Hazard analysis and critical control point of milkfish floss production as indigenous food from Banten province

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Abstract. Milkfish floss is indigenous food from Banten which is produced by Small and Medium Enterprise (SME). Milkfish floss is potential to be developed due to the high demand from outside Banten areas, but it is very easy to get rancidity, spoilage by the microbes, or existing dust and hair. Therefore, milkfish floss production process still needs to improve the processing method according to the standards to produce a safe and good product. Quality assurance is done by compiling hazard analysis and control point (HACCP) documents. The aim of this study was to identify hazards of raw material and production chain, determine CCPs in every chain, and create HACCP document plan. The research method was conducted by interview, observation, laboratory analysis, and literature review. The compiling of the HACCP document is carried out in several steps including creating a HACCP team, identification of consumers and product descriptions, making processing flow diagrams, identifying hazards, determining critical control points (CCPs), determining the critical limit, monitoring, and correcting action. The hazards that may occur in milkfish floss are residues of heavy metals, pathogenic microbes, thorns, dust, and hair. The CCPs of raw material are fish, lemongrass, lime leaves, shallot, and garlic, while the CCPs of the processing are the acceptance of fish, cleaning, steaming, frying, draining, and packaging.

Keywords: milkfish floss, HACCP, food quality, food safety

1. Introduction
Milkfish is a fishery product that is consumed by many people. Milkfish products have huge potential to be developed because of the high demand for it [1] Processed milkfish product is perishable food because its high nutritional content, so the microbes can grow easily. The nutritional contents of milkfish are protein (20%), fat (0.72%), ash (2.812%), carbohydrates (0.114%), and water (75.85%) [1].

One of the processed products of milkfish is milkfish floss and indigenous from Banten Province. Milkfish floss processed by steaming and frying of milkfish meat and seasoned with many spices. The product has fine shape, delicious taste, good odor, and relatively has long shelf life [2].

The high potential of contamination makes the processing chain very important. The hygiene processing must be applied because if the contamination happens like physical, chemical, and microbiological, it will risk the consumer [3]. So, food safety assurance must be applied and the manufacturer can protect the consumer [3].
Food safety assurance that has been recognized worldwide is HACCP (Hazard Analysis and Critical Control Points). HACCP is a quality assurance system to identify, assess, and control potential hazards as well as a control system that focuses on prevention. The objective of HACCP is to prevent potential hazards like biological, chemical, and physical hazards, and reduce the risk of hazards emerge by controlling the critical control points (CCP) in every production chain. Control of the critical limits during the production process is the key factor to ensure the quality of the final product [3]. Therefore, the aim of this study was to identify the hazards of raw material and production chain, determine CCPs in each stage, and create the HACCP document plan.

2. Research methodology

2.1. Time and place of research
This research was conducted at the Laboratory of Food Technology and Agroecotechnology, Faculty of Agriculture, University of Sultan Ageng Tirtayasa and at one of milkfish floss Small and Medium Enterprise (SME) in Serang City, Banten Province in July-September 2019. The products of selected SME have halal certification, P-IRT certification, and high sales capacity.

2.2. Data collecting technique
Collecting data used survey methods, in-depth interviews with open questions, observation of every processing chain from raw material to final product, laboratory analysis, and documentation. Laboratory analysis was carried out to determine the hazards that may exist in raw materials and production chains.

2.3. Data analysis technique
All data from interviews and observation were processed and mapped on diagrams. Laboratory analysis was carried out on the possibility of chemical, microbiological, and physical contamination of raw materials and during the production chain. Analysis of chemical hazard of lead (Pb) and cadmium (Cd) contaminants were carried out using Atomic Absorption Spectroscopy (AAS). Analysis of microbiological hazard consisted of Eschericia coli, Vibrio parahaemolyticus, Vibrio cholerae, Salmonella sp, and Staphylococcus aureus. Physical hazards that might occur and were visible to the eye such as dust, hair and other foreign objects that should not be present in food. This data became a supporting document in determining the CCPs and preparing the HACCP plan.

3. Results and discussion

3.1. General description of milkfish floss SME
The object of study was “Bilvie” milkfish processing SME at Cipocok Jaya District, Serang City. This SME was founded in 2006 and has seven permanent workers and several temporary workers who are hired when Eid Al Fitr holidays or long weekend. This SME produces 100 milkfish floss with a size of 100 grams per day. The milkfish floss has been certified by home industry production from public health office and halal from Indonesia Ulama Council. The market of milkfish floss are around the Serang City, Serang Regency, Tangerang and Bekasi.

3.2. Production chain of milkfish floss
The raw materials needed in the production chain were milkfish, cooking oil, coconut milk powder, lemongrass, salt, sugar, shallots, bay leaves, lime leaves, coriander, garlic, and water for washing fish. The process of making milkfish floss began with cleaning the fish which include cleaning the scales and offal, filleting, steaming, refining fish meat, mixing spices and fish, frying, draining oil, and packaging. The picture of the milkfish floss production chain shows in Figure 1.
3.3. Hazard analysis identification of raw materials and packaging

Hazard identification and analysis includes potency of physical, chemical and microbiological hazards in raw materials and packaging used to make milkfish floss. The identification details shown in Table 1.

Table 1. Hazard analysis identification of raw materials and packaging

| Raw Material | Hazards | Causes | Ways of Control |
|--------------|---------|--------|-----------------|
| Milkfish     | Microbiological pathogen bacteria : Chemical : Pb, Cd residue, Physical : sand, dirt, dust | 1. Contaminated living conditions 2. Incorrect storage condition | 1. Choosing the right supplier 2. Frozen storing |
| Water        | Microbiological pathogen bacteria : Chemical : Pb, Cd residue, Groundwater standard | not | 1. Using water which source is not close to dirty environments 2. filtration |
| **Physical** | **Microbiological** | **Chemical** | **Unsuitable storing** | **Environmental contamination** | **Choosing the right supplier** |
|--------------|---------------------|-------------|------------------------|-------------------------------|-----------------------------|
| sand, dirt, dust | pathogen bacteria, mold | Pb, Cd residue | 1. Unsuitable storing (high moisture content) | 2. Environmental contamination | 1. Frozen storing 2. Vacuum packing 3. Choosing the right supplier |
| **Lemongrass** | pathogen bacteria, mold | Pb, Cd residue | 1. Unsuitable storing (high moisture content) | 2. Environmental contamination | 1. Frozen storing 2. Vacuum packing 3. Choosing the right supplier |
| **Lime leaves** | pathogen bacteria, mold | Pb, Cd residue | 1. Unsuitable storing (high moisture content) | 2. Environmental contamination | 1. Frozen storing 2. Vacuum packing 3. Choosing the right supplier |
| **Bay leaves** | pathogen bacteria, mold | Pb, Cd residue | 1. Unsuitable storing (high moisture content) | 2. Environmental contamination | 1. Frozen storing 2. Vacuum packing 3. Choosing the right supplier |
| **Shallot** | pathogen bacteria, mold | Pb, Cd residue | 1. Unsuitable storing (high moisture content) | 2. Environmental contamination | 1. Frozen storing 2. Vacuum packing 3. Choosing the right supplier |
| **Garlic** | pathogen bacteria, mold | Pb, Cd residue | 1. Unsuitable storing (high moisture content) | 2. Environmental contamination | 1. Frozen storing 2. Vacuum packing 3. Choosing the right supplier |
| **Coriander** | pathogen bacteria, mold | Pb, Cd residue | 1. Unsuitable storing (high moisture content) | 2. Environmental contamination | 1. Frozen storing 2. Vacuum packing 3. Choosing the right supplier |
| **Sugar** | osmophilic bacteria | Pb, Cd residue | 1. Unsuitable storing (high moisture content) | 2. Environmental contamination | 1. Choosing the right supplier 2. Filter the sugar so the foreign objects do not contaminate |
| **Salt** | halophilic bacteria | Pb, Cd residue | 1. Unsuitable storing (high moisture content) | 2. Environmental contamination | 1. Choosing the right supplier 2. Filter the sugar so the foreign objects do not contaminate |
Improper storing and drying process can lead to increased growth of *Aspergillus* in herbs and spices. *Aspergillus* can produce mycotoxins which are very dangerous to health. One of mycotoxins that can be found in spices is aflatoxin. Consumption of contaminated food with high doses of aflatoxins can cause acute aflatoxicosis and can cause hepaticotoxic manifestations or in chronic cases can result in death due to fulminant liver failure [4]. Therefore, it is necessary to ensure that the raw material for milkfish floss is free from mold.

Microorganisms on fisheries products are from several sources like soil, surface water, dust, digestive tracts of humans and animals, environment, preparation, storing, and processing. Microbiological criteria measure of risk management which shows the acceptance of the food. Pathogenic bacteria are very dangerous because they produce metabolites which are harmful to the body. Some of the pathogenic microbes that found in fish are *Eschericia coli*, *Vibrio parahaemolyticus*, *Vibrio cholerae*, *Salmonella sp*, and *Staphylococcus aureus* [5].

Milkfish can be contaminated by heavy metals. Heavy metals which are hazardous and toxic materials in the waters can come from land activities around these waters like industrial activities, oil mining, agriculture, transportation, hospitals, and any other domestic activities [6]. Heavy metals will contaminate sea water and surrounding waters so it will accumulate in the bodies of aquatic living things [7]. Heavy metals that can contaminate milkfish are lead and cadmium. Lead has high toxicity to humans and can damage brain development in children, causing red blood cell blockage, anemia, and affect

| Physical : sand, dirt, dust | 2. Environmental contamination | 1. Choosing the right supplier  
2. Filter the salt so the foreign objects do not contaminate |
|-----------------------------|-------------------------------|--------------------------------------------------------------------------------|
| Powdered Coconut Milk      | Microbiological: lipophilic bacteria  
Physical : sand, dirt, dust | 1. Unsuitable storing  
2. Environmental contamination |
|                            |                               | 1. Choosing the right supplier  
2. Filter the powdered coconut milk so the foreign objects do not contaminate |
| Cooking Oil                | Chemical: High peroxide number/rancid, Pb, Cd, Hg, Sn, As  
Physical: Color is not yellow clear, dust | Exposure to oxygen and light too long |
| Primer Packaging           | Plastic Monomer               | 1. Choosing the right supplier  
2. Storage keep away from light and oxygen,  
3. Packaging store in dry and clean conditions |
| Secondary Packaging        | Cardboard monomer, dust, dirt | 1. Choosing the right packaging  
2. Environmental contamination |
|                            |                               | 1. Choosing the right supplier  
2. Choosing the right supplier  
3. Packaging store in dry and clean conditions |

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other limbs [8]. Chronic cadmium poisoning causes the damage of the urinary system, respiration system, blood circulation and heart, reproduction system, the olfactory system, and bone fragility [9].

The physical hazards occur because of raw material and processing. Physical hazards can be defined as hard, sharp foreign objects that are not expected to be present in the food product and may be intrinsic or extrinsic. Physical hazards may cause injuries in the mouth, teeth, pharynx and/or throat or can lead to asphyxiation in a worst-case scenario. But, some strange materials in food products may not be a physical hazard but rather an undesirable material such as hair, insects, or sand that are not likely to cause injuries [10].

Choosing the right suppliers and good storing conditions must be done to avoid various physical, chemical and microbiological contaminants. Apart from raw materials, potency of primary and secondary packaging’s monomers migrate into food are high, especially when heated or at high temperatures. Choosing the right packaging and store in clean and dry conditions can prevent dust or other dirt [11].

3.4. Hazard analysis identification of production chain
Hazard identification and analysis include potential physical, chemical and microbiological hazards in processing chains. The identification details shown in Table 2.

| Process              | Hazards                        | Causes                                      | Ways of Control                                                                 |
|----------------------|--------------------------------|---------------------------------------------|--------------------------------------------------------------------------------|
| Cleaning the scales and offal | Microbiological: pathogen bacteria | 1. Cross contamination from equipments and workers 2. Environmental contamination | 1. Using gloves 2. Using clean equipments and made from stainless steel |
| Filleting            | Physical: fine scales, dust Microbiological: pathogen bacteria | 1. Cross contamination from equipments and workers 2. Environmental contamination | 1. Using gloves 2. Using clean equipments and made from stainless steel |
| Washing              | Physical: fine scales, dust Microbiological: pathogen bacteria Chemical: heavy metals | 1. Bad water quality 2. Environmental contamination | 1. Using water which source is not close to dirty environments 2. Water filtration |
| Steaming             | Physical: fine scales, dust Cross contamination from equipments and workers | 1. Using gloves 2. Using clean equipments and made from stainless steel | |
| Frying               | Physical: dirt, dust, scale, charred Chemical: heavy metals Cross contamination from equipments and workers | 1. Using gloves 2. Using clean equipments and made from stainless steel |
3. Using good quality of cooking oil

Draining

| Physical: dust | Chemical: residual oil, rancid odor |
|---------------|------------------------------------|
| 1. Not dry draining |
| 2. Cross contamination from equipments, workers, environment |

Packaging

| Physical: dirt, dust | Microbiological: pathogen bacteria |
|---------------------|-----------------------------------|
| Cross contamination from equipments, workers, environment |

1. Using gloves
2. Using clean equipments

Poor milkfish floss production process can affect the quality of the final product. Physical hazards can arise due to contamination from workers because of not applying proper food processing methods. In addition, contamination in the process can occur due to poor maintenance of equipment, unclean washing of equipment, or unhygienic production place.

Heavy metal contamination such as lead and cadmium in milkfish floss processing chain can be prevented by using uncontaminated raw materials. When using raw materials that are contaminated with metals, the processing process cannot eliminate it. Because when processing of milkfish floss there is no addition of organic materials. Metals can bond with natural organic material and synthetic organic material [12]. The process of forming these bonds can occur through the formation of organic salts with carboxyl groups like citric acid, tartrate acid, etc. Beside that, metals can bind to atoms which have free electrons in organic compounds to form complexes [13]. When the draining process is not done properly, the remaining oil contained in the floss is still a lot, which will cause rancidity [14].

Fish is a product that has a very high risk of contamination, because the dead fish carry out an uncontrolled metabolic process. The metabolites are good substrates for pathogenic bacteria. Beside raw materials, microbiological contamination in the fish processing process can also occur due to cross-contamination from equipment, handling, packaging, other materials, and workers [15]. Therefore, manufacturers must frequently sanitize the equipment and carry out Good Manufacturing Practices (GMP).

3.5. Determination of critical control points (CCP) on raw materials

Critical Control Points (CCP) are steps that can be implemented to prevent or eliminate hazards to a safe point. Determining CCP on raw materials is very important because the quality of raw materials greatly affects the final product produced and making it safe for consumption [11]. The determination details shows in Table 3

| Raw Material | Hazards | Is there a hazard? (Q1) | Can the production process eliminate and reduce hazards? (Q2) | Conclusion |
|--------------|---------|--------------------------|---------------------------------------------------------------|------------|
| Milkfish     | Microbiological : pathogen bacteria | Yes | Yes: CC P  
No: Not CCP | Yes: CC P  
No: Not CCP | CCP |
|          | Chemical : Pb, Cd residue | Physical : sand, dirt, dust | Microbiological : | Yes | No | Not CCP |
|----------|-----------------------------|-------------------------------|------------------|-----|----|--------|
| Water    |                             |                               | Yes, pathogen bacteria | Yes | No | Not CCP |
| Lemongrass | Chemical : Pb, Cd residue | Physical : sand, dirt, dust | pathogen bacteria, mold | Yes | No | CCP    |
| Lime leaves | Chemical : Pb, Cd residue | Physical : sand, dirt, dust | pathogen bacteria, mold | Yes | No | CCP    |
| Bay leaves | Chemical : Pb, Cd residue | Physical : sand, dirt, dust | pathogen bacteria, mold | Yes | No | CCP    |
| Shallot  | Chemical : Pb, Cd residue | Physical : sand, dirt, dust | pathogen bacteria, mold | Yes | No | CCP    |
| Garlic   | Chemical : Pb, Cd residue | Physical : sand, dirt, dust | pathogen bacteria, mold | Yes | No | CCP    |
| Coriander | Chemical : Pb, Cd residue | Physical : sand, dirt, dust | pathogen bacteria, mold | Yes | No | Not CCP |
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Table 3 shows that CCPs in the raw materials are milkfish, lime leaves, bay leaves, lemongrass, shallots, and garlic. Milkfish becomes CCP because it is very easy to grow microbes as hazards in fishery products. According to NADFC Standard No. 23 on 2017, the maximum limit of Pb and Cd contamination in fresh fish are 0.20 and 0.10 mg/kg, while according to NADFC standard No. 16 on 2016, the maximum limit of microbial contamination in fresh fish are TPC $10^5$ colonies/g, $E. \ coli <3$ APM / g, Salmonella negative, and Vibrio negative. The process of washing and processing fish is CCPs because it can reduce hazards.

The spices such as shallots, garlic, lemongrass, lime leaves and bay leaves, are very likely to cause microbiological hazards such as mold and physical hazards such as dust or dirt. Aflatoxin-producing mold can grow on spices due to improper storing, so the water content is increased [4]. The maximum limit of microbiological contamination in spices is TPC $10^4$ colonies/g. Washing, drying, and processing of spices is CCPs because it can reduce the hazards [16].

### 3.6. Determination of critical control points (CCP) on processing chain

On the processing chain, several kinds of physical, chemical and biological hazards were found. It is important to determine the CCP on every chain of the production process to determine the critical point and control must be applied to reduce potential hazards [11]. The determination details shown in Table 4.

Table 4 shows that CCPs in the milkfish floss processing are fish receiving, cleaning scales / washing, steaming, frying, draining, and packaging. The process of receiving milkfish becomes CCP because it is very easy to grow hazards in fishery products and the subsequent process, namely washing, can reduce microbes and reduce physical hazards such as dissolving dirt. The steaming and frying process becomes CCP because the heating process can reduce the microbes in the milkfish fish process. If given the appropriate heat in food, it will reduce the microbes [17]. The process of draining becomes CCP because if the process is not correct it will leave a high oil residue on the product and cause rancidity. Packaging
becomes CCP because if workers pack unhygienic, microbiological and physical contamination will contaminate the product.

| Process         | Hazard                                      | Is there hazard? (Q1) | Any precaution? (Q2) | Are processes designed specifically to reduce hazard? (P3) | Can the hazard increase to an unsafe condition? (Q4) | Are further processing can reduce the harm (Q5) | Conclusion |
|-----------------|---------------------------------------------|-----------------------|----------------------|-----------------------------------------------------------|---------------------------------------------------|-----------------------------------------------|------------|
| Fish Receiving  | Microbiological: pathogen bacteria          | Yes                   | Yes                  | Yes                                                        | -                                                 | -                                             | CCP        |
| Cleaning the scales and offal | Microbiological: pathogen bacteria         | Yes                   | Yes                  | Yes                                                        | -                                                 | -                                             | CCP        |
| Filleting       | Physical: fine scales, dust Microbiological: pathogen bacteria | Yes                   | No                   | -                                                          | -                                                 | -                                             | Not CCP    |
| Washing         | Physical: fine scales, dust Microbiological: pathogen bacteria Chemical: heavy metals | Yes                   | Yes                  | Yes                                                        | -                                                 | -                                             | CCP        |
| Steaming        | Physical: fine scales, dust                 | Yes                   | Yes                  | Yes                                                        | -                                                 | -                                             | CCP        |
| Fish Refinement | Physical: fine scales, dust Microbiological: pathogen bacteria | Yes                   | No                   | -                                                          | -                                                 | -                                             | Not CCP    |
| Frying          | Physical: dirt, dust, scale, charred Chemical: heavy metals | Yes                   | Yes                  | Yes                                                        | -                                                 | -                                             | CCP        |
| Draining        | Physical: dust Chemical: residual oil, rancid odor | Yes                   | Yes                  | Yes                                                        | No                                                | -                                             | CCP        |

Table 4. Determination of critical control points (CCP) on processing chain
3.7. Determination of corrective action

HACCP is a system used to measure the level of hazard, predict risks, and establish the right supervision through an emphasis on process prevention and control [11]. HACCP determination aims to control potential hazards that affect the safety of food products. The HACCP determination process is collecting information on CCP identification, preventive measures, critical limits, process of monitoring, correction, verification, and records which shows in Table 5.

Table 5. Determination of corrective action

| CCP | Control / Preventive Measures | Critical Limits | Monitoring | Correction | Verification | Recording |
|-----|--------------------------------|-----------------|------------|------------|--------------|-----------|
| Fish and Fish Receiving | Request fish quality (CoA) certification, cold storing | Fresh, odorless Microbiological: *E. coli* <3 APM/g, *Salmonella sp.* negative, *Vibrio cholerae* <3 APM/g, *Vibrio parahaemolyticus* <3 APM/g, Chemical: Pb <0.2 mg/kg, Cd <0.1 mg/kg, Physical: no dirt, dust, soil | Sampling incoming materials | Choosing the right supplier, Returning the bad materials | Doing microbiological, chemical, physical contamination analysis | Reports and results of microbiological and chemical tests |
| Lemon grass, Lime Leaves, Bay Leaves, Shallots, Garlic | Request certification (CoA) of spices quality, Using clean materials and tools (GMP / SSOP), Frozen storing (freezer), Vacuum packaging | Physical: No dust, dirt Microbiological: *E. coli* <3 APM/g, *Salmonella sp.* negative, *Clostridium* <10² colonies / g, mold and yeast <10² colonies / g | Sampling incoming materials | Choosing the right supplier, Returning the bad materials | Equipment is clean and made of stainless steel, workers must work according to GMP / SSOP, microbiological and chemical tests | Photos, reports and results of microbiological and chemical tests |
| Washing | Using good quality water | *E. coli* <2 APM/mL No dust/hair | Laboratory tests periodically | Washing the fish under running water | Microbiological tests periodically | Microbiological test report and result |
| Process   | Description                                                                 | Method/Condition                                                                 | Test/Report                                                                 |
|-----------|-----------------------------------------------------------------------------|-------------------------------------------------------------------------------|----------------------------------------------------------------------------|
| **Steaming** | Using the correct temperature and steaming time for fish, Using clean equipment | Cooked fish, no dirt and dust, Direct observation of steaming, The steaming process is to be observed, the use of clean equipment | Clean production equipment and room, Steaming temperature and time are right, Photos, reports and results of microbiological and chemical tests |
| **Frying** | Using good quality oil, Using the correct frying temperature and time, Using clean equipment, Request certification (CoA) of oil quality | The use of rancid oil will increase free radicals in the product and it is not accepted, if the frying time is too long it will burn, Direct observation of frying (frying is not too long and using the correct temperature) | Clean production equipment and room, The frying temperature and time are right, Oil in good condition, Photos, reports and results of peroxide tests |
| **Draining** | Draining until the fish dry, using clean equipment | Drains the oil until no drips, Direct observation of drainage, The draining process is continuously observed and cleaning of equipment periodically | Check the peroxide number test, Check the dryness of milkfish, Photos, reports and results of peroxide tests |
| **Packaging** | GMP/SSOP, Worker hygiene (no physical contamination), Microbiological: \( E_{coli} \leq 10^2 \) colonies/g, \( Staphylococcus\ aureus \leq 10^4 \) colonies/g, QC observation of foreign objects, visual control, done product sampling | Clean production procedure, products not sold, Clean production equipment, workers work according to GMP / SSOP | Photos, reports and results of peroxide tests |

Based on Table 5, the raw materials that become CCP are fish and spices (shallot, garlic, lemongrass, lime leaves, and bay leaves), while the production processes that become CCP are fish receiving, washing, steaming, frying, draining, and packaging. The process of receiving raw materials can eliminate or reduce potential hazards to a safe point. The methods that can be done are by choosing the right supplier, using clean processing equipment, freezing and cold storing, and vacuum packaging. Whereas in the processing process, the methods that can be done are to perform GMP / SSOP by workers, using good raw materials, and using clean processing equipment. The process of draining and packaging is a step that is quite prone to contamination. The draining process must be carried out until dry so as not to cause oil residue which can cause rancidity. The packaging process focuses on the sanitary conditions of the equipment, the work environment, and the workers who must always be in clean condition.
4. Conclusion

Various aspects of the production of milkfish floss (raw material, packaging, and processing) have more than three types of potential hazards of microbiology, physical and chemical aspects. The raw materials that become CCP are fish, lemongrass, lime leaves, shallot, and garlic. In the processing process, CCP are the acceptance of fish, cleaning, steaming, frying, draining and packaging. Hazard identification and CCP are the basis and key for making HACCP documents and reports.

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