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The Potential of Halal Anti-Foam Production from Vegetable Oil Derivatives: a Review

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ABSTRACT

The foam that occurs in the process can cause problems with the effectiveness of the process or the quality of the final product. The economic consequences of uncontrolled foaming can be very significant and cause serious losses and require expensive operating changes. Foaming problems can be just as expensive as treating other types of problems, such as corrosion, fouling, or emulsion. Indonesia is known as the largest producer of palm oil, so it has the potential as a producer of downstream palm oil derivative products, especially halal anti-foam with renewable raw materials. In the food industry, only calcium alginate, monoglycerides (MGS), and diglycerides (DGS) are permitted. The use of renewable raw materials in industrial processes is one of the steps to realizing the Sustainable Development Goals, especially the second goal, which is *zero hunger* in 2030. The details of the mechanism of action and the use of anti-foam in the food, medicine, cosmetics, textile, oil refining, petrochemical, paint, and pulp paper industries were discussed. Furthermore, the potential use of palm oil as raw material for halal anti-foaming is very prospective, considering that there are not many palm oil-based anti-foam products applied in various food industries.

Keywords: *Diglycerides, Economic Potential, Halal Anti-Foam, Monodiglycerides, Palm Oil Derivatives, Zero Hunger*

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1 Introduction

Foam, in the most general sense, is a material whose structure consists of gas cells dispersed in a liquid, solid, or gel continuous phase. However, in the field of colloidal science, foam is most often thought of as a gas dispersion in the liquid phase. Prevention of the foaming process has been around since the early 20th century when mechanical devices began to be used, such as air jets, perforated spiral ducts, centrifuges, pressure changes, heating elements, ultraviolet light, X-rays, and supersonic waves. Ways to suppress foam formation are expensive because they involve the energy required for this purpose. In order to reduce costs, chemical methods are preferred over using mechanical devices [1]. The formation of foam in the process can cause problems in the effectiveness of the process or the quality of the final product, such as causing defects in the surface layer, preventing efficient product filling into the container, reducing the effectiveness of the fermentation process, and others.

Defoaming agent or anti-foam agent is a chemical additive that can reduce and inhibit the formation of foam in industrial processes that use liquid materials. The terms anti-agent foam or defoamer are often used interchangeably with the same meaning. Commercial antifoam is usually sold in the form of an oil-in-water emulsion with an average *drop size* of between 3 and 30 micrometers. The size of the solid particles in antifoam compounds is usually between 0.1 and a few micrometers [2].

Halal issues have become an interesting and important study theme after Law No. 33 of 2014 concerning Halal Product Guarantee was passed and its derivative laws were enacted. Halal Product Guarantee is legal certainty regarding the halalness of a product as proven by a Halal Certificate. Meanwhile, what is meant by products are goods and/or services related to food, beverages, drugs, cosmetics, chemical products, biological products, genetically engineered products, as well as goods used, used, or utilized by the public. Given the wide scope of product definition intended by the legislation, it can be said that all goods and or services used by the community must be certified halal, including anti-foam products.

Based on Indonesia Food and Drug Administration Regulation No 11 of 2019 only listed calcium alginate, monoglycerides (MGS), and diglycerides (DGS), which are permitted as food additives and function as anti-foaming [3]. MGS and DGS are food additives that can be sourced from animals or vegetables, including palm oil. Although only three types of anti-foam are allowed to be used in the food sector, several countries have used silicone-based anti-foam, including North America, Latin America, Europe and Asia, especially Japan and China, for example, for processing cereals, cakes, bread, *rendering stages* in meat processing, producing gelatin, and powdered soybeans. Central Bureau of Statistics data shows that imports of Glycerol Mono Stearate (GMS) (one of monoglycerides type) in the 2017-20 period recorded an increase with a mixed annual growth rate (CAGR) of 5.08%. In the same period, GMS exports also occurred but experienced a declining trend from year to year. This condition can be seen in **Figure 1**.

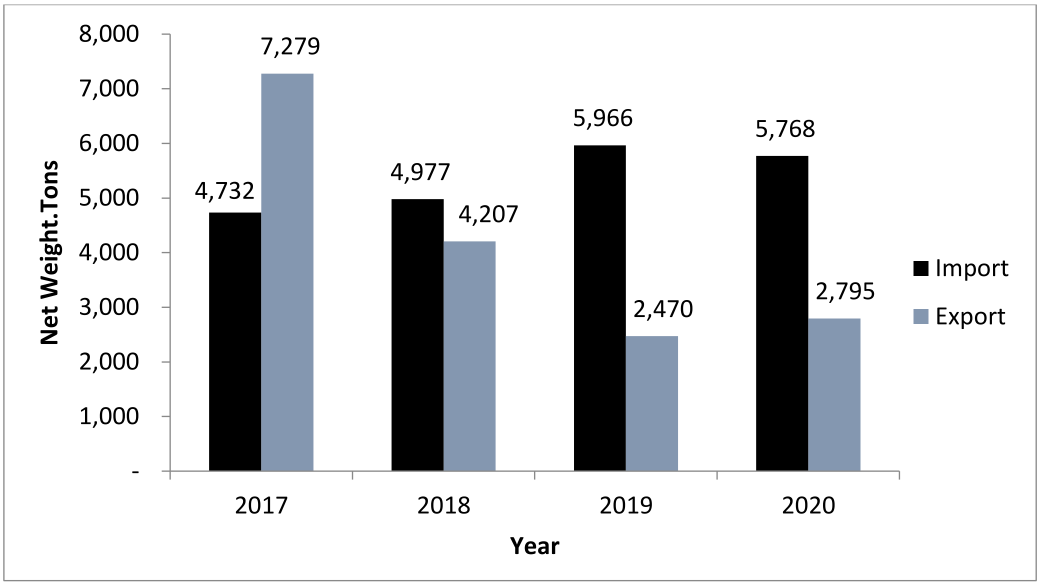

Figure 1. Import-Export of Glycerol Mono Stearate in the period of 2017-2020.

There is an import activity of GMS and at the same time exports, because domestically the food additives factory has been built, but it is suspected that not all of the specifications for domestic needs can be met by domestically produced products. There are at least 15 oleochemical producers in the country and some of them produce GMS. Various anti-foam studies using raw materials derived from palm oil have been carried out. Research on measurement the performance of glycerol esters to suppress foam formation at various concentrations has been carried out. In this study, the performance test of the glycerol ester was carried out by measuring the density, viscosity, foaming ability and foam stability in a solution of Sodium Dodecyl Sulphate (SDS) and heterogeneous foaming agent NF24. Moreover, a commercial anti-foam silicone oil was used in this study to compare performance data glycerol ester under study [4].

The chemical method of MGS synthesis produce a mixture of acylglycerols (DGS, and tryacylglycerols) and make the synthesis of MG from a single fatty acid type impossible by this route [5]. In addition, because glycerol and fatty acids react spontaneously at 110 °C and the reaction proceeds significantly at higher temperatures, it is difficult to prevent the formation of DGS and triglycerides during direct esterification at higher temperatures [6]. One alternative to overcome this problem is through an enzymatic process with the help of certain enzymes. Lipase enzymes due to their selectivity and specificity offer a better way on the synthesis of a single fatty acid that is very pure and contains only monoglycerides. Through the enzymatic process MGS, DGS, and triglycerides can be produced with glycerol as raw material and *refined bleached deodorized palm oil* (RBDPO) with a lipase catalyst [7]. The use of lipase and substrate enzymes can lead to halal critical points related to the use of substrates and their auxiliary materials.

Meanwhile, the synthesis of Glycerol Mono Oleate (GMO) (one of monoglycerides type) can be carried out through esterification of glycerol with oleic acid with a yield of 43% using p-toluenesulfonic acid as a catalyst [8]. Another study showed that the catalytic esterification of glycerol with oleic acid (OA) can be optimized with a mesoporous hydrophobic zirconia-silica heterogeneous acid catalyst (ZrO_2-SiO_2-Me & Et-$PhSO_3$ H). The results were compared with commercial catalysts (Aquivion and Amberlyst 15) to examine the effect of catalyst acidity on conversion, yield and product selectivity. The results of the optimization process with hydrophobic mesoporous zirconia-silica heterogeneous acid catalyst showed 80% conversion with 59.4% GMO and 34.6% Glycerol Di-Oleic (GDO) selectivity according to the combined selectivity of GMO and GDO of 94.8 % on the ratio of OA to equimolar glycerol, reaction temperature of 160 ^oC, 5% catalyst concentration by weight of OA and reaction time of 4 h. The results of the comparison of catalyst performance revealed that the hydrophobic and mild acid ZrO_2-SiO_2-Me & Et-$PhSO_3H$ were out performed than those of Amberlyst 15 and Aquivion [9] .

The 2030 Agenda for Sustainable Development Goals (SDGs), which was adopted by all member states of the United Nations in 2015, provides a common blueprint for peace and prosperity for people and the planet. At its heart are the 17 SDG 's Goals, which are a call to action for all countries, both developed and developing countries, in a global partnership. Awareness of ending poverty and other deprivation must go hand in hand with strategies that improve health and education, reduce inequality, and spur economic growth – all while tackling climate change and working to conserve our oceans and forests. The use of renewable raw materials in the development of halal anti-foaming materials from palm oil is one step towards realizing the second goal of the SDGs, namely *zero hunger*.

2 Anti-Foam Mechanism of Action

Various action mechanisms of anti-foam have been proposed over the last half century. However, the very complex complexity of the phenomena that occur makes the proposed theory often not fully developed properly. Thus, experimental evidence to prove it often becomes less supportive of the theory being developed. The foam itself is very complex, consisting of polydisperse gas bubbles separated by a draining film. The nature of the collapse process of the foam film, which is part of the foam is still not fully understood [10]. Anti-foam acts as a suppressor of foam formation in a system in one or two ways namely, removing the foam stabilizer from the bubble wall or destroying it. In principle, there are 3 (three) different layer-breaking mechanisms for oil-based antifoam, namely: Bridging-Stretching mechanism, Bridging-Dewetting mechanism , and Spreading-fluid entrainment mechanism [11].

The breaker efficiency of solid particles is mainly determined by the hydrophobicity, measured by the value of the contact angle α_{aw}. It has been experimentally demonstrated that hydrophobic particles can break the foam film by the so-called Bridging-Dewetting mechanism. This mechanism implies that the solid particles first come into contact with two opposite surfaces of the foam film form a solid bridge between them (**Figure 2**). If the particles are sufficiently hydrophobic (α_{aw} is greater than a certain critical value), they are wetted by the liquid and the contact lines eventually come into direct contact with each other and the foam film is perforated on the particle surface [11].

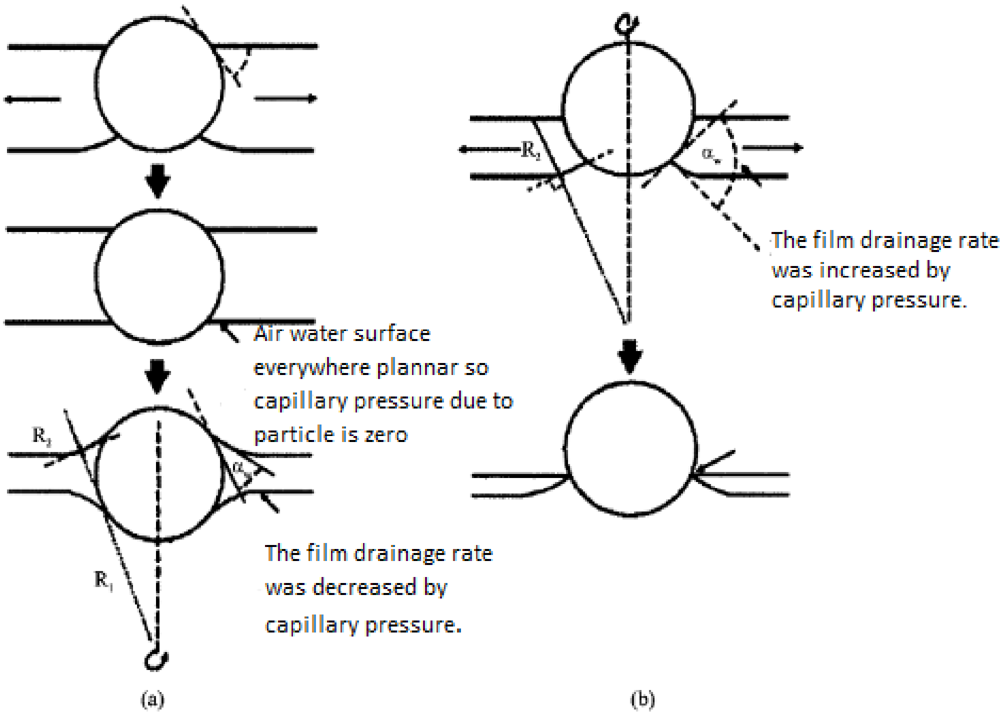

Figure 2. Mechanism of a foam film surface with fine spherical solid particles: a) $\alpha_{aw} < 90^{o}$ and b) $\alpha_{aw} > 90^{o}$.

Denkov points out that two types of anti-foam can be distinguished (called "fast" and "slow") for short because of their different modes of action. The anti- foam is able to quickly break the foam film at the initial stage of thinning the film. As a result, fast anti-foam destroys foam completely in less than a minute, in foam stability tests. Microscopic observations have shown that antifoam rapidly breaks the foam film by the so-called "bridge" mechanism, which involves the formation of a foam layer oil bridge between two foam film surfaces. The stability/instability of this oil bridge is explained by using the capillarity theory. In contrast, the oily granules of the slow antifoam cannot enter the surface of the foam film and are first ejected into Plateau Borders (PB). Only after being compressed by the constricted walls of the PB (due to water drainage from the foam), the slow anti-foam granules can enter the solution surface and destroy the adjacent foam film [12].

3. Use of Anti-Foam in Several Industries

Anti-foam is widely used in various industries, including the food industry, medicine and cosmetics, oil and gas, *pulp and paper*, and textiles. According to the Decree of the Minister of Religion of the Republic of Indonesia No. 748 of 2021 concerning types of products that must be certified Halal, related to products are food, beverages, drugs, cosmetics, chemical products, biological products, genetically engineered products and consumer goods. Considering that halal certification in Indonesia adheres to the principle of traceability, every product used either as raw material or auxiliary material or additional material must be analyzed at halal critical points in the stages of the production process and distribution.

A. Food Industry

The types of anti-foam for food products that are permitted by Indonesia Food and Drug Administration are calcium alginate, monoglycerides (MGS), and diglycerides (DGS).

i) Calcium Alginate

Food Additives calcium alginate can be produced from raw materials Sodium Alginate and Calcium chloride [13]. The halal critical point in the potassium alginate material lies in the provision of raw materials for alginate or sodium alginate, which uses ethanol to precipitate alginate as described by the Haug and Larsen method [14] or, when refining sodium alginate [15]. There are various ways to obtain dry sodium alginate in powder form. Generally, the extraction process of sodium alginate from brown seaweed is based on two categories, which differ from each other especially in the intermediates formed during the extraction process. The first process, calcium alginate and alginic acid are the main intermediates, while in other processes only alginic acid is formed without the formation of calcium alginate [15].

ii) Monoglycerides and diglycerides

Monoglycerides and Diglycerides are usually added to commercial food products in small amounts. These two ingredients help to mix ingredients like oil and water that won't mix well [16]. Monoglycerides and diglycerides can be synthesized by reacting triglycerides with glycerol through the glycerolysis reaction of triglycerides with a base catalyst. The halal critical point in the production of these additives is the source of the fatty acids used, which can use vegetable or animal sources, in addition to the decolorization process that uses activated carbon.

B. Drug and Cosmetic Industry

Anti-foam in the pharmaceutical industry, such as silicone-based defoamer, which is specially designed for waste treatment plants in the pharmaceutical industry. Meanwhile, the chemical pharmaceutical application of polysiloxane (silicon) began in the early fifties, when polydimethylsiloxane was first used as an antifoam in the manufacture of drugs. One of the early applications of polysiloxane, which is still very interesting, was its use in medicines to combat gas in the intestines [17] .

Under various conditions, anti-foam is also used to improve the performance of bioprocesses and other production processes. Anti-foam is often added to bioprocesses although not much is known about its effects on cells or products. However, it is known that certain anti-foam can affect the growth rate of prokaryotic and eukaryotic organisms in addition to changing surface properties, such as lipid content, resulting in changes in permeability. This in turn could benefit recombinant protein production systems for soluble proteins, as has been demonstrated by increased secretion of amylase, or the achievement of greater protein yields due to increased biomass. However, in some cases, certain concentrations of antifoam appear to have a detrimental effect on cell and protein production, and the effect varies depending on the protein expressed [18]. Commonly used anti-foam agents in the pharmaceutical industry are insoluble oils, polydimethylsiloxane, and other silicones, certain alcohols, stearate, and glycols.

C. Textile industry

In general, defoaming used in textile processing can be divided into two main categories namely: a) non-silicon oil-based defoaming, and b) silicone oil-based defoaming. Non-silicone oil defoaming can be further classified as:

i) **Mineral Oil**

This non-silicone defoamer does not work at high alkalinity and high temperatures. Non-silicone defoaming efficiency is lower than that of silicone anti-foaming; however they do not cause silicone grease spots. They are also much cheaper than silicone-based defoaming.

ii) **Alkyl phosphate**

Phosphates are insoluble in water and are therefore made dispersed by the use of selected surfactants. When, such an emulsified product is added to water, it rapidly causes air displacement and allows rapid wetting and sinking, thereby preventing flotation of the fabric. They show excellent alkali stability because they are phosphate esters. This foam control agent is more accurately called a deaeration wetting agent.

iii) **Ethylene oxide (EO)/propylene oxide (PO) block copolymer**

Faster production cycles have resulted in the advantages of high turbulence equipment, such as soft flow, jet immersion and continuous systems. Conventional scouring, dyeing, and finishing agents produce a lot of foam, which results in fabric entanglement and dry foam spots. Therefore, the need for low foaming detergents and scouring agents and other wet process auxiliaries is important. EO/PO copolymers usually have good dispersing properties and are often suitable when deposit problems are a problem. It is an organic surfactant, which is basically suitable for formulating foamless detergents. They are soluble in aqueous media at room temperature. They can be used as shear-stable antifoams, which are active as foam control agents above their cloud point.

Meanwhile Silicone-based defoaming relies on the physicochemical properties of silicone on the defoaming mechanism. Silicon has low surface and interfacial tension. This allows them to flow easily over the film. They searched for the openings between the foam-stabilizing surfactants at the liquid-air interface and occupied them. The low surface tension and interfacial properties of silicone combined with the lack of foam stabilizing properties cause the foam walls to thin and collapse.

However conventional silicone antifoamers, when used in the formulation of these detergents or wetting agents, show poor compatibility, and lead to unstable mixtures, which tend to separate and also cloud the formulation to cloudiness. The EO/PO block copolymers have been able to overcome the above limitations and, when added to this nonionic surfactant formulation, provide a stable homogeneous dispersion, and exhibit low foaming characteristics for the surfactant. Classic silicone defoamers are based on poly-dimethyl siloxane of various molecular weights, filled or pre-activated with fumed or precipitated silica and then emulsified suitable for their application in aqueous media for textile processing.

D. Industry Oil Refinery and Petrochemical

The formation of foam in the oil refinery process leads to operational problems. Foaming can occur in both aqueous and non-aqueous systems and in a wide variety of processes, such as distillation, extraction, gas and liquid separation, and other separations. The economic consequences of uncontrolled foaming can be very significant and cause serious losses and require expensive operating changes. The problem of foam formation can be as expensive as treating other types of problems, such as corrosion, fouling, or emulsion, conditions like this also occur in processes in the petrochemical industry [19]. Polypropylene glycol is one of the materials that is widely used for the manufacture of anti-foam, which is applied to the oil and petrochemical industries.

E. Paint Industry

Defoaming agents for paints and coatings are additives that quickly remove foam during paint application and contribute to achieving an even, blemish-free coating. Paint consists of solid particles and a binder dispersed in water or solvent. Particles provide opacity and color. The binder binds the particles together into a coherent paint film, when the solvent or water has evaporated. The main products of this industry are water-based emulsion paints for household use, solvent-based household paints, and water-based/mixed solvent-based paints for industrial use. Foaming is a particularly serious problem with water-based paints and water/solvent-based paints especially where emulsion polymers are used as binders [20]. Mineral oil is one of the materials that is widely used for the manufacture of anti-foam which is applied to the paint industry.

F. *Pulp and Paper* Industry

The final product of the pulp and paper industry is office stationery. There are not many palm oil-based anti-foaming applications in the pulp and paper industry. The BASF company developed a defoaming agent based on an oil-in-water emulsion in which the oil phase forms 5 to 50 wt% of the emulsion, comprising a mixture of (i) fatty acid esters of C12 to C22 carboxylic acids with C1 to C22 mono to trivalent alcohols; (ii) Polyglycerin esters, which can be obtained by esterification of at least 20% of polyglycerin containing at least 2 glycerin units with at least one C12 to C36 fatty acid; (iii) fatty acid esters of C12 to C22 carboxylic acids and polyalkylene glycol, a molar mass of polyalkylene glycol up to 5000 g/mol, and possibly; (iv) long-chain alcohols, fatty acid esters of alcohols with at least 22 C atoms and C1 to C36 carboxylic acids, distillation residues, which can be obtained in the production of alcohols of higher carbon numbers by oxysynthesis or the Ziegler process and which can be alkoxylated, and/or or; (v) hydrocarbons with a boiling point of more than 200 ^{o}C or fatty acids with 12 to 22 carbon atoms [21].

4. Potential of Palm Oil as a Source of Halal Anti-Foam Production

A. Comparison of Commercial Anti-Foam with Palm Oil Derivative Products

Currently, research and development of silicone oil as an anti-foam material has been carried out for its use in various industrial processes. Its current use is in the form of the active ingredient which is emulsified in a certain medium. Dow is a silicone oil producer with the name Xiameter (Polydimethylsiloxane) with an anti-foam function as shown in **Table 1**. However, it is known that the use of silicone oil as an anti-foaming agent has a negative impact on the final product obtained, such as scattering in paint products and its drawbacks are non-edible. So, currently, many vegetable-based anti-foam materials have been developed that are soluble or partially soluble in the medium and are safe for consumption. Anti-foaming materials derived from starch, vegetable oils, fatty acids and their composites have been widely developed [4].

Table 1 Food grade anti-foam and defoaming

Product name	Phase	Use	Active Substance Content (%)	FDA Code
XIAMETER ACP-1920	Solid	Biofermentation, Fermentation, Filtration. Dry Drink Mix. Powdered Soup, Powdered Soy, Margarine Production. Powdered Flavoring and Seasoning	20	FDA21 CFR 173.340.
XIAMETER AFE-1510	Liquid	Bioethanol Production, Fermentation. Beverage Processing. Meat Processing, Fruit Negetable Processing, Dairy Processing.	10	FDA21 CFR 173.340.
XIAMETER AFE-0010	Liquid	Distillation and Evaporation. Fermentation. Beverage Production. Bread Production. Poultry Processing. Soy Bean Cooking, Potato Manufacturing, Whey Processing	10	FDA21 CFR 173.340
XIAMETER ACP-1920	Solid	Biofermentation, Fermentation, Filtration. Dry Drink Mix. Powdered Soup, Powdered Soy, Margarine Production. Powdered Flavoring and Seasoning	20	FDA21 CFR 173.340

Glycerol ester is a palm oil derivative product made by the esterification process of glycerol and free fatty acids. Glycerol ester is one of the efforts to increase the added value of glycerol as a by-product of biodiesel production. Products from the esterification process of glycerol and free fatty acids include triglycerides, diglycerides, monoglycerides, and free fatty acid [22]. These four fractions are thought to have the ability to suppress the formation of foam or break up the formed foam.

Glycerol ester oleate is a mixture of glycerol esterification reaction and palm oil fatty acids, where the final product obtained is influenced by process conditions, such as temperature, duration of operation, stirring, and the presence of moisture during the reaction. The product obtained is a mixture of unreacted oleic fatty acids, glycerol monooleate, glycerol dioleate, and glycerol trioleate. Free fatty acids and glycerol trioleic are constituents that can easily form emulsions with water or even dissolve in water if there is a surfactant with the right characteristics [4]. Glycerol ester producing countries are Malaysia, South Korea, and China. However, until now, glycerol ester as an anti-foaming agent is still in the research stage and there is no official product yet.

B. Halal Critical Point in the Production Process of Anti-Foam from Palm Oil

A material can be said to be a non-critical material (also referred to as a positive list material) if the material is included in mining/excavation materials, chemical/synthetic materials, vegetable materials that do not require further processing or without the addition of other materials, animal materials (eggs, fresh milk, honey and fish), microbial products obtained by natural processes and several other types of polymeric materials. The list of non-critical materials is explained in the Decree of the Minister of Religion of the Republic of Indonesia No. 1360 of 2021 concerning materials exempted from the obligation to be certified halal.

The anti-foaming of palm oil is guaranteed to be halal because it comes from plants, the critical point of which is the prohibition of the tools and materials added during processing and packaging and the possibility of becoming hazardous materials. As an example of tracing the critical point of materials, in the palm oil production process, activated carbon in the bleaching process (bleaching stage). Activated carbon in this process may be derived from animal bones. The animal bones used can determine the halal or haram of the activated carbon. The halal/haram status of activated carbon can affect the halal/haram status of vegetable oil. Even though activated carbon in the oil processing process only acts as an auxiliary process, it is not included as raw material or additional material in the production process. This description is a strong reason why the oil used in the production process must also be clearly halal. So that products produced by industry or business actors can also have halal status.

5. Economic Potential of Palm Oil-Based Anti-Foam Development

Indonesia is known as the largest producer of palm oil. Indonesia's palm oil production per year continues to increase. In 2020 provisional data show a total production of 48.3 million tons [23]. This increase in production correlated with the area of oil palm plantations opened in addition to productivity factors in oil palm land. The total production of palm oil and the area of land for palm oil plantations in the country is as shown in **Figure 3**. The increase in plantation area in 2017 experienced a very significant increase of around 25% from 2016. However, after that the increase in land area only ranged from 1-3 % during the period 2017 to 2021. This is presumably due to the limited land available to be cleared for oil palm plantations.

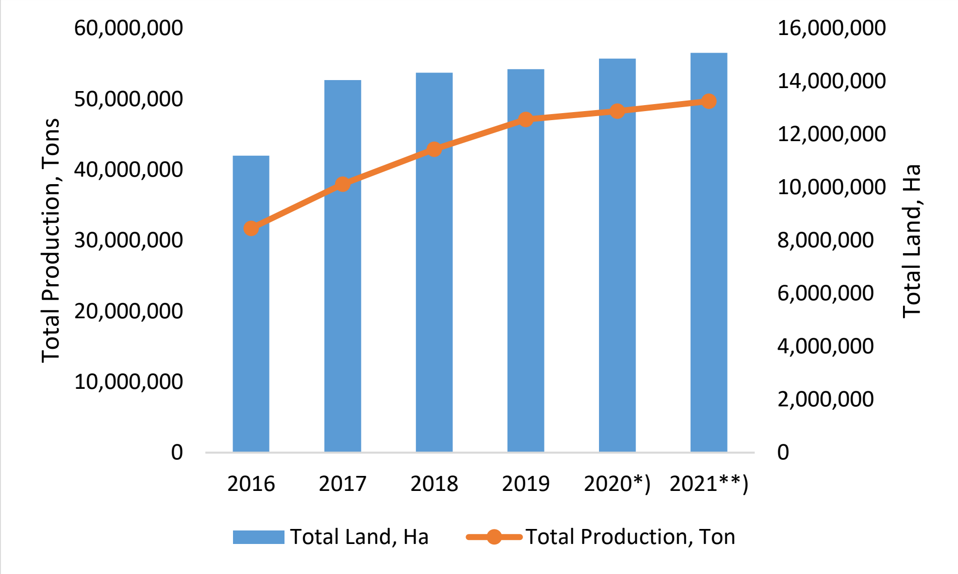

Figure 3. Palm Oil Production and Oil Palm Plantation Area in Indonesia from 2016-2021 (*): temporary; **): estimate; Source: Director General of Plantations, Ministry of Agriculture, 2020)

Meanwhile, the average production growth in the period 2016 to 2021 was 9.3%. In 2020, this commodity had a contribution of 14.07% to exports of the manufacturing industry sector with an export value of 18,444.0 million US dollars. This value has increased by 18.43% from the previous year. These commodities were mostly exported to India, China and Pakistan, amounting to US$ 2,987.3 million, US$ 2,867.5 million and US$ 1,667.4 million, respectively [24]. From 2016 to 2021, Indonesia contributed 54.0% to 68.1% of world production, as shown in **Figure 4.**

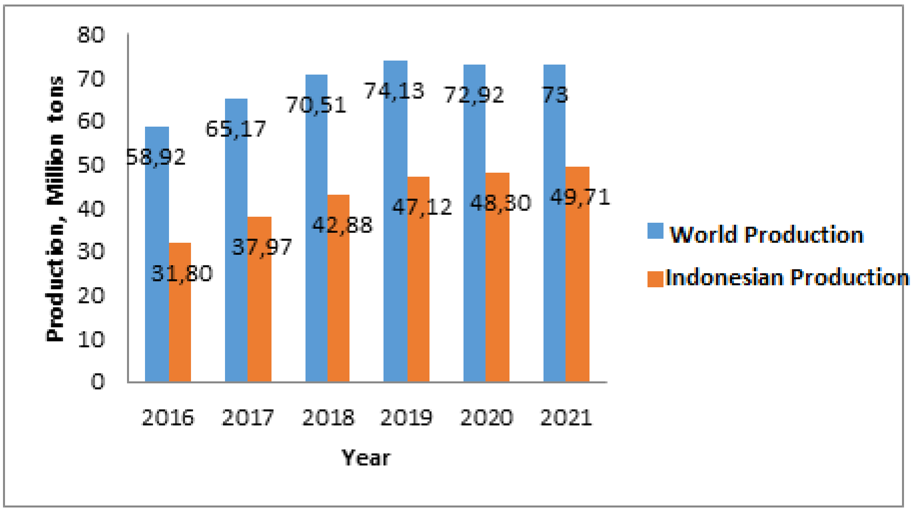

Figure 4. Indonesian CPO Production compared to Total World Production. Source: Processed from various sources

Meanwhile, the projected demand for Crude Palm Oil (CPO) in Indonesia in 2025 is estimated at 6.9 million tons for food, 11.2 million tons for biodiesel industry, 2 million tons for other industries and 31 million tons for exports [25]. Policy The mandatory biodiesel program will affect the supply and demand for domestic CPO. Through the minister of energy and mineral resources regulation No. 32 of 2008 concerning provision, utilization, and trading of biodiesel as other fuels as last amended by regulation of the minister of energy and mineral resources No. 12 of 2015. This policy was implemented in 2008 with a blended biodiesel content of 2.5% and increased gradually increased to 7.5% in 2010. In the period 2011 to 2015 the percentage of biodiesel was increased from 10% to 15%. Furthermore, on January 1, 2016, the biodiesel content was increased to 20% (B20) and it went well.

Glycerol is the main by-product in the biodiesel manufacturing process, every 100 pounds of biodiesel produced can produce 10 pounds of impure glycerol or 10% [26]. With an estimated total domestic CPO production in 2025 of 51.1 million tons, the amount of impure glycerol formed is estimated to be around 5.11 million tons. Thus, it is necessary to consider the use of the glycerol by-product into a product that has more economic value.

Pure glycerol can be used as a raw material for making products in the pharmaceutical, cosmetic, chemical and food and feed industries. The by-product of the transesterification process produces impure glycerol, which is usually polluted with catalyst, methanol, water, soap and esters. The association of American feed control (AAFCO) in 2015 approved the maximum level of methanol that can be used in animal feed is 5,000 ppm, while the US Food and Drug Administration (FDA) requires a maximum limit of 150 ppm for food and feed. Meanwhile, the mean content of methanol in impure glycerol ranged from 270 -78020 ppm [27]. Thus, if you want to use it as a raw material in the pharmaceutical, cosmetic, food and feed industries, impure glycerol as a by-product of biodiesel synthesis must be purified first. Purification of glycerol on a small scale requires large costs so it must be carried out on a large scale to obtain operational cost effectiveness [28]. Therefore, glycerol used for the pharmaceutical-cosmetic and food industries is usually not a by-product of biodiesel production. Alternatively, glycerol can be obtained from the Fat Splitting process, wherein the oil is brought in contact with water at high pressures of about 5 mpa to 6 mpa and high temperatures of about 250 ^{o}C to 260 ^{o}C in the counter-flow method. The reaction products are fatty acids and sweet water, which contains about 15% glycerin. This process produces more glycerin than those of transesterification and saponification.

Conclusion

Anti-foaming materials that are allowed to be used in the food sector are only calcium alginate, monoglycerides, and diglycerides. The critical point in the potassium alginate material lies in the supply of alginate raw materials that use ethanol to precipitate alginate. Meanwhile, the critical point for monoglycerides and diglycerides was the use of activated carbon in the bleaching process with a halal carbon source. Moreover, the use of glycerol from biodiesel production is not recommended for raw materials in the pharmaceutical-cosmetic, food and feed industries, considering the relatively high levels of methanol and other contaminants. Therefore, the potential of palm oil as a halal anti-foam raw material is very open considering the large domestic supply of palm oil and not many palm oil-based anti-foam products on the market, especially for use in the non-food industry.

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