply chain, thus new technological approaches also needed to be introduced for upgrading the keeping quality of fish.(Kaminishiet al., (2000) have summarized that some of the indicators related to fish freshness, shown in Figure 02. This study was focused to determine the factors affecting freshness quality selected marine fishes in Sri Lanka along the supply chain.

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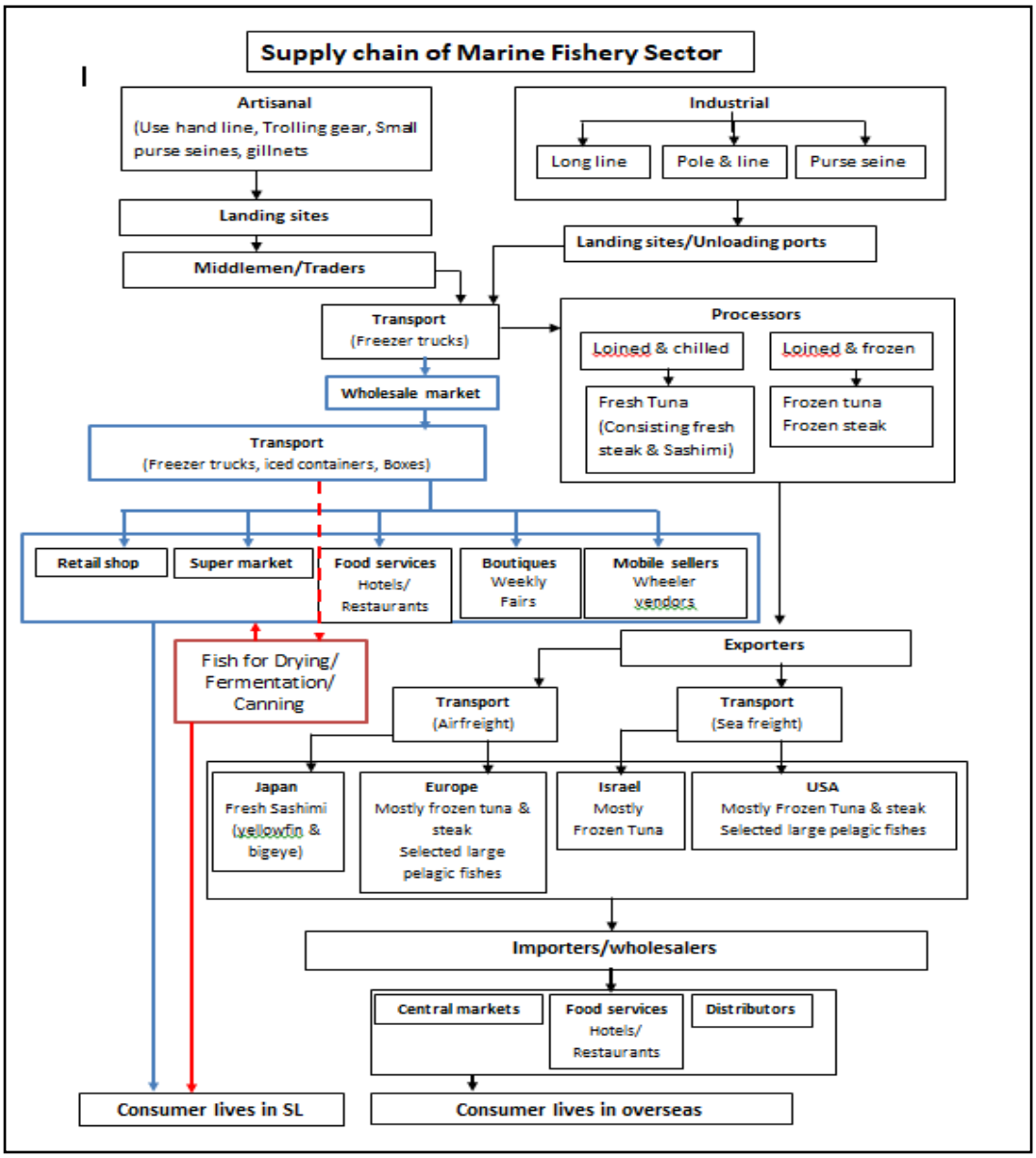

Figure 1: Supply Chain of Marine Fishery Industry

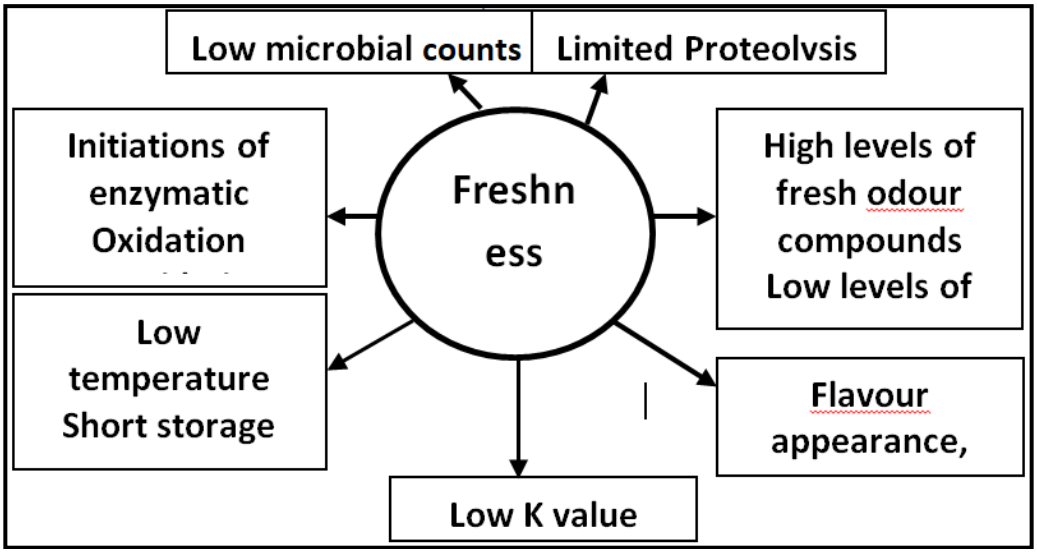

Figure 2: Freshness Quality Indicators (Kaminishi*et al*., 2000)

2. OBJECTIVES

2.1 GENERAL OBJECTIVE

To determine the factors affecting to freshness quality selected marine fishes in Sri Lanka along the supply chain.

2.2 SPECIFIC OBJECTIVES

- To determine post-harvest handling practices throughout the supply chain of marine fish.
- To identify chemical biochemical parameters of the cold chain of marine fish.
- To identify organoleptic parameters of marine fish freshness.
- To determine microbial parameters throughout the supply chain.

3. METHODOLOGY

3.1 SITE SELECTION AND SAMPLING

Considering the time frame and representing fish landing centers which were restricted to the Negombo fishery harbour for the sampling of fish. Considering the time and distance appropriate route of the supply chain (as a result of the pilot survey) was identified for sampling. Key points of the supply chain also identified. Yellowfin tuna (*Thunnus albacares*) and Frigate tuna (*Auxisthazard*) were selected for the sampling and further analysis for freshness quality. The fish varieties were selected based on the commercial value and types of fishing gear used. One visit of the fish landing center and another one for collecting point from the fishery harbor to the retail stall of the fish sale destination were observed and sampled.

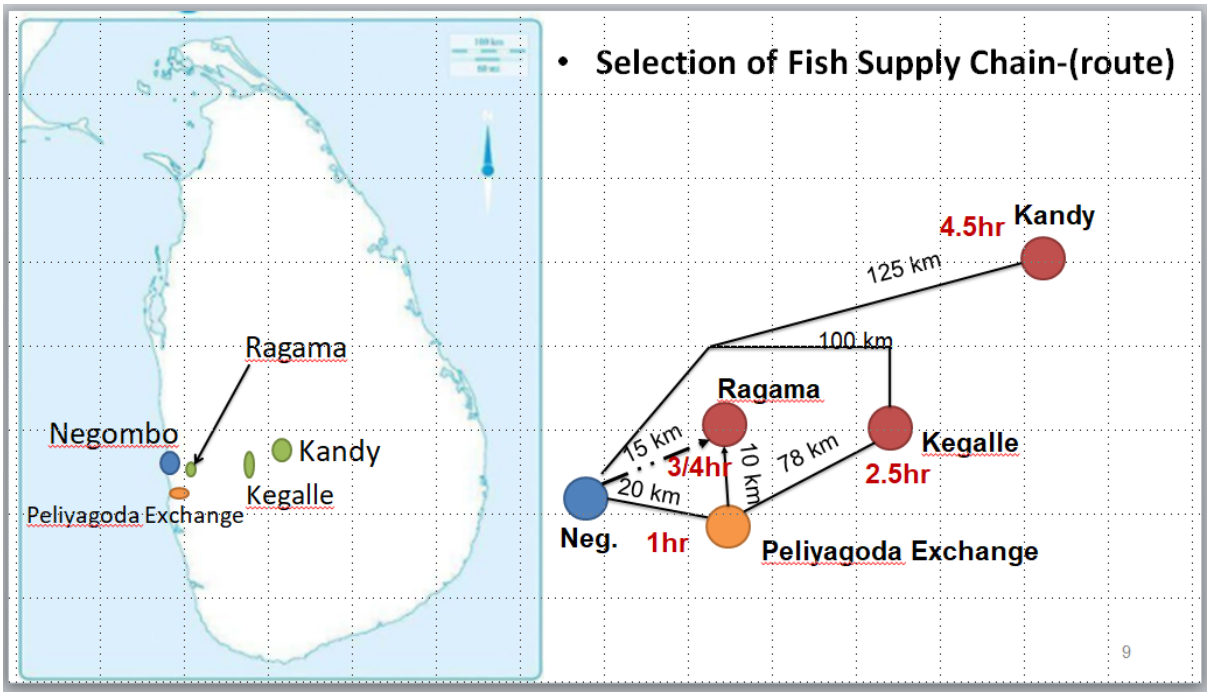

Figure 3: Sampling Route Map of the Study

The selected areas of the project are Fish landing sites of Negombo ***MahaLellama*** and ***KudaLellama/Wella***, Panadura, Beruwala and Peliyagoda wholesale fish market. Negombo is one of the main hubs of marine fish supply location in the Western province of Sri Lanka up to the year 2013 recorded around 41,000 mt. (Fisheries outlook 2016). Generally, large fish are supplied from multi-day boats whereas small fish caught in day-boats. Fish from both multi-day boats are landed at Fishery Harbour (Lellama) in Negombo. The present study was conducted with fish samples obtained in the fish supply chain begun at fish landing in Negombo from October, 2018 to May, 2019. One chain consisted of the distribution of large fish along four consecutive stages: 1) From multiday boats anchored at Negombo fishery harbour 2) Auction place at pier of fishery harbour 3) Exchanging place of the wholesale market center of Peliyagoda 4) Immediately after transporting of fish in a vehicle to the sales destination 4) At selected fish retailing stalls throughout the supply chain considering the distance and travelling duration (hour) to the mid country.

3.2 SAMPLING PLAN

Table 1: Five Samples per Point per Once a Month Were Done as Follows

Place	**Yellow fin tuna (*T. albacares*)**	**Frigate tuna (*A. Thazard*)**
Landing center	05	05
Exchange center (Peliyagoda)	05	05
Retail stall (Ragama)	05	05
Retail stall (Kegalle)	05	05
Retail stall (Kandy)	05	05

Fish were sampled in the field visit once a month on the above selected species. Randomly selected and purchased five samples in four places in Negombo and Peliyagoda wholesale market. Five samples in two places from the retail market stall also selected. All fish samples were moved along the fish supply chain

and followed commonly adhered handling practices and all samples units were transported under chill storage conditions to the within two–four hours.

3.3 Visual Examination (Organoleptic Test)

Sensory analysis was done those collected samples using Freshness Quality Index (QIM) method, which was a detrimental method, developed by Martinsdottir in 2001.

3.4 Microbiological Analysis

Fish samples tested for APC at 37 ºC, Coliforms, Faecal coliforms, *E.coli*, *Samonella*s*pp.* and *Listeria monocytogenes* (SLS 516 part 5:2013)
Counts of coliforms, Faecal coliforms and E.coli- MAN technique (SLS 516-12: 2013).
ISO 6579: 2002 used to detect *L. monocytogenes*&*Salmonella spp*.

3.5 Biochemical Analysis of Fish

All fish investigated for Total Volatile Nitrogen (TVN) content using Kjeldhaldistrilation method (EC/149/1995)

3.6 Microbiological Analysis of Water and Ice

Samples of water near boat anchoring of the fishery harbor, wholesale (exchange) market, packed containers, water from municipal water supply line in harbor premises, water used to make ice in ice plants, ice available for sale for fish handling operations and retail stall were sampled into sterile containers (500ml), stored with ice in chill bins and transported to laboratory in 2 – 4 hours. Water and ice samples were analyzed for APC at 37^0C, Coliforms, faecal coliforms, *E.coli*, *Faecal streptococci* (SLS 1461 Part 1/Sec 3: 2013) and *Salmonella* spp.(ISO 19250:2010 (E))

4. Results

4.1 Determination of Organoleptic Parameters

Organoleptic parameters were detected by using QIM method which has been developed byMartinsdóttir et al (2001).

Table 2: QIM Score of Frigate Tuna and Yellow Fin Tuna Fish

Quality parameter	Body part	Description	Mean score Frigate tuna	Description	Mean score Yellow fin tuna
Appearance	Skin	Rather dull, becoming discolored	1.1±0.48	Rather dull, becoming discolored	1.1±0.51
	Stiffness	Firm, elastic	1.2±0.37	Soft	2.1±0.45
Eyes	Cornea	Opalescent	0.98±0.14	Opalescent	1.2±0.35
	Form	Flat, slightly sunken	1.0±1.98	Flat, slightly sunken	1.2±0.82
	Colour of pupil	Opaque	1.2±0.42	Opaque	1.2±0.71
Gills	Colour	Less coloured, becoming discolored	1.5±0.74	Discoloured, brown spots	2.00±0.80
	Smell	Neural, grassy, musty	1.3±0.74	Neural, grassy, musty	1.4±0.65
	Mucus	Milky	1.1±0.51	Milky	1.1±0.48
Viscera	Viscera	Beginning to get dissolved	1.00±0.00	Beginning to get dissolved	1.00±0.05
Blood	Colour	Dark red	1.1±0.40	Brown	2.00±0.32
Fillets	Colour	Waxy, milky	1.0±0.52	Waxy, milky	1.1±0.65
Quality Index Range (0-22)		**Total score**	**13.4±0.52**	**Total score**	**15.4±0.53**

The QIM measurement of Frigate tuna was indicated overall score around 13.00 (Reference range 0.00 - 22.00), that's mean acceptable quality level for the consumer is about 40% (60% scores were given for rejection). For Yellow fin tuna was reported as 32% acceptability (total score is 15.4).

4.2 Determination Biochemical Parameters Cold Supply Chain

Figure 04 and 05 show that TVB-N level has been detected selected three fish species in different points of the supply chain as against the core temperature of fish flesh. Retail stall of Kegalle was indicated that high values (in mg/100g) such as 52 for yellowfin tuna and 54 for frigate tuna.

Core temperature values for the fish flesh in Kegalle retail stall was also recoded in highest all species (around 10°C)

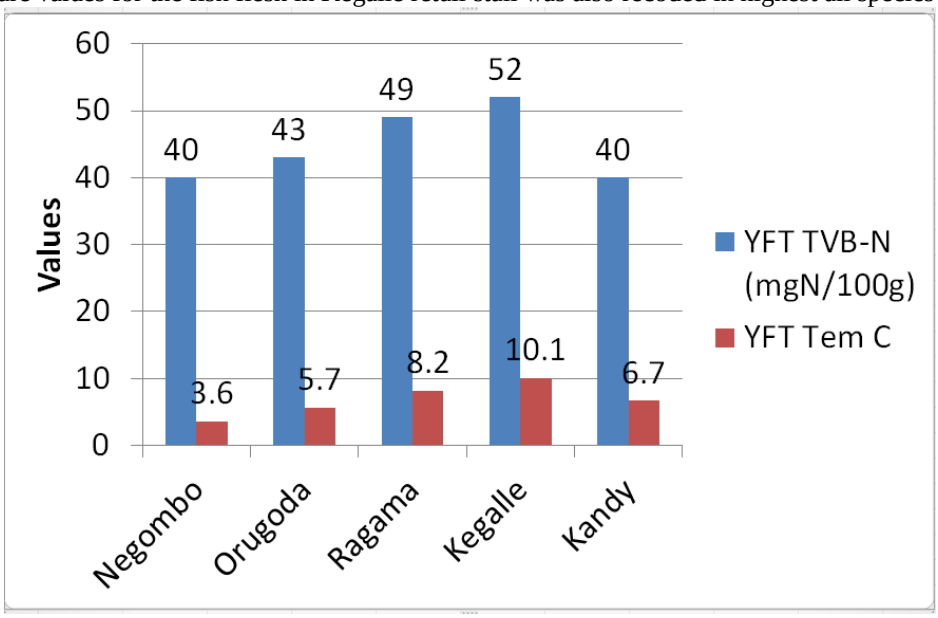

Figure 4: Temperature & TVB-N Levels of Yellow Fin Tuna through Supply Chain

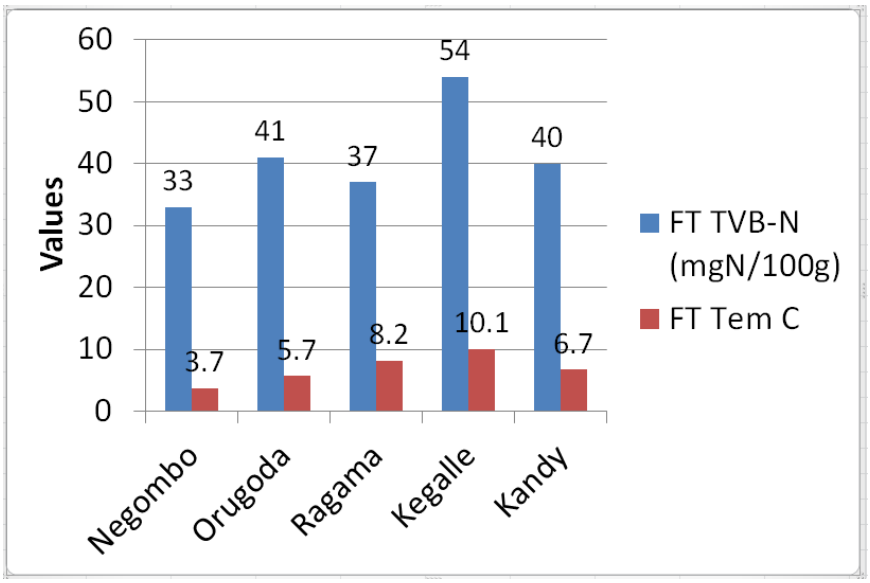

Figure 5: Changes of Temperature & TVB-N Levels of Frigate Tuna through Supply Chain

Table 3: Analysis of TVB-N in Fish Samples of Supply Chain

Location	Fish	TVN-N (mgN/100g) Range	Mean TVB-N(mgN/100g)
Negombo	Yellowfin tuna	24.30- 52.58	40
	Frigate tuna	18.15- 48.25	33
Peliyagoda	Yellowfin tuna	24.25- 61.08	43
	Frigate tuna	12.61- 68.70	41
Ragama	Yellowfin tuna	31.20- 68.23	49
	Frigate tuna	31.54- 42.58	37
Kegalle	Yellowfin tuna	25.68- 105.80	52
	Frigate tuna	38.40- 108.48	54
Kandy	Yellowfin tuna	28.51- 52.60	40
	Frigate tuna	24.56- 61.58	40

As per table 03 indicates that highest mean TVB-N value was recorded (52 for yellowfin tuna and 54 for frigate tuna) in Kegalle retail stall. Negombo, Peliyagoda and Kandy sampling points recorded around 40 mg N/100g of the TVB-N value.

a. DETERMINATION OF MICROBIOLOGICAL PARAMETERS

Table 3: Microbiological Analysis of Tuna fish from Multi Day Fishing Boats

Sample set	**YFT Meat APC cfu/g Range**	**FT Mean APC cfu/g Range**	**YFT Total Coliforms (Range) MPN/g**	**FT Total Coliforms (Range) MPN/g**	**Salmonella**
1	5.0×10^4 Range 7.0×10^3 – 1.0×10^5	1.8×10^7 Range 8.0×10^4 – 1.0×10^8	ND – 30% .> 500 – 16%	ND – 3% .> 500 – 15%	ND
2	3.0×10^6 Range 7.0×10^5 – 1.0×10^7	2.0×10^7 Range 8.0×10^4 – 1.0×10^8	ND – 30% .> 500 – 15%	ND – 6% .> 500 – 14%	ND

1= Just unloading; 2= two hours after unloading; YFT- Yellowfin tuna; FT- Frigate tuna

As per table 03 indicates that, the mean value of Aerobic Plate Count of both fishes were considerably increased within two hours after unloading the landing center.

Table 4: Microbiological Analysis of Fish from PeliyagodaWhole Sale Market

Fish	**Mean APC cfu/g**	**Total Coliforms (range) MPN/g**	**Salmonella**
Yellowfin tuna	1.0×10^7 Range $5.0 \times 10^4 – 2.0 \times 10^7$	ND - >1100	Absent
Frigate tuna	1.0×10^7 Range $8.0 \times 10^4 – 2.0 \times 10^8$	ND - > 1100	Absent

The APC level of both fish species was recorded as 1.0×10^7 cfu/g, but salmonella was not detected.

Table 5: Microbiological Analysis of Fish in Retail Market Places

Sample point	**Fish**	**Mean APC cfu/g**	**Total Coliforms (range) MPN/g**	**Salmonella**
Ragama	Yellowfin tuna	$9.0 \times 10^5 – 2.0 \times 10^7$	3 - >1100	Absent
	Frigate tuna	$19.0 \times 10^5 – 2.0 \times 10^8$	ND - > 1100	Absent
Kegalle	Yellowfin tuna	$5.0 \times 10^4 – 2.5 \times 10^7$	4 - >1100	Absent
	Frigate tuna	$8.0 \times 10^4 – 2.5 \times 10^8$	3 - > 1100	5% (+)ve
Kandy	Yellowfin tuna	$5.0 \times 10^4 – 2.0 \times 10^7$	ND - >1100	Absent
	Frigate tuna	$8.0 \times 10^4 – 2.0 \times 10^8$	3 - > 1100	Absent

Table 05 shows that, Kegalle retail stall was recoded in highest level of microbial counts. Salmonella also detected about 5%.

Table 6: MicrobiologicalAnalysis of Ice Samples

Sample set	**Mean APC cfu/ml**	**Total Coliforms (range) MPN/100ml**	**Salmonella/100ml**
Ice from boat	$2.0 \times 10^3 – 6.0 \times 10^5$	ND – 20000+	Absent
Ice from factory ice (NB)*	$3.0 \times 10^3 – 1.0 \times 10^6$	ND - 1800	Absent
Ice from ice plant (NB)*	$3.0 \times 10^4 – 1.0 \times 10^8$	1- 2800	Absent
Ice from ice plant (Pel)*	$3.0 \times 10^4 – 2.5 \times 10^7$	ND- 2000	Absent
Ice from packed fish	$8.0 \times 10^4 – 2.5 \times 10^8$	23 – 25000+	3% (+)ve

* NB= NegomboFish Landing ,Pel= PeliyagodaWholesale Market

Some samples of the packed ice were detected salmonella spp and total coliform count also indicated as highest level.

Table 7: MicrobiologicalAnalysis of Water Samples

Sample set	**Mean APC cfu/ml**	**Total Coliforms (range) MPN/100ml**	**Salmonella/100ml**
Harbor basin	$5.6 \times 10^4 – 89.0 \times 10^5$	950 – 18000+	Absent
Water from tap (NB)*	$1.5 \times 10^1 – 3.0 \times 10^4$	ND - 5	Absent
Water from ice plant (NB)	$5.0 \times 10^1 – 6.0 \times 10^6$	ND - >900	Absent
Water from tap (Pel)*	$1.0 \times 10^1 – 2.5 \times 10^4$	ND- 10	Absent
Water from tap retail stall (Ke)*	$1.0 \times 10^2 – 3.5 \times 10^4$	ND – >900	3% (+)ve

* NB= Negombo Fish Landing ,Pel= PeliyagodaWholesale Market, Ke= Kegalle

Tap water of Kegalle retail stall was detected salmonella positive and total coliforms count was highest in harbor basin water samples.

5. CONCLUSION

Though the maximum distance (125 Km) and distribution time (4.5 hours) of the Kandy retail stall, the TVB-N values of selected tuna fishes were not considered high compare with the Kegalle retail stall. It was indicated that the stall was not used an adequate amount of ice and not maintained required temperature levels. Poor hygienic practices also reported that Kegalle retail stall comparing with other sales points along the supply chain by signing a positive indication of Salmonella of the potable water. Cross contaminations also happened when handling the fish such as packing, serving and distributing. Some retail stalls were not constructed well, which has the potential to grow microbe particular displaying surfaces due to poor cleanliness. The core temperature of the fish flesh and TVB-N values has been indicated considerably high in some retail stalls. Based on that data mean value of the acceptability by the consumer was recorded as 40% for Frigate tuna fish and 32% for yellowfin tuna fish as per the QIM indicator. Finally in this study can be recommended to make aware better hygienic and cleanliness practices of the working environment & utensils of the retail stalls and use of adequate amount of package icing when displaying and packing.

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