Marketing system, quality and safety characteristics of mackerel (Rastrelliger sp.) at the domestic market in Jakarta, Indonesia

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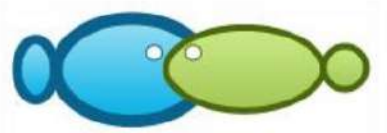

Marketing system, quality and safety characteristics of mackerel (*Rastrelliger* sp.) at the domestic market in Jakarta, Indonesia

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Abstract. Fish is a highly perishable food, which needs proper maintenance during distribution and marketing, to provide a good quality product to consumers. This study aims to identify the distribution chains of fresh fish and the socio-economic characteristics of participants, namely fishermen and retailers, and also to analyze the quality and safety of mackerel throughout the domestic distribution process. The study was conducted at the domestic fish market in Jakarta, Indonesia. The intermediaries involved in distribution and marketing, play an important role in fish product delivery to customers. The distribution chain data were collected from retailers through a survey using a questionnaire combined with an interview. Quality characteristics of fish were determined by taking the same type of samples from 56 locations, including fish landing, auction, wholesales, supermarkets and traditional markets. Based on market participants, the distribution chain consisted of fishermen, traders, collectors, wholesalers, and retailers/supermarkets. The results indicated that majority of the market participants were males at the productive age and fish capture, marketing and distribution was their main job, with a low level of education. Based on the total volatile base nitrogen (TVB-N) content, all the fish transported from the landing location to the supermarket complied with the quality standard, while in the traditional trading site 22.09% exceeded the maximum limit. In terms of food safety characteristics, mackerels were contaminated with pathogenic *Escherichia coli* from fish auction and the contamination level increased during distribution. The presence of these bacteria was mainly due to poor hygiene practices during handling.

Key Words: distribution, quality, total volatile bases, *Escherichia coli*.

Introduction. The provision of fish to consumers from the production center, require marketing, distribution and maintenance to keep the quality and safety of the product. This also help in sustaining the economic system in Jakarta, the capitality of Indonesia, making it a trading center for various goods, especially fisheries. The increasing demand for fish products was probably due to its great advantages compared to other foodstuffs. According to Albert & Marc (2013), it is the most nutritious and healthiest food ingredient with high protein and low-fat content. It is also reported by Ström et al (2011), that it is a very important food ingredient and a source of essential amino and unsaturated fatty acids, vitamins, and minerals. However, it is a highly perishable commodity and its quality deteriorates very rapidly. Therefore, its quality is affected when stored for human consumption for a long time, and requires some efforts to be preserved during distribution and marketing.

According to BPS (2018), fish production in Jakarta was dominated by small (30%) and large (25%) pelagic fish, mollusks (27%), demersal fish (16%), crustaceans and reef fish 1%. Among the small pelagic fish, mackerel (*Rastrelliger* sp.) is the most

preferred by consumers in Jakarta community (Ministry of Marine and Fisheries 2018). Therefore, its quality and safety related topics need special consideration.

Accurate and comprehensive data regarding the quality and safety of fresh mackerel, during distribution and marketing at the domestic market in Jakarta are not available. Therefore, it is necessary to identify the marketing system, as well as the quality and safety of mackerel in the distribution chain. This is a preliminary study aimed to improve the quality and safety of fish, and also the distribution monitoring, in order to provide good quality in the domestic market.

Material and Method

Study site and period. This study was conducted for a period of four months, from March to June 2019, at domestic markets in Jakarta. The marketing and distribution chain started from fishing vessels, auction places, wholesale stores, supermarkets and traditional trading sites (Figure 1).

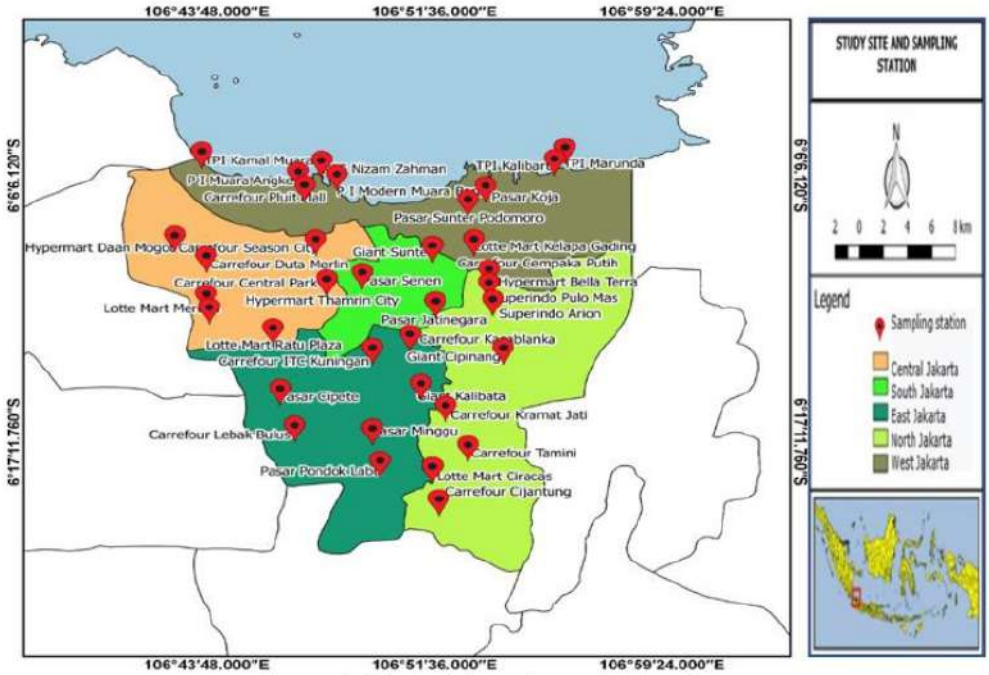

Figure 1. Study side and sampling location.

Material. The materials used were mackerel, ice, some chemicals for *Escherichia coli* analysis and Total Volatile Bases (TVB) assessment, include *Lauryl triptose* broth, EC broth, L-EMB agar, tryptone, methyl red Voges-Proskauer medium and citrat agar, perklorat acid (PCA) 6%, phenolftalein indicator, anti-foaming silicon, NaOH 20%, H_3BO_4 3%, and HCl 0.02 N. The equipment used included a scale at 0.001 g of accuracy (Metler Toledo), a Stomacher homogenizer (Interscience), filter paper (Whatman), distillation sets (Foss), incubator (Thermo Scientific), autoclave (Chemoto Scientific), water bath (Thermo Scientific), oven (Thermo Scientific), glassware (Pyrex), and micropipette (Eppendorf).

Research methods. This study used a survey, interviews and laboratory testing methods. The respondents were 50 fishermen and 270 market participants, including 30 collectors, 60 wholesalers, 5 agents, 3 restaurant owners, 32 quality supervisors at supermarkets, and 140 retailers at traditional markets. For quality and safety testing,

790 samples in total, were obtained from 5 landing side locations (150 samples), 3 fish auction and 2 wholesale markets (150 samples), 32 supermarkets (155 samples), and 14 traditional markets (335 samples). The locations were determined based on random sampling which proportionally represented all districts in Jakarta. The fish samples were placed in a cool box, preserved with crushed ice at a ratio of 1:1 (Wiranata et al 2017; Panai et al 2013). The samples were then taken to the laboratory for further analysis.

Marketing system. The survey involved interviews, and the study areas were inspected in terms of identifying the fish distribution chain, as well as the socio-economic characteristics of market participants.

Quality and safety characteristics. The quality of *Rastrelliger* sp. was determined by the Total Volatile Bases Nitrogen (TVB-N) analysis, while its safety characteristics were determined by the presence of pathogenic *E. coli*. The TVB-N was analyzed using the Kjedhal distillation method, based on Indonesia National Standard 2354.8:2009 (Sepka et al 2017). The extract was prepared by mixing 10 grams of the sample with 30 mL of 6% perchloric acid (PCA), and was homogenized for 2 minutes. The blend was then filtered using Whatman no 1 filter paper to obtain a clear extract. Then, 50 mL of the extract was pipetted into the distillation tube and added a few drops of phenolphthalein indicator and anti-foaming silicone, and placed in the distillation flask. Then, distillation commenced, while 30 mL of 10% NaOH and 100 mL of distilled water were added to the flask. The steam distillate was collected in a flask containing 100 mL of 3% boric acid together with 3 to 5 drops of indicators. The steam distillation procedure was continued until 200 mL of green color distillate was collected in a flask. The blank correction was determined by the steam distillation of 50 mL of distilled water sample, instead of the extract. The green color distillate was titrated with 0.02 N hydrochloric acid using a burette until the green color solution turned pink. The result was calculated and expressed in mg TVB-N 100 g^{-1} of fish (Sepka et al 2017):

$$\text{TVB-N (mg 100 g}^{-1}\text{)} = (Vs\text{-}Vb) \times \text{NHCl} \times 14.007 \times df \times 100 \times 10^{-1}$$

Where:
Vs - volume of hydrochloric acid for sample titration;
Vb - volume of hydrochloric acid for blank titration;
df - dilution factor.

E. coli analysis was carried out using a 3-tube Most Probable Number (MPN) method, based on the Indonesian National Standard 2332.1:2015 (Sutiknowati 2016) which included presumptive, confirmed, isolation, morphological and biochemical tests. The MPN value was determined according to the number of positive tubes and compared to MPN-index-table (Blodgett 2010). The numbers of pathogenic *E. coli* bacteria in the sample were expressed in MPN gr^{-1}.

Data analysis. The descriptive statistics were used to analyze the data obtained and they were displayed as percentages in tables and in graphs using the Microsoft Excel program. The distribution chains were also represented by diagrams based on the market participants involved.

Results and Discussion

Fishery production. Fishery production in Jakarta fluctuates every year, as shown in Figure 2: only 3.63% of Jakarta fisheries production was obtained through aquaculture, while 96.37% was captured. Between 2012 and 2015, the fish production rate increase was about 10.18%, while in 2016, it decreased with 49.94%, compared to the previous year, then it lightly decreased until 2018. This decrease in production occurred both in aquaculture and capture fisheries, probably due to the Jakarta Bay reclamation program, and the enforcement of several regulations related to the fisheries activity. According to Puspasari et al (2017), the Jakarta Bay reclamation had an impact on the aquatic

environmental conditions, such as water clarity decrease, the diversity of phytoplankton and macro zoobenthos decrease, fish production decrease due to the elimination of some fishing areas. In addition, Mustaruddin et al (2020) stated that the reduction of the fishing area due to the fishing ground pollution caused the significant reduction of the production rate to 82.2 thousands metric tons year^{-1}. Wiryawan et al (2013) stated that in 2012, the estimation of lost fishing grounds area due to reclamation was about 1,527.34 ha. From 2012 to 2014, the area was concentrated along the Jakarta Bay (Wiryawan et al 2013) and in 2016 the reclamation area was extended to the southern part of Seribu Island (Puspasari et al 2017). The the prohibition of using some fishing gear (trawl and seine nets), the interdiction to catch some species (spawning lobsters, crabs, blue swimming crabs) and the licensing suspension of certain types fishing vessels affected fisheries production. In tuna production, for example, the volume of tuna exports decreased by 16% from October to December 2014, since the enforcement of Regulation No 56/2014 (Arthatiani & Apriliani 2015).

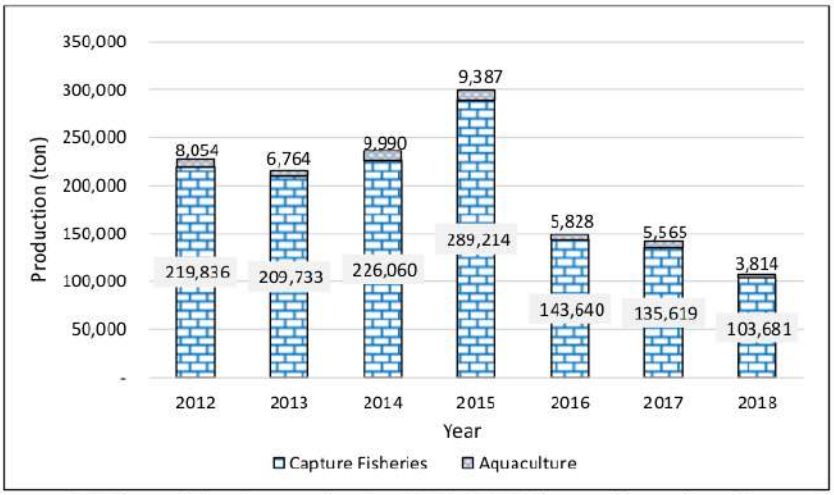

Figure 2. Jakarta fisheries production 2012-2018 (https://satudata.kkp.go.id).

Socio-economic characteristics of market participants. Fish marketing practices in Jakarta domestic market were performed by several institutions and participants, which included fishermen, brokers, collectors, wholesalers, restaurant owners, supermarkets and retailers. The socio-economic characteristics of the market participants, which included their age, gender, marital status, educational level, marketing experience, and knowledge of Good Handling Practices (GHdP) were presented in Table 1.

Table 1 shows that the majority (68.75%) of the participants were within the age of 41-60 years, followed by those between 31-40 (21.88%), under 30 (7.81%), and those above 60 years. It was found that most of the market participants were in their economic active years, between 15-64 years (BPS 2018). According to Farikha & Ardyanto (2016), the economic active years generated a high productivity. Table 1 further showed that male respondents have a greater proportion of the market participants (57.50%) compared to females (42.50%). This result was different with frozen fish marketing in Owerri Municipal, Nigeria, that 93.33% of the marketers were female (Esiobu & Onubuogu 2014) and also in Oyo State that 85% of the marketers were female (Ayanboye et al 2015). However, the current study indicated that both males and females participated in fish marketing. This was also supported by Harper et al (2013), that women's involvement in fisheries was widespread throughout the world. Their roles ranged from catching and processing fish to the sale and finance aspects of this industry.

Table 1

Socio-economic characteristics of market participants

Socio-economic variables	*Frequency*	*Percentage (%)*
	Age	
< 30	25	7.81
31-40	70	21.88
41-50	111	34.69
51-60	109	34.06
>60	5	1.56
Total	320	100
	Sex	
Male	184	57.50
Female	136	42.50
Total	320	100
	Marital status	
Married	307	95.94
Single	13	4.06
Total	320	100
	Education	
No formal education to primary education	134	41.88
Secondary education	99	30.94
Tertiary education	69	21.56
Diploma/graduated	18	5.63
Total	320	100
	Marketing experience (Year)	
≤10	88	27.50
10-20	126	39.38
20-30	89	27.81
>30	17	5.31
Total	320	100
	Job status	
Main job	320	100
Side job	0	0
Total	320	100
	GHdP knowledge	
Good	57	17.81
Fair	108	33.75
Poor	155	48.44
Total	320	100

The data showed that 95.94% of the market participants were married, while 4.06% were single, and all the respondents (100%) stated that selling fish was their main occupation and source of family income. About 41.88% of the market participants in the domestic market in Jakarta did not have any formal education, 30.94% attended junior high school, 21.56% attended senior high school and 5.63% attended a diploma level of education. Therefore, most of the market participants have a low education level. The same result was also recorded by Robin et al (2018), which stated that the education level of fishermen in some coastal areas in Jakarta was very low. Although some respondents answered that education is not an essential subject for fish market, rather than to adapt and be familiar with the new technology. This corroborated the report of Madugu & Edward (2011), which stated that a low education level indicated low literacy skills of market participants. Furthermore, Triyanti & Shafitri (2012) also stated that a low education level was the major reason for the slow adoption of new technology. The same statement was also made by Dongondaji (2010) that literacy has a positive influence on adopting the technology. Most of the respondents (39.38%) had a marketing

experience between 10-20 years, followed by 27.81% with 20-30 years, 27.50% with less than 10 years, and 5.31% with more than 30 years. According to Putri (2016), working experience has a positive effect on productivity, and it indirectly increases profitability (Sri Muliani & Suresmiathi 2015). Ali et al (2008) stated that marketing experience affects participants' profit through a better understanding of the system, condition, trends, and prices. In terms of knowledge of GHdP, 48.44% of the participants had a poor level, while 33.75 % had fair level and only a few (17.81%) had a good level.

As a major implication, the majority of the market participants had a lower knowledge level on how to keep fish in good condition, due to the low levels of education and training, while fish is one of the most perishable foods and its quality maintenance is essential. According to Lusianawaty & Ghani (2015), education and training increase knowledge and skills, which influence personal behavior.

Distribution chain. The distribution chain can be described by a sequence of operators, from producers to the final consumers (Apituley et al 2013). In this study, the fresh fish distribution chain was relatively short, with only six categories of market participants before the final consumer, such as: collectors, suppliers, wholesalers, retailers, restaurants, and supermarkets, as shown in Figure 3.

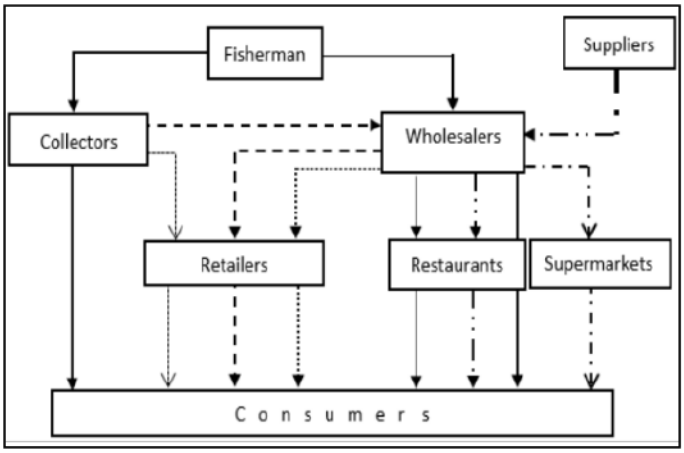

Figure 3. Fish distribution chain at the domestic market in Jakarta.

The main source of fresh fish for domestic consumption in Jakarta are the local fishermen and the suppliers from other provinces, such as Lampung, Banten, West Java and some regions in Central Java. Most fresh fish from local fishermen were marketed through collectors, while those from other regions were traded on the Muara Angke Market and on the Modern Market, located in Nizam Zachman Fishing Port. Figure 3 shows that collectors bought fish directly only from fishermen, while wholesalers obtained it both from fishermen and suppliers. Therefore, fish sold to retailers, restaurant owners, and supermarkets, and are finally delivered to the consumers. Collectors have a dominant part in domestic fish marketing, due to their closer cooperation with fishermen, involving capital assistance, consequently they conserve contractual privileges on the catch. In absence of established fish distribution chains, cooperation and agreements between market participants are prevalent. The selection of the distribution chain by the market participants was influenced by many factors, essentially related to the mutual satisfaction of their requirements, such as: limitations of business capital, transportation capacity and storage facilities. Hanafiah & Saefuddin (1986) state that several aspects affecting the distribution chain of fishery products are the company's financial position, production scale, product nature and the location to the final consumer.

Quality and safety characteristics

Total Volatile Bases (TVB) analysis. Total Volatile Bases (TVB) is a group of biogenic amines formed in non-fermented food products during storage, due to enzymatic and bacterial protein degradation (Connell 1995). Therefore, TVB levels are the most widely used indicator for the chemical assessment of marine fish spoilage (Zhong-yi et al 2010; Amegovu et al 2012). The higher the TVB level, the worse the fish quality. According to Connel (1995), an acceptable limit of the total volatile base - nitrogen for fish is 30 mg 100 g^{-1} muscle. However, Farber (1965) recommended TVB-N levels of 10 mg N 100 g^{-1} or less for very fresh fish, 10-20 mg N 100 g^{-1} for fresh fish with 20–30 mg 100 g^{-1} as a maximum limit for consumption, resulting that levels over 30 mg 100 g^{-1} correspond to spoiled fish. The average range of TVB-N and the percentage of samples compliant with TVB-N level during distribution were presented in Table 2.

Table 2

Range, average and percentage of samples complied with TVB-N level

Distribution chains	*Range of TVB (mg N 100 g^{-1})*	*Average of TVB (mg N 100 g^{-1})*	*% of sample complied with TVB-N level*
Fish landing	8.17-15.92	12.19±2.23	100
Fish auction	9.19-17.91	12.87±2.84	100
Wholesale	10.11-24,09	16.83±3.50	100
Supermarkets	13.02-23.98	18.89±2.29	100
Traditional markets	10.63-44.49	23.16±5.89	77.91

Based on the total volatile base - nitrogen level, Table 2 shows that 100% of mackerel on the landing side, fish auction market and supermarkets complied with TVB-N standard limit, while in the traditional trading site only 77.91% complied with the standard limit. The quality of mackerel during marketing tends to decrease as the TVB level increases, especially in traditional markets. Generally, mackerel on the landing side and fish auction were within the limits of very fresh to fresh quality (8.17-17.91 mg N 100 g^{-1}), those on wholesale and supermarkets were within the range of fresh to maximum limit for consumption (10.11–24.09 mg N 100 g^{-1}), while those on traditional markets were within the fresh quality to spoiled (10.63-44.49 mg N 100 g^{-1}). Deni (2015) also found that fish traded at auction places were in the category of fresh. Connell (1995) indicated that the TVB-N level of fresh fish ranges between 5-20 mg N 100 g^{-1}.

Quality loss in the traditional market was due to poor hygiene in handling conditions, including equipment and location bacterial contamination. There is a direct proportionality relationship between the bacterial load and TVB-N value (Immaculate & Jamila 2018). Eyo (2001) stated that the prime cause of spoilage in fish is bacteria and enzymatic action which result in the production of various volatile compounds and chemical action involving the oxygen of the air and fat in the flesh of the fish. The poor handling and low awareness of marketer relating to the cold chain implementation in traditional markets was also reported in Malawi (Kapute et al 2012) and Sri Lanka (Jinadasa 2014). The lack of cold chain applications, especially in traditional markets, was a major problem in some countries. Despite that all the samples from supermarkets relatively complied with the TVB-N level, some samples have been rejected by sensory analysis due to poor appearance and texture. The same result was reported by Genç et al (2013) for meagre fillets, which were already unacceptable after 8 days, in terms of off-odors, even if their TVB-N content was within the regulated levels. Tejada & Huidobro (2002) stated that TVB-N, although being appropriate and widely used as a legal chemical indicator of seafood spoilage, it is however an inadequate sign of quality during the initial stages of fish damage.

In this study, most of the fish marketed at the traditional trading sites were kept without ice during the sales operations, at temperatures ranging from 22.3±3.4°C to 25.2±0.8°C. According to Ola & Oladipo (2004), fish spoiled faster at ambient temperature than in the chilling container. Maintaining the quality of fresh fish was

carried out through various methods, however, according to (Ghaly et al 2010), the ideal method was their preservation at chilling temperature, in order to delay bacteria growth and biochemical processes causing quality deterioration (Adawyah 2014).

Furthermore, Ariyani et al (2008), stated that at 0-6°C, microorganisms and enzymes activity were retarded. It was also reported that there were significant quality differences between fish stored at cold temperatures compared to those stored in ambient, such as spotted grunter (Osibona & Ezekiel 2014), tilapia (Makawa 2014) and other fish species (Immaculate & Jamila 2018).

According to the TVB level by Farber (1965), 15% of mackerel obtained in the distribution chain were very fresh, 47% were fresh, 28% were fit for consumption and 10% were spoilt (Figure 3). All the spoilt fish were found in traditional markets.

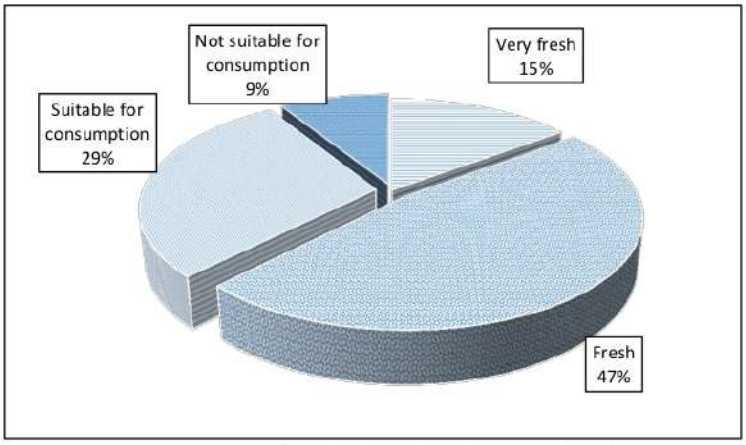

Figure 3. Freshness level of mackerel during distribution.

Escherichia coli analysis. *E. coli* is an organism that typically colonizes the intestinal tract of warm-blooded animals, including humans being the most affluent anaerobe bacteria of the intestinal microflora (Cooke & Ewins 1975; Kaper et al 2004). The presence of E. coli in water and food is a strong indication of recent sewage or animal fecal contamination, because of poor hygiene practices during handling (Sutiknowati 2016; Kim et al 2017). Thus, this bacterium has long been considered as an indicator of recent fecal pollution in food and environment water. Some strains of *E. coli* cause diseases, such as diarrhea, indigestion, and dysentery (Made & Dwipayanti 2010; Wong et al 2012). Besides as an indicator of poor hygiene practices during handling, *E. coli* was also used as a food safety indicator. The total of *E. coli* in mackerel samples, expressed in Most Probable Number per gram (MPN g^{-1}) was shown in Table 3.

Table 3

Number of *Escherichia coli* of mackerel samples

Distribution chains	*Total sample*	*% of the positive sample*	*Number of Escherichia coli (MPN g^{-1})*	*Standard (BSN 2013)*
Fish Landing	150	12.67	3.0-75	
Fish auction	90	18.89	3.0-120	
Wholesale	60	11.67	6.1-93	<3 (MPN g^{-1})
Supermarkets	155	1.29	11-20	
Traditional markets	335	11.64	3.0 to >1100	

The number of *E. coli* of mackerel samples (Table 3) showed that their contamination has occurred at the landing side (3.0-75 MPN g^{-1}) and continued to increase during distribution (>1100 in traditional markets). Contamination indicates poor hygiene

practices during handling. The poor hygiene of equipment and environment in all stages of distribution (fishing vessel, landing side, fish auction, wholesales, and traditional markets), the lack of some hygiene facilities, as well as the poor application of cool chain system during handling were the main factor of this contamination. This was also supported by Deni (2015), stating that the implementation of sanitation and hygiene on boats, cleanliness of handling equipment, and fishermen during fishing was not implemented properly. Indrasari (2020) stated that one of the major problems related to coastal areas in Jakarta were waste and poor sanitation, which was a source of *E. coli* contamination for fish during landing and marketing in the auction. Field observation determined that most of Fish Auction and Traditional Market also have poor hygiene during marketing, due to inadequate drainage and building construction. Some animals, in particular rodents were considered a major source of pathogenic *E. coli* contamination and infection (Jang et al 2017; Ferens & Hovde 2011).

It was also reported that *E. coli* was present in fish sold at some traditional markets in Indonesia, such as cuttlefish and fresh shrimp in Pontianak (Sari & Apridamayanti 2014), fresh and smoked tuna in North Halmahera (Akerina 2018), Layang (*Decapterus russelli*) in Palu (Maruka et al 2017), and tuna in Aceh (Ummamie et al 2017). The similar situations were also reported in other countries, such as Brazil (Lascowski et al 2013), Nigeria (Eze et al 2011), and Iraq (Abbas 2014). *E. coli* is known as one of the most important pathogenic microbial in the field of food quality and safety. Their presence in fish and fishery products for human consumption is not only a potential disease source, but also mediates the transfer of antibiotic resistance to humans. Through the food chain contamination, *E. coli* can lead to mass mortality (Fattahi et al 2015).

Conclusions. The participants in the domestic market of Jakarta were in their economic active years. Both males and females participated in fish marketing, although males (57.50%) had a greater proportion than females (42.50%). Fish marketing is the main job and source of the family income of the participants. 41.88% of them had a low education level. The distribution chain of fresh fish at the domestic market in Jakarta was composed of fishermen, traders, collectors, wholesalers and retailers/supermarkets. Based on the total volatile base - nitrogen level, 100% of mackerel at landing side, fish auction, market and supermarkets complied with the TVB-N limit, while in the traditional trading site only 77.91% met the standard. Inappropriate cold chain applications, poor sanitation, and hygiene practices during distribution and selling were the main causes of the decline in fish quality. The *E. coli* contamination of mackerel started from the unloading and increased during marketing. Measures are required in order to preserve the fish safety and quality, including training related to GHdP, provision of supporting facilities for maintenance during distribution and marketing, as well as monitoring the fresh fish compliance to the safety standards, when necessary by enforcement regulation initiated by the authorities.

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