Canning of Traditional Acehnese Food Made by Dried Little Tuna (Euthynnus affinis) Using Two Sterilization Methods

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Abstract. Dried fish of Euthynnus affinis which is also known as “little tuna” or “tongkol” is called ikan kayu in Bahasa Indonesia or keumamah in Acehnese. Keumamah is similar with Japanese katsuobushi which is prepared from dried and smoked bonito. Traditional dishes which made from keumamah are quite many and the one that is famous among Acehnese is called keumamah tumis (cooked keumamah or CK) which is cooked with special Acehnese herbs and spices. This study aimed to determine the effect of sterilization methods on the quality of canned CK. Two variables examined were the treatment of fish as raw material, i.e., B1 = boiled and sun-dried little tuna, B2 = boiled and fried little tuna and the sterilization method: M1 = water bath sterilization for 120 minutes and M2 = sterilization using pressure canner at 115 °C for 60 minutes. Heat penetration study and calculation of sterilization time (Fo value) were conducted using thermocouple data logger for canned CK sterilized using pressure canner. Proximate, total plate count (TPC) analysis and pH were done for fresh fish. Canned CK were analyzed for proximate, peroxide value, and microbiological analysis (TPC). The results showed that the canned CK had an average water content of 49.85%, ash, protein and fat content were 2.18%, 17.74%, and 21.0%, respectively. The pH was 4.85, Peroxide Value (PV) of 5.87%, and the products’ TPC were < 1 x 101 colony/g. Heat penetration study indicated that the Fo for canned CK sterilized at 115 °C for 60 minutes was 5.76 min and at 100°C for 120 minutes was 0.54 min.

1. Introduction
The Indonesia is one of the largest archipelagic countries in Asia where fish is the greatest commodity to be explored. The Province of Aceh is located in the westernmost part of Indonesia with a coastline of up to 1,660 km and sea area of 295,370 km². With this condition, the fishery processing industries have the brightest potential to grow in Aceh Province.

In the world of Indonesian fisheries, the term "cob or tongkol in Bahasa Indonesia" is for small tuna, namely the eastern little tuna (Euthynnus affinis), the frigate and bullet tunas (Auxis sp.), and long-tailed tuna (Thunnus tonggol) [1]. The most common types of fish found in Aceh Province are tuna (Thunnus sp), skipjack (Katsuwonus pelamis) and little tuna (Euthynnus affinis). In certain season, the amount of little tuna caught by fisherman abundant and exceeding the need of the community, therefore it is necessary to maintain the quality of the fresh fish. In order to reduce the risk...
of spoilage, proper handling and processing are needed to preserve and increase the value added of the products obtained.

The emergence of pollution cases is due to imperfect processing, where it is not hygienic, does not comply with commercial standards and does not follow the procedure of "good manufacturing practice". All of these will trigger the emergence cases of dangerous food poisoning. However, if the sterilization process is successful, the product value added will increase significantly compared to the sale or export of fresh fish. Processed fish can also reduce the amount of fish that is wasted and deteriorated when the amount of fish caught by fishermen is an abundance.

One of fish preservation that is commonly done in Aceh Province since long time ago is making keumamah. Keumamah or ikan kayu in Bahasa Indonesia is made from boiled and sun-dried "tongkol" or little tuna. Keumamah is similar with Japanese katsuobushi which is prepared from dried and smoked bonito. Traditional dishes which made from keumamah are quite many and the one that is famous among Acehnese is called keumamah tumis which is cooked by stir-frying keumamah with special herbs and spices. For the rest of this article keumamah tumis will be written as cooked keumamah and abbreviated as CK. To maintain the quality of CK, proper sterilization process is needed so that it can last for a longer time without reducing taste, color, aroma and the nutritional value.

Sterilization is a heat process carried out at high temperatures, usually >100°C with the aim to eliminate all types of microorganisms including molds, yeast, bacteria and its spores that are formed. Unproper sterilization process can change the color, taste, aroma and nutrients of food. In order to obtain a good quality of CK the selection of the appropriate sterilization method is critical.

The sterilization method using a pressure canner (retort) is the most common sterilization process used for canning or bottling food. The sterilization process is designed to kill microbes, especially Clostridium botulinum which is heat resistance. Sterilization is carried out at a sterilization temperature at 121°C at a certain time until the heat given is sufficient to destroy pathogenic bacteria but will minimize the reduction of the nutritional and organoleptic qualities [2].

Sterilization using water bath or heating with boiling water is one method of sterilization that uses a temperature of 100°C at a certain time to kill microbes and avoid contamination of a product. The sterilization process using boiling water is usually applied to products that contain acids [3].

Canned foods must be commercially sterile, which means if there are microorganisms survive, these microbes will not be able to grow and destroyed canned foods in storage conditions at room temperature. Canning CK is a way of preserving and storing processed little tuna in canned containers that can be hermetically and sterilized so that the product is not easily to deteriorate physically, chemically, or biologically. In addition, canning also aims to extend the shelf life, to increase the sale value of little tuna compared to fresh little tuna before it is processed.

Hot filling is a common method used to fill the product into a can or a jar before sterilization process. The product is previously heated until it reaches ± 82°C. The results of a study showed that the products packaged in bottles and filled with hot filling method thus sterilized using boiling water can last for five weeks if the product stored at 5-10°C [4].

Hasnidar (2004), conducted a study using two methods of sterilization in the production of canned CK. The 1st method was heating CK at 80°C then filled into a bottle and sterilized at 118°C in an autoclave for 30 minutes. In the 2nd method, the CK was filled into a bottle (without preheating), then boiled in water at 100°C and sterilized at 118°C for 30 minutes. The results showed that only the first method was successful to preserve the canned CK for two weeks [5].

Sterilization using the boiling water method can only be used for food products that contain acids, while for low acids food the sterilization process must be done in a pressure canner (retort). The main problem that often occurs in the process of food canning is safety and quality of food. The nutritional value of foods with high protein content such as fish (pH > 4.5) can be reduced after canning [6]. Changes in nutritional value after canning can be caused by improper temperature and time combination during sterilization. Sterilization using high temperature (± 121 ° C) for a long time in the canning process can cause protein denaturation [7]. In addition, canned fish can be contaminated as
well with microbial heat-producing toxins. Other microbiological hazards are contamination by histamine (scromboid toxins) and algal toxins which are also heat-resistant [8].

This research aimed to find the best sterilization method to preserve CK so that it can be stored for a longer period of time at ambient temperature. The best method indicated minimal changes in nutritional value and fulfill the microbial standard for canned food.

2. Materials and methods
This study examined two variables i.e., 1) the treatment of fresh little tuna as raw material, which consisted of two factors: B1 = boiled and sun-dried little tuna, B2 = boiled and fried little tuna and 2) the sterilization method, which also consisted of two factors: M1 = water bath sterilization for 120 minutes and M2 = sterilization using pressure canner (retort) at 115 °C for 60 minutes.

2.1. Preparation of boiled and sundried little tuna
The fresh little tuna was first washed thoroughly with running tap water then removing the head, tail, thorns and bones so that only the meat was obtained. The fish was cut into four parts, then boiled for 20 minutes, drained and dried for 2 to 3 days under the sun. The dried little tuna was immersed 12 hours before the surface can be cleaned and cut into small pieces (± 2 cm x 2 cm x 3 cm) then ready to be cooked.

2.2. Preparation of boiled and fried little tuna
Fresh fish was purchased from the Lampulo Baru Market in Banda Aceh. Weeded fish are washed thoroughly with running water and fish meat was cut into four parts. Five (5g) of salt and 300 ml of lime juice then added into the fish meat, turned over every 5 minutes so that the salt and lime juice were absorbed. Water was finally added until the meat was completely submerged and then boiled for ±10 minutes and drain. After cooled and dried, the fish parts were fried into 2000 ml of cooking oil at 170-200°C for ± 10 minutes. Finally, the dried and fried fish was cut into small pieces and ready for cooking.

2.3. Process for making cooked keumamah
The cooking process of CK was done first by heating 300 ml cooking oil then stir-fried the spices. The blended spices were consisted of onion, garlic, red chili, cayenne, asam sunti (salted, fermented and dried bilimbi - Averrhoa bilimbi), ginger, and turmeric which had been blended previously. After blended spices were half cooked then curry leaves and chopped green chili were added into the mixture. Finally, small pieces of boiled and sundried little tuna or boiled and fried little tuna was added, mixed and cooked thoroughly.

2.4. Sterilization, cooling and ripening processes
Before the sterilization process began, the jar (9.2 cm x 6.5 cm) and the lid were heated in boiling water for 15 minutes. It was drained and while the jar was still hot, the warmed CK (± 170 g) was filled into the jar and closed immediately with the hot lid. Sterilization were conducting using two methods: first, in a water bath at 100°C for 120 minutes and second, in a retort (pressure canner) at 115°C for 60 minutes. Upon completion of sterilization, all jars were drained and stored at room temperature.

2.5. Thermal penetration study for the Fo calculation
For this purpose, the thermocouples gland with build-it logger (TSP Micro, Ellab, Denmark) were placed at two positions. The retort temperature measurement was done by placing a thermocouple right above the water level at the base of pressure canner (retort). For the core product temperature measurement, a thermocouple was placed inside a can before the can was seammed. This thermocouple was positioning in the middle of the can pointing upward to the geometric center and was held by stuffing the product (warmed CK). The recorded temperatures were converted into data (Lethality rate,
L) using a docking system (Pro Multi Reader, Ellab, Denmark) and an application software (ValSuite Pro, Ellab). The experiments were repeated several times and the data obtained were compared and evaluated carefully.

2.6. Analysis of fresh little tuna and canned CK
Analysis of fresh little tuna included proximate analysis: water content (method of SNI 01-2891-1992, point 5.1), ash content (SNI 01-2891-1992, point 6.1), protein content (SNI 01-2891-1992, point 7.1), fat content (AOAC method 938.06-33.6.04.2005), total plate count (TPC) analysis and pH. For canned CK similar analysis were performed which were proximate analysis, peroxide value, and microbiological analysis (total plate count or TPC).

2.7. Statistical Analysis
All the experiments in this study were performed in triplicates. The significant differences in water, ash, protein, and fat content as well as the results of Peroxide Value (PV) were analyzed using two-way analysis of variance (ANOVA). Significantly different groups were compared at a 95% confidence level (P < 0.05).

3. Results and discussion

3.1. The quality of fresh little tuna
Proximate analysis and total plate count (TPC) were conducted for the fresh little tuna before it was processed to be CK. The results can be seen in Table 1.

| Parameters        | Percentage (%) ± SD |
|-------------------|---------------------|
| Water / moisture  | 75.25 ± 0.18        |
| Ash               | 2.0 ± 0.07          |
| Fat               | 0.54 ± 0.01         |
| Protein           | 24.20 ± 0.14        |
| pH                | 5.64 ± 0.10         |
| Total Plate Count (TPC) | 3.3 x 10^5 cfu/g   |

A study reported that the water content of fresh tuna was 80.40%, fat content of 0.28%, protein content of 20.9% and ash content of 1.20% [9]. If this is compared with the results of this study as in Table 2, the water content is slightly lower, the ash content is slightly higher, the fat and protein content are still in the range. Usually, the pH level of fresh fish ranges from 6.4 to 6.6 while in this study the pH of fresh fish is 5.64. This might be due to glycolysis occur in fish [10]. Based on SNI 7388:2009 the limit of microbial contamination of fresh fish is 5.0 x 10^5 cfu/g. Therefore, the fresh fish as raw material for the CK was still meet the SNI standard [11].

3.2. The quality of canned CK

3.2.1. Water content. The most important property in a food is water content. Water content contained in food will affect the appearance, texture, taste and will determine the durability of the food itself. The results of the analysis showed that the canned CK water content ranged from 44.53 to 53.50% with an average of 49.85%. The results indicated that the sterilization method (M) had a significant effect (P≤0.05) on the canned CK water content (Figure 1). It can be seen that the highest water content was obtained when the canned CK sterilized using waterbath for 120 minutes (M1) and decreased when sterilization carried out using a pressure canner at 115°C for 60 minutes (M2).
All food ingredients contain different amounts of water. Water is the most important component in a food. The analysis result showed that the water content of fresh fish was 75.25% which far higher than the canned products' water content. These can be caused by the treatment received by fresh fish, since the fish were dried into *keumamah*, boiled, fried and because of the heat received by the products during cooking, hot-filling process as well as when sterilizing for a long time. Water content in food will shrink after experience the cooking process using high temperatures. The higher the sterilization temperature used, the more the water content decreased.

![Figure 1. Influence of sterilization methods on the water content of canned CK](image1)

![Figure 2. Effect of method and time of sterilization (M) on the ash content of canned CK](image2)

### 3.2.2. Ash content
Ash content is closely related to mineral content in food. The higher the ash content contained in food ingredients the higher the mineral content in these materials [12]. In principle, the analysis of minerals in food can be divided into two, namely the analysis of total minerals or total ash and analysis of each type of mineral. In this study the ash content analysis was carried out in the form of total ash analysis.

The results of the analysis showed that the sterilization method (M) had a significant effect (P≤0.05) on the ash content of canned CK, as can be seen in Figure 2. The graph indicated that the
The lowest ash content was for the product that sterilized using water bath at 100°C for 120 minutes (M1) and increased when sterilized using pressure canner at 115°C for 60 minutes (M2).

The ash content indicates that there is inorganic mineral contain in the foodstuff. The slight increment of ash content from fresh little tuna to canned CK can be caused by the addition of spices when cooking. The ash is obtained from a material that is first dried and then bonded and the residue is mineral. About 96% of the food is made up of organic matter and water, the rest are minerals. The mineral component can be determined by the determination of the residual combustion of the mineral salt or known as aromatic.

3.2.3. **Protein content.** Protein is one of the food substances in the form of amino acids which have functions as builders and regulators for the body. The results of data analysis showed that the protein content of canned CK ranged from 16.97-18.72% with an average of 17.74%. The effect of raw materials and methods as well as time of sterilization on canned CK can be seen in Figure 3.

The use of heat in food processing such as boiling, steaming and frying can affect the nutritional value of food, especially protein content. The protein in the food consumed is absorbed by the intestine in the form of amino acids. Protein is a source of amino acids consisting of carbon, hydrogen, oxygen and nitrogen. Protein plays an important role which functions as a builder and regulator of the human body [12].

In the cooking process, the treatment of fish as raw materials which was boiled and fried then sterilized using a pressure canner or water bath causing a decrease in protein content significantly from 24.20% (fresh fish) to averagely 17.74% (canned CK). As can be seen in Figure 5, the reduction was more when the canned CK made from fish that was boiled and fried compared to the boiled and sun-dried fish. Protein reduction occurs during food processing at high temperatures. During the sterilization process, around 40% of the total amino acids in fish meat are degraded depending on how high the temperature and how long the sterilization process are conducted.

Figure 5 also demonstrated that there was no significant reduction of canned CK protein content when sterilized using water bath (100°C) for 120 min. These indicated that there was a reduction in protein content when a higher sterilization temperature used (115°C) even though the processing time was shorter (only 60 min). However, the overall reductions were statistically not significant.

3.2.4. **The fat content.** Fresh little tuna contains omega-3 fatty acid of 1.5g /100g and omega-6 fatty acids of 1.8g /100g [13]. Determination of fat content in a food is important, especially in fish. Fish fat
contains omega-3 polyunsaturated fatty acids, especially EPA and DHA which are good for the human body. In food, fat acts as a carrier for vitamins, flavor and as important as the calories source [12].

The results of the fat content on canned CK ranged from 4.49 to 6.27% with an average of 5.19%. The results of analysis of variance showed that the raw material treatment (B) and the sterilization method had no significant effect (P> 0.05) on the fat content.

3.2.5. Peroxide value. Peroxide value is an index of the amount of fat or oil that has undergone oxidation. Oils that contain unsaturated fatty acids can be oxidized to produce a peroxide compound. A high peroxide value indicates fat or oil has oxidized. Peroxide compounds can accelerate the process of rancidity and food deterioration.

The results of the analysis showed that the peroxide value of canned CK ranged from 5.83 to 5.90 mEq/kg with an average value of 5.87 mEq/kg. The effect of raw material treatment on the fat content can be seen in Figure 4. As can be seen in the graph, the highest PV was found in canned CK prepared from boiled and dried fish (B1) and decreases with when boiled and fried fish was used (B2).

![Figure 4](image-url)

**Figure 4.** Effect of raw material treatment on the peroxide value (PV) of canned CK

Rancidity in oil is caused by the oxidation of fatty acids to form free radicals thus produce peroxide which is an intermediate product that will decompose to form carbonyl compounds (aldehydes and ketones) [12]. An increased of peroxide value indicates that the oil has undergone oxidized.

Deterioration of oil is caused by repeating used of oil for heating and or frying. Based on Indonesian National Standard-SNI (2013) the maximum limit for cooking oil peroxide value is 10 meq/kg [14].

The PV of canned CK in this study was 5.85-5.88 meq/kg therefore it still meets the SNI-3741-2013. The low PV indicated that the heating process has less effect on the rancidity of the canned CK. This was because during fish frying, the oil used was the fresh oil and it was still in its best quality and has never been rancid. Rancidity in food products can cause products to decline in quality and selling power. Rancidity occurs due to the interaction of fat and air (oxygen) which causes the formation of peroxides that are unstable and easily decomposed into derivatives such as aldehydes, ketones and other compounds with low molecular weight.

3.2.6. The microbiological analysis. TPC test for canned CK was done to find out the number of aerob mesophillic microbes per gram sample if they are still existed in the products after sterilization and to find out the quality of the products during storage. The tests were carried out to determine whether or not the canned CK was safe to be consumed for a long time.

The occurrence of microbial contamination in a canned food due to imperfect processes during product sterilization in a pressure canner or water bath. A recommended temperature to kill microbes
according UN-FAO is 121°C [15]. A recommended sterilization time is depending on the amount and types of initial microorganisms that are possibly contaminated the food.

The sterilization condition used in this study was 115 °C for 60 minutes. The vegetative cells can be killed, but for bacterial spores which highly heat resistance may not be able to be killed completely. The results of the TPC on the canned CK in week 0 showed that there was no microbial contamination. Based on the Indonesian National Standard (SNI-7388-2009) for food processing product that use sterilization such as canned fish, the microbial contamination limit is <1x10^1 colony/g. In this study, no single colony grew on solid media in petri dishes. Therefore, it can be said that the sterilization processes have produced canned CK which have met the SNI-7388-2009 at week 0, based on the TPC analysis.

3.2.7. Calculation of the \( F_0 \) value. The standard parameter used to indicate the success of a thermal treatment is called the \( F_0 \) value (the thermal process severity). The \( F_0 \) value of a thermal process in this research was determined by means of physical method which used the temperature changes during thermal process at the slowest heating point (SHP) of the product. The results are related to the thermal destruction rate at a reference temperature [15]. The \( F_0 \) value was identical with time in minute if the SHP of a product reached 121.1 °C.

Heat penetration study resulted that the \( F_0 \) for canned CK sterilized at 115 °C for 60 minutes was 5.76 min. This \( F_0 \) value has meet the safety standard for the survival of \( C. \) botulinum, pathogenic bacteria that are commonly caused serious illness if present in food. According to UN-FAO, “the minimum thermal process required to provide safety from the survival of \( C. \) botulinum is equivalent, in sterilizing effect, to 2.8 min at the slowest heating point (the SHP) of the container. This process is commonly referred to as a "botulinum cook" [15].

The \( F_0 \) for canned CK sterilized using water bath at 100 °C for 120 minutes, however, only 0.54 min. The differences between \( F_0 \) for the two sterilization methods caused by the heat generated by each method. Pressure canner (retort) applied pressure during its process thus the temperature can increase far above 100°C in a short time. This equipment allows sterilization temperature to be set at 121°C. Water bath sterilization on the other hand, generates maximum heat only as a boiling water temperature (~100°C) at all time. Therefore, the heat that penetrates into the product particularly at the slowest heating point (SHP) will reach 100°C as the maximum temperature after a long sterilization time.

Theoretically, the \( F_0 \) obtained by water bath sterilization was not sufficient yet for a "botulinum cook" to kill \( C. \) botulinum completely which required minimum \( F_0 \) of 2.8 min. However, the result of total plate count (TPC) analysis indicated that no microbial treats found in canned CK. Samples taken from the two products showed no single colony grew on solid media in petri dishes. The TPC analysis were done in the same week with the production of canned CK. This result might be caused by the lower pH (< 5) of the CK due to the addition of specific herbs and spices which can be functioned as natural preservatives for the product. However, a further study is essential to examined the product quality during storage for at least six months to one year after production. Therefore, a storage test at room temperature is necessary to be done to prove if there is a potential threat, microbiologically and to make sure that the sterilization process is already sufficient and successful or further experiment with longer sterilization times are needed.

4. Conclusion

The sterilization method used in preserving the canned CK reduced the water content in a significant amount when compared to the water content of fresh fish. Water content in food will shrink after experience the cooking process using high temperatures. The treatment of fish as raw materials which was boiled and fried then sterilized using a pressure canner or water bath causing a decrease in protein content significantly from 24.20% (fresh fish) to averagely 17.74% (canned CK).

The PV of canned CK in this study was 5.85-5.88 meq/kg therefore it has meet the Indonesian National Standard-SNI. The low PV indicated that the heating process has less effect on the rancidity
of the canned CK. The microbial contamination limit according to the SNI-7388-2009 for food processing such as canned fish is <1x10^1 colony/g. In this study, no single colony grew on solid media in petri dishes for canned CK right after sterilization and before the storage test. The sterilization process, either using water bath at 100°C for 120 min or pressure canner at 115°C for 60 min have met the SNI-7388-2009 based on TPC analysis at week 0. The fish treatment which is recommended to be used is the boiled dan fried little tuna based on the results of peroxide value (PV) analysis.

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