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EFFECTIVITY OF COLD CHAIN SYSTEM IN PEELED DEVEINED TAIL ON (PDTO) COOKED PEEL VANNAMEI SHRIMP (Litopenaeus vannamei) AT PT. XYZ, EAST JAVA

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ABSTRACT

Shrimps are commodities that prone to deteriorate at room temperature. Good application on cold chain system is expected to inhibit the growth of bacteria that cause deterioration in the quality due to the unavailability of a suitable environment for bacterial activity. Tthis study aimed to determine the processing characteristics of peeled deveined tail on (PDTO) cooked peel Litopenaeus vannamei shrimp, and to identify the effectiveness of cold chain application on microbiological, organoleptic, and sensory quality at PT. XYZ, East Java, by a quantitative descriptive method with an observational approach. The results showed that the processing of PDTO Cooked Peel vannamei shrimp at PT. XYZ, East Java includes raw materials receiving, weighing I, washing I, cutting heads (de heading), washing II with a shrimp washing machine, size separation, cutting, washing III, soaking, cooking preparation, weighing II, cooking, cooling, peeling, washing IV, freezing, machine glazzing, hardening, weighing, packaging in poly bags and sealing, final checking, metal detecting I, packing in cartons, storage in cold storage, metal detecting II and loading. The cold chain of shrimp processing is applied on room, water, and shrimp raw materials effectively assessed from the results of standardized microbial, organoleptic, and sensory tests.

Keyword: Organoleptic, Temperature measurement, Sensory test.

I. INTRODUCTION

Crustacean meat is known for its pleasant taste, described as umami, which is one of the basic taste sensations, along with sweet, salty, bitter, and sour (Duppeti *et al.* 2022). Taste is the main criterion for consumer acceptance which is directly influenced by the quality of the shrimp. Raw shrimp have little taste and are generally not consumed fresh. Processing is one way to improve the taste and shelf life of aquatic products. Various processing methods are used for shrimp consumption, such as boiling, drying, roasting, smoking and steaming, because the processing will affect the nutritional composition, texture, and taste (Oluwaniyi *et al*., 2010). Therefore, the method of processing directly affects the taste of the shrimp.

Shrimp is a fishery commodity that is easily degraded at room temperature. The perishable nature of shrimp is caused by biochemical reactions and microbial activity which begin immediately after death (Gokoglu & Yerlikaya, 2008; Martinez-Alvarez *et al.*, 2009; Elliot *et al.*, 2021). Vannamei shrimp (*Litopenaeus vannamei*) is one of the most popular cultivated shrimp. This shrimp is also a shrimp species that is cultivated globally because of its taste, economic value, disease resistance and high nutritional value (Udayasoorian *et al.*, 2017; Nurhayati *et al*., 2018).

Due to the nature of its quality that is easily degraded, shrimp commodities require proper handling. One of the efforts to maintain the quality of shrimp is through the freezing method (Zulfikar, 2016). The level of freshness of fishery commodities is a determining factor for the final quality of fishery products thus the application of cold

chains during the flow of raw materials becomes critical (Gonçalves & Blaha, 2011). The general principle of the cold chain system is to condition a low (cold) material temperature (Badrin *et al*., 2019).

Vannamei shrimp processing in Indonesia has high economic value. Previously reported by (Hafina and Sipahutar, 2021), that the export volume of vannamei shrimp increased 0.53% compared to the previous year of around 136.3 thousand tons, and the value of shrimp exports rose 23.9% compared to the previous year, which was around US$ 1.13 billion. The increase in export power should be supported by a qualified processing system. In relation to trade in food products, food safety assurance is required (*food* safety), quality (*wholesomeness*) and avoid possible losses (*fraud*). In terms of quality, shrimp easily declines during the processing stages, frozen storage, after thawing, and due to temperature fluctuations (Gonçalves & de Oliveira, 2016).

The application of a good cold chain system is expected to inhibit the growth of bacteria that cause deterioration in the quality of shrimp due to the unavailability of a suitable environment for bacterial activity. The purpose of this study is to determine the processing characteristics of vannamei shrimp *(Litopenaeus vannamei)* form *peeled deveined tail on (*PDTO*) cooked peel*, and identify the effectiveness of cold chain implementation on microbiological, organoleptic, and sensory quality at PT. XYZ, East Java.

II. RESEARCH METHODS

2.1 Place and Time of Research

This research was conducted at a vannamei shrimp processing company (PT. XYZ), Situbondo, Jawa Timur. Research activities were carried out from February to May 2023.

2.2 Tools and Materials

The raw materials used are fresh types of shrimp *Litopenaeus vannamei.* Test materials used include *plate count agar*, Nacl, EC *broth, brillian green lactose broth, lauryl tryptose broth, paraffin oil, purple carbohydrate broth, muller hinton agar,* dan *butterfield's phosphate buffered.* The tools used are the form of organoleptic scores, scales, thermometers, and *colony counter*

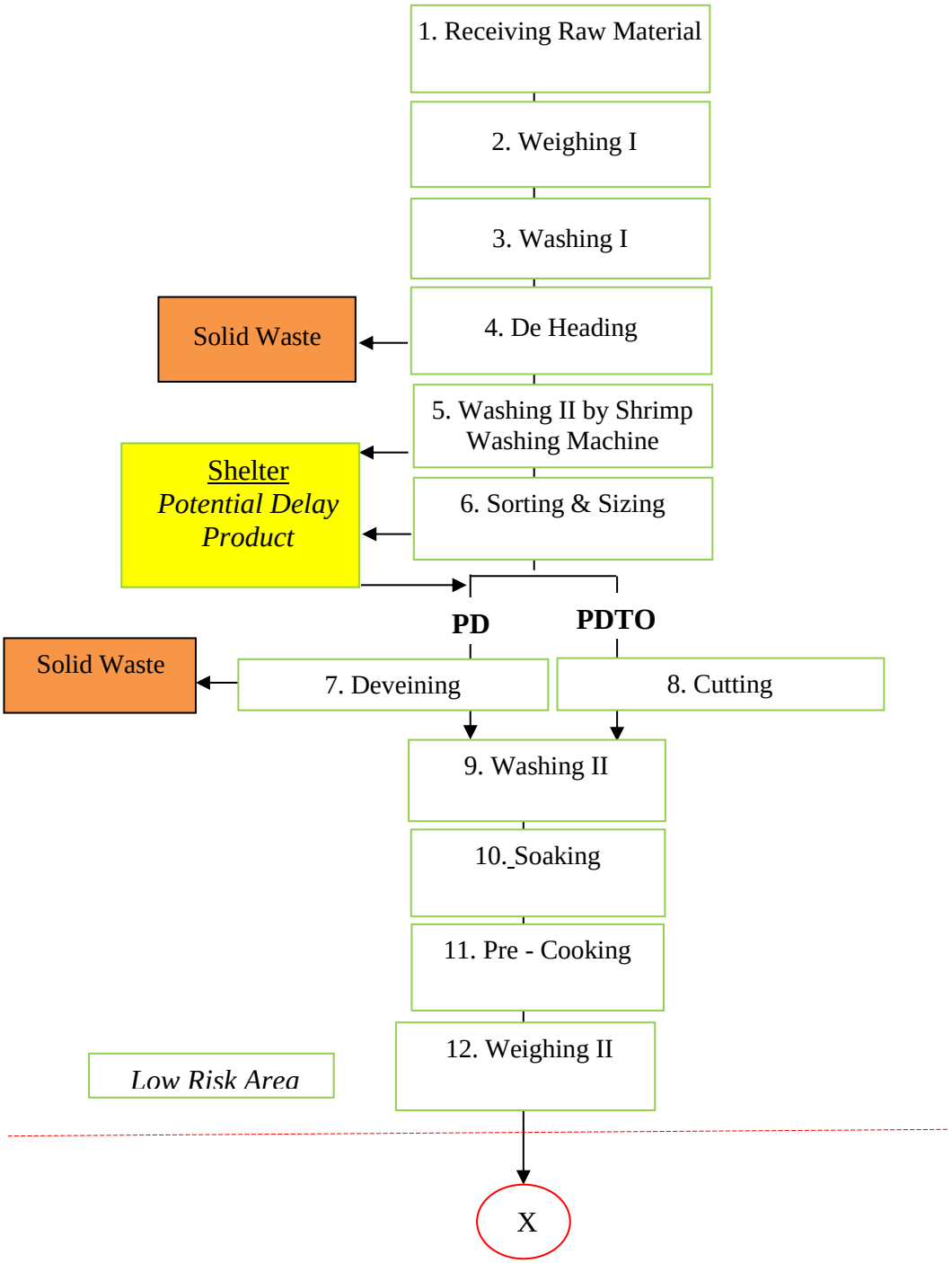
2.3 Research Methods

The study used a quantitative descriptive method with an observational approach to the vannamei shrimp processing chain (*Litopenaeus vannamei*) shaped *Peeled Deveined Tail On* (PDTO) *Cooked Peel* by method *Individually Quick Frozen* (IQF). Coliform test and E. coli refers to SNI 2332.1-2015. Salmonella test refers to SNI 01-2332.2-2006. Determination of Total Plate Numbers (ALT) refers to SNI 2332.3-2015. The V. parahaemolitycus test refers to SNI 01-2332.5-2006. The application of cold chain is identified by measuring room temperature, water, and shrimp. The effectiveness of cold chain application was identified through the approach of organoleptic, sensory, and microbial quality parameters.

III. RESULTS AND DISCUSSION

3.1 Processing Process of PDTO *Cooked Peel*

PDTO is a form of processing at PT. XYZ, Situbondo, Jawa Timur. PDTO is a form of processed shrimp that is split from segments 1-5 with one third of the body of the shrimp to remove the intestines, then cooked next done peeling the skin. The processing process for PDTO products can be briefly seen in Figure 1.


1. Receiving Raw Material
2. Weighing I
3. Washing I
4. De Heading
Solid Waste
5. Washing II by Shrimp Washing Machine
Shelter
Potential Delay Product
6. Sorting & Sizing
PD
PDTO
Solid Waste
7. Deveining
8. Cutting
9. Washing II
10. Soaking
11. Pre - Cooking
12. Weighing II
Low Risk Area
X

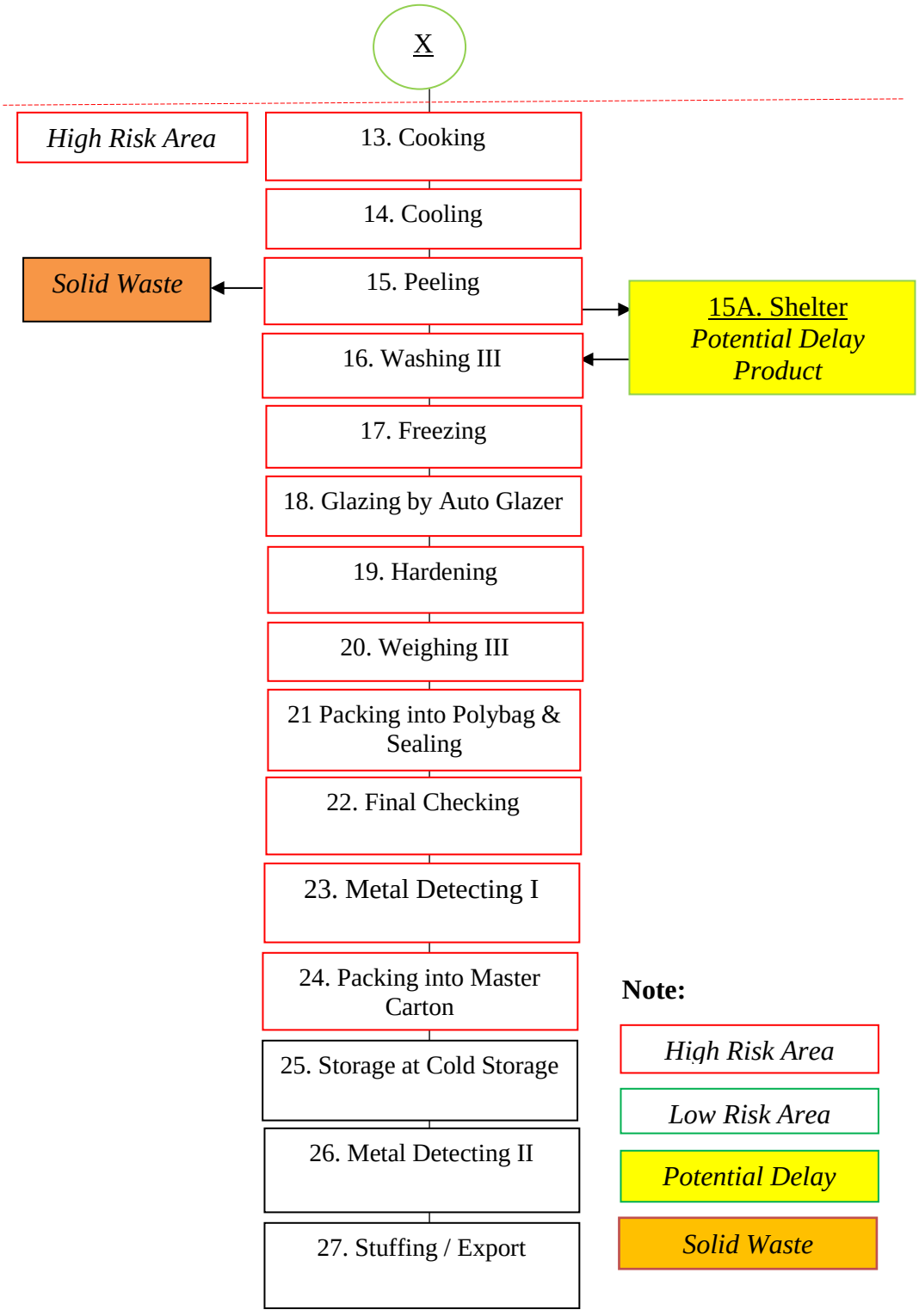


Figure 1. PDTO Cooked Peel Shrimp Processing Process Flow at PT. XYZ

The shrimp processing stage includes receiving raw materials, weighing I, washing I, cutting the head, washing II with a shrimp washing machine, size separation, cutting, washing III, soaking, preparing for cooking, weighing II, cooking, cooling, peeling, washing IV, freezing, machine ice coating, hardening, weighing, packing in polybags and seals, final checking, metal detection I, packing in cartons, storage in frozen warehouse, metal shorting II and loading (Figure 1).

Raw material for vannamei shrimp (*Litopenaeus vannamei*) obtained from suppliers originating from Bima, Mataram, Banyuwangi, Situbondo, and Tarakan (Kalimantan). Prior to demolition, raw material selection measures are carried out in the form of chemical (antibiotic) testing, microbiological testing and organoleptic testing. According to SNI 01-3458.2-2006, the purpose of the raw material acceptance stage is to obtain raw materials that are free of pathogenic bacteria and meet quality requirements. Potential hazards at this stage are contamination by pathogenic bacteria and poor quality of raw materials (BSN, 2006). The raw materials used are fresh raw materials. Based on organoleptic, SNI 01-2728.1-2006 stipulates the raw material requirements for frozen boiled peeled shrimp to be worth at least 7 (BSN, 2006). The results of organolpetic testing of raw materials at the acceptance stage at PT. XYZ indicates that the raw material is feasible for processing because it complies with the standards SNI (Table 1).

Table 1. Organoleptic Test Results for Fresh Shrimp Raw Materials

Observation	**Organoleptic Value**			**SNI-01-2728.1.2006**
	Appearance	**Odor**	**Texture**	
I	9	9	9	
II	9	7	9	
III	9	7	8	
IV	9	8	9	Minimum 7
V	8	8	8	
VI	9	8	9	
VII	9	7	8	
Average				8

The characteristics of the raw materials received are intact, less translucent, the light starts to fade, original color, firm joints, fresh smell specific to the type, and texture that is elastic, compact, and congested. (Nurhayati *et al*., 2018) through his research on the quality of vannamei shrimp reported that the decline in the quality of shrimp includes four stages, namely the pre-rigor, rigor mortis, post-rigor, and decay phases. The category of raw materials received by PT. XYZ is included in the shrimp phase *pre-rigor* until *rigor-mortis*. At the stage of receiving raw materials, sorting is also carried out with the aim of uniforming the size of the shrimp.

The next stage is weighing I which aims to determine the initial mass of intact shrimp complete with head, body, skin and tail (shape HO) before processing. The shrimp are then washed (washing I) using water and ice to maintain the temperature of the shrimp < 5 ˚C. Shrimp washing is done using the help of a large capacity shrimp

washing machine 1740 L. The shrimp then removed the head manually by holding the shrimp body with the left hand, then holding the shrimp head with the right hand, placing the thumb on the joint between the head and the shrimp body, then turning the shrimp head to the right until it detaches from the shrimp body without removing the genjer (head meat). This process produces a form of shrimp product *head less* (HL)

Washing II is done after the process of cutting the heads of the shrimp. The washing process is carried out using a shrimp washing machine with water and ice temperatures < 5 ˚C to maintain the freshness and quality of the shrimp. The clean HL shrimp were then sorted again based on size. The HL sorting process is carried out using a machine *grading. Grades at this stage are divided into*: (i) 1st *grade,* or fresh shrimp which means good quality; (ii) 2nd *grade,* soft shrimp, which means that the shrimp skin has begun to soften but is still of a good quality standard or includes shrimp broken back which is not more than 3 mm; (iii) 3rd *grade,* the shrimp is very soft which means the shrimp skin is very soft and has experience broken shell, broken tail, black tail, scratch on shell, and moulting.

Next, is the cutting process HL shrimp using a knife stainless steel. Cutting is done towards the back of the shrimp from the first segment to the fifth segment then removing the shrimp intestines. The depth of cutting on the 1st - 3rd segment is 0.8 cm and on the 4th - 5th segment is 0.2 cm. This process is done without peeling the shrimp skin first. After cutting, washing III was carried out on HL already. Washing III is carried out with running cold water, then the draining process is carried out for 1-2 minutes.

The next stage is soaking the shrimp in a food grade salt and phosphate solution. During the soaking process, cold chain system is maintained. According to (Elisa *et al.*, 2022), soaking resistance aims to increase the water holding capacity (WHC), restore the initial weight of the shrimp, and improve the quality of the shrimp. It was stated that the weight of the shrimp increased in the first 2 hours of the soaking process. At PT. XYZ, preparation of the immersion solution is carried out by dissolving the salt and phosphate with water and then adding ice to reach a maximum temperature of the immersion solution of 5 ˚C. A number of soaking solutions are prepared in the mixing machine container, then the shrimp is put into the machine. Soaking is done for 2-3 hours. After the immersion stage, weighing II is carried out which aims to check the increase and suitability of the mass weight with company standards.

The next process is cooking by steaming in a non-pressure saturated steam environment, provided that the central temperature of the shrimp is not colder than 72 ˚C after cooking. The cooking stage aims to produce a ready-to-eat product. The length of the cooking process is regulated by the speed of the conveyor belt. After exiting the steam engine, it is cooled using cold water spray with the target of lowering the cooking temperature to < 5 ˚C. Cooling is done quickly, no more than 5 minutes. Once cooled, strip the steamed shrimp to remove skin and legs. At this stage, application of cold chain is done by giving bulk ice on the surface of the shrimp. Furthermore, IV washing was carried out using cold water at < 5 ˚C. After washing, the shrimp were then frozen using the IQF method. Freezing using a tunnel machine can be done by turning on the tunnel machine and reaching a standard of -33°C, with a standard shrimp center temperature of at least -18 ˚C.

The next stage is the ice coating with the machine (*glazing*). Glazing aims to improve texture and prevent dehydration during storage in cold storage by forming a thin layer

of ice on the surface of the shrimp. The glazing method applied to the product is spray type. The next stage is the weighing stage III. Weighing is done after the shrimp comes out of the tunnel hardening machine. Next, the hardening stage is carried out. The next stage is weighing III and then packaging in polybags.

The next stage is the final inspection of the shrimp, and metal detection I, then packaging using cartons. The packaging process in this master carton is a product protection treatment from external contamination and is given an identity on the product and packaging into the master carton. After packing in the master carton then sealing and strapping process is carried out. After that, the shrimp were stored at freezing temperature. Frozen storage room temperature < - 22 ˚C. The preparation of pallets is adjusted to the type and shape of the finish product by applying the FIFO system (*First In Fist Out*) in order to facilitate the process of loading / stuffing. The next stage is metal detection II. This stage is carried out before the procession of loading or loading.

3.2 Application of the Cold Chain System

Shrimp experience a decrease in quality and lead to a process of decay due to autolysis (enzymatic and chemical) processes, oxidation processes, bacteriological processes, and due to dehydration processes (Nurjanah *et al.*, 2017). Shrimp quickly decomposes due to enzyme activity derived from the normal microflora in their innards (Hatha *et al.*, 2023; Abd-El-Aziz and Moharram, 2016). Therefore, cooling and cleaning the organs that are the sources of autolysis enzymes and point sources of microorganism contamination are important as an effort to maintain the quality of shrimp (Jeyasekaran *et al.*, 2006). Cold chain is a form of flow of supply of raw materials to become products that condition the temperature is maintained at a certain value during handling, production process, to distribution (Bogataj *et al.*, 2005). There are three challenges in product cold chain applications, namely how to maintain product storage and handling temperature conditions in distribution, document temperature conditions throughout distribution, and maintain product safety (temperature, counterfeiting) throughout the distribution chain (Priyandari *et al.*, 2017).

Temperature observation in the application of cold chain in the processing of PDTO cooked peel vannamei shrimp at PT. XYZ, Situbondo, Jawa Timur carried out on room, water, and shrimp products. Shrimp have a much shorter shelf life and are more susceptible to post-harvest quality deterioration due to their smaller size, chemical composition, and high content of non-protein nitrogen compounds (Shamshad *et al.*, 1990; Ahmad *et al.*,2013). Therefore, it is very important for the shrimp processing industry to establish processing methods to maintain the freshness and quality of the shrimp. Although there are many preservation options available, freezing and cooking are the most commonly used techniques for preserving shrimp to maintain quality and safety concerns (Das *et al.*, 2023).

The average shrimp temperature meets the shrimp handling standards based on SNI 01-3458.2-2006 (Table 2). The highest shrimp temperature was 4.5 ˚C at the grading stage, 4.1 ˚C at the cutting head stage, and 4.0 ˚C at the cutting head stage. This can indicate the high holding time at these stages. The cause of the high holding time which results in an increase in temperature at PT. XYZ needs to be investigated further. Shrimp temperature observations were carried out until the immersion stage. After the soaking stage is the pre-cooking stage and the cooking stage. At this stage, heat treatment is given to

the shrimp material. (Martinez-Alvarez *et al.*, 2009) through his research on the effect of several cooking methods on shrimp quality, *Parapenaeus longirostris* reported that heat treatment effectively eliminated the presence of microfloral in fish raw materials, including *Pseudomonas spp*., *Enterobacteriaceae*, and TVB testing with a temperature of 15 ˚C for psychrophilic microbes and 25 ˚C for mesophilic microbes.

Temperature observations were also made on water (Table 3) as a medium that has direct contact with shrimp raw materials at PT. XYZ. The average water temperature meets the standard SNI 01-3458.2-2006, namely < 5 ˚C. The water used for washing and soaking is low temperature, which is caused by the addition of ice during the process. The highest water temperature is used at the sorting stage (4.23 ˚C).

Table 2. Shrimp Temperature

No.	Process Stage	Average
1	Receiving Raw Materials	3,3
2	Weighing I	2,8
3	Washing I	3,3
4	De Heading	4,1
5	Washing II	3,0
6	Grading	4,5
7	Cutting	4,0
8	Washing III	3,4
9	Weighing II	3,2
10	Soaking	3,0

Table 3. Water Temperature

No.	Process Stage	Average
1	Washing I	2,13
2	Washing II	3,37
3	Sortir	4,23
4	Washing III	1,83
5	Soaking	1,83
6	Washing IV	0,70
7	Glazzing	0,20

Application of cold chain in space is an effort to suppress the activity of enzymes and microorganisms (Table 4). Room temperature can affect the temperature of the water used and the temperature of raw materials in cold chain applications (Lestari *et al.*, 2022).

Table 4. Room Temperature

No.	Process Stage	Average
1	Receiving	20,73
2	De Heading	19,80
3	Cutting	19,97
4	Packing	21,93
5	Ante room 1	-2,03
6	Ante room 3	-2,47
7	Cold Storage 2	-20,83
8	Cold Storage 3	-21,10
9	Cold Storage 4	-20,73

3.3 Organoleptic Quality Testing

At PT. XYZ, the shrimp raw materials received are whole fresh shrimp. The relationship between time and temperature and quality parameters characterize the decline in the quality of shrimp distributed through the cold chain (Ahmad *et al.*,2013). In this study, the effectiveness of cold chain application was assessed through a comparison of the organoleptic test parameters of fresh shrimp raw materials with the sensory test of PDTO cooked peel shrimp products. The perishability of shrimp is irreversible, where the quality of raw materials will determine the quality of the final product. The quality of the final product also provides an overview of the procedures for handling and processing raw materials into final products. Table 5 shows the sensory test results for the final product PDTO vannamei shrimp cooked peel.

Table 5. Sensory Test

Observation	Organoleptic Value			SNI 3458 : 2016
	Appearance	Odor	Meat	
I	9	9	9	Minimal 7
II	8	7	9	
III	9	8	9	
IV	7	7	8	
V	9	8	8	
VI	9	9	7	
VII	8	7	8	
Rata – rata				8

Compared with the quality of raw materials (Table 1), the quality of the final product also has a value that meets SNI standards. Based on SNI 3458:2016 the standard value that frozen cooked shrimp products must have is at least 7. The quality of frozen shrimp after thawing has an average organoleptic value of 8. This is influenced by a number of things, including the raw materials having good quality and several processing processes including: the soaking process which aims to improve the taste of the shrimp. The soaking process can improve the taste of the product, can maintain the texture and elasticity of the product, maintain the moisture content of the product so that the product looks fresh. In addition, the final product freeze at PT. XYZ is going well. Good freezing is done so that the resulting shrimp looks shiny. Apart from soaking and freezing, a glazing process is then carried out which aims to prevent dehydration during storage and improve appearance. The glazing process is to prevent oxidation, dehydration and improve appearance because a uniform thin layer of ice is formed (Zulfikar, 2016).

3.4 Microorganism Testing

The results of microbiological testing of raw materials and final products can be seen in Tables 6 and 7. According to (Badri *et al.*, 2019), shrimp contain bacteria that are concentrated in the head, shell and digestive tract. The series of shrimp processing processes cleans these parts so as to suppress bacterial growth in shrimp products. The reduction in the number of microbes in shrimp products was also contributed by the application of an effective cold chain and thermal process treatment at the cooking stage (Adawyah, 2007; Martinez-Alvarez *et al.* 2009). Shrimp frozen storage has an impact on reducing the number of bacterial populations. The decrease is getting bigger along with the lower the frozen storage temperature and the longer the storage time (Sedik *et al.*, 1991).

Table 6. Microbiological Test of Fresh Shrimp Raw Materials

Observation	ALT (kol/g)	E.Coli (MPN/g)	Coliform (MPN/g)	V. parahaemoyticus (MPN/g)	Salmonella	V. cholerae (Per 25g)	S. aureus (CFU/g)
SNI	$5{,}0 \times 10^5$	< 3	< 3	< 3	Negatif	Negatif	< 10
PT.XYZ	$5{,}0 \times 10^5$	< 3	< 3	< 3	Negatif	Negatif	< 10
1	$8{,}2 \times 10^3$	< 3	< 3	<3	Negatif	Negatif	< 10
2	$9{,}7 \times 10^3$	< 3	< 3	< 3	Negatif	Negatif	< 10
3	$8{,}8 \times 10^3$	< 3	< 3	< 3	Negatif	Negatif	< 10
4	$6{,}3 \times 10^3$	< 3	< 3	< 3	Negatif	Negatif	< 10
5	$7{,}3 \times 10^3$	< 3	< 3	< 3	Negatif	Negatif	< 10
6	$8{,}4 \times 10^3$	< 3	< 3	< 3	Negatif	Negatif	< 10
7	$8{,}1 \times 10^3$	< 3	< 3	< 3	Negatif	Negatif	< 10
8	$7{,}8 \times 10^3$	< 3	< 3	< 3	Negatif	Negatif	< 10

Table 7. Microbiological Test of Shrimp Products

Observation	ALT (kol/g)	E.Coli (MPN/g)	Coliform (MPN/g)	V. parahaemoyticus (MPN/g)	Salmonella	V. cholerae (Per 25g)	S. aureus (CFU/g)
SNI	**$5{,}0 \times 10^4$**	**< 3**	**< 3**	**< 3**	**Negatif**	**Negatif**	**< 10**
PT.XYZ	**$5{,}0 \times 10^4$**	**< 3**	**< 3**	**< 3**	**Negatif**	**Negatif**	**< 10**
1	$7{,}0 \times 10^2$	< 3	< 3	<3	Negatif	Negatif	< 10
2	$6{,}0 \times 10^2$	< 3	< 3	< 3	Negatif	Negatif	< 10
3	$5{,}0 \times 10^2$	< 3	< 3	< 3	Negatif	Negatif	< 10
4	$9{,}0 \times 10^2$	< 3	< 3	< 3	Negatif	Negatif	< 10
5	$1{,}0 \times 10^2$	< 3	< 3	< 3	Negatif	Negatif	< 10
6	$8{,}0 \times 10^2$	< 3	< 3	< 3	Negatif	Negatif	< 10
7	$2{,}0 \times 10^2$	< 3	< 3	< 3	Negatif	Negatif	< 10
8	$2{,}0 \times 10^2$	< 3	< 3	< 3	Negatif	Negatif	< 10

IV. CONCLUSION

PDTO Cooked Peel vannamei shrimp processing process at PT. XYZ, Jawa Timur includes raw material receiving, weighing I, washing I, de heading, washing II with a shrimp washer, size separation, shearing, washing III, soaking, cooking preparation, weighing II, cooking, cooling, stripping, washing IV, freezing, icing by machine, hardening, weighing, packing in polybags and seals, final checking, metal detection I, packing in cartons, storage in frozen warehouses, metal shorting II and loading. The cold chain system in the process series is applied to room, water, and shrimp raw materials effectively assessed from the results of standardized microbial, organoleptic, and sensory tests.

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