

Determination of critical control points in fish-based snacks preparation as foods for school children

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Abstract

Fish-based snacks, such as siamay (steamed fish dumpling), otak-otak (fish-dough sticks), and pempek (fried fish-dough native to Palembang, Indonesia), are being vend around the schools in Indonesia. This study was aimed to identify critical points of the snacks' preparation line, therefore the possible hazards from physical, microbiological, and chemical contaminants could be handled properly. It was done by interviewing and observing the snacks vendors' application of good ready-to-eat (RTE) food processing practices. Then, based on the data obtained, the critical points were determined using a decision tree. The critical points of fish-based snacks observed in this study were raw material purchasing, raw material storage, cooking, and serving of the snacks. The raw material purchasing became a critical point because of the possible existence of histamine, which sourced mainly from scombroid fish; in this case: mackerel, tuna, and cob, which were used as raw material by 33, 12, and 3% of the respondents, respectively. When storing the raw materials, 64% of the vendors were not using cold storage. The cooking step, by means of steaming (48%), frying (43%), roasting (8%) and boiling (1%), was a critical point to address microbiological hazards. The recontamination possibility was also becoming a point of concern, because long holding time between cooking and selling the snacks was found in 53% of the vendors (more than four hours by 85% of them), and most of them (72%) stored the cooked snacks in room temperature. The serving step became a critical point because 22% of the stalls used by the vendors were located in unclean environment, and 75% of the stalls were unsheltered, which made them susceptible to rainwater splashes. The food safety extension material is expected to be more specified, based on this identification of critical points and their causes.

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Keywords

Critical point

Fisheries products

Foods for school children

Introduction

Foods for school children (FSC) are one of Indonesian government's concern because of their high consumption by school children. Data obtained from monitoring and verification of FSC safety profile in 2008 showed that nearly 100% of school children have the habit of eating FSC (NADFC, 2013). This finding implied that FSC had high demand among school children. The availability of these foods in public places spurred school children to consume them more.

The diversity of snacks in Indonesia is increasing rapidly along with the country's growth. One of broadly sold snacks is fish-based snacks (FBS). FBS are commonly vended as FSC. Some examples of popular FBS for school children are fishballs, otak-otak (fish-dough sticks), pempek (fried fish-dough native to Palembang, Indonesia), siamay (steamed fish dumplings), takoyaki (octopus ball snack native to Japan), and seafood satay.

There is a need of food safety assurance for ensuring the safety of FBS consumed by school children. One of the methods to assure the safety of foods is by making preventive actions. This requires information about possible hazards and critical control points related to the food. The aims of this study were to discover significant hazards and determine critical points of FBS, and to establish their controlling strategies.

Materials and Methods

This study was done by interviewing FBS vendors in Bogor City and observing their food processing practices. There were four stages of this study: developing questionnaire and observation form; selecting respondents; doing interview and observation; processing data and determining hazards and critical points.

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Questionnaire and observation form development

The questionnaire and observation form were developed to evaluate the conformity of the FBS vendors to good RTE-food processing practices. The questionnaire was developed with reference to School Food Safety Extension Guidelines (NADFC, 2005); whereas the observation form was developed with reference to the Head of National Agency of Drug and Food Control's regulation number HK.03.1.23.04.12.2207 on Methods of Small Scale Industry Inspection (NADFC, 2012) and form for Canteen Inspection (BAU, 2013). The questionnaire and observation form were tried with 10 FBS vendors to evaluate and revise the questionnaire.

Respondent selection

The number of respondents was determined using Slovin's equation. The population of elementary school, middle school, high school, and universities in Bogor City is 339, 160, 162, and 16 respectively. It was assumed that there were one FBS vendor in every school and three in every university. A calculation using Slovin's equation was done and generated 42 as minimum sample number. The samples then were selected randomly using stratified sampling method.

Interview and observation

The interview and observation were done to 63 FBS vendors in 50 schools (21 elementary schools, 11 middle schools, 13 high schools, and 5 universities) at 8 AM to 4 PM. The questionnaires were filled by the surveyors by interviewing the vendors, whereas the observation form was filled by observing the vendors' application of good RTE-food processing practices.

Hazards and critical points determination

Data obtained from the questionnaires were analyzed by calculating their frequencies using IBM SPSS version 20. Hazard analysis and critical points determination were done by using steps adapted from the first and second principles of HACCP (Schothorst, 2004; FDA, 2011). Hazard analysis was done in two steps: determining possible hazards in every FBS preparation step and determining the significance of the hazards. Critical points determination was done to every identified significant hazard in each preparation step using the critical point determination tree.

Results and Discussion

Fish-based snack for school children preparation line

There are 13 kinds of FBS found in this study. The most frequently found was siomay (26%) (Rahayu et al., 2015). Based on the similarities in their preparation steps, they could be categorized into

seven groups. In general, preparation steps of FBS started with purchasing of raw material; followed by storage of raw material, first cooking, storage, secondary cooking, serving, and packing step.

Group A (siomay) and B (fried fish balls and pempek) had all the steps, but they were different in their cooking method: FSB in group A were steamed, whereas those in group B were fried. Processing steps in group C (boiled green mussels) and D (takoyaki, okonomiyaki, and batagor) did not include first cooking and storage steps. The green mussels were only cooked once, i.e. by boiling. The same thing applied to takoyaki and okonomiyaki, FBS native to Japan made from tako or octopus, which were cooked by frying. Group E (seafood satay consisted of shrimp balls, crab balls, lobster balls, and crab sticks), F (dim sum, ekado, fish cake, processed siomay), and G (otak-otak) are FSB that did not have raw material purchasing, storage, and first cooking steps; because the vendors were using half-processed FSB which were available in the market. The next steps of group E, F, and G were similar, except in the cooking process, which were grilling, steaming, and frying, respectively.

Potential hazards in fish-based snacks

Potential hazards in preparation line of fish-based snacks could enter from their raw materials and bad food handling practices. Hazards possibly occurred in fish-based snacks were categorized into physical, microbiological, and chemical hazards. There was a significant chemical hazard identified in purchasing step in FSB group A and B, i.e. histamine. Histamine is a toxin frequently found in fish which belongs to Scombridae family. FSB for school children made from that kind of fish were found in this study; those were mackerel (33%), tuna (12%), and cob (3%).

Histamine is biogenic amine compound which is formed from an amino acid called histidine because of the activity of histidine decarboxylase enzyme, which could be sourced from the fish's body and from microbes exist in its gastrointestinal tract or other contaminating microbes (Dalgaard et al., 2008). Only fish with free histidine higher than 100 mg/100g could generate histamine (Ganowiak et al., 1990). Some fish, mainly from Scombridae family, have high levels of free histidine, for example, skipjack tuna (1,192 mg/100g), yellowfin tuna (740 mg/100g), and chub mackerel (600 mg/100g) (Perez-Martin et al., 1988; Antoine et al., 1999).

Bacteria that have histidine decarboxylase enzyme mostly come from Enterobacteriaceae family, for example, *Morganella morganii*, *Klebsiella pneumoniae*, *Citrobacter freundii*, *Clostridium*

perfringens, *Enterobacter aerogenes*, *Vibrio alginolyticus*, and *Proteus sp. M. morgani*, *Proteus sp.*, and *Klebsiella sp.*, are frequently found as main causes in histamine poisoning cases following tuna consumption (Rispayeni, 2005). Histamine poisoning symptoms start a few minutes after consuming fish, which consist of vomiting, diarrhea, swollen lips, cramps, and burning throat. These symptoms last for less than 12 hours and could be cured by antihistamine therapy.

Purchasing step had another significant hazard, i.e. lead (Pb) contained in the raw material. A previous study by Apriyadi (2005) showed that lead contamination in medium-sized green mussels was as much as 33.7-36.8 mg/L. In human, lead could accumulate in back marrow and brain. Lead poisoning could cause change of dALA (δ -amino levulinic acid) to porphobilinogen and disruption in the binding process of iron ion into protoporphyrin IX in hemoglobin developing process (WHO, 1972).

The next step was serving the FBS. In the serving step 77 and 30% FSC used chili sauce and chili paste as a condiment when serving FBS. The 43% of vendors also served chili-peanut sauce as a condiment (Figure 1). The chili and peanut have possible hazard such as Rhodamin B in chili and aflatoxin in peanut. Rhodamin B is a colorant that is prohibited to be used in food because it is carcinogenicity, neurotoxicity, reproductional and developmental toxicity, and acute toxicity (Gresshma and Reject, 2012). Aflatoxin is toxin produced by *Aspergillus flavus* and *Aspergillus parasiticus*, and it is mutagenic, teratogenic, and carcinogenic. Peanut is the most vulnerable commodity to aflatoxin contamination. A previous study of chili sauce found that 10 of 25 samples (40%) contained Rhodamin B (Putra *et al.*, 2014). The other study found aflatoxin content in peanut samples from 15 retailers ranged from 0 to 1,154 ppb, and 80% of the samples contained more than 30 ppb of aflatoxin (Dharmaputra, 2002).

Packing step could introduce chemical hazard if packaging materials used in this step release monomers that migrate into foods packed in it. Most of FBS for school children in Bogor City were packed in plastic (70%) as primer packaging for take away, and glassware (89%) for eat in, whereas some used styrofoam (7% for takeaway; 1.4% for eat in) and melamine (4.1% for eat in). Migration could happen as an effect of high temperature, long-time storage, and processing. With the higher temperature of packaged foods, there will be a higher probability for migration to occur. Migration from packaging materials could introduce toxic components into foods, i.e. vinyl chloride, acrylonitrile, vinyl acetate,

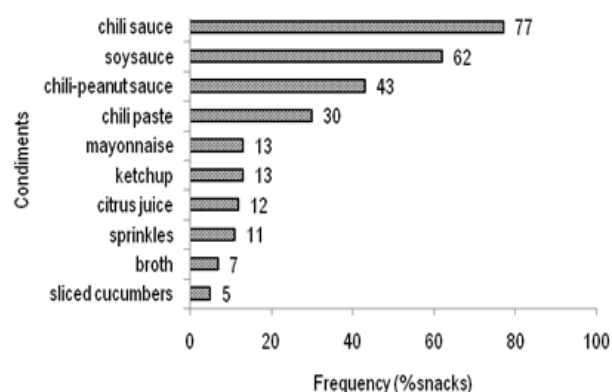


Figure 1. Condiments used by the respondents when serving fish-based snacks

styrene, and formaldehyde. Vinyl chloride monomers could react with guanine and cytosine on DNA; whereas acrylonitrile could react with adenine. Vinyl acetate has been proved as a cause of cancer in animal thyroid, uterus, and liver (Irawan and Supeni, 2013). Styrene monomers also have the potential to weaken estrogen activity, which could interfere with gonadal sex differentiation pathway in *Rana rugosa* (Ohtani *et al.*, 2001), and boost necrosis of human umbilical cord mononuclear cells (Diodovich *et al.*, 2009). As much as 30 of 62 melamine dishes samples taken from modern markets in Jakarta were found releasing formaldehyde (NADFC, 2009). Formaldehyde in a compound is dangerous to human health (Tangdiongga *et al.*, 2015). These showed that there were probabilities of hazards from packaging materials that should be noticed.

Microbes potentially contaminating fisheries products are biological hazards that require attention. There are two major groups of bacteria that have the possibility to contaminate fisheries products, i.e. indigenous microflora (bacteria that normally live in aquatic environment), such as *Aeromonas hydrophyla*, *Clostridium botulinum*, *Vibrio parahaemolyticus*, *Vibrio vulnificus*, *Vibrio cholerae*, and *Listeria monocytogenes*; and non-indigenous bacteria, which come from domestic or industrial waste pollution, such as *Staphylococcus aureus*, *Salmonella* spp., *Shigella* spp. and pathogenic strains of *Escherichia coli* (APEC Secretariat *et al.*, 2013). In fresh fish, indigenous pathogenic bacteria usually exist in low level. *Listeria monocytogenes*, *Clostridium botulinum*, and other pathogenic bacteria could reach significant level in fisheries products if the processes applied are inadequate, recontamination occur after processing, or the products have been kept in supporting conditions for the bacteria's growth (APEC Secretariat *et al.*, 2013). Storage of raw material or half-processed foods in an open container could result in contamination. In this study,

Table 1. Critical points in fish-based snacks for school children

Processing steps and potential hazards	Food groups						
	A	B	C	D	E	F	G
Raw material purchasing							
Histamine	√	√	-	-	-	-	-
Lead	-	-	√	-	-	-	-
Second cooking							
Pathogenic microbes	√	√	√	√	√	√	√
Parasites	√	√	√	√	√	√	√
Viruses	√	√	√	√	√	√	√
Serving							
Pathogenic microbes	√	√	√	√	√	√	√
Viruses	√	√	√	√	√	√	√
Rhodamin B	√	√	-	√	√	√	√
Aflatoxin	√	√	-	-	-	-	-
Packaging							
Melamine monomers	√	-	-	-	-	-	-
Plastic monomers	√	√	√	√	√	√	√
Styrofoam monomers	√	√	√	√	√	√	√

Note :

^A:Siomay

^BFried fish balls, pempek

^CBoiled green mussels

^DTakoyaki, okonomiyaki, batagor

^ESeafood satay (shrimp ball, crab ball, lobster ball, crab stick)

^FDim sum, ekado, fish cake, processed siomay

^GOtak-otak

√:Critical point

- : Not critical point

vendors who were storing their raw or processed materials in open containers were found. Others were keeping their foods' condition by packing them in plastic, store them in closed containers, and packing processed foods with leaves (Figure 2).

Parasites are known could cause diseases in human and could be transferred by fish or crustaceans. Parasites have a complex life cycle which involves one or more intermediate host (or hosts), and they are usually transferred to human through raw or inadequately cooked foods. Some saltwater fish species act as secondary hosts of some nematodes. Nematodes that are common in fisheries products are *Anisakis* spp., *Capillaria* spp., *Gnathostoma* spp., and *Pseudoterranova* spp. These nematodes are found in saltwater fish's liver, abdominal cavity, and flesh. One of the nematodes that could cause illness in human is *Anisakis simplex*; which could be inactivated in their infective stage by heating at 60°C for 1 minute and freezing at -20°C for 24 hours. Fish are also hosts of protozoa, but there is no record of human illness caused by protozoa-infected fish (APEC Secretariat *et al.*, 2013).

Illnesses caused by foodborne viruses are usually happening as a result of bad personal hygiene of food handler and contaminated water and ice. Outbreaks caused by foodborne viruses from fish and crustaceans are relatively rare, but those from seashells are quite

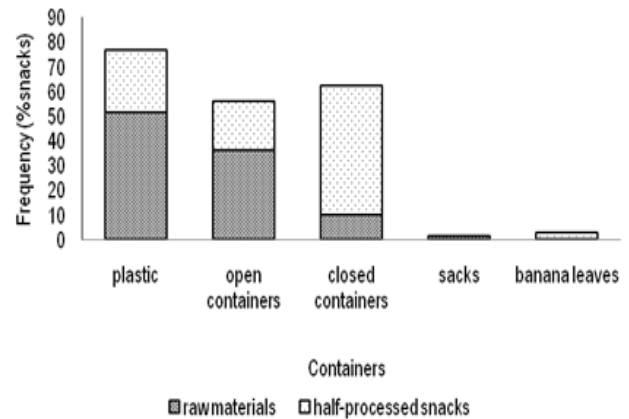


Figure 2. Storage container of fresh materials and half-processed fish-based snacks

often (APEC Secretariat *et al.*, 2013). Seashells that are harvested on coast polluted by human and animal feces could become vehicles of virus transfer to human. Enteric viruses that could cause illness that are transferred through seafood are hepatitis A, caliciviruses, astroviruses, and noroviruses (APEC Secretariat *et al.*, 2013).

Critical points in fish-based foods for school children

Critical points are defined as points in food processing steps which if not controlled properly, could cause the product to be hazardous to health. Critical points identified in every group of FBS for school children are shown in Table 1. Histamine was identified as a cause of critical point in purchasing step of siomay, fried fish balls, and pempek. Histamine cannot be eliminated in cooking step, therefore controlling in purchasing step must be applied in order to prevent the existence of histamine. Suggested means to prevent it is by selecting fresh fish, which indicated by bright red gills, processing or cooking the fish as soon as possible, and not keeping the fish in room temperature for a long time. Immediate and fast freezing of fish could also prevent the accumulation of histamine (FDA, 2011). After harvesting, fish that are introduced to air or water with temperature exceeds 28.3°C must be immediately moved into a chamber which temperature 4.4°C or lower. Storage in 4°C will prevent the growth of histamine producing mesophilic bacteria and will reduce the growth rate of some histamine producing psychrotrophic bacteria. Freezing storage ($\leq 18^{\circ}\text{C}$) could stop the growth of bacteria that produce decarboxylase enzyme, which assist the change of histidine into histamine (FAO/WHO, 2013). There were still many vendors (64%) that stored raw materials in room temperature, whereas only 31% of those who stored the raw materials in freezing temperature. Lead

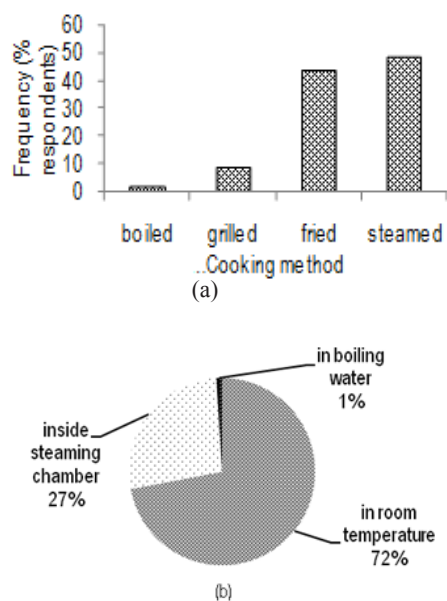


Figure 3. Method of cooking(a); and storage condition in waiting time before sold(b)

was identified as the cause of critical point in green mussels purchasing step. A controlling measure that could be taken by the vendors is choosing mussels harvested from unpolluted area for their raw material.

Critical point in cooking step sourced from biological hazards in the forms of pathogenic microbes, viruses, and parasites which were potential in every group of FBS. These hazards usually come together with raw materials, and they should be addressed in cooking step. Cooking process done by FBS vendors were mostly (48%) by steaming (Figure 3a).

Hazards from pathogenic bacteria could be controlled by heating, cold storage, and recontamination prevention. The multiplication of contaminating microbes could happen as a result of keeping the raw materials in room temperature for a long time. Forty-eight percent of the vendors usually vend for more than five hours in a day. Long holding time (more than four hours) for half-processed foods also found in 84.9% of the vendors. Cooking process should be done until the foods are perfectly and evenly cooked. It must be done until the foods' core temperature reaches 70°C for at least two minutes (Safefood, 2004). Additionally, the cooked foods, like siomay and pempek, should not be kept in room temperature for more than two hours, because microbes can grow very fast in this danger zone, that is the temperature between 5 and 60°C (Safefood, 2004). High-risk RTE-foods that have been held at danger zone for more than two hours but not more than four hours should be consumed immediately, but if they have been held for more than four hours,

they should be thrown away (ANZFA, 2001). There were only 27% of vendors who held the foods' temperature by placing the products in steaming chamber and 1% in boiling water, whereas the big portion of them (72%) kept their products at room temperature (Figure 3b).

Biological hazards could also cause critical point in serving step. This was because of the dirty environment around vending sites (22%), unclean stalls surfaces (38%), and unprotected stalls from rainwater splashes (75%). Besides, serving step also became critical point because of chemical hazards, i.e. rhodamin B in chili sauce and aflatoxin in chili-peanut sauce which were used as complementary condiments when serving the FBS. Those chemical hazards are potential in each FBS group, except for green mussels, because there were no condiments used when they were served. Vendors are suggested to store peanut in a dry place and keep them from insects and rats. Insects and rats could facilitate contamination of aflatoxin producing molds during storage. Rhodamin B in chili sauce should be avoided by careful selection of chili sauce, i.e. those without peculiar color. Vendors who are providing condiments should carefully read the information on the products' label, in particular, the ingredients and distribution permission from NADFC or government's health office.

Packing step also became a critical point because of potential chemical hazard from migrating packaging components. The safety of plastic used as food packaging is based on the number of plastic monomers migrating into foods. The safe ways to use food packaging are using glass-based packaging, especially for FSC that are eaten at vending site; and not using black recycled plastic bags as the primer packaging of FSC. Another point of attention when packing foods is plastic and styrofoam packaging must not be used for packing hot foods (> 80°C) (Irawan and Supeni, 2013).

Conclusion

The result of this study showed that the critical point in preparation line of fish-based snacks for school children was in purchasing of raw material, because the potential of hazard from lead in green mussels and histamine in siomay, fried fish balls, batagor, and pempek, which used uncontrolled *Scombridae* family members as their raw material. Other critical points identified in this study were cooking and serving step, because of the potential of biological hazards in the form of pathogenic bacteria, viruses, and parasites. Additionally, in serving step,

the potential hazards from rhodamin B and aflatoxin also identified from condiments added in this step, i.e. chili sauce and chili-peanut sauce. Packing step was also considered as a critical point if it is done using melamine-based, plastic, or styrofoam packaging for high-temperature foods; because the monomers of those materials could migrate to foods. It is suggested to study the critical points in distributors and producers of processed fisheries products because there were some vendors visited in this study who did not know about the raw material of fisheries products they sold. There is also a need of follow-up measures, i.e. food safety extension about fish-based foods for school children for vendors around schools and provision of cold storage facilities so that the critical point in food for school children preparation step can be adequately controlled.

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