Model of strategy quality improvement of tuna and other species in the cold chain system (FUZZY expert systems approach)

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Abstract. Based on Decree of the Minister of Marine Affairs and Fisheries No. KEP.45/MEN/2011 regarding the Estimation of Fish Resources Potency in Fisheries Management Areas in Republic of Indonesia (WPPNRI), Indonesia has eleven WPPNRIs with total potencies of 6.520.100 tons year^{-1}. Maluku is located on three WPPNRIs namely WPPNRI 714, 715 and 718 with potencies of 1.729.100 tons year^{-1} or approximately 26.52% of the total national fish potencies, therefore Maluku is highly potential as an exporter of Tuna and other species. From the aspect of quality, fish has perishable characteristics so the product life cycle becomes shorter. The promptness and accuracy of handling becomes a very important element. The key factor is cold chain system, which is able to guarantee the quality of TTC since catching to export. The quality of TTC export should meet international standards, regional standards (the importing country) and Indonesian national standard (SNI). The question now is, how TTC cold chain system in Maluku is able to meet TTC export grade according to the three standards mentioned above. It requires a model of quality improvement strategy of TTC in Maluku to meet the TTC export standards. This study aims to formulate a model of quality improvement strategy in the TTC cold chain system in Maluku. The method used is Fuzzy Expert System (FES) with a combination of fuzzy logic and weight product. There are two inputs used in this process, namely the variables of quality of fish and fish processing. The output generated is several quality improvement strategies of fish and its processing. From the analysis results, after the quality improvement in the cold chain system according the recommendation from FES, grade A increased by 6% and grade B by 3%, meaning that the total TTC export grade (grade A and grade B) increased by 9% compared to before the quality improvement.
Key Words: tuna and other species, quality, Fuzzy expert systems, weight product, Maluku.

Introduction. Tuna is one of the leading sectors of fisheries in Indonesia. The top five countries producing canned tuna in the world is dominated by the ASEAN countries, namely Thailand, Vietnam, Philippines, Ecuador and Indonesia. The five countries dominate 97.53 percent of the world market share of canned tuna (Aquafind 2010). The growth of tuna export volume in Indonesia continues to increase significantly, almost 60% of tuna exports in Indonesia is in the form of fresh and frozen tuna, the export volume of tuna quarterly in 2014 amounted to 32.86 thousand tons, significantly increased by 11.36%, in the first quarter in 2015 became 36.56 thousand tons (MMAF 2015). Based on Decree of the Minister of Marine Affairs and Fisheries No. KEP. 45/MEN/2011 regarding the Estimation of Fish Resources Potency in Fisheries Management Areas in Republic of Indonesia (WPPNRI), Indonesia has eleven WPPNRIs with total potencies of 6.520.100 tons year^{-1}. Maluku is located on three WPPNRIs namely WPPNRI 714, 715 and 718 with potencies of 1.729.100 tons year^{-1} or approximately 26.52% of the total national fish potencies, therefore Maluku is highly potential as an exporter of tuna and others species [(tuna, tongkol and cakalang in Indonesian - TTC); tuna (yellowfin tuna - *Thunnus albacares*, southern bluefin tuna - *Thunnus maccoyii*, bigeye tuna - *Thunnus obesus*, albacore - *Thunnus alalunga*), mackerel tuna (*Euthynnus affinis*) and skipjack tuna (*Katsuwonus pelamis*) in English] and National Fish Barn.

The quality and safety have become global standard that must be fulfilled. Internationally, fish export requirements should meet the requirements of the World Health Organization (WHO) and Food and Agriculture Organization (FAO) summarized in the CODEX concerning general principles of food hygiene and safety, which is issued by Codex Alimentarius Commission (FAO 2015).

From the aspect of quality, fish has perishable characteristics so the product life cycle becomes shorter. The promptness and accuracy of handling becomes a very important element. The key factor is cold chain system, which is able to guarantee the quality of TTC since catching to export. The quality of TTC export should meet international standards, regional standards (the importing country) and Indonesian national standard (SNI). To solve the problem, it requires a concept model of cold chain system integrated from catching to consumption (from sea to table) or in other words, the cold chain system must guarantee the fulfillment of quality standards for export of TTC which are intact and integrated from cacthcing/fish hold in a fishing vessel, demolition, processing/production, to storage and distribution (Lailossa et al 2010). The principle of cold chain system can be seen in Figure 1.

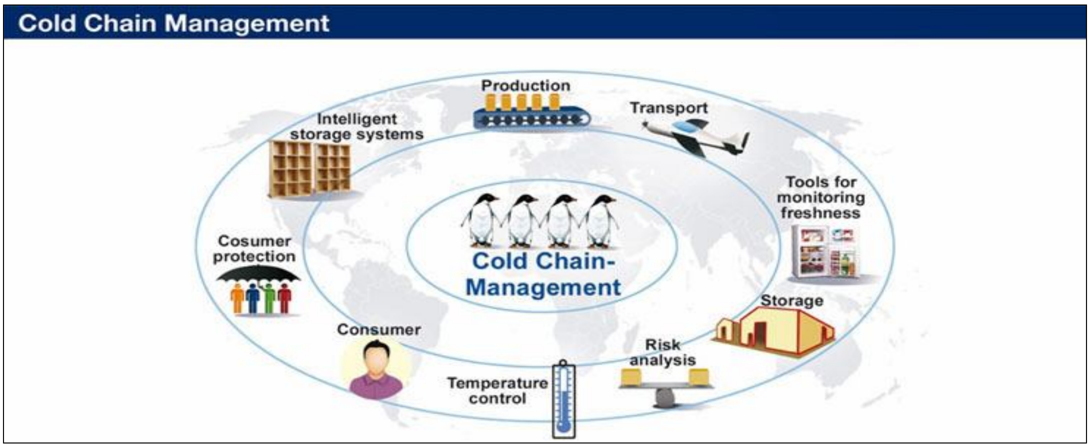


Figure 1. Cold chain management (http://www.farmavera.com.tr/dosyalar/slider/Diagram_coldchain.jpg).

From the results of previous studies (Lailossa 2015a, b), there are several factors that cause the decline of the quality of TTC in Maluku, among others, TTC handling techniques when catching, TTC fish slaughter, technical handling and storage of fish on vessel, sanitation and hygiene equipment and vessel environment, technical transfer and handling of fish from vessel to fish landing ports, storage and processing techniques of fish according to the standards. There are three important vertices in the cold chain system, which greatly affect the quality of TTC exports in Maluku, namely, handling process of TTC quality in the vessel, handling and storage in the fishing port or fish landing port, and processing and packaging in Fish Processing Unit (Lailossa 2015b). The question is, how TTC cold chain system in Maluku is able to improve export quality grade of TTC in Maluku in accordance with the standards that have been set above. There are some National Standardization of Indonesia (SNI) documents that are used as a standard of the quality of TTC (Table 1).

Fuzzy logic is a method that is able to represent uncertainty, vagueness, inaccuracy, lack of information and partial truths. There are several reasons why many people use fuzzy logic (Singh et al 2013; Hozairi & Ahmad 2015) including: [1] fuzzy logic is able to model complex nonlinear functions, [2] fuzzy logic can develop and apply the experiences of experts directly, [3] fuzzy logic is easily combined with other methods to build the system, [4] fuzzy logic is easily developed and applied. While there are many studies related to the development of fuzzy logic combined with some MADM methods (El-Wahed 2008; Nguyen et al 2014; Igoulalene et al 2015; Shidpour et al 2016).

Fuzzy expert system is an expert system using fuzzy calculation in which rule-based and knowledge-based are based on one's expertise, which is used to assess the importance of each attribute. Expert system uses knowledge base as a rationale. Knowledge base consists of a number of rules arranged systematically and specifically, the central processing is the inference engine, which is an application design that serves to provide questions and receive input from the user, then perform logic process according to the available knowledge base, to further generate output in the form of a conclusion or decision (Torlak et al 2011; Sikchi et al 2013; Shidpour et al 2016).

Table 1

Some National Standardization of Indonesia (SNI) documents that are used as a standard of the quality of TTC

SNI Code	*Standard*
SNI 2346 : 2011	Guide for sensory test in fishery product
SNI 7501 : 2009	The maximum limit chemical contamination
SNI 7387 : 2009	Heavy metal limits
SNI 7388 : 2009	The maximum limit of microbial contamination in food
SNI 4104 : 2015	Frozen tuna loin (revision SNI. 4104.2006)
SNI 4110 : 2014	Frozen fish (revision SNI. 4110.2006)
SNI 4872 : 2015	Ice for handling and processing fish
SNI 8087 : 2014	Good handling process on the boat
SNI 8088 : 2014	Unloading fresh fish handling from the fishing boat in the harbor
SNI 8089 : 2014	Unloading frozen fish from the fishing boat in the harbor
SNI 8090 : 2014	Fresh fish handling facility on the hold of fishing boat
SNI 8091 : 2014	Frozen fish handling facility on the hold of fishing boat

This study aims to produce a conceptual model of TTC quality determination and to determine improvement strategy in the cold chain system in order to improve the quality of TTC export grade in Maluku. The benefits expected from the research is as information for the user or enterprise in the decision making to improve the quality gradually and continuously (continually improvement). Fuzzy Expert System (FES) with a combination of fuzzy logic and product weight, is expected to deal with ambiguity, uncertainty and dynamic properties of the variables of TTC quality determination. Combination of Fuzzy Logic and Weighted Product (F-WP) includes Group Decision Support System (GDSS). GDSS is used for decision-making in groups where the decision cannot depend on one's expertise (expert system) only, but also the input of each criterion, remain to be resolved by the fuzzy set so that the decision taken is increasingly rigorous and unbiased, then the fuzzyfication and defuzzyfication process of the system will be able to determine the quality of TTC in detail. Several studies conducted use Fuzzy-Weighted Product (F-WP) method (Purnomo 2008; Nurmahaludin & Cahyono 2015).

Material and Method. Based on the purposes of this study, the method used to determine the quality improvement strategy of TTC is Fuzzy expert system with a combination of fuzzy logic and weight product (Figure 2).

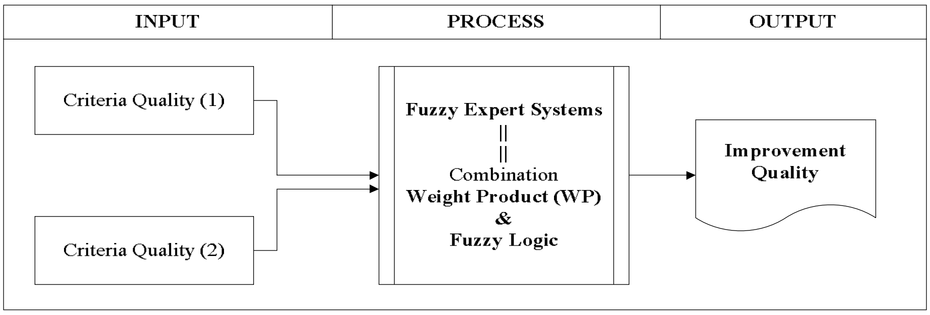


Figure 2. Block diagram of improvement of TTC quality system.

Input. There are two inputs in this study, the first input is TTC quality criteria with 6 variables of TTC quality (Q1-Q6), namely the sensory (Q1), chemistry (Q2), physics (Q3), metal contamination (Q4), microbial contamination (Q5) and physical contamination (Q6), and the second input is the quality of TTC process with 11 variables (T1-T11), namely the fish handling process on the boat (T1), handling process of killing fish (T2), heading/gutting and trimming (T3), cleaning and washing process 1 (T4), storage process in the fishery port (T5), handling and distribution to TLC (T6), sorting process (T7), cleaning and washing process 2 (T8), weighing process (T9), storage in resevoir (T10) and packaging process (T11).

Process. Both inputs are then processed with fuzzy expert system with a combination of fuzzy logic and weight product. Before the process of fuzzy calculation, 6 variables of TTC quality (Q1-Q6) and 11 variables of the quality of TTC process (T1-T11) will be assessed and weighted by some TTC experts as the expert system using weight product (WP) method, and then inserted as rule based fuzzy. The rule (Ruled Based) used is a pattern of IF <premise> then <consequent>. After fuzzyfication and defuzzyfication, the system will be able to determine the quality attributes of each input for the quality of fish and the quality of TTC process in detail.

Output. From the results of FES simulation process, the output quality from input 1 is TTC grade and the output quality from input 2 is quality process. If the output quality of both input process has reached the export grade standard (grade A and B) and according to desired quality process standard, it means that the quality improvement strategy will not be carried out, but if the output quality is below the export grade and the process quality is below the standard, the quality improvement will be carried out. From the results of FES simulation also found task crucial, namely the task which is crucial point. The task crucial will be the focus of quality improvement strategy in the cold chain system.

Results and Discussion. Based on Figure 2, TTC quality improvement is obtained with the two approaches, the first approach, the quality of fish and the improvement strategy and the second approach, process quality and the improvement strategy, the results of both strategies can be described as follows:

Determination of fish quality and improvement strategy. Determination of criteria for quality of the fish is determined by 6 variables (Q1-Q6) in accordance with SNI. Before the process of fuzzy calculation, the 6 criteria will be assessed by several experts to be weighted using Weight Product (WP) method (Figure 3).

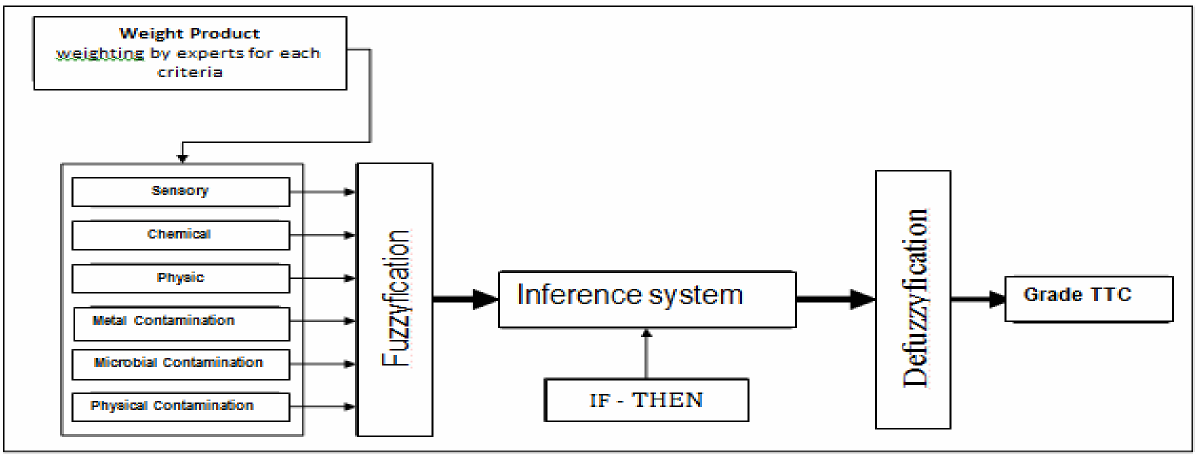


Figure 3. FES implementation block diagram of the TTC quality.

The results of weight preference given by experts to each attribute can be seen in the column of weight quality in Table 2.

Table 2

Value weight quality preferences on each variable

	Variable (Q)	Quality weight	Quality atrribute				
			VP	P	M	G	VG
Q1	Sensory	20%	15-55	45-75	65-85	75-95	85-100
Q2	Chemical	20%	15-55	45-75	65-85	75-95	85-100
Q3	Physic	15%	15-55	45-75	65-85	75-95	85-100
Q4	Metal contamination	15%	15-55	45-75	65-85	75-95	85-100
Q5	Microbial contamination	15%	15-55	45-75	65-85	75-95	85-100
Q6	Physic contamination	15%	15-55	45-75	65-85	75-95	85-100

Note: VP - very poor; P - poor; M - moderate; G - good; VG - very good.

which is obtained by means of: $W_j = \frac{w_j}{\sum w_j}$:, where:

$$Q1 = \frac{20}{20+20+15+15+15+15} = 0.2,\quad Q2 = \frac{20}{20+20+15+15+15+15} = 0.2,\quad Q3 = \frac{15}{20+20+15+15+15+15} = 0.15,$$

$$Q4 = \frac{15}{20+20+15+15+15+15} = 0.15,\quad Q5 = \frac{15}{20+20+15+15+15+15} = 0.15,\quad Q6 = \frac{15}{20+20+15+15+15+15} = 0.15$$

The weight for each variable that has 5 ratings (output quality) with minimum and maximum value as shown in Table 3, the number of fuzzy attribute of fish quality can be seen in Figure 4 and fuzzy variable data for the quality of fish can be seen in Figure 5.

Table 3

Output quality of TTC

Output quality	Min	Max
Very poor (VP)	15	55
Poor (P)	45	75
Moderate (M)	65	85
Good (G)	75	95
Very good (VG)	85	100

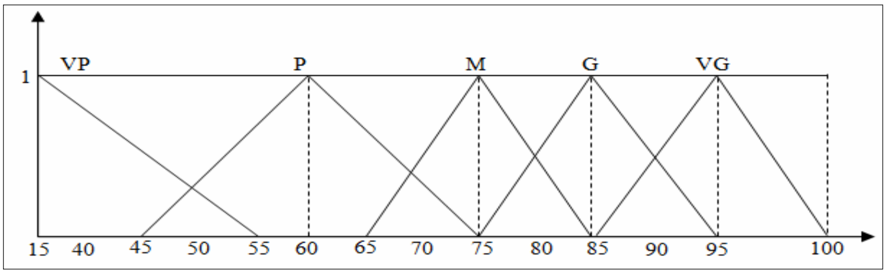
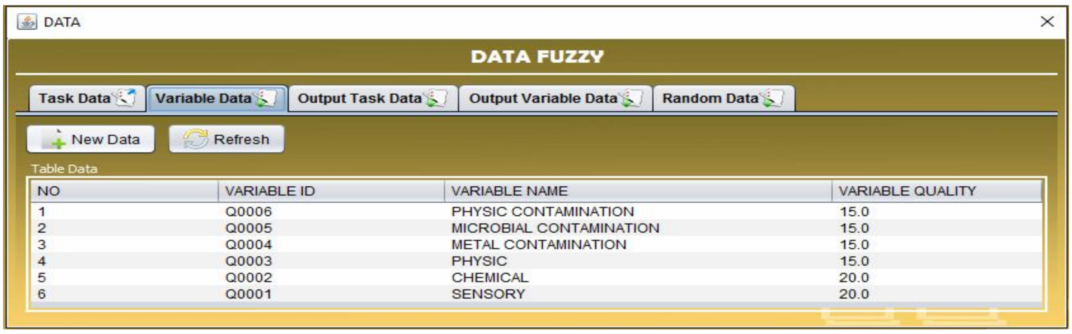


Figure 4. Fuzzy numbers of quality attributes.



NO	VARIABLE ID	VARIABLE NAME	VARIABLE QUALITY
1	Q0006	PHYSIC CONTAMINATION	15.0
2	Q0005	MICROBIAL CONTAMINATION	15.0
3	Q0004	METAL CONTAMINATION	15.0
4	Q0003	PHYSIC	15.0
5	Q0002	CHEMICAL	20.0
6	Q0001	SENSORY	20.0

Figure 5. Fuzzy data variables for the TTC quality.

The rule (Ruled Based) uses pattern of IF <premise> then <consequent>, a rule that will be made in accordance with the number of variables and ranked with existing attributes. To determine the quality of frozen TTC, there are six variables and attributes as 5 rule-base, so that the number of rules made is 6^5 = 7,776.

The next stage, the rule-based which has been obtained is stored as a knowledge base, which will be used to determine the quality of frozen TTC to evaluate the input of the six variables (Q1-Q6). Membership function used is Triangular Fuzzy Number (TFN). To perform the process of acquisition of knowledge in order to construct the If-Then Rules, interviews with three experts on the quality and frozen TTC processing strategy are done. The test results on determination of the quality of frozen TTC based on the input of 6 variables can be seen in Figure 6 and described in detail in Table 4.

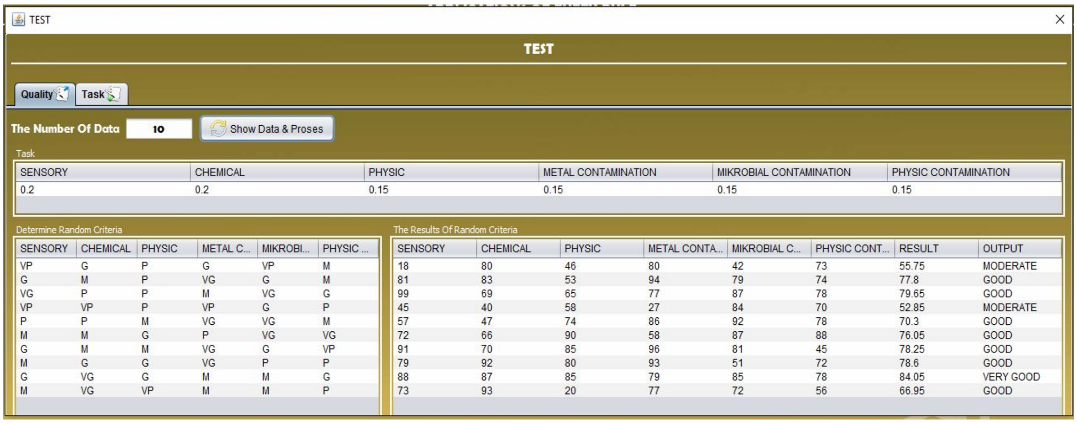


Figure 6. The result of TTC test quality.

Table 4

The result of TTC test quality

Rule	*Q1*	*Q2*	*Q3*	*Q4*	*Q5*	*Q6*	*Result*	*Output*
	20%	*20%*	*15%*	*15%*	*15%*	*15%*		
1	18	80	46	80	42	73	55.75	Very good
2	81	83	53	94	79	74	77.8	Moderate
3	99	69	65	77	87	78	79.65	Good

Determination of TTC processing quality is based on the input of 6 variables (Q1-Q6), as shown in Table 5. For instance experiment is used and can be described as follows:
[1] If (Sensory = Very Poor) and (Chemical = Good) and (Physics = Poor) and (Metal Contamination = Good) and (Microbial Contamination = Very Poor) and (Physical Contamination = Moderate), the value of result = 55.75, then the Fish Condition = Moderate.

[2] If (Sensory = Good and (Chemical = Good) and (Physics = Poor) and (Metal Contamination = Very Good) and (Microbial Contamination = Good) and (Physical Contamination = Moderate), the value of result = 77.8 the condition of fish = Good.

[3] If (Sensory = Very Good) and (Chemical = Moderate) and (Physics = Moderate) and (Metal Contamination = Good) and (Microbial Contamination = Very Good) and (Physical Contamination = Good), the value of result = 79.65 the condition of fish = Good.

After the process of quality determination is completed, then FES will provide strategic recommendations to the users to make improvements on a variable that has poor quality with the aim to increase the grade of quality of the fish. FES provide recommendations as shown in Table 5. In this study grade A and grade B is the TTC which has fulfilled to export standard quality (Very Good and Good, respectively).

Table 5

Strategic improvement quality of TTC

Rule	Q1 20%	Q2 20%	Q3 15%	Q4 15%	Q5 15%	Q6 15%	Result	Min	Result	Task crucial	Output	Quality strategy
1	18	80	46	80	42	73	55.75	18	Q1	S	M	Upgrade to B
2	81	83	53	94	79	74	77.8	53	Q3	P	G	Upgrade to A
3	99	69	65	77	87	78	79.65	65	Q3	P	G	Upgrade to A

Based on the test results in Table 4 found the result of "MODERATE" quality, strategy recommended in Table 5 is "UPGRADING QUALITY TO GRADE B" by maintaining the critical variable (task crucial), namely Sensory (S).

Based on the test results in Table 4 found the result of "GOOD" quality, strategy recommended in Table 5 is "UPGRADING QUALITY TO GRADE A" by improving the critical variable (task crucial), namely Physics (P).

Based on the test results in Table 4 found the result of "GOOD" quality, strategy recommended in Table 5 is "UPGRADING QUALITY TO GRADE A" by improving the critical variable (task crucial), namely Physics (P).

Determination of process quality and improvement strategy. The same process on the variable of TTC quality (Q1-Q6) above will be carried out to the variable of quality of TTC process (T1-T11) as shown in Figure 7.

The results of weight preference given by experts to each attribute can be seen in the column of weight quality in Table 6, which is obtained by means of:

$W_j = \frac{w_j}{\sum w_j}$: where

$$T1 = \frac{15}{15+15+10+10+10+10+5+10+5+5+5} = 0.15,$$

which is obtained by the same way with T1, so the values of T2 = 0.15, T3 = 0.10, T4 = 0.10, T5 = 0.10, T6 = 0.10, T7 = 0.05, T8 = 0.10, T9 = 0.05, T10 = 0.05 and T11 = 0.05.

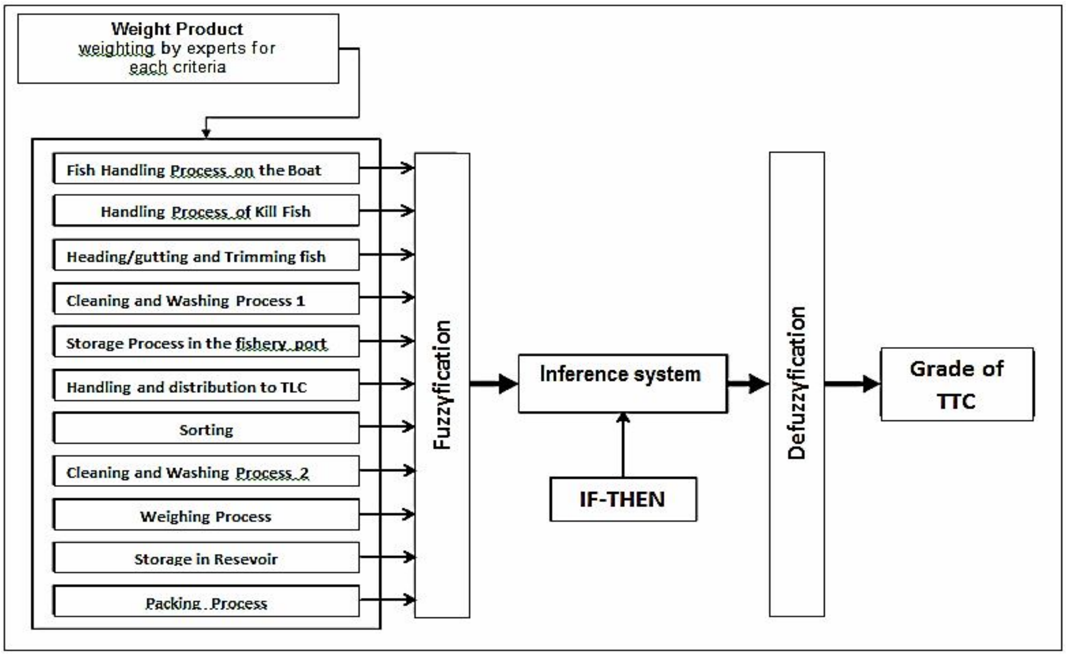


Figure 7. FES implementation block diagram of the quality process of TTC.

Table 6

Weight quality process preferences value of TTC on each variable

Task	Task name	Task type		Task weight	Task attribute				
		Quality	*%*		*VP*	*P*	*M*	*G*	*VG*
T1	Fish handling process on the boat	Y	70	15%	40-65	55-75	65-85	75-95	85-100
T2	Handling process of kill	Y		15%	40-65	55-75	65-85	75-95	85-100
T3	Heading/gutting and trimming	Y		10%	40-65	55-75	65-85	75-95	85-100
T4	Cleaning and washing process 1	Y		10%	40-65	55-75	65-85	75-95	85-100
T5	Storage process in the fishery port	Y		10%	40-65	55-75	65-85	75-95	85-100
T6	Handling and distribution to TLC	Y		10%	40-65	55-75	65-85	75-95	85-100
T7	Sorting	N	30	5%	40-65	55-75	65-85	75-95	85-100
T8	Cleaning and washing procces 2	N		10%	40-65	55-75	65-85	75-95	85-100
T9	Weighing process	N		5%	40-65	55-75	65-85	75-95	85-100
T10	Storage in resevoir	N		5%	40-65	55-75	65-85	75-95	85-100
T11	Packaging process	N		5%	40-65	55-75	65-85	75-95	85-100

Y and N are the quality of task type, that means T1-T6 affect 70% and T7-T11 affect 30% of the quality.

Then the weight for each variable has 5 ratings (output quality) with minimum and maximum value as shown in Table 7, the number of fuzzy attribute of fish quality can be seen in in Figure 8 and fuzzy variable data for the quality of fish can be seen in Figure 9.

Table 7

Output of the quality process

Output quality	*Min*	*Max*
Very poor (VP)	40	65
Poor (P)	55	75
Moderate (M)	65	85
Good (G)	75	95
Very good (VG)	85	100

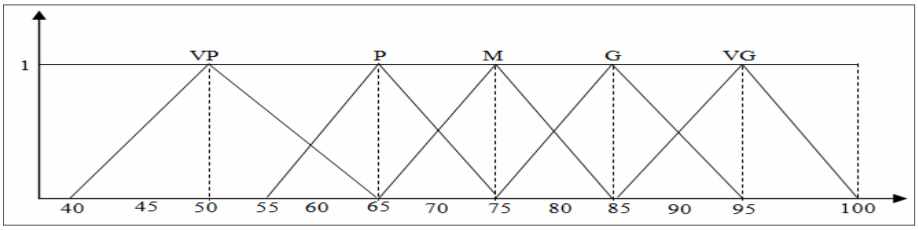
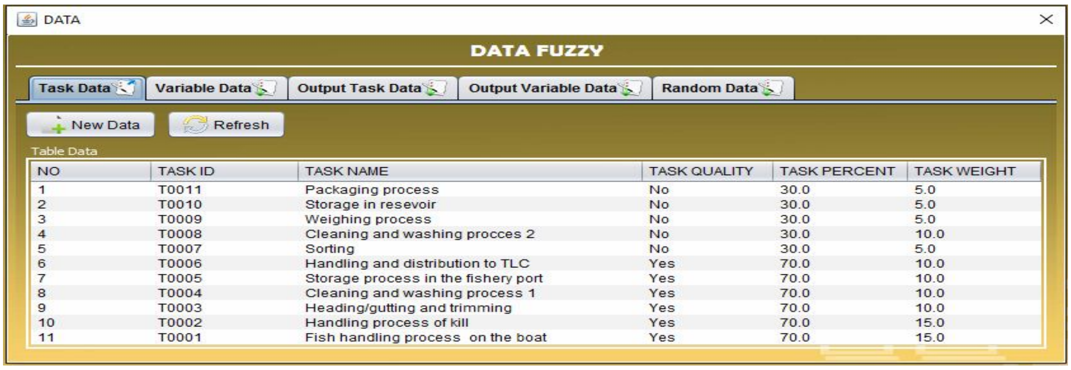


Figure 8. Fuzzy attribute numbers of TTC quality.



NO	TASK ID	TASK NAME	TASK QUALITY	TASK PERCENT	TASK WEIGHT
1	T0011	Packaging process	No	30.0	5.0
2	T0010	Storage in resevoir	No	30.0	5.0
3	T0009	Weighing process	No	30.0	5.0
4	T0008	Cleaning and washing procces 2	No	30.0	10.0
5	T0007	Sorting	No	30.0	5.0
6	T0006	Handling and distribution to TLC	Yes	70.0	10.0
7	T0005	Storage process in the fishery port	Yes	70.0	10.0
8	T0004	Cleaning and washing process 1	Yes	70.0	10.0
9	T0003	Heading/gutting and trimming	Yes	70.0	10.0
10	T0002	Handling process of kill	Yes	70.0	15.0
11	T0001	Fish handling process on the boat	Yes	70.0	15.0

Figure 9. Fuzzy data variable (T1-T11) of TTC quality process.

Based on Figure 10, it can be explained in detail that the test results on determination of the quality of frozen TTC is based on the input of 11 variables (T1-T11), as in Table 8.

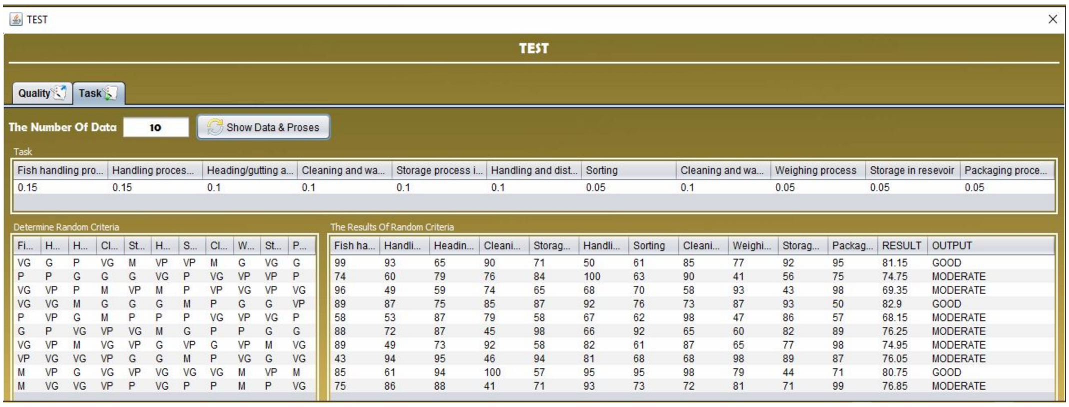


Figure 10. The result of TTC quality process.

Table 8

The result of quality process test

Rule	T1	T2	T3	T4	T5	T6	T7	T8	T9	T10	T11	Result	Output
	0.15	*0.15*	*0.1*	*0.1*	*0.1*	*0.1*	*0.05*	*0.05*	*0.05*	*0.05*	*0.05*		
1	89	99	93	65	90	71	50	61	85	77	92	95	81.15
2	83	74	60	79	76	84	100	63	90	41	56	75	74.75
3	71	96	49	59	74	65	68	70	58	93	43	98	69.35

For instance experiment is used and can be described as follows (VG = very good, G = good, M = moderate, P = poor, VP = very poor):

[1] If (fish handling process on the boat = VG) and (handling process of kill = VG) and (heading/gutting and trimming = P) and (cleaning and washing 1 = M) and (storage process in the fishery port = P) and (handling and distribution to TLC = VP) and (sorting = G) and (cleaning and washing stage 2 = G) and (weighting = M) and (storage in a resevoir = P) and (packaging = M), the value of result = 73.55, then the Fish Condition = MODERATE.
[2] If (fish handling process on the boat = G) and (handling process of kill = VG) and (heading/gutting and trimming = VP) and (cleaning and washing stage 1 = VG) and (storage process in the fishery port = VP) and (handling and distribution to TLC = VP) and (sorting = G) and (cleaning and washing stage 2 = VG) and (weighing = M) and (storage in a resevoir = VG) and (packaging = G), the value of result = 71.65 then the Fish Condition = MODERATE.

[3] If (fish handling process on the boat = P) and (handling process of kill = VG) and (heading/gutting and trimming = VG) and (cleaning and washing stage 1 = G) and (storage process in the fishery port = VP) and (handling and distribution to TLC = VG) and (sorting = P) and (cleaning and washing stage 2 = P) and (weighing = P) and (storage in a resevoir = G) and (packaging = VP), the value of result = 71.35 then the Fish Condition = MODERATE.

After the process of quality determination is completed, then FES will provide strategic recommendations to the users to make improvements on a variable that has poor quality with the aim to increase the grade of quality of the fish. Based on the test results on determination the quality of fish in Table 8, then FES provide recommendations as shown in Table 9.

[1] Based on the first test results in Table 8 obtained the results of “MODERATE” quality, strategy recommended in Table 9 is “IMPROVING THE PROCESS”, to improve the process at critical variable (task crucial) T6 namely Handling and distribution to Tuna Loading Centre (TLC) is improved.

[2] Based on the second test results in Table 8 obtained the result quality "MODERATE" strategy recommended in Table 9 is “IMPROVING THE PROCESS” to improve the process at critical variable (task crucial) T5 namely weighing process in the fishery port is improved.

[3] Based on the thrird test result in Table 8 obtained the result quality “MODERATE” strategy recommended in Table 9 is “IMPROVING THE PROCESS” to improve the process at critical variable (task crucial) T10 namely storage in reservoir is improved.

Result analysis. In this study grade A and grade B is the TTC which has fulfilled to export standard quality (Very Good and Good, respectively). Grade C is Moderate. Based on the test results of assessing the quality of TTC catching results in Maluku, it is assummed that: TTC which has reached grade A is retained and quality improvement is not carried out, TTC with grade B will be upgraded to grade A with quality improvement strategy based on the recommendation results of the test and TTC grade C will be upgraded to grade B with quality improvement strategy according to the recommendation results of the test.

After the improvement based on the recommendation results of FES obtained the average results as in Table 10. Grade A = 6%, grade B decreased by -3% and grade C decreased by -3%. It means that after conducting quality improvement, the average of quality of the fish grade A increased by 3%, which is obtained from an upgrade of grade B to grade A by 3% and grade B increased by 3% which is obtained from an upgrade of grade C to grade B by 3%.

Conclusions. After going through several stages and testing of the results of the implementation of FES to determine the quality of TTC and its strategy, it can be concluded, FES with a combination of fuzzy logic and weight product is able to analyze and determine the quality of TTC by 2 input namely: 6 input variables of quality criteria and 11 input variables of process TTC quality, based on SNI. After the repair process in the cold chain system, average grade TTC export quality (grade A and grade B) experienced an average increase, grade A 3% (which is obtained from an upgrade of grade B to grade A by 3%) and grade B at 3% (which is obtained from an upgrade of grade C to grade B by 3%), means the total grade of export TTC (grade A and grade B) increased by 6%, from the TTC before in doing quality improvement.

Table 9

Strategic improvement quality of TTC

Rule	*T1*	*T2*	*T3*	*T4*	*T5*	*T6*	*T7*	*&8*	*T9*	*T10*	*T11*	*Result*	*Min*	*Result*	*Task crucial*	*Problem type*	*Output*
	0.15	*0.15*	*0.1*	*0.1*	*0.1*	*0.1*	*0.05*	*0.05*	*0.05*	*0.05*	*0.05*						
1	99	93	65	90	71	50	61	85	77	92	95	81.15	61	T6	T6	Quality	G
2	74	60	79	76	84	100	63	90	41	56	75	74.75	41	T9	T9	Non quality	M
3	96	49	59	74	65	68	70	58	93	43	98	69.35	43	T10	T10	Non quality	M

Table 10

The results of TTC quality improvement

No	*TTC fisherman catch data*	*Quality assessment result*			*Strategic*	*End result of quality*			*% improvement quality*		
		Grade A (Ton)	*Grade B (Ton)*	*Grade C (Ton)*		*Grade A (ton)*	*Grade B (ton)*	*Grade C (ton)*	*Grade A (ton)*	*Grade B (ton)*	*Grade C (ton)*
1	25	14	8	3	Grade A quality is maintained, Grade B upgraded to Grade A and Grade C upgraded to Grade B	19	5	1	5%	-3%	-2%
2	30	17	8	5		22	6	2	5%	-2%	-3%
3	23	13	5	5		18	4	1	5%	-1%	-4%
4	40	18	15	7		26	12	2	8%	-3%	-5%
5	38	25	10	3		30	6	2	5%	-4%	-1%
6	44	27	13	4		37	6	1	10%	-7%	-3%
7	37	22	12	3		32	5	0	10%	-7%	-3%
8	27	13	12	2		20	5	2	7%	-7%	0%
9	33	15	10	8		20	10	3	5%	0%	-5%
10	35	16	10	9		20	10	5	4%	0%	-4%
Average value of improvement quality (%)									6%	-3%	-3%

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