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Halal-Haram Studies: Food-Grade Lubricants in the Food Industry

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ABSTRACT

Food-grade lubricants are important in the food industry because they maintain the efficiency and safety of the production process. Halal and haram aspects in Islam are essential in food-grade lubricants because of potential contamination of lubricants in food products. The halal or haram status of a lubricant is determined by the raw materials, manufacturing process, and potential contamination of food-grade lubricants. Some food-grade lubricants use animal-derived raw materials such as stearic acid. The primary source of raw lubricant material is the animals used. The use of prohibited animals will change the status of lubricants to haram. In addition to raw materials, lubricant production can use non halal materials such as alcohols and catalysts. If the catalyst and alcohol used are not in accordance with SNI 99004-2021, then food-grade lubricants cannot be halalised. Lubricants can also be contaminated by L. monocytogenes. The infections caused by these bacteria are health hazards, especially for humans with weakened immunity. This potential surely causes harm to humans and can affect the halal status of lubricants. Due to the critical need for halal lubricants, the oil and gas company PT Pertamina has initiated the existence of five halal-certified lubricants in Indonesia: FG-GO 150, FG-GO 220, FG-GO 320, FG-GO 460, and FG-HO 46.

Keywords: *Contamination, Food-Grade Lubricant, Food Security, Halal, Raw Material.*

1 Introduction

Product safety and halal status are top priorities in the food industry. Lubricants are an important part of maintaining equipment performance and ensuring the efficiency and

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safety of food products. In the midst of the increasing demand for halal products, the study of halal food-grade lubricants is crucial. This is due to the potential for lubricants to be mixed into food products, even in small quantities. The halal criteria for food-grade lubricants include potential contamination, raw materials, and production processes involving ingredients that affect the halal status of lubricants.

One potential threat to food safety is the contamination of food by pathogenic bacteria such as *Listeria monocytogenes* [1]. These bacteria can cause serious infections particularly in pregnant women, infants, and older adults [2]. In this context, lubricants in the food industry play an important role as heat transfer media and lubricants in food production equipment. However, the presence of *L. monocytogenes* in this lubricant can threaten not only the safety of the product but also its halal status [3].

The halal aspects of lubricants are also reviewed in terms of the raw materials of the lubricants. Food-grade lubricants contain several ingredients produced by animals, such as stearic acid, which can be synthesized from adipose tissues or animal fats [4]. The halal critical point of animal ingredients used in the manufacture of food-grade lubricants is the type of animal used for synthesizing stearic acid. Based on the Qur'an, it is explained that dogs, pigs, fanged animals, and animals slaughtered without mentioning the name of Allah are haram to consume [5]. The use of raw materials or other materials containing haram compounds can affect the halal status of food products [6]. Therefore, the study of halal-haram raw materials for food-grade lubricants is a subject that cannot be ignored to ensure compliance with halal standards in the food industry.

The Halal-Haram study on food-grade lubricants in the food industry also covers the manufacturing process. In the process of making synthetic food-grade lubricants, modifications are necessary to modify the chemical chain arrangement of the raw materials to match the desired properties. This modification process requires additional substances, such as alcohol and catalysts [7]. The source of these additives can be a critical point that can affect the halal status of the lubricant.

The objective of this study was to investigate the halal status of food-grade lubricants, explore the critical points in the production of food-grade lubricants, evaluate the impact of *L. monocytogenes* bacterial contamination, and discuss efforts that can be made to ensure the halal status of food products through halal studies on food-grade lubricants. This article focuses on raw-material detection and contamination strategies, prevention, and mitigation against *L. monocytogene* contamination in the context of halal-friendly food industry lubricants. Through this approach, it is hoped that effective measures can be developed to prevent the contamination of food-grade lubricants with non-halal components and minimize the risk of contamination by *L. monocytogenes*. Through this article, it is hoped that in-depth insights can be obtained about the challenges faced in maintaining halal and food safety through the use of halal lubricants in the food industry and can encourage reflection on collaborative solutions that can be implemented to overcome these risks effectively and sustainably.

2 Materials and methods

This article was based on a literature review using the approach of analyzing various scientific articles. The purpose of this study was to provide an empirical overview of food-grade lubricants used in the food industry for halal certification in Indonesia and to understand the extent of halal-haram risks and critical points of food-grade lubricants in terms of ingredients, manufacturing processes, and their use, which are believed to have the potential to be contaminated with *L. monocytogenes bacteria*. The data and information from this literature study come from a number of articles on *food-grade lubricants* in the industry and SNI-99004-2021 regarding Halal food requirements to determine the extent to which the halal industry can be implemented in this study. The data analysis technique obtained from reading related literature was explained qualitatively through the deductive method, focusing on general decisions to obtain conclusions.

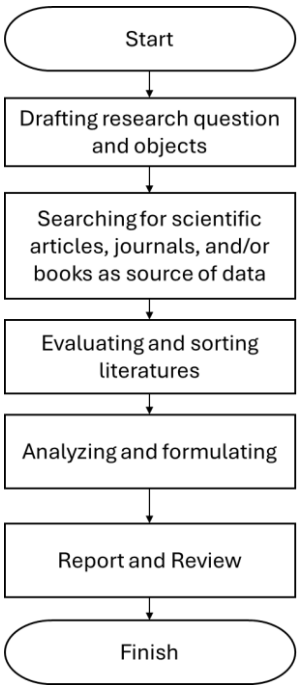

Fig. 1 Systematic Literature Review Process

The author uses references to the SJPH Criteria of the Decree of the Head of the Halal Product Assurance Agency Number 57 of 2021 concerning the Criteria for the Halal Product Assurance System, the Decree of the Head of the Halal Product Assurance Agency, and SNI-99004-2021 regarding Halal food requirements as the main references regarding food safety, halal-haram risks, critical points in the production process, and the use of food-grade lubricants found in the food industry

3 Results and discussion

3.1 Materials for Food-grade Lubricants

Food-Grade Lubricants come in many types, and each type has its own function. Some types of lubricants commonly used in the food industry can be seen in Table 1 [1].

Table 1. Food-grade Lubricants

Type	usage	composition
Food industry lubricant (grease)	The general use of tools in the food industry	Synthetic hydrocarbon (70-80%), hydro treated polymer (10-20%), fumed silica (7-10%)
Food industry lubricant (grease)	The general use of tools in the food industry	White oil (>97%), dialkyl-dimethyl-aluminumsilicate, additive (anti-corrotion, anti-oxidation)
Cooking oil	Additive to enhance the lubricant's performance	Rapeseed oil
Aluminum complex grease	Gear lubricant (subjected to high temperature and pressure) (Repsol, 2018)	White Oil, stearic acid, benzoic acid

Most of the lubricants found in Table 1 use vegetable- or petroleum-based oils as their main ingredients. Some lubricants such as Al-complex greases use stearic acid as an additive. Stearic acid can be found in fish oil, milk, land animal fats, and vegetable oils with a composition of 5-50% of total fatty acids. Stearic acid is more commonly found in animal fats because of the elongation of palmitate [8].

Table 2. Stearic acid content in meat

Product	Stearic Acid content (%)
Beef	12,8-18
Lamb	16,1-23,9
Goat	15-17,3
Pork	11,9-14
Horse	5,5-7,5

Table 2 presents the composition of stearic acid in red meat from farm animals. The highest stearic acid content was found in goat meat (reaching 23.9%). A previous study also showed that the stearic acid content in buffalo adipose tissue was 32.92% of the total fatty acid [4].

Stearic acid is also present in pork, and it has a considerable content compared with other types of meat (up to 14%). According to the Quran Surah Al-Baqarah verse 173, Allah SWT forbade pork from consumption [9]. Referring to SNI 99004:2021, all products containing pigs should not be used in halal production or as growth media in microbial production [6]. therefore, if stearic acid used as a manufacturing material is obtained from pork, the lubricant has a haram status and cannot be used in the halal food industry.

Meat other than pork, as mentioned in Table 1 can change its halal status if the slaughtering process is not carried out according to sharia law [6]. SNI 99003: 2018 regulates halal

slaughter standards for ruminants in Indonesia. Halal slaughter includes hygienic slaughterhouses, animal slaughterers meeting the requirements, animal inspections before and after slaughter, availability of halal supervisors, and slaughter until complete death (the cessation of the cardiovascular system) in accordance with Islamic law [10].

In general, the process of selecting halal food-grade lubricant raw materials can be seen in Fig. 2.

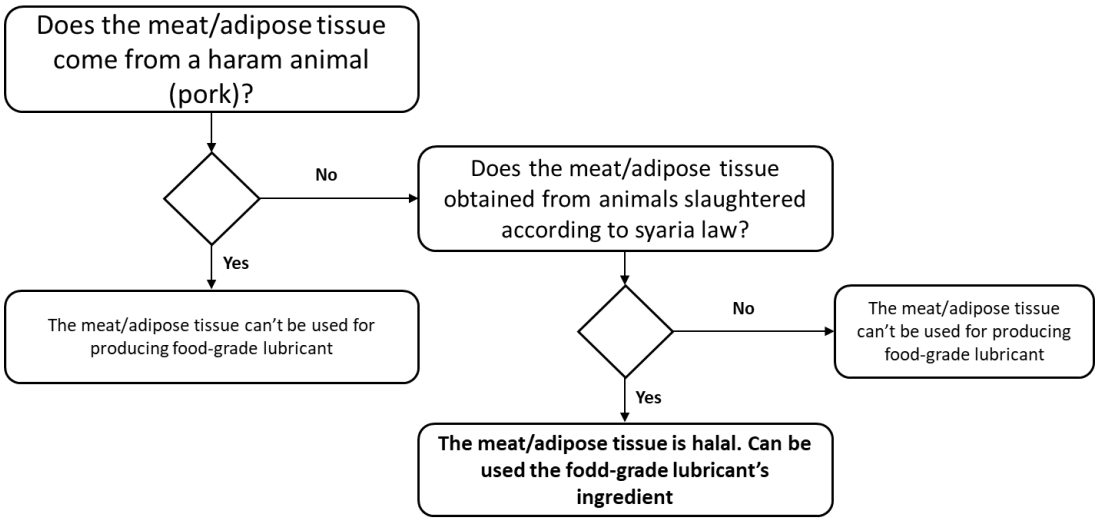

Fig. 2 Procedure for selecting raw halal materials for food-grade lubricants.

Prevention of the use of non-halal raw materials is an important step to ensure the halal status of food-grade lubricants. One effective method is to detect raw materials in food-grade lubricants. Polymerase Chain Reaction (PCR) is a method for detecting animal DNA in foods. The PCR methods investigated include general PCR amplification and real-time fluorescence PCR. The advantage of PCR over other animal origin detection methods is that PCR is rapid, reliable, and sensitive [11]. The principle of PCR is to analyze the animal DNA chain of products and food ingredients. DNA in pigs has characteristics that differ from those of other animals. research by Cheng, et al (2014) showed that PCR analysis can identify food samples containing chicken, duck, and pig blood [11]. In the context of food-grade lubricants, this method can be used to determine whether food-grade lubricants use pork as a raw material.

The use of raw materials from animals slaughtered without compliance with sharia law affects the halal status of food-grade lubricants. To prevent this, the SNI has established slaughterhouse rules. Point 4.12 in SNI 99003:2018 states that organizations/slaughterhouses must have written procedures to ensure the traceability of halal products [10]. Traceability includes the origin of the animal, animal care, procedures before, during, and after slaughter, and management of the results of slaughter. The existence of these standards can prevent the use of non-halal ingredients in food-grade lubricants. Without a clear procedure, the traceability of food-grade lubricant raw materials is difficult, making it difficult to obtain halal certification for such food-grade lubricants.

3.2 Lubricant Production in The Food Industry

This part should explore the significance of the results of the work, not repeat them. A combined Results and Discussion section is often appropriate. Avoid extensive citations and discussion of published literature.

The esterification process by reacting carboxylic acids with alcohols is known as esterification. In the context of bio-based oils like vegetable oils (VOs), which consist of natural esters (triglycerides), they need to undergo transesterification to enhance their lubricating properties. The production of biolubricant involves a two-stage transesterification reaction. In the first stage, triglycerides react with primary short-chain alcohols, such as methanol or ethanol, resulting in the formation of another alcohol and mixtures of fatty acid methyl esters (FAME) or fatty acid ethyl esters (FAEE). Methanol is generally preferred due to its favorable physicochemical properties, such as solubility in sodium hydroxide (NaOH) solution and rapid reaction with triglycerides. Methanol, which is often referred to as "wood alcohol," is readily available[7].

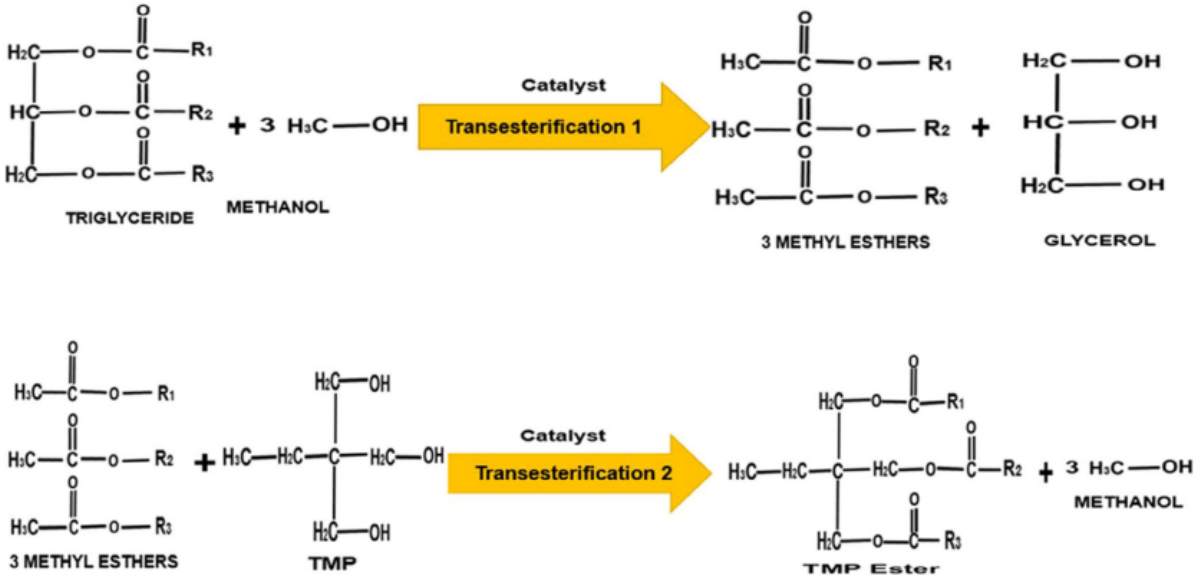

Fig. 3 Esterification and transesterification (two-staged) reaction using a polyol, TMP.

In the second stage of the transesterification process, vegetable oil-derived methyl esters react with polyols to produce triesters, which serve as biolubricant. A key advantage of polyols is their lack of α-hydrogens, which enhances their thermal stability at high temperatures by preventing self-polymerization and free fatty acids [7]. Figure 3 illustrates the esterification and transesterification (two-stage) reaction process of tertiary alcohol (TMP). Transesterification is the most commonly used process to convert vegetable oils into methyl or ethyl esters, which are the main components of biolubricant[12]. This process involves a chemical reaction between triglycerides and alcohols (usually methanol or ethanol) with the help of catalysts (bases, acids, or enzymes) that must be halal. Referring to SNI 99004:2021, all products containing alcohol should not be used in halal production[6]. Therefore, if methanol or ethanol used as a manufacturing material is used as a consumable material, the lubricant has a haram status and cannot be used in the halal food industry.

Although halal biolubricant offer many advantages, there are several challenges that need to be overcome, including the following:

a) **Oxidative stability**: Vegetable oils tend to have low oxidative stability, which can affect the life of the lubricant.
b) **Production costs**: The production of halal biolubricant is relatively expensive compared to petroleum-based ones.
c) **Technology development**: Further research is required to develop more efficient and economical production technology.
[7], [12]

Halal biolubricant have great potential to replace petroleum-based lubricants in the food industry due to the advantages of halal and *thayyib*, biodegradability, non-toxicity, and compliance with food safety regulations. Although it still faces challenges, with the development of appropriate technology and compliance with halal standards, halal biolubricant can be a sustainable solution for the food industry in the future.

3.3 Contamination of *L. monocytogenes* in Food Industry Lubricants

L. monocytogenes is a pathogenic bacterium that can cause listeriosis in humans and animals. These bacteria can be found in natural environments such as soil, water, and plants. However, it can also enter contaminated foods, such as meat, unpasteurized dairy products, and products contaminated during production or storage. *L. monocytogenes* can cause fever, nausea, vomiting, diarrhea, headache, and fatigue in individuals infected with the bacterium [2]. These infections are particularly dangerous in pregnant women, newborns, the elderly, and people with weakened immune systems [1]. Prevention of listeriosis includes ensuring that food is properly processed and stored, paying attention to the expiration date of food products, and avoiding high-risk foods if a person is at high risk of *L. monocytogenes* infection [3].

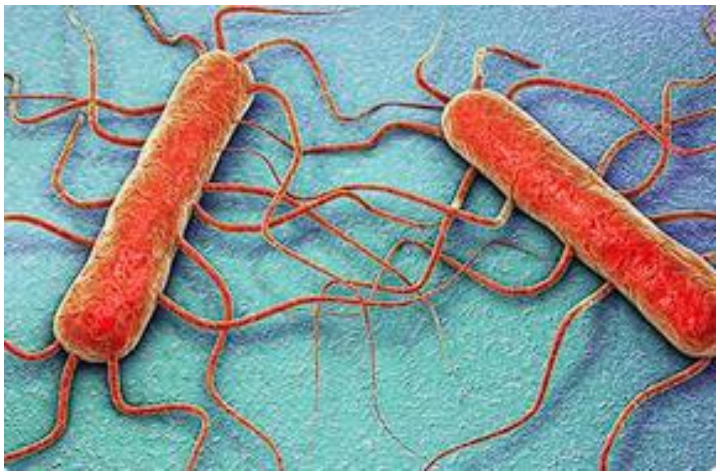

Fig. 3 *Listeria monocytogenes*

L. monocytogenes is known for its ability to survive in extreme conditions, such as cold temperatures, low pH, and salt accumulation. These bacteria can form biofilms on various

surfaces, including metals and plastics, and they are often found in food industry machinery. These biofilms are difficult to clean and can be sources of repeated contamination [1]. Contamination of *L. monocytogenes* in food industry lubricants can occur from several sources:

a) **Plant environment: The soil**, water, and dust surrounding plants can contain *L. monocytogenes*.
b) **Raw Materials**: Contaminated raw materials can cause bacteria to enter the plant.
c) **Factory Personnel**: Poor personal hygiene can lead to contamination.

The main contamination pathways of lubricants in the food industry are as follows:

a) **Indirect Contact**: Lubricants used in food processing machinery can become contaminated if the machine is not properly cleaned.
b) **Cross-Contamination**: Contaminated lubricants can spread to other surfaces or food through contact with equipment or workers' hands.[1], [2]

The general requirements for halal in food products can vary depending on the interpretation of religion and the standards applied. However, in general, several principles and conditions are generally recognized in determining whether a food product is halal or not. The following are some common requirements that are often considered: the main ingredients, production process, additional materials, labels and certifications, quality control, and processing where bacterial contamination has a critical point in quality control that can affect the quality and halal status of the entire process and products produced in the factory production process. Therefore, intensive prevention in the form of Equipment used in the food industry must be designed with hygiene in mind to minimize hard-to-clean areas that can be breeding grounds for L. monocytogenes. Lubricants used in the food industry must meet food safety standards, such as NSF H1 or H3, to ensure they are safe in the event of incidental contact with food. A strict hygiene program is essential. This includes regular cleaning and sanitizing of plant equipment and environments and hygiene training for all plant personnel. It is important to conduct regular monitoring and testing for the presence of *L. monocytogenes* in lubricants and equipment. Fast and accurate testing methods can aid in the early detection and control of contamination [3].

Contamination of *L. monocytogenes* in food-grade lubricants poses a serious problem requiring special attention. In accordance with SNI-99004-2021 concerning Halal Food Requirements to determine the extent to which bacterial contamination in the halal industry can cause lubricants to become non-halal [6]. A comprehensive approach, including the hygienic design of equipment, safe lubricant selection, strict hygiene programs, and regular monitoring, is key to preventing and controlling contamination. With proper preventive measures, the risk of *L. monocytogenes* contamination can be minimized, thus ensuring the safety of food products and the health of consumers.

3.4 Halal Food-grade Lubricants in The Food Industry

Halal food-grade lubricants need to be implemented in the food industry. The use of halal-certified food-grade lubricants is starting to attract the attention of food companies,

especially in Indonesia. The largest oil and gas company in Indonesia, PT Pertamina, produces the first 5 products of halal-certified food-grade lubricants in Indonesia [13].

Table 3. Halal-certified food- grade PT Pertamina lubricant

Product Name	Ingredients	Function	Information
FG-GO 150	Water-soluble polyalkylene glycol, a Food Grade Additive	Gear Oil for the Food Industry	Gear oil obtained its first halal certificate in Indonesia and met the US FDA 21 CFR part 178.3570 regulations
FG-GO 220			
FG-GO 320			
FG-GO 460			
FG-HO 46	Synthetic Oil (Water glycol) as a Food-Grade Additive	Hydraulic Oil for Food	Hydraulic oil obtained its first halal certificate in Indonesia and met the US FDA 21 CFR part 178.3570 regulations

The production of halal-certified food-grade lubricants shows the importance of halal in various aspects for the country's economy, especially countries with a majority Muslim population. Halal products provide safety for Muslim and non-Muslim communities. Halal certification is expected to improve quality standards and product quality, thereby having a positive impact on the food industry, especially the community as consumers. This then impacts the economy in the community. Data has shown that the development of halal certification for products can reduce a country's income deficit. In Indonesia, halal products account for 21% of all exported products, up from 19% in 2016. The increase in exports also contributes USD 3.8 million to GDP per year in Indonesia [14]. Based on these data, it is hoped that the development of halal-certified lubricants can be an important factor in the development of halal food products, which will later improve the community's economy.

4 Conclusion

The review of food-grade lubricants in the food industry highlights three key findings. First, Stearic acid, a common lubricant ingredient often derived from animal fats, poses halal concerns that can be addressed through DNA identification and impurity detection. Second, Various lubricant production methods exist, each with unique advantages and critical points, particularly regarding the impact of additional ingredients on product reliability. The use of additives such as alcohol and catalysts can affect the halal status of lubricants if they do not comply with the halal requirements for food ingredients. Future research should focus on developing protocols for producing halal-certified lubricants. Third, *L. monocytogene* contamination of food industry lubricants poses a significant health risk. Preventive measures include hygienic equipment design, safe lubricant selection, strict hygiene programs, and regular monitoring. Solutions to minimize contamination include modifying the lubricant materials, preparing maintenance SOPs, conducting routine inspections, and ensuring traceable documentation. Lastly, halal biolubricant, with their biodegradability,

non-toxicity, and compliance with food safety regulations, can replace petroleum-based lubricants.

Halal certified lubricants have been implemented by several companies, such as PT Pertamina, by issuing the first 5 halal-certified food-grade lubricants in Indonesia: FG-GO 150, FG-GO 220, FG-GO 320, FG-GO 460, and FG-HO 46. The initiation of the production of halal-certified food-grade lubricants is expected to support the country's economy through the halal food industry. Despite these challenges, the development of appropriate technology and compliance with halal standards can provide sustainable solutions for the halal bio-lubricant industry.

Acknowledgements

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