Identification of Potential Hazard and Halal Control Points for Perishable Food During Food Logistics

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ABSTRACT

Food logistics services is a fast-paced and globalized industry that enables short-lived and perishable supply chains transported from initial sources to customers within weeks, days, and sometimes hours. However, some concern arises as it poses several risks and exposes the food to hazards due to quick handling and the large volume involved. This paper briefly discusses the types of hazard associated with halal food logistics and identify the potential source of hazards that may occur during the activities. The study focuses on perishable food. The study identifies hazards during product handoffs or transfers at ports, transfer facilities, distribution centres (movement into or out of), and customer deliveries. The result established two out of the eight logistics activities evaluated to have control points (CP) and halal CP; which are storage temperature checks and product packaging and repackaging activity such as...
the need to do segregation, temperature control and packaging during food transport. The study suggests control measures to reduce or prevent the hazard. The information presented here is valuable for the food logistics providers in delivering products to the customer in adequate condition at the right time.

**Keywords**: food logistics, control points, control measures, biological hazard, chemical hazard

**INTRODUCTION**

Foods are being transported across the globe in which 5.54 billion tonne-kilometres (tkm) by sea, 2.91 billion tkm by land, 15 million tkm by air and 930 million tkm by rail as reported in 2010 (Poore & Nemecek, 2018). The quantity and types of foods transported, along with the multitude of containers, temperature and handling requirements for each food product, emphasize that the process is crucial and vulnerable to contamination during transportation and storage. Risk factors for contamination include improper production practices, temperature abuse, unsanitary cargo areas, improper loading or unloading procedures, damaged packaging, shipping containers in ill repair, bad employee habits, and road conditions. As Muslim consumers are increasingly aware of halal, they request halal products and halal processes, notably supply chain activities (Bonne & Verbeke, 2008). As a result of this demand, the Halal supply chain sector has become one of the region's fastest-growing logistics segments. (Baharudin et al., 2011).

Ensuring halal and food safety events is extremely important throughout the supply chain, which requires preventing biological, chemical, or unauthorized agents or hazards from being incorporated into the products. Hazard analysis and identification of control points are two imperative principles in hazard analysis critical control points. It utilises tools to analyse the processes of the food logistics process, assesses the potential risks for each operation link, identifies the critical control points, and gives the appropriate risk weights to ensure the food's safety, quality, and reliability (Zhang & Chen, 2011). The hazard identification process in transport and logistics are commonly based on several standards and food regulations, among which are the Food Safety Modernization Act 2017 on Sanitary Transportation of Human and Animal Food, Codex General Principles of Food Hygiene (CXC 1-1969), Malaysia Food Regulations 1985, MS1500:2019 Halal Food-General Requirements and MS2400:2019 Halal Supply Chain as references. In addition, Good Manufacturing Practices (GMP) and Sanitation Standard Operating Procedures (SSOP) also should be in place to support the halal supply chain.
activities.

There is, however, currently very little information on potential hazard and halal control points during transportation and holding and how it prevents perishable food from physical, chemical and microbial contamination. Thus, this paper will describe the types of hazards that affect the food's safety and quality during the logistics of perishable food. Delivery of non-perishable and other grocery items, as well as non-food items, are not covered. Potential hazards and control points were identified based on the four logistics service activities, which are: warehouse, materials handling, packaging and transportation. Several preventive and control measures are suggested to reduce or eliminate the identified potential hazards.

METHODOLOGY

The discussion of this paper is derived from extracted literature reviews. The search for related publications available was mainly conducted by referring to online databases such as Emerald, Elsevier, Springer, and Wiley. Google Scholar was also used to help find the related articles. Potential hazards and control points were identified based on the four logistics service activities, which are: warehouse, materials handling, packaging and transportation.

Literature from these areas was used as the primary references in this paper. Findings were compiled, analysed and tabulated. Hazard and control measures were identified. Predominantly, the literature was reviewed within the range of eight years from 2010 to 2021 to get the latest ideas and issues regarding the study area to form the framework for this paper. Several preventive and control measures are suggested to reduce or eliminate the identified potential hazards.

RESULTS AND DISCUSSION

Logistics necessitates order, delivery, and quality fulfillment, in which the quantity provided satisfies the transaction between the supplier and the client. Not only that but the order must also be delivered at the right location and at the right time, which necessitates transportation and freight distribution planning. Meanwhile, quality implies that the order must be delivered undamaged (in good condition), suggesting that any damage during transit and delivery must be avoided.
With regards to transporting food, today's food supply chain delivers a highly significant number of food and types with numerous container, temperature, and handling requirements, as well as various modes of transportation available. As a result, foods and food ingredients are thus vulnerable to abuse and/or contamination during transportation and storage. Particularly when it comes to perishable foods, extra measures should be given when handling perishable food. Perishable foods, such as fruits and vegetables, dairy, fish, and meat products, have a limited shelf life after harvest or production. The time it takes for them to become unmarketable or inedible is determined by the food product and several factors mentioned above (Mercier et al., 2019).

**Halal Control Points for Perishable Food During Food**

HACCP is a tool that does not rely on end-product testing (Codex, 1991b). The HACCP system considers all potential risks and factors which course harm to the health of the consumer (Kirby, 1994) and is also applied to determine the critical control points required to control the identified hazards. In the global food value chain, combining Islamic dietary law with HACCP principles in areas such as hygienic, wholesome, and halal food has become increasingly significant. An integrated approach to attaining a harmonised Halal – HACCP implementation system would be enabled by embedding Islamic dietary rules in accordance with the HACCP technique. It provides a solid foundation for halal certification and helps to maintain its credibility (Kohilavani et al., 2013).

As establishing HACCP is an extensive procedure, this paper focuses on identifying the control point (CP) that is highly related to halal food transport and logistics. Therefore, Figure 1 shows the possible hazard present during the logistics activities of perishable food. The literature search identified warehousing, materials handling, packaging, and transportation as logistics points with potential exposure to hazards. Eight activities start from product arrival and end with product dispatch (Rodrigue, 2020), as indicated in Figure 1, are believed to pose physical, biological, and chemical hazards. Such hazards could arise from failing to refrigerate food, inadequate cleaning of vehicles between loads, and failure to adequately protect food during transportation, leading to the three types of hazards.
Out of eight activities, two Halal Control Points (CP) related to halal issues, such as the mixing of haram and halal food and the presence of harmful elements, have been determined. The Halal CP was determined based on the process flow diagram and hazard analysis. The details of hazards and control measures during food transport activities of perishable food are presented in Table 1. Ensuring proper temperature controls during transportation is essential to ensure the safety and quality of foods before it reaches the store or the restaurant. Product safety implies that the product does not exceed an acceptable level of risk, including freshness/taste and the quality of most critical products (Siddh et al., 2015). Aramyan et al. (2007) emphasised that product safety is associated with the pathogenic organism or chemical and physical hazards such as chemical contaminants, microbiological and microorganisms.

In halal principles, it has been stated in Al-Qur'an that Halal food should not contain harmful ingredients or substances that could endanger the consumer or are known as hazards (Saifudin et al., 2017) (Saad & Ramli, 2019). Hazards may be introduced into the food at any time during harvesting, formulation and processing, packaging and labelling, transportation, storage, preparation, and serving (Singh et al., 2019). Based on the facts above, physical, chemical and biological hazards should be avoided during Halal transport and logistics. Physical hazards in foods are defined as extraneous materials foreign to the food itself, including any materials that inadvertently make their way into the food originating from the manufacturing equipment (pieces of metal) or the packaging (glass, plastic). Other materials that could be a hazard as well are insects (in most cases); hair; metal fragments; and pieces of plastic, glass, or
wood. In most cases, physical hazards arise from plant incidents and equipment breakdown or damage to packaging materials releasing physical hazards (e.g., glass bottles, wood chips) (Batt, 2016). However, in some cases, it may be unavoidable, such as the presence of bonefish or seed from fruit. Routine inspection of equipment and scheduled maintenance/replacement of critical parts is a reasonable means of avoiding physical hazards.

Pesticides and other chemicals that may be applied or carried on raw materials and chemicals used in food processing, such as cleansers and sanitisers, provide a chemical danger. Any non-viable threat, such as proteins that may be allergies to a portion of the population, is considered a chemical hazard (Batt, 2016). During transport and logistics activities, exposure to chemical hazards is mostly related to detergents used during cleaning.

Biological hazards concern the presence of microorganisms that could cause foodborne illness. The major causes of foodborne illnesses include bacteria (Salmonella, Campylobacter, Listeria, Vibrio cholerae, enterohaemorrhagic Escherichia coli), viruses (Norovirus, Hepatitis A), parasites (Echinococcus spp, Taenia solium, Ascaris, Cryptosporidium, Entamoeba histolytica, Giardia), prions, fungi, and chemical agents (naturally occurring toxins such as mycotoxins and phycotoxins, persistent organic pollutants such as dioxins and polychlorinated biphenyls, heavy metals such as lead, mercury and cadmium) (World Health Organization, 2020a, 2020b; Luna-Guevara et al., 2019). According to the European Food Safety Authority (EFSA) and the European Center for Disease Prevention and Control (ECDC), Salmonella enteritidis, Campylobacter spp., Shiga-toxin-producing Escherichia coli, Yersinia spp. and Listeria monocytogenes as the major bacteria species implicated in human cases of foodborne illnesses (European Food Safety Authority, 2021). As the vast majority of bacterial contamination occurs on the surface, the product's surface temperature is a crucial determinant of bacterial growth and should be regularly checked.

Cases related to the contamination of perishable food have been widely reported. The European Commission recorded the highest number of notifications from the Asia-Pacific region in 2015. Aflatoxin contamination of nuts, nut products and seeds imported from China and Salmonella contamination in fruits and vegetables and nuts, nut products and seeds imported from India produced the three highest notifications from all regions for 2015 (European Commission, 2016). In addition, Salmonella contamination of herbs and spices, fruits and vegetables, nuts, nut products, and seeds was responsible for the highest number of notifications overall. These were
predominantly products imported from India, Thailand, Vietnam and Bangladesh (European Commission, 2016).

Meanwhile, in 2015–2020, the RASFF received 412 notifications for poor temperature control/cold chain disruption for various food categories, with 405 being Border rejection notifications. Crustaceans and cephalopods were the most popular food category, followed by fish and fish products. Precisely, tuna and salmon (71 and 21 out of 241, then 29.5% and 8.7%, respectively) were the most temperature-abused fish species. Then shrimps (31 out of 58, 65.5%), squid and octopus (21 and 19 out of 54, 38.9% and 35.2%, respectively) were also notified. Seafood has the highest incidence since it is highly perishable and must be stored and/or transported at the melting ice temperature (Visciano & Schirone, 2021).

**Control Measures for Perishable Food**

Regarding the cases mentioned above, EU legislation is constantly becoming more stringent. The last modification of Regulation (EC) No 852/2004 on the hygiene of foodstuffs, for instance, the Commission Regulation (EU) No 2021/382, established that equipment and/or containers used for the harvesting, transport or storage of allergic substances cannot be used for any other food not containing such substance unless they have been cleaned and checked at least for the absence of any visible debris. Then, the operators in the food industry need to control not only the correct labelling concerning allergens but also the risk of their accidental presence derived from the transfer through utensils and working surfaces. Such stringency also has been emphasised in MS2400-1,2,3:2019, which requires complete segregation between the halal and non-halal products to be ensured during logistics processes. In other words, cross-contamination (i.e., mixing halal and non-halal) must be avoided during supply chain activities (Department of Standards Malaysia, 2019a; 2019b). Most of the facts highlighted in Halal standards were also emphasised its importance by Food and Drug Agency (FDA).

On a global scale, recent development in the Food Safety Modernization Act by FDA emphasised sanitary transportation as one of its seven foundation rules to minimise risk. The rule requires those who transport food to use sanitary transportation best practices to ensure the safety of the food. The proposed rule aims to ensure that transportation practices do not create any risks related to physical, biological or chemical hazards. As a control measure, sanitation should be a root concern before certain foods even make it into packaging or shipment bundles. Surfaces and machinery should get regularly
disinfected and sanitised. Water sources, lines, nozzles or tanks should remain free of pathogens and biofilms — this also prevents the spread of foodborne illnesses. Transport vehicles, fleets, and storage surfaces should all be verified clean, even if the items are already packaged and secure. Apart from that, the new rule requires the industry to prepare documentation of the inspection of a vehicle for cleanliness before loading, verify and document that adequate measures are taken to maintain the cold transportation chain for foods requiring time/temperature control. Next, shippers must specify the sanitary requirements for a vehicle or transportation equipment and maintain the records to demonstrate that the information is being provided to carriers.

Meanwhile, carriers will be required to prove to shippers and, upon request, to receivers that they have maintained appropriate temperature control for the food during the transportation operation. Carriers will be required to give shippers information regarding past cargo hauled in bulk vehicles used for food transportation and cleaning those vehicles. Carriers must develop and implement written procedures describing how they will provide this information to shippers and receivers. Carriers must create and implement documented protocols that detail their cleaning, sanitising, and inspection procedures for vehicles and transportation equipment.

The perishable food transportation business has reached a point where hygienic transportation, telematics, and automated refrigeration systems will be the next frontiers. Advances will focus on how perishable food products can be carried safely and economically to markets while maintaining the highest level of wholesomeness, eating quality, and nutritional quality for consumers, regardless of where they live (Brecht et al., 2019). Modern technology can help manage and monitor temperature controls throughout the supply chain. It is suggested that a temperature monitoring system that provides real-time temperature monitoring during the transportation and storage of foods in the distribution centre should be installed. Efforts to minimise risk factors are essential as failure to address them will cause a chain effect; for instance, poor quality goods or services will cause downtime and consequent failure to satisfy the customer's requirements on time. Another impact could be that the firm's reputation may pose risks, often generated by issues not directly related to the supply chain itself. Therefore, the fundamental component of the supply chain, not only equipment and facilities but products, information, services, and human resources, are critical in maintaining the safety surrounding the product and people involved in supply chain activities, particularly when handling perishable food (Shashi et al., 2018).
### Table 1. The details of hazards that are likely to happen during food transport activities of perishable food

<table>
<thead>
<tr>
<th>Activities with the potential hazard</th>
<th>Hazard and its source/cause</th>
<th>Control measures</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>1. Product Arrival</strong></td>
<td><strong>Physical Hazards</strong></td>
<td><strong>Control measures</strong></td>
</tr>
<tr>
<td></td>
<td>● External contamination from bird droppings, vermin/rodents, flying insects and rainwater during the loading process.</td>
<td>● Curtains/cushions fitted to all loading bays to prevent external contamination.</td>
</tr>
<tr>
<td></td>
<td>● Pests/rodents and or flying insects due to poor hygiene/debris build-up</td>
<td>● Pre-requisite programs should be in place to control all identified hazards, which include;</td>
</tr>
<tr>
<td></td>
<td>● Physical dangers posed by straps, thermocouples, staples, and strange bodies were discovered on pallets at the point of entry.</td>
<td>1. Daily hygiene schedules and cleaning programs, glass policy and daily audits.</td>
</tr>
<tr>
<td></td>
<td>● Chemical contamination from chemical/pesticide at the source of origin.</td>
<td>2. Internal and external pest control programs.</td>
</tr>
<tr>
<td></td>
<td><strong>Microbiological Hazards</strong></td>
<td>3. Supplier quality assurance systems and HACCP are in place and verified/audited by the Technical Department to eliminate/reduce potential foreign body or microbiological contamination.</td>
</tr>
<tr>
<td></td>
<td>● Microbiological contamination during the process at the source of origin.</td>
<td>4. Intake inspections to identify foreign body contamination on arrival</td>
</tr>
<tr>
<td></td>
<td><strong>Transfer to storage area awaiting dispatch</strong></td>
<td>5. Validation by way of Chemical MRL testing programme.</td>
</tr>
<tr>
<td></td>
<td><strong>Physical Hazards</strong></td>
<td>● Pre-requisite programs should be in place to control all identified hazards, which include;</td>
</tr>
<tr>
<td></td>
<td>● Physical contamination from Warehouse operatives.</td>
<td>1. Daily hygiene schedules and cleaning</td>
</tr>
<tr>
<td></td>
<td>● Glass contamination from internal light sources.</td>
<td></td>
</tr>
</tbody>
</table>

1. Pests/rodents and or flying insects due to poor hygiene/debris build-up programs, glass policy and daily audits.

2. Staff awareness/training programmes are in place, with training records kept and documented.

3. Staff awareness/training programmes are in place, with training records kept and documented.

4. Staff awareness/training programmes are in place, with training records kept and documented.

Stora

3. Storage Temperatures checks

Halal Control Point 1

Microbiological Hazards

- Microbiological contamination as a result of the refrigeration unit's failure

Physical Hazards

- Physical contamination from Warehouse operatives.

- Microbiological contamination as a result of the refrigeration unit's failure

- Physical contamination from warehouse workers.

- Glass contamination from internal light sources.

- Equipment is inspected daily and during activities.

- Procedures for maintenance, refrigeration breakdown, and daily temperature checks, computerised and alarmed monitoring of refrigeration units.

- Personnel hygiene policies and procedures are in place, and all employees are aware of them and have received training, which is documented.

- Pre-requisites programmes are in place to control identified hazards which include; Procedures for maintenance, refrigeration breakdown, daily temperature checks, computerised and alarmed monitoring of refrigeration units.

- At this point in the process, the products are still in their original cartons/boxes, and contamination is considered highly unlikely.

- Pre-requisites to control named hazards include; Procedures for maintenance, refrigeration breakdown, daily temperature checks, computerised and alarmed monitoring of refrigeration units.

- Products at the stage of this process remain intact in their original cartons/boxes.
5. **Product packaging and repackaging**

**Halal Control Point 2**

- Microbiological Hazards
  - Poor sanitary and personal hygiene might introduce microbiological contamination during the process.

- Physical Hazards
  - Physical contamination from warehouse operatives.
  - Glass contamination from internal light sources.
  - Pests/rodents and or Flying insects due to poor hygiene/debris build-up.

- Personnel hygiene policies and procedures in place with all staff aware/trained with records of training.

- At this stage of the process of repacking and sealing exposes the highest risk of contamination.

6. **Products are transferred onto a pallet.**

- Physical Hazards
  - Physical contamination from warehouse operatives.
  - Glass contamination from internal light sources.
  - Pests/rodents and or Flying insects due to poor hygiene/debris build-up.

- At this stage of the process, the product is bagged and sealed and the risk of contamination is highly unlikely.

7. **Products are loaded onto a vehicle and dispatched out.**

- Physical Hazards
  - External contamination from bird droppings and/or rainwater.
  - The taint of the finished product is due to poor trailer hygiene.

- Microbiological Hazards
  - Microbiological growth due to the breakdown of refrigeration unit on a truck.

- All bay doors are fitted with curtains/cushions to prevent external contamination.

- Hygiene programmes are in place; trailers are cleaned and sanitised regularly by an external contractor, and records are retained.

- Trailer hygiene is monitored during despatch procedure pre-requisites to
8. Finish dispatch checks

**Physical Hazards**
- Physical contamination from operative
- Glass contamination from internal light sources.
- Pests/rodents and or Flying insects due to poor hygiene/debris build-up.
- All bay doors are fitted with curtains/cushions to prevent external contamination.
- Hygiene programmes are in place, trailers are cleaned and sanitised regularly by an external contractor, and records are retained.
- Trailer hygiene was monitored during despatch procedures.

**CONCLUSION**

The food delivery service is the last step of food preparation before reaching consumers. It is the final stage of the food supply chain operation that usually receives the least attention. To deliver safe, quality and halal food to customers, knowledge or education on food safety and food handling, together with good hygiene practices, are essential in the delivery activities. Halal control points were identified at the storage temperature checks and Product packaging and repackaging of the food with the risk of biological and physical contamination. Therefore, preventive measures must be implemented at these hazard points. The fact that food transportation is different from food manufacturing and unique in terms of location, logistics and the various types of foods they deliver, efforts in controlling the halal aspect and safety of the food need to be improved and changed to ensure no incidents of contamination and foodborne illnesses will occur.

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**CONFLICT OF INTERESTS**

The authors declare no competing interests, such as financial or personal.
relationships, regarding the writing of this article.

**AUTHORS’ CONTRIBUTIONS**


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