The development of quality evaluation model for capture fisheries supply chain in Java southern coast

Adi Djoko Guritno[1*], Mirwan Ushada[1], Novita Erma Kristanti[1], Melinda Sugiana Dharmawati [1], Nur Achmad Sulistyo Putro[2]

(1.Department of Agroindustrial Technology, Faculty of Agricultural Technology, Universitas Gadjah Mada, Jalan Flora No. 1 Bulaksumur, Yogyakarta, Indonesia 55281;

2. Department of Computer Science and Electronics, Faculty of Mathematics and Natural Sciences, Universitas Gadjah Mada, Sekip Utara Bulaksumur, Yogyakarta, Indonesia 55281)

Abstract: This research highlighted the quality evaluation model for capture fisheries supply chain in Java Southern Coast. The model was developed by using organoleptic testing and a fuzzy inference model. The characteristic of perishable capture fisheries required an appropriate packaging handling during the supply chain. Improper storage methods might bring a result in varied packaging temperature and fish texture quality degradation in each supply chain tier. There was a high need for a quality control method for capture fisheries supply chain. The research objectives were: 1) to identify the quality degradation in each supply chain tier by using organoleptic testing and packaging temperature; 2) to develop a quality evaluation model for capture fisheries by using fuzzy inference. The model could be used to prevent quality degradation during the supply chain. The seven tiers of capture fisheries supply chain were identified as: a fisherman, fish auction, trader, trader (2 days storage), wholesaler, retailer, and consumer. The quality degradation was not evaluated on the tier of consumer due to the research focus on the supply and production. The four types of packaging were evaluated as: an ice cube, gel, pack, and shaved ice. The test material quality was assessed by using organoleptic testing which was taken based on the parameters of eye, gill, mucus, meat, smell, and texture for two types of capture fisheries: Tuna (*Thunnus albacore*) and Skipjack (*Katsuwonus pelamis*). The organoleptic testing indicated that the Styrofoam and ice pack packaging was mostly preferred among six supply chain tiers. Most of the packaging temperature confirmed the relationship with the organoleptic score. The fuzzy membership was developed based on three human senses as vision, smell, and touch. The fuzzy inference rule was developed based on the National Standard of Indonesia: SNI 2729-2013. The input of fish quality parameters is based on organoleptic test parameters such as eyes, gills, mucus, meat, odor, and texture. The output was categorized as good, moderate, and poor quality. The research results indicated that the capture fisheries quality could be evaluated by using a fuzzy inference model. The model could be used to propose a cold chain system in the capture fisheries supply chain.

Keywords: fuzzy inference, quality evaluation, supply chain, organoleptic testing, fish

Citation: Guritno, A. D., M. Ushada, N. E. Kristanti, M. S. Dharmawati, N. A. S. Putro. 2021. The development of quality evaluation model for capture fisheries supply chain in Java southern coast. Agricultural Engineering International: CIGR Journal, 23 (4):183-197.

1 Introduction

Indonesia is the largest archipelago country in the world; in which Indonesia's total sea reaches 70% of its total area (Kementerian Kelautan dan Perikanan [KKP], 2015; 2018). The facts indicate that Indonesia has an enormous potential fisheries production and ranked in 3rd world rank under China and India. The fishery production strength is an essential foundation to support food security

Received date: 2020-01-21 **Accepted date:** 2021-04-14

[*]**Corresponding author:** Adi Djoko Guritno, Ph.D, Department of Agroindustrial Technology, Faculty of Agricultural Technology, Universitas Gadjah Mada, Tel: +62 811254285. Fax:+62 274 551219. E-mail: adidjoko@ugm.ac.id.

and promote the national economy. National fishery production consists of aquaculture fisheries, marine fisheries, and general fisheries. The capture fisheries are one of the fishery sector's leading products that support the country's income and can be globally traded. Based on a research data, the capture fisheries production trend was tended to increase every year and stable during periods of 2011-2016.

The data of KKP (2015) indicated the capture fisheries production reached 5.71 million tons in 2011, increased to 5.83 million tons in 2012, and to 6.12 million tons in 2013. Furthermore, in 2014, the production reached 6.48 million tons in which the increase was not as proportional as 2013. The output in 2015 reached 6.52 million tons and 2016 for 6.83 million tons. It concluded the production of capture fisheries was stable from 2011 to 2016. Sunoko and Huang (2014) stated that Tuna has made an essential contribution to Indonesian capture fisheries. Nurani et al. (2011) stated that Java southern coast has a potential Tuna resource as a part of fisheries management zone of Indian Ocean Fisheries. These facts indicated enormous resources of capture in Java southern coast, which could stimulate the core activities related to logistics in supply chain design, such as: procurement or purchasing, transportation, warehousing, material handling, distribution, recycling, returns, waste disposal, and communications (Waters, 2007). Guritno and Suwondo (2017) explained that the inefficiency in the fish supply chain was caused by several parameters, namely: the auction floor area usage factor (91.67%), the number of traders (75%), and the length of the port (58.33%). The longer chain in supply caused the higher probability of quality degradation in capture fisheries (Guritno and Tanuputri, 2017). Most of these industries usually bought raw materials (fish) from collectors and/or traders. The capture fisheries production activity in Java southern coast increased the complex risk for quality. The preliminary research was done to identify the supply chain strategy of sea-fish capture based on logistics cost structure (Guritno et al., 2018).

Product quality is difficult to be evaluated. Some of the previous studies had modeled the quality based on satisfaction parameters (Ushada and Murase, 2009) and consumer preference (Ushada and Murase, 2011). The characteristic of perishable capture fisheries requires proper handling in temperature packaging during the supply chain. Improper storage methods may bring a result in varied packaging temperature and quality degradation in each supply chain's tiers (Guritno et al., 2016). There is a high need for a qualified evaluation method for capture fisheries supply chain.

The quality of fish can be evaluated by using an organoleptic testing approach. In aquaculture, Mokrani et al. (2018) used organoleptic testing to define the quality of European sea bass and shelf life during their storage in ice. Cléach et al. (2019) used organoleptic testing for fish freshness which was combined with mitochondrial activity for the quality indicator. Jones et al. (2016) used organoleptic testing for flavor enhancement of freshwater farmed barramundi through dietary enrichment with cultivated sea lettuce. Martínez et al. (2018) used organoleptic testing on quality enhancement of smoked sea bass fillets. Based on these studies, it was suggested to use organoleptic testing to monitor capture fisheries quality.

Artificial intelligence has been used to model product quality. Some of the other studies have used the artificial intelligence approach to define the relationships among product quality and capacity-constrained worker (Ushada et al., 2013), workload (Ushada et al., 2015), environmental ergonomics (Ushada et al., 2017), and trust (Ushada et al., 2021).

The fuzzy inference model is an artificial intelligence which consists of three steps. These are fuzzification, rule-based reasoning, and defuzzification. The fuzzification transforms numeric to linguistic fuzzy input. The rule-based system is used for the input reasoning. The defuzzification process is the fuzzification reverse. Fuzzy inference has been applied to some applications in food quality control. Zare and Ghazali (2017) used fuzzy logic model for sardine product quality assessment. Sharma et al. (2018) combined fuzzy and Analytical Hierarchy

Process for sustainable food supply chain management. Raut et al. (2019) applied fuzzy for quality deterioration in fruits and vegetable supply chain. Zhou et al. (2018) applied near-infrared computer vision and neuro-fuzzy model-based feeding decision systems for aquaculture fish. However, none of these models were applicable for capture fisheries during the supply chain.

This research proposed the quality evaluation model in the capture fisheries supply chain by combining organoleptic testing and fuzzy inference model. The research objectives were: 1) to identify the quality degradation in each the supply chain tier by using organoleptic testing and packaging temperature; 2) to develop a quality evaluation model of capture fisheries by using fuzzy inference. The research advantages were to support the prevention of capture fisheries quality degradation during supply chain and logistics in an archipelago country like Indonesia.

2 Material and methods

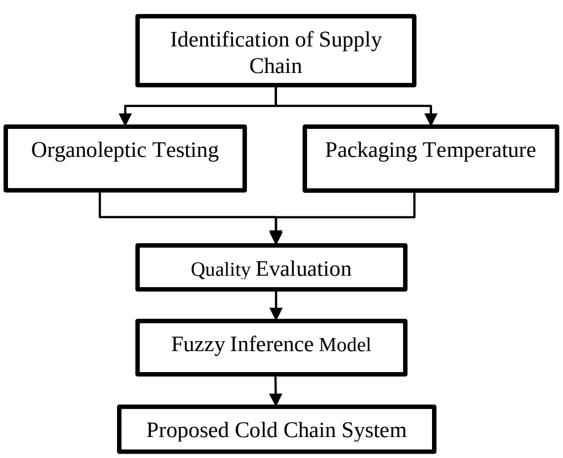


Figure 1 Research methods for quality evaluation model for capture fisheries

Figure 1 indicated the research methods for the quality evaluation model for capture fisheries. The method consists of the following steps:

2.1 Material

The test material quality was evaluated for two types of capture fisheries: Tuna *(Thunnus albacore)* and Skipjack *(Katsuwonus pelamis)*. The selection of these types due to the long and integrated supply chain in Java southern coast (Guritno et al., 2018)

2.2 Packaging model

Table 1 Packaging model

Packaging Model	Packaging Code
Styrofoam box with the ice cube	K
Styrofoam box with the ice gel	A
Styrofoam box with the ice pack	B
Styrofoam box with the shaved ice	C

Table 1 indicated the packaging types. Packaging type 'K' was the control which used a Styrofoam box with water and ice. 'A' was a packaging which used a Styrofoam box with the ice gel. 'B' was a packaging which used a Styrofoam box with the ice pack. 'C' was a packaging which used a Styrofoam box with the shaved ice.

2.3 Organoleptic testing

Organoleptic testing was pursued on three Fish Auction Site (FAS) in three coastal area districts of Yogyakarta Province. They are: Bantul district: FAS 'Depok Beach', Gunung Kidul district: FAS 'Pelabuhan Perikanan Pantai Sadeng' and Kulon Progo District: FAS 'Trisik Beach'. The respondents were decided on one actor for each tier in each FAS. A total of eighteen respondents were acquired in organoleptic testing.

Table 2 Organoleptic testing

Human Sensory Parameter	Classification	Specification
	Fresh	Eye, Gill, Mucus, Meat
Vision	Normal	
	Pasty	
	Fresh	Smell
Smell	Neutral	
	Sour	
	Elastic	Texture
Touch	Less elastic	
	Not elastic	
Quality	Good	Quality class
	Medium	
	Poor	

Table 2 indicated the organoleptic testing. It was developed based on three human senses: 1) Vision; 2) Smell; 3) Touch. The human senses of vision were classified into three classifications: 1) Fresh; 2) Normal; 3) Pasty. The human senses of smell were classified into three classifications: 1) Refreshing; 2) Neutral; 3) Sourness. The human senses of touch were classified into three) classifications: 1) Elastic; 2) Less elastic; 3) Not elastic. The input parameters were based on the parameter of organoleptic testing as Eye, Gill, Mucus, Meat, Smell, and Texture. The quality was defined as the freshness quality of the fish class and then classified as good, medium, and poor quality.

2.4 Fuzzy inference model

Fuzzy inference rules were set to classify the capture fisheries quality based on the relationships among the eye, gill, mucus, meat, smell, and texture of fish. In this study, an open-source software; Fuzzy Inference System Professional (Fispro) version 3.5 was used (Guillaume and Charnomordic, 2011;2012).

The general process of the fuzzy inference was performed on three processes as fuzzification, rule-based system, and defuzzification. The fuzzification process was a process that converts a numerical value of the parameter of organoleptic testing as eye, gill, mucus, meat, smell, and texture into a fuzzy input (linguistic value). The rule-based system was used to formulate the conditional statements that comprise the fuzzy logic. The defuzzification process was the fuzzification reverse process. It converts the fuzzy value into a crisp value of good, medium, and poor quality of captured fish.

2.5 Capture fisheries supply chain in Java southern coast

The supply chain identification was intended to identify the change of ownership and capture fisheries management in each supply chain tier. The change of ownership generated significant consequences on risk, quality management, and logistics cost. The general profile of capture fisheries in the Southern Coast of Java was indicated in the Figure 2. The supply chain of capture fisheries in Southern Coast of Java consisted of seven tiers. The tiers were classified into five primary stakeholders: fisherman, collector, trader, industry, retailer, and consumer. The quality degradation was not evaluated on the tier of consumer due to the research focus on the supply and production.

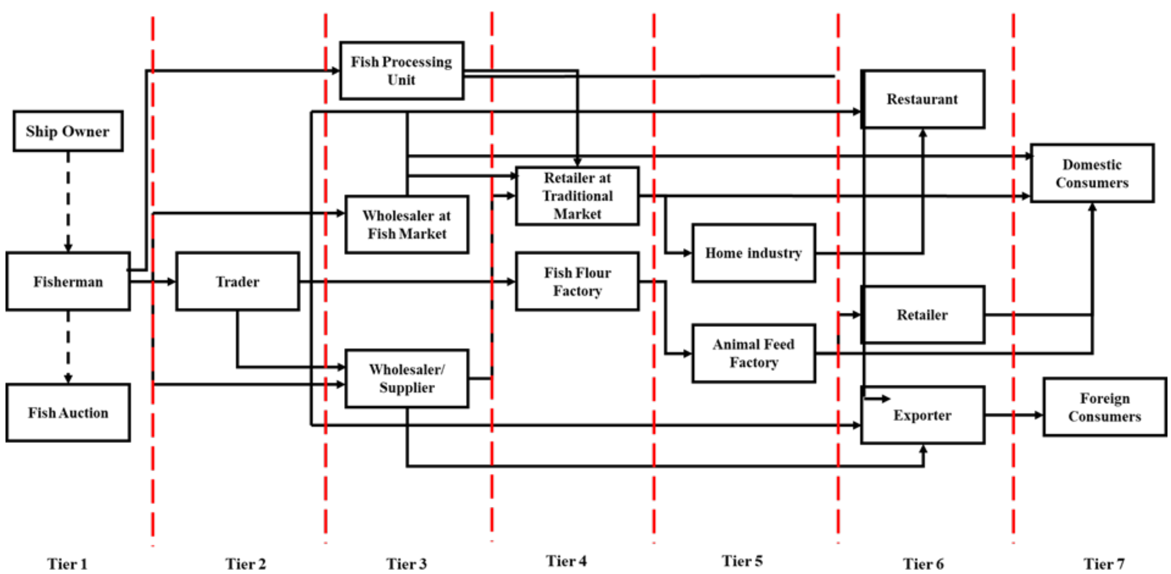


Figure 2 The capture fisheries supply chain in Java southern coast, Indonesia

3 Results and discussions

3.1 Supply chain

Fishermen are defined as captains and crew in charge of fishing the captured fish. The captured fish is shared with the ship owner by a certain amount based on the agreement. The fisherman owned the ship with the small measured Gross Tonnage (GT), below 20 GT. The ship, which is more than 30 GT, is owned by the ship owner and is rent to fisherman.

The rental cost is paid after the fisherman sold their capture fish to the collectors. The duration time is varied based on the GT of the ship. The ship with the small GT is known as Conventional Speedboat or in Bahasa Indonesia it is called as Perahu Motor Tarik (PMT). The PMT has an average sailing time of 1 day, and the ship with the size of GT can sail within 10 to 11 months.

Collectors are defined as stakeholders who buy fish from fishermen. Some of the collectors buy wholesale fish and others based on their consumers demand. In fact, several collectors provide funds to fishermen for fishing operational and logistics. As consequences, the fishermen must sell their captured fish to the collectors; while the collectors provide the appropriate payment to the fishermen based on the initial agreement. Traders are stakeholders who sell fish in the market or traditional market. They buy fish from collectors, and some of them sell fish to the processing industry to produce semi-finished or finished products. Some examples of these industries are fish meal processing, nugget processing, and smoked fish processing.

Up to date, the function of FAS has transformed from distribution to warehousing since the less tender process of capture fisheries between the fisherman and the consumer. Some of their functions are focus on weighing and inventory of the capture fisheries. Price is determined based on the agreement between fisherman and buyers (In this term, they could be the collectors and the ship owners).

In fact, some of the collector acts as the ship owners who support the fishermen’s logistic cost. The logistic cost is used for the essential profit sharing. The sharing is defined as half of the net margin. Subsequently, the collector pursued the quality grading based on the fish size and quantity. The grading determines the next step in processing the capture fisheries results. The premium quality like export-oriented Tuna is processed in the canning and frozen fish. The medium quality Tuna is processed into the local fermented product in market, known as "pindangan". For fish other species, which less preferred by the export market; are processed to the local market. Some examples of local market are fish market in the surrounded port, traditional market and supermarket.

3.2 Organoleptic testing

Table 3 Organoleptic testing (6 respondents for each 3 coastal area); scale 1 to 9

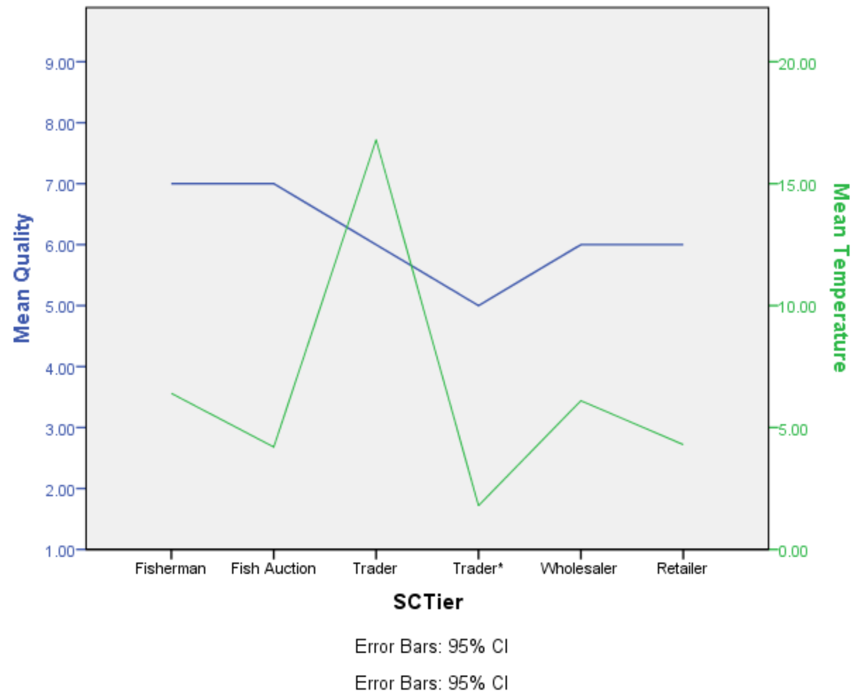
Tiers	Specification	Tuna (*Thunnus albakocore*)				Skipjack (*Katsuwonus pelamis*)			
		K	A	B	C	K	A	B	C
Fisherman	Eye	6	8	8	8	6	7	8	7
	Gill	7	7	8	7	6	7	7	7
	Mucus	7	7	7	7	7	7	7	6
	Meat	6	9	7	7	6	6	7	6
	Smell	6	8	9	6	7	7	7	6
	Texture	7	7	8	7	8	8	8	7
	Mode	7	7	8	7	6	7	7	7
	Average	6,4	7,7	7,8	7,0	6,7	7,0	7,3	6,5
	Standard Deviation	0,6	0,8	0,8	0,6	0,8	0,6	0,5	0,5
Fish Auction	Specification	K	A	B	C	K	A	B	C
	Eye	6	8	8	8	6	7	8	7
	Gill	7	7	7	7	6	7	7	7
	Mucus	7	7	7	7	7	7	7	6
	Meat	6	9	7	7	6	6	7	6
	Smell	6	8	9	6	7	7	7	6
	Texture	7	7	8	7	8	8	8	7
	Mode	7	7	7	7	6	7	7	7
	Average	6,4	7,7	7,7	7,0	6,7	7,0	7,3	6,5
	Standard Deviation	0,6	0,8	0,8	0,6	0,8	0,6	0,5	0,5

	Specification	K	A	B	C	K	A	B	C
Trader	Eye	8	8	8	7	5	6	6	5
	Gill	7	7	5	6	5	7	7	6
	Mucus	7	7	7	7	7	6	7	6
	Meat	6	8	6	8	7	5	6	5
	Smell	6	7	7	6	6	6	6	6
	Texture	6	8	8	8	7	7	6	7
	Mode	6	8	8	7	7	6	6	6
	Average	6,7	7,5	6,8	7,0	6,2	6,2	6,3	5,8
	Standard Deviation	0,8	0,5	1,2	0,9	1,0	0,8	0,5	0,8
Trader (two days storage)	Specification	K	A	B	C	K	A	B	C
	Eye	3	7	3	6	3	4	4	7
	Gill	5	5	5	5	4	4	5	5
	Mucus	5	7	6	6	4	5	3	4
	Meat	6	5	6	3	5	5	5	5
	Smell	5	5	6	6	5	5	4	6
	Texture	4	6	7	6	6	4	5	6
	Mode	5	5	6	6	4	4	5	5
	Average	4,7	5,8	5,5	5,3	4,5	4,5	4,3	5,5
	Standard Deviation	1,0	1,0	1,4	1,2	1,0	0,5	1,0	1,0
Wholesaler	Specification	K	A	B	C	K	A	B	C
	Eye	3	8	7	6	3	6	6	4
	Gill	7	7	7	6	4	6	6	4
	Mucus	6	7	6	6	5	5	3	4
	Meat	6	6	6	5	3	5	5	7
	Smell	6	6	6	6	6	6	6	6
	Texture	6	7	7	7	6	6	6	6
	Mode	6	7	7	6	3	6	6	4
	Average	5,7	6,8	6,5	6,0	4,5	5,7	5,4	5,2
	Standard Deviation	1,4	0,8	0,5	0,6	1,4	0,5	1,2	1,3
Retailer	Specification	K	A	B	C	K	A	B	C
	Eye	3	8	7	3	3	5	4	4
	Gill	5	6	7	6	5	5	5	5
	Mucus	6	7	6	6	5	5	3	7
	Meat	6	6	6	4	4	5	4	5
	Smell	6	6	6	6	6	6	5	6
	Texture	5	7	7	6	6	6	5	6
	Mode	6	6	7	6	5	5	5	5
	Average	5,2	6,7	6,5	5,2	4,8	5,3	4,3	5,5
	Standard Deviation	1,2	0,8	0,5	1,3	1,2	0,5	1,0	1,0

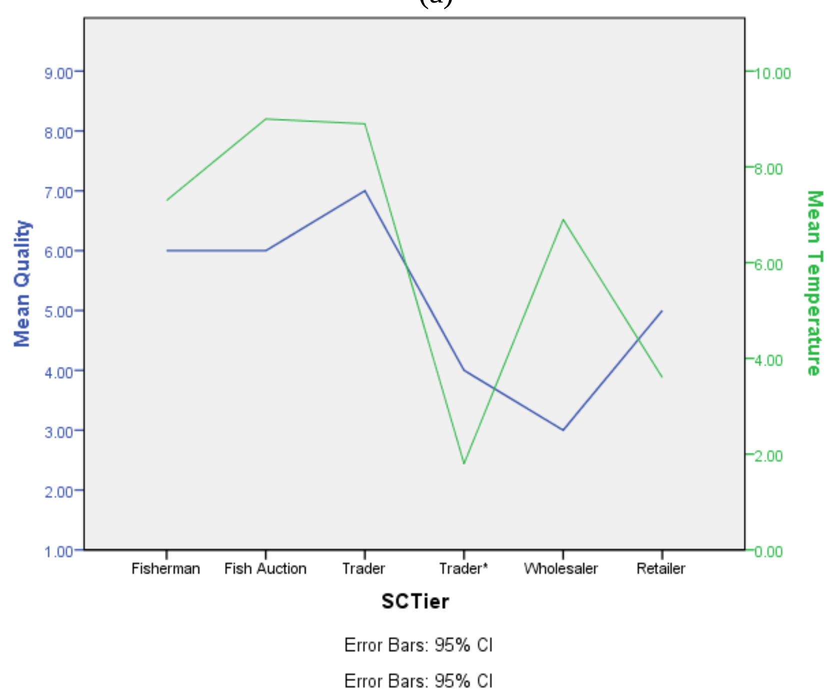
Table 3 indicated the packaging organoleptic test on each supply chain tier. Based on the mode values, the type B packaging was the most preferred for Tuna in the fisherman's tier. The mode value was confirmed by the high value of average (7.8) and standard deviation of 0.8. For Skipjack, the entire of packaging type indicated no difference among the tires based on the mode values.

Based on the mode values, the entire types of packaging was preferred in the fish auction tier. In the trader tier, packaging type A and B were mostly preferred by Tuna respondents. The type K packaging was mostly preferred for Skipjack. In the trader tier with two days of storage, indicated no difference among packaging types. In the wholesaler tier, the entire packaging indicated no difference for Tuna and Skipjack. In the retailer tier, the packaging type B was mostly preferred for Tuna and there was no difference for Skipjack.

Figure 3 indicated the comparison chart results of temperature measurements with fish quality on various packaging models in the fisherman, fish auction, trader, trader* (with two days of storage), wholesaler, and retailer tiers. Temperature measurements were carried out using a food pro-thermometer. Food pro-thermometer used the method of measuring infrared energy radiation. Three fish samples were evaluated for each packaging.



(a)

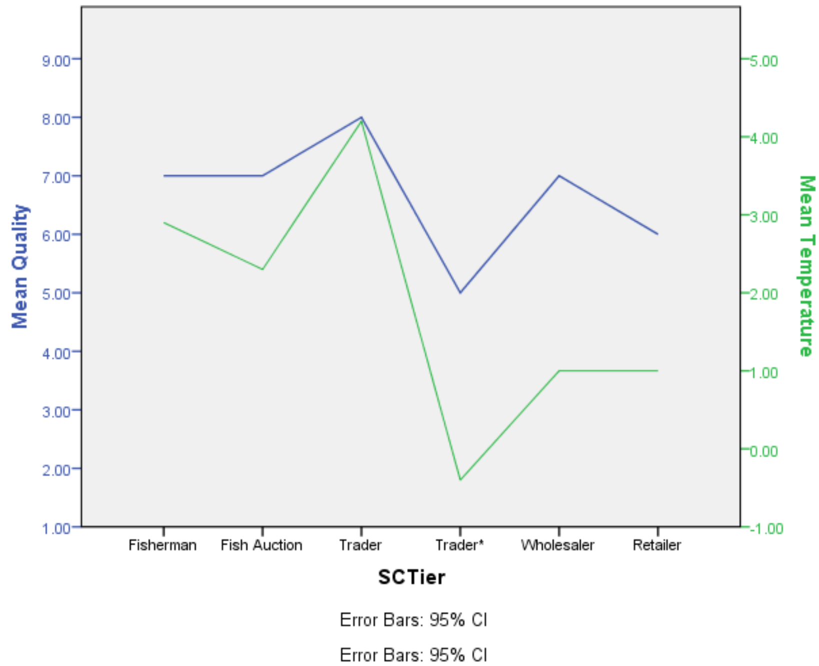


(b)

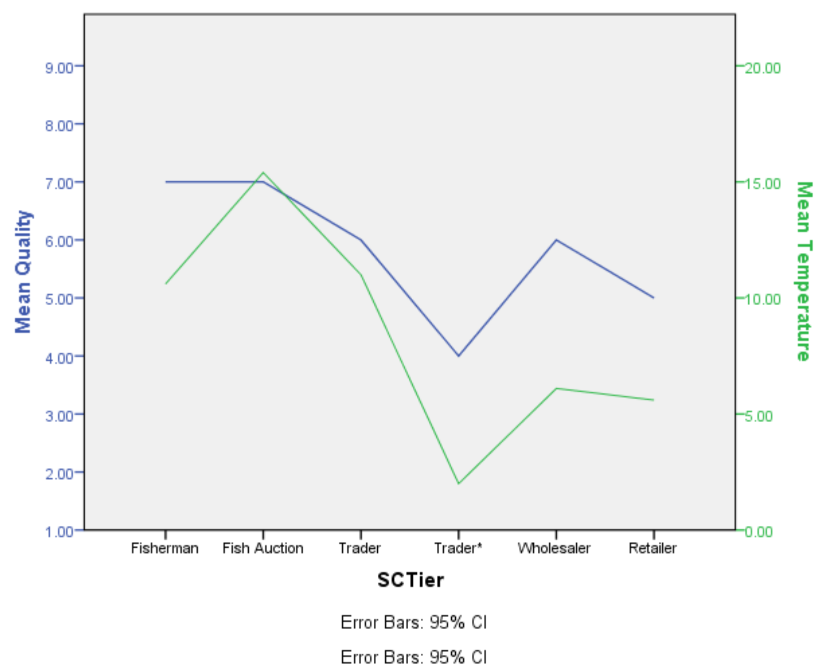
(a) Tuna; (b) Skipjack

Figure 3 Comparison of temperature and fish quality (Packaging model K-type)

Figure 3a indicated the highest temperature in trader tier. The highest organoleptic score confirmed the relationship with the highest of temperature for Skipjack (Figure 3b). Figure 3 indicated the lowest temperature both for Tuna and Skipjack in tier of trader*.



(a)



(b)

(a) Tuna; (b) Skipjack

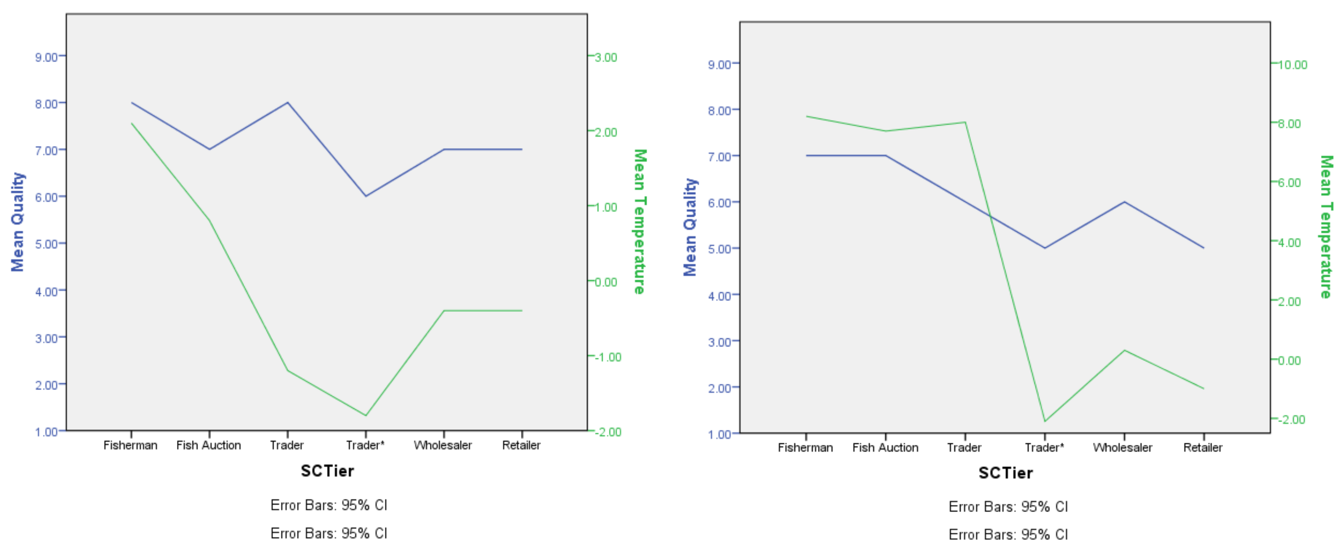
Figure 4 Comparison of temperature and fish quality (Packaging model A-type)

Figure 4 indicated the highest temperature in trader for Tuna and fish auction tiers for Skipjack. It stated the confirmation between the highest temperature and score of organoleptic. Figure 4 showed the lowest temperature on trader* indicated for both Tuna and Skipjack.

Figure 5 indicated the highest temperature for packaging B in the fisheries tier for Tuna while the trader tier for Skipjack. The lowest temperature was confirmed for both Tuna and Skipjack in trader tier*.3.3 Fuzzy inference model

The fuzzy membership function was developed based on three human senses, as vision, smell, and touch. The human vision senses were classified into three classes as: fresh, normal, and pasty (Table 4). The human smell senses were classified to three classes as: fresh, neutral, and sourness. The human touch senses were classified to three classes as: elastic, less elastic, and not elastic. The fuzzy rule was developed based on National Standard of Indonesia SNI 2729-2013. The input parameters were the organoleptic testing parameters, as: eye, gill, mucus, meat, smell, and texture.

The human vision was classified based on eye, gill, mucus, and meat. The human smell was classified based on smell. The human touch was classified based on texture. The fuzzy model's output was the freshness quality of fish as: good, medium, and poor (Table 5). The entire values of the parameter testing ranged from the value of 1 to 9. The six parameters were classified into three human senses. The packaging type was not taken in the model because it focuses on human senses.



(a) Tuna; (b) Skipjack

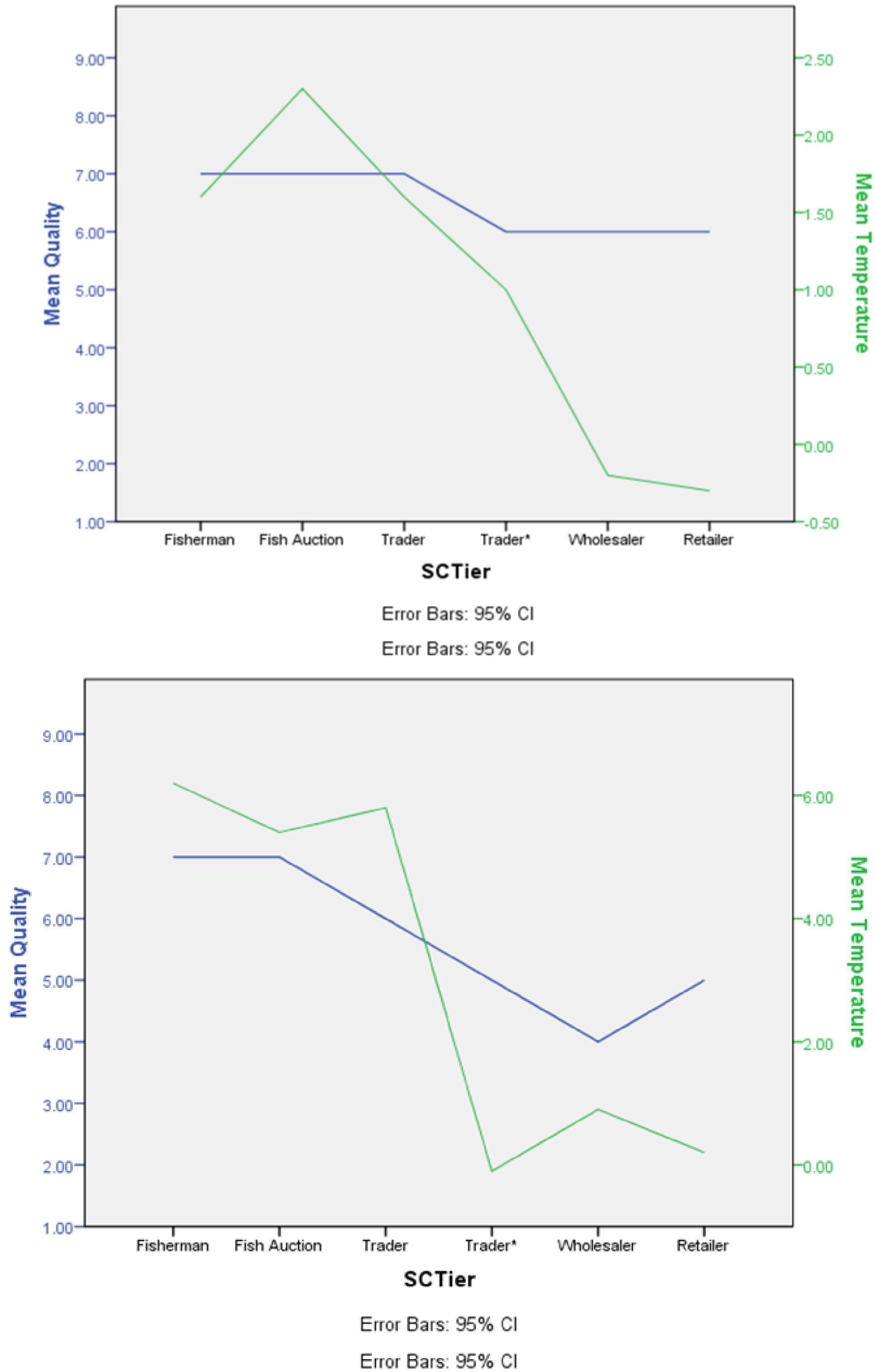
Figure 5 Comparison of temperature and fish quality (Packaging model B-type)

Table 4 The input of fuzzy membership

Human Senses Parameter	Membership Function	Ranges of Value	Sources of Parameters
	Fresh	7 to 9	Eye, gill, mucus, meat
Visual	Normal	3 to 8	
	Pasty	1 to 4	
	Fresh	6 to 9	Smell
Smell	Neutral	4 to 7	
	Sour	1 to 5	
	Elastic	6 to 9	Texture
Touch	Less elastic	3 to 7	
	Not elastic	1 to 4	

Table 5 The output of fuzzy membership

Parameters	Membership Function	Range of Values
	Good	6 to 9
Quality	Medium	3 to 7
	Poor	1 to 4



(a) Tuna; (b) Skipjack

Figure 6 Comparison of temperature and fish quality (Packaging model type-C)

Figure 6 indicated the highest temperature for packaging C on the tier of the fish auction for Tuna and trader for Skipjack. The lowest temperature was shown on the retailer for Tuna and trader* for Skipjack.

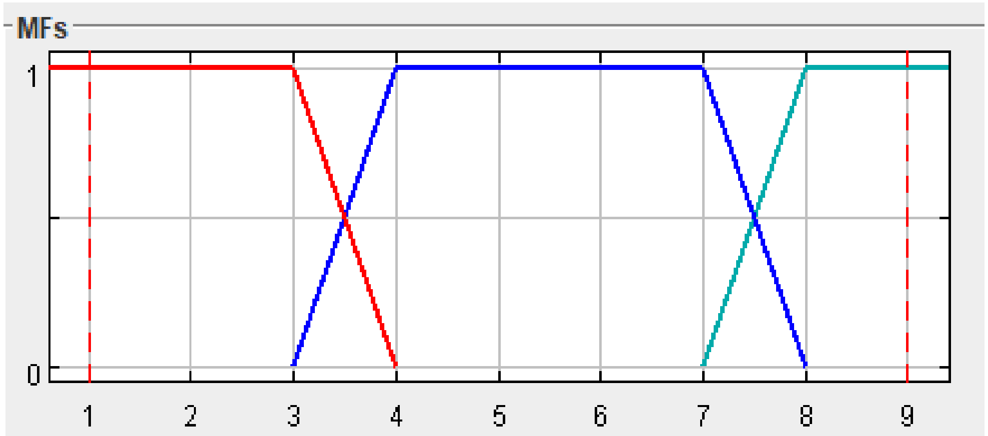


Figure 7 Fuzzy membership for senses of visual; (Pasty was indicated by red color, normal by dark blue color and fresh by light blue color)

Figure 7 indicated the fuzzy membership function of the input of the visual parameter. The pasty criteria ranged 1 to 3, while fuzzy values ranged 3 to 4. The normal criteria ranged 4 to 7, while fuzzy values ranged 3 to 4 and 7 to 8. The fresh criteria ranged 8 to 9, while fuzzy values ranged 7 to 8.

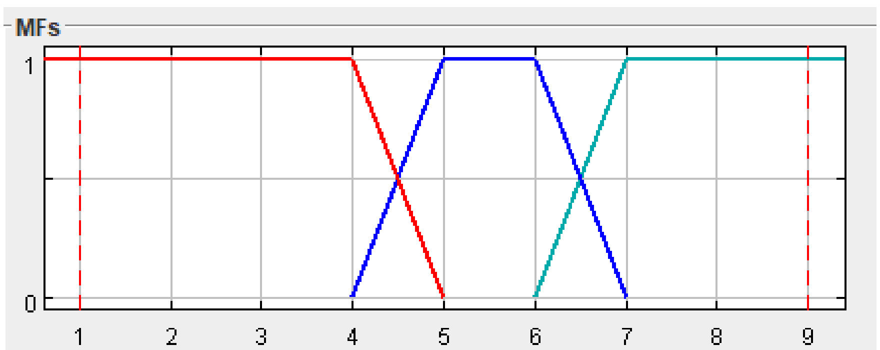


Figure 8 Fuzzy memberships for smell senses (Sour was indicated by red color, neutral by dark blue color and fresh by light blue color)

Figure 8 indicated the Fuzzy membership for the input of smell parameter. The criteria of sour ranged from to 1 and 4, while fuzzy values ranged from 4 to 5. The neutral criteria ranged 5 to 6, while fuzzy values ranged 4 to 5 and 6 to7. The criteria of freshness ranged from 7 to 9, while fuzzy values ranged 6 to 7.

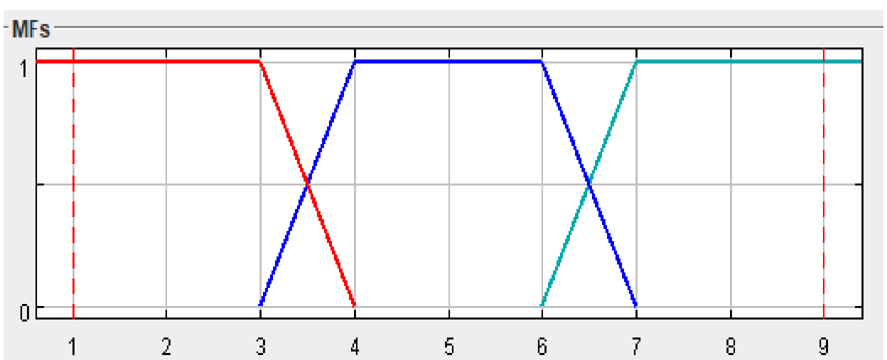


Figure 9 Fuzzy membership for senses of touch (Not elastic was indicated by red colour, less elastic by dark blue colour and elastic by light blue colour)

Based on the classification of each parameter, the rule was developed in Table 6 as follow:

Table 6 Fuzzy membership rule

No	Input			Output
	Senses of Visual	Senses of Smell	Senses of Touch	Quality
1	Fresh	Fresh	Elastic	Good
2	Fresh	Fresh	Less Elastic	Medium
3	Fresh	Fresh	Not Elastic	Medium
4	Fresh	Neutral	Elastic	Good
5	Fresh	Neutral	Less Elastic	Poor
6	Fresh	Neutral	Not Elastic	Poor
7	Fresh	Sour	Elastic	Poor
8	Fresh	Sour	Less Elastic	Poor
9	Fresh	Sour	Not Elastic	Poor
10	Normal	Fresh	Elastic	Good
11	Normal	Fresh	Less Elastic	Poor
12	Normal	Fresh	Not Elastic	Poor
13	Normal	Neutral	Elastic	Good
14	Normal	Neutral	Less Elastic	Poor
15	Normal	Neutral	Not Elastic	Poor
16	Normal	Sour	Elastic	Poor
17	Normal	Sour	Less Elastic	Poor
18	Normal	Sour	Not Elastic	Poor
19	Pasty	Fresh	Elastic	Good
20	Pasty	Fresh	Less Elastic	Medium
21	Pasty	Fresh	Not Elastic	Poor
22	Pasty	Neutral	Elastic	Poor
23	Pasty	Neutral	Less Elastic	Poor
24	Pasty	Neutral	Not Elastic	Poor
25	Pasty	Sour	Elastic	Poor
26	Pasty	Sour	Less Elastic	Poor
27	Pasty	Sour	Not Elastic	Poor

Figure 9 indicated the Fuzzy membership of input of touch parameter. The not elastic criteria ranged from 1 to 3, while fuzzy values ranged from 3 to 4. The criteria of less elastic ranged 4 to 6, while fuzzy values ranged 3 to 4 and 6 to 7. The criteria of elastic ranged 7 to 9, while fuzzy values ranged 6 to 7.

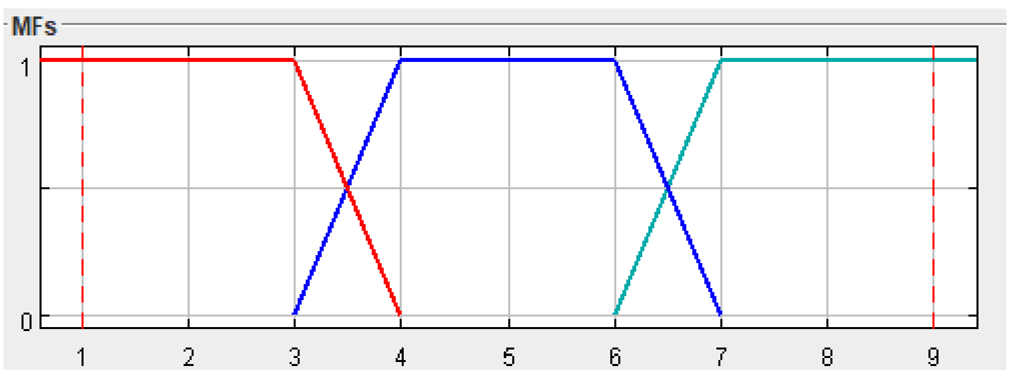


Figure 10. Fuzzy membership for capture fisheries quality (Poor was indicated by red color, medium by dark blue color, and good by light blue color)

Figure 10 indicated the fuzzy membership of output of quality evaluation. The criteria of poor ranged from 1 to 3, while fuzzy values ranged from 3 to 4. The criteria of medium-ranged 4 to 6; while fuzzy values ranged 3 to 4 and 6 to 7. The criteria of good ranged from 7 to 9; while fuzzy values ranged from 6 to 7.

3.4 Recommendation for cold chain system

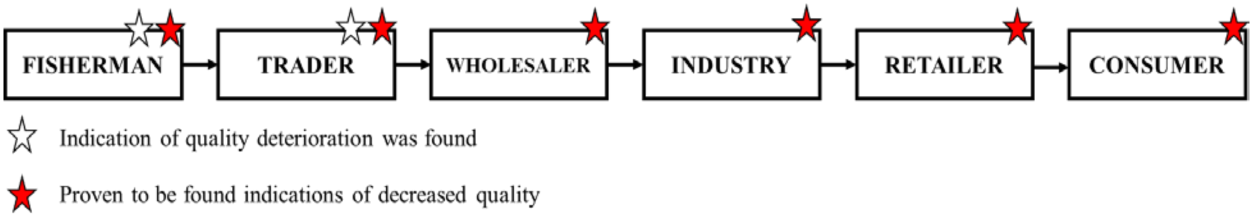


Figure 11 Quality degradation in the capture fisheries supply chain

The indicator of quality degradation can be identified from the tier of fishermen as the red-eye fish due to inappropriate capture method. On the other side, many fish were found to be stomach blasts, pasty gills, and contained mucus due to inappropriate method of storage in the sea (Figure 11).

Based on these findings; the length of time in sailing and material handling were become the critical points in quality management. Most of quality degradation was identified in the fisherman tier due to the freezer unavailability. In facts, the fisherman utilized the ice block and water with stacked storage. In the local traditional market, the fish could be found with the red-concave eye condition, and the mucus gill with white clots.

Based on the observation, capture fisheries supply chain in Java southern coast has not yet fully implemented the cold chain system or known as non-cold chain system (Figure 12). Figure 12 proposed the cold chain system for 6 tiers capture fish supply chain. Fisherman, wholesaler and fish processing unit tiers were recommended to use freezer. Four fish market, traditional market, retailer and consumer tiers were recommended to use the alternatives packaging of Styrofoam and icepack based on the research result.

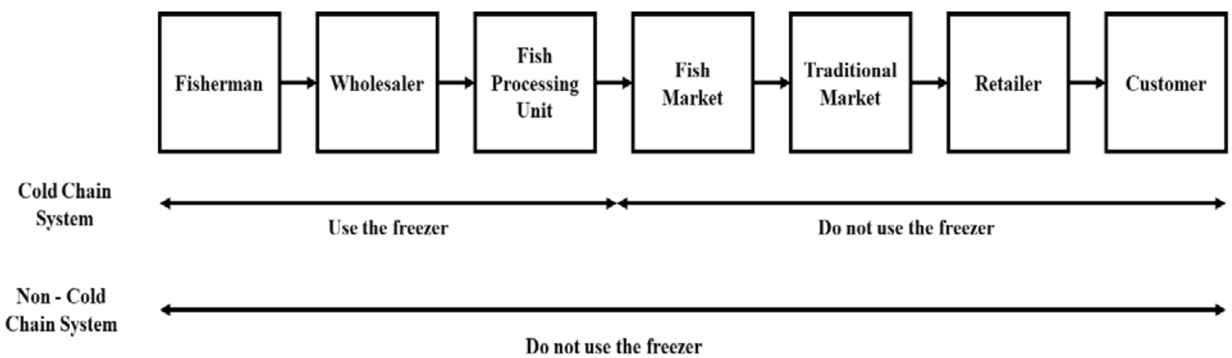


Figure 12 The proposed cold chain system on the capture fisheries supply chain in the Java southern coast

Most of the ports in Java southern coast have implemented non-cold chain system in the conventional way. On the other side, some ports have implemented the non-cold chain system partially. Some limited fishermen have used freezer. In this circumstance, the collectors provided the freezer to collect supply from the fishermen in frozen form. Besides, the ports have provided the rental freezer for capture fisheries to support the cold chain system implementation.

However, most of the cold chain system implementation is for export-oriented tier. The other tiers such as traditional market and retailer did not use the freezer in the storage. They used the conventional ways of using iced and water due to high cost investment of freezer. This indicated the low implementation of cold chain system which caused the quality degradation of the capture fisheries in Java southern coast. The recommended packaging of Styrofoam and icepack could be used as alternatives for freezer; especially for fish market, traditional market, retailer and consumer tiers. In the short term, the government should encourage the knowledge dissemination for fish market, traditional market, retailer and consumer to utilize cold chain system tiers. In the long term, the government of Republic Indonesia strongly increased the production of fish farming to maintain the environmental sustainability.

4 Conclusion

The quality of capture fisheries supply chain was evaluated as fisherman, fish auction, trader, trader* (2 days of storage), and wholesaler. The four (4) types of packaging were used in this research. The quality was evaluated using organoleptic testing based on parameters of eye, gill, mucus, meat, smell, and texture on four (4) types of packaging and two (2) types of Tuna and Skipjack. The packaging type B with Styrofoam and ice pack was most preferred based on organoleptic testing. Subsequently, the relationship between organoleptic score and packaging temperature were identified. Most of the packaging temperature had the linear relationship with the organoleptic score. Fuzzy rule was developed based on National Standard of Indonesia SNI 2729-2013. The input parameters were developed based on parameter of organoleptic testing as Eye, Gill, Mucus, Meat, Smell and Texture. The output of fuzzy membership was categorized as good, medium, and poor. The research results indicated that the quality evaluation of capture fisheries could be monitored by using fuzzy inference model.

The recommended packaging of Styrofoam and icepack could be used as alternatives for freezer; especially for fish market, traditional market, retailer, and consumer tiers. This method could be used to prevent the quality degradation in the capture fisheries in Java southern coast. In the short term, the government should encourage the knowledge dissemination for fish market, traditional market, retailer and consumer tiers to utilize cold chain system. In the long term, the government of Republic Indonesia strongly increased the production of fish farming to maintain the environmental sustainability. This research entailed the future work for testing the fuzzy inference model compared with the organoleptic test.

Acknowledgment

The writers wish to acknowledge financial support from Ministry of Research, Technology and Higher Education of the Republic of Indonesia by 2019 Universitas Gadjah Mada Grants of “Penelitian Terapan Unggulan Perguruan Tinggi” No. 2769./UN1.DITLIT/DIT-LIT/LT/2019.

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