Study of product quality in the transportation of smoked anchovy in Buton Regency Southeast Sulawesi

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Abstract. Smoked anchovy is a product that is very popular with consumers for several reasons, among others: high nutritional value and vitamin, long shelf-life compared to other durable fish products durable, unique taste, source of calcium that is not easily soluble in water, and so consuming it can prevent bone loss. Smoked fish processing in Buton is still of a traditional method, which may result in lack of attention to fish quality. There are four stages of transporting smoked anchovy products, namely: 1) from the sea to the processing sites, 2) during processing, 3) from the processing sites to the market, 4) from the market to the consumers. The effect of transportation on the quality of smoked anchovies depends much on transportation, smoking temperature, containers and treatment before, and after processing.

1. Introduction
Anchovy is a rich source of protein and calcium. The current utilization of anchovy is very limited, that is, only in fresh or dried form. Besides riced anchovies, already an export commodity, people generally see the fish as an alternative food of low status and economic value. They are mostly consumed by the middle to a low class of communities. Therefore, to raise the value on public's perception, there should be an effort to convert anchovy into processed food products of a high added value.

Anchovy is a food commodity that easily degrades quality. Therefore, in order that it can arrive at consumers before decaying, preservation is necessary. This is required to extend the shelf life of fish, especially during the fishing season. This becomes the basis for Southeast Sulawesi people to find ways to preserve their catches of anchovies, which increase in the fishing season. The people of Buton regency in Southeast Sulawesi process anchovies by traditional fumigation, of which the resulted fish is called "Kaholeo". Kaholeo processing is a household scale industry operated by women in the Waruruma Sub-District, Kokalukuna District, the Town of Bau-bau. This industry has been done and passed down from generation to generation, but until now, it has not made substantial progress.

Food fumigation or smoking, particularly fish, is one of the oldest processing technologies traditionally done to maintain the shelf life of fish. Fumigation can be defined as the process of penetration of volatile compounds into fish as the result of the burning of wood [1], which can produce products with a specific flavour and aroma [2], a long shelf life because of its anti-bacterial activity [3].
and inhibit the enzymatic activity in fish, thus affecting the quality of smoked fish [4]. Chemical compounds from the wood smoke are usually phenol (which act as antioxidants), organic acids, alcohols, carbonyls, hydrocarbons, and nitrogen compounds such as nitrous oxide [2], aldehydes, ketones, esters, ethers, which stay on the surface and then penetrate into the flesh of fish [5].

As a unique product of Southeast Sulawesi, several attempts have been made to introduce, promote, and research related to this product. Kaholeo or smoked anchovy is the product that the local government often shows in exhibitions of both local and national levels. Similarly, in the program of Youth Camp for Asia's Future 2008 (Kema Youth for Asia Progress 2008) in South Korea, presented by Sri Wulandari Putri, Kaholeo won the First Champion among 23 countries in the contest of traditional foods in the food category with a distinctive, delicious and savory taste. [6] has studied the quality and nutritional value of smoked anchovies (Kaholeo). Further, [7] have explored the possibility of utilizing fermented smoked anchovy as safe and nutritious ingredients of food flavouring. This opportunity can be taken for possible export to Japan, which previously imported wood fish that is also used for flavouring food.

The traditional processing of smoked fish can lead to poor attention to the fish quality. Various activities can degrade the quality of fish as it has the characteristic of easily degrading. Changes in the fish quality can be observed starting from the initial catch to the period when the product is ready for consumption. This situation can be seen in the case of the fish transportation in Buton Regency of Southeast Sulawesi. There are four stages in the transportation of smoked anchovy products, namely: 1) from the sea to the processing locations, 2) during processing, 3) from the processing location to the market, 4) from the market to the consumers.

Proper transportation is important for the maintenance of fish quality. Poor transportation in tropical environment can cause substantial losses, such as the physiological damage due to unrefrigerated transport, less protective storage containers, and physical damage out of uncareful loading and unloading. This condition can lead to the decline in taste, quality, and value of fish sold. The objective of the study which then directs further discussion was to examine the effect of transportation in the processing industry on the quality of smoked anchovies.

2. Material and methods
This research was conducted in Waruruma Village, Kokalukuna District, Bau Bau City, Southeast Sulawesi Province. The method used in this research is a survey method in the smoked anchovy industry. The data obtained were analysed descriptively qualitatively.

3. Results and discussion
In this study, the effect of transportation on the quality of smoked anchovies is reviewed starting from the time before the fish is processed to the finished product of smoked anchovy. A flow diagram of delivery is presented in Figure 1.

![Flow diagram of anchovy delivery](image)

**Figure 1.** Flow of anchovy delivery from upstream to downstream

3.1. Transportation from the sea to the processing site
In general, the quality assurance of caught fish landed for the raw material of the fish processing industry is still low. Various causes of this problem are at every stage of the supply chain activities in the fish processing industry. With the fishermen, the fish do not always have good organoleptic quality. The poor handling of fish along the supply chain leads to potentially severe physical damage or contamination in fish. The quality assurance of raw materials for the smoked anchovy processing industry can be seen when the fish are inside the boat.

Anchovies are caught by using netting equipment and transported to land by boat. The landed fish quality can be seen from its organoleptic characteristics: colour, smell, and texture. The resulted
evaluation of the fish’s organoleptic characteristics gives the average score of more than 7 to 8, while with the score of over 6 the fish is categorized into fish of good quality and appropriate for consumption. This indicates that fishermen know the importance of maintaining the freshness of fish, i.e. they keep the fish with icebox in the storage in the boat.

Fish is a food that easily declines in quality. The quality of anchovy before entering processing at the fishermen level physically shows good quality. As the fish is caught by the industry itself for its needs of processing, the quality of the fish is maintained according to the industry needs. Fishing activities and fish storage in the boat on the sea are also a critical point of control in a series of handling raw materials for the processing industry. Potential risks in the fishing activity and in the boat storage include the decomposition of fish, physical damage (physical defects in the body of fish), and the growth of pathogenic bacteria. Prevention from the potential risks can be done by applying a good fish handling technique, that is, maintaining the fish temperature of no more than 50°C and proper fish storage techniques.

Good handling is needed by minimizing defects in fish to reduce the development of spoiling bacteria, especially when the storage condition is likely to support the growth of bacteria. Refrigerating the fish quickly and maintaining its temperature of no more than 50°C can extend the rigor period of fish and slow the process of decomposition caused by enzymes and fat oxidation. Thus, the shelf life can be quite long. Storage conditions with the temperature between 10°C and 50°C will also inhibit the growth and spread of spoiling bacteria into the flesh through the blood vessels and the lining of the abdominal cavity [8]. Potential Risks and storage during fishing on the sea are presented in Table 1.

| Processing Stage | Potential risks | Causes | Description | Prevention |
|------------------|----------------|--------|-------------|------------|
| Handling of anchovies caught by fishermen | Physical | Storage without ice | High temperature of storage accelerates fish damage marked by changes in colour, smell, and texture of fish that is getting soggy | Insulated storage containing ice |
|                  | Changes in the physical characteristics of fresh fish | Storage temperature of more than 5°C |             |            |

The landing site is not far from the fish processing unit, making the fish still in good condition for processing. The transport from the boat to the processing location only uses plastic containers (buckets). The compositions are presented of the quality components of wet anchovies in Table 2.

| Quality Component | Total |
|------------------|-------|
| Energy (Kcal)     | 77    |
| Protein (g)       | 16    |
| Fat (g)           | 1     |
| Carbohydrate (g)  | 0     |
| Calcium (mg)      | 500   |
| Iron (mg)         | 1     |
| Phosphor (mg)     | 500   |
| Vit A (RE)        | 47    |
| Vit B (mg)        | 0.05  |
| Vit C (mg)        | 80    |

Table 1. Potential risks and storage during fishing

Table 2. Quality Components of wet anchovies (in 100 grams)
3.2. Transportation during the traditional processing

Fish used for fumigation should be fresh, not physically defect, and of high quality. One thing to keep in mind, there is no method and equipment, no matter how best they are, that can prevent possible damage.

Processing smoked anchovy (kaholeo), as presented in Figure 2. The processing stages include sorting and washing, draining, smoking and cooling. Like other traditional processing, the basic treatment of anchovies is the reduction of the water content by fumigation or smoking. Unlike other fumigation or drying, this anchovy fumigation is not preceded by salting (without salting process). This is because the fish to be processed are small sizes, so it is enough to use the fumigation to remove the water.

The purpose of fish fumigation is first to obtain a preserving power generated by the smoke. The second goal is to get a distinctive aroma regardless of its preservative ability. Fumigation is a method of processing or preservation by utilizing a combination of drying treatment and natural chemical compounds from the combustion of natural fuels. Burning will produce smoke compounds in the form of vapour and droplets of tar and heat. Smoke compounds stick to the fish and dissolve in the water on the surface of the fish's body, thus forming a distinctive aroma and taste as well as golden or brownish colour.

The fumigation used in the processing of smoked fish is hot fumigation which includes open and closed processes. Open fumigation is carried out in the open space such as home yards, while closed fumigation is done in a closed room (which is a common practice today) such as in the kitchen or specific fumigation houses. Fumigation usually lasts for 3-6 hours with a distance of 50-100 cm between the fire source and the smoked products. With such the distance, according to [6] the temperature ranges from 50 to 700 °C. The fuels used include hardwood (usually mangrove wood), coconut shell, or husk. The resulted product of kaholeo can be seen in Figure 2.

\[
\begin{align*}
\text{Fresh anchovies} \\
\downarrow \\
\text{Sorting and washing} \\
\downarrow \\
\text{Draining} \\
\downarrow \\
\text{Spreading on bamboo racks} \\
\downarrow \\
\text{Fumigation or smoking for 6 hours} \\
\downarrow \\
\text{Kaholeo}
\end{align*}
\]

Figure 2. Processing of smoked anchovies

This processing is dominated by traditional fishermen who have limited skills, knowledge, tools and facilities, sanitation, hygiene and capital, and firmly uphold their traditional practices. The fumigation equipment consists of a furnace as a source of heat, and smoke, on the top of which are placed racks made of woven bamboo or rattan. Unlike the fumigation tools for large fish (such as tuna and milkfish), these racks are made with a certain density that can withstand anchovies well enough to pass the smoke through. The racks are put on top of the stove with the support of poles made of wood, or they are hung by using a rope.
Figure 3. Tools in a smoking room, bamboo racks seen from above: (a), woven bamboo when rolled in (b), stove and supporting poles

The anchovy fumigation is generally held in a closed room (in a specific space), using woven bamboo racks (Figure 3). Racks are placed above the smoking with the supporting poles or legs and sides made of wood. When not in use, the woven bamboo racks can be removed, cleaned (washed), and rolled.

Anchovy fumigation is generally very simple, using rather dirty bamboo racks for grilling the fish. It is likely to trigger bacterial contamination in the smoked fish products. In the process of fumigation, a possible risk can arise from an uncontrolled or unmeasured, concentration of roasting. Having been baked, fish are put on an open or less hygienic container. Usually, they are put in a bamboo basket uncovered. Thus, the growth of microorganisms and the infestation of flies/insects can easily occur.

According to [9], traditional smoking techniques typically use simple equipment, without any consideration for maintaining the quality of fish as raw material, thus with very low standards of sanitation and hygiene. Consequently, the final product is not attractive in form and appearance.

In the smoking process, the most important element is the smoke released from the burning wood, which is composed of vapour and very tiny solid particles. Smoke contains such components as water, aldehydes, acetic acid, ketones, alcohols, formic acid, phenol, and carbon dioxide [10]. The quality and quantity of chemical elements contained in the smoke depending on the type of wood used. The following is the influence of fumigation process on the fish quality:

3.2.1. Effect of smoking on the quality of protein in anchovies. In some areas, there are several variations in the treatment of fish smoking, such as boiling and drying before fumigation and the different types of fish used in the fumigation of fresh water or sea water, fatty and less fatty fish. Thus, it is difficult to obtain general conclusions about the effect of drying and fumigation on the quality protein [11]. The heating process or the reaction between protein and smoke in the smoking process causes protein denaturation, i.e. the changing structure of protein from the original structure, Maillard browning reactions and reduced types of amino acids. This happens at a different temperature range due to the different fish protein content in different types of fish and the same protein content among the different fish species [12]. The hardening that occurs in smoked anchovies is caused by protein denaturation.

3.2.2. Effect of smoking on the fat quality of anchovies. Fish fat is known for having a complex fatty acid composition. The fat composition in sea fish and freshwater fish varies. Freshwater fish contains a high content of C16 and C18, but low content of C20 and C22. In contrast, sea fish has a high content of C20 and C22, but low content of C16 and C18 [13]. Theoretically, the fumigation process protects fats from damage because the smoke components such as phenolic compounds protect fats from oxidation [14]. Besides, [15] states that the factors that can alter the fat molecule by heating are the heating length, temperature, and direct contact with oxygen. Therefore, fumigation tends to cause less fat damage than drying in the sun. This can also be caused by a longer direct contact with oxygen in the sun drying, resulting in greater fat breakdown. In addition, the fat content in each anchovy is relatively low.
3.2.3. Smoking fish with carcinogens. The discussion of smoke as cancer-causing agents (carcinogens) and changes in the gene (mutagens) has become increasingly prevalent. Fumes, not only cigarette smoke but also smoke on the grilled fish, baked or smoked, are suspected of being a dangerous cancer agent. There are three main groups of compounds claimed to be the culprit of cancer, namely a group of polycyclic aromatic hydrocarbons (PAH), N-nitroso compound (NNC), and heterocyclic aromatic amines (HAA). PAH compounds are commonly found in smoked fish, NNC in bacon, and HAA in grilled, or roasted fish. However, the resulted PAH level of smoked anchovy is lower than that of bread, biscuits or other food [6]. Fumigation can produce a high content of HAP, and fumigation of fat-containing foods can affect the formation of HAP. Anchovy with a low-fat content is one of the inhibitors against the formation of PAH in smoked anchovy.

3.2.4. Effect of smoking on organoleptic. Organoleptic is the testing of foodstuff based on preferences and willingness to use a product. In the assessment of food, the properties to determine whether a product is acceptable or not are its sensory characteristics. The effect of fumigation on organoleptic aspects is presented in Table 3.

3.2.5. Storage of smoked anchovies. After fumigation is complete, the fish is left to cool to room temperature. It is better not to pack the product while it is still hot or warm because this causes the air to condense and the fish will be easily spoiled by the growth of moulds. Smoked fish should be allowed to cool, for example, by putting on open, and clean space. A fan can be used to help cool the smoked fish as long as contamination by dirt can be prevented. In this way, the smoked fish can be cooled within 1-2 hours.

| Parameter  | Description of smoked fish quality                                                                 |
|------------|---------------------------------------------------------------------------------------------------|
| Appearance | Bright and shiny. When dark and faded, the smoked fish is of poor quality, which could be caused by poor treatment or fumigation. No dirt in the form dried blood or other dirt. The presence of such dirt is an indication of poor processing and fumigation. The smoked fish has no indications of moulds or sticky liquid. |
| Colour     | Smoked fish is golden brown, yellowish brown or dark brown, and the colour is spread evenly and caused by the maitlaid reaction resulting from the reaction of carbon compounds and amino components on the surface of fish’s body in addition to the effect of phenol and alcohol compounds. |
| Smell      | Specific smell which is caused by the maitlaid reaction. This rather bad smell is the effect of the activities by the proteolytic microorganisms breaking down into compounds that smell like hydrogen sulphide and indole. |
| Taste      | Delicious taste; this delicious smoke flavour is influenced by the fat content. Fat can affect taste and rancid smell. |
| Texture    | Crispy texture; not soft, not brittle and not sticky. |

The storage of smoked fish will play an important role in the distribution and marketing. If poorly packaged or stored, smoked fish will easily decay, and so low access to the market. For a wide range of distribution, it is time to use a low temperature during storage, and this can no longer be avoided. The easiest way to determine the quality of smoked fish is by looking at its sensory or organoleptic quality. Another way is to test it physically, chemically and microbiologically, which certainly requires special, complicated and expensive techniques, equipment and specialized personnel. Sensory quality assessment is adequate if done properly. The quality of various smoked fish can be seen from their five major sensory parameters, namely: appearance, colour, odour, taste and texture, as shown in Table 3.
3.3. *Transportation from processing locations to the market*

In general, transportation from the smoked anchovy processing locations to the market has a lack of attention to sanitation and hygiene aspects. This can be observed from the container and means of transportation used in the process. Containers for the smoked anchovies are sacks, baskets, or cardboards. The sacks commonly used are made of jute, plastic, or nets. Such packages or containers cannot yet protect the smoked anchovies from disturbances during transportation, especially in terms of hygiene. One example is presented in Figure 4.

![Figure 4. Storage container of smoked anchovies](image)

The delivery from the processing site to the market needs tools that will facilitate the process. The selection of tools depends on the number of smoked anchovies to be delivered. There are two commonly used means of transportation: motorbikes and public transport. Shakings during transportation can result in broken or ruined anchovies because the product is quite fragile. This can make it look crushed and attractive to consumers.

3.4. *Transportation from the market to the consumer*

![Figure 5. Marketing of smoked anchovies to consumers](image)

Marketed smoked anchovies get a positive public response in Southeast Sulawesi. Buyers are generally divided into two: primary and secondary. Secondary buyers are those who buy the products and then resell them. This often occurs in the traditional market. Then, they sell again in the town. Meanwhile, the primary buyers are those who buy for their own consumption. Figure 5 shows the
smoked anchovy marketing in the traditional market. Like the delivery from the processing site to the market, the transportation from the market to the consumer also uses the same containers, thus less hygienic. Transportation means include motorcycles, cars, rickshaw, and ocean freight. They are used by both the primary and secondary buyers.

The containers or packaging used by both sellers and buyers do not yet receive adequate attention to the hygiene of smoked anchovies. Therefore, to improve the quality, it is necessary to formulate a special packaging of its own characteristics, and most importantly, it must be sterile from germs, more practical and interesting to consumers.

4. Conclusions

Networking of smoked anchovy processing begins with fishing, industrial processing, marketing, and consumers. The effect of transportation on the quality of smoked anchovies is greatly dependent on the means of transportation used, fumigation temperature, containers, and treatment before and after fish processing.

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