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Traditional Biotechnology Approaches in *Halal* Food Production: A Comprehensive Review

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ABSTRACT*: The concepts of halal and thayyib are key considerations in Muslim-majority nations. Halal and thayyib are the highest quality standards, as well as indicators of product competitiveness. This concept can be applied to all products or services consumed. Traditional biotechnology is one application of the halal and thayyib principle. Traditional biotechnology involves the activity of microorganisms, namely, fermentation. Fermented products include tape, kombucha, yogurt, bread, and tauco. These five products are well known within Muslim communities, hence the need for critical examination of their halal and thayyib aspects. In terms of halal, fermented products must ensure the halal status of the raw materials, media used, and food additives. Meanwhile, in terms of thayyib, fermented products must ensure food safety, process hygiene, and the use of high-quality raw materials, thereby allowing Muslim consumers to feel safe and confident in consuming these products.*

Keywords: *traditional biotechnology; fermentation; halal; microorganism; thayyib*

1. INTRODUCTION

The current world population as of 2024 is 8.2 billion (Affairs, 2024). Especially, Indonesia is the country with the largest population in the world, totaling approximately 284.4 million people (Badan Pusat Statistik, 2025). As one of the countries with the largest Muslim populations, Indonesia has the potential to become a global producer of *halal* products by strengthening Micro, Small, and Medium Enterprises (MSMEs) (Zahrandika & Permadi, 2022). *Halal* is a fundamental requirement for Muslim consumers in food consumption, and the *halal* trend is particularly important as it addresses the potential risks of contamination with prohibited substances in food products (Ma'rifat et al., 2017).

Halal is not only determined by the production process but also encompasses the services associated with production, including handling, storage, distribution, and logistics. Moreover, the concept of *halal* in food extends beyond the production process itself; it also emphasizes the integrity and purity of all ingredients involved. Both primary and supplementary raw materials must be verified as *halal*-certified and safeguarded from any potential contamination by non-*halal* or impure (*najis*) substances, ensuring that the entire production chain upholds ethical, spiritual, and quality standards in harmony (Talib et al., 2020). Among these, food products are of particular importance, as they play a crucial role in human development. The term *halal* refers to what is lawful, permissible, and allowed under Islamic law (Khotibul Umam et al., 2024). Therefore, the development of *halal* food is crucial, as it refers to products permitted or prohibited for consumption by Muslims in accordance with the Qur'an and the Hadith (Addina et al., 2020).

The concept of *halal*, which is upheld by Muslims and reinforced by Government Regulation No. 42 of 2024 on the Implementation of the *Halal* Product Assurance Sector, emphasizes that all products and services consumed by the public must guarantee *halal* integrity, from preparation and processing to the supply chain, particularly in logistics from upstream to downstream (Siregar & Zahradika, 2023).

Accordingly, *halal* practices in microbiology are crucial for Muslims, particularly in fermentation processes within traditional biotechnology, where *halal* aspects must be carefully considered. Biotechnology is divided into two types: traditional and modern. Examples of traditional biotechnology include fermented derivative products such as yogurt, kefir, cheese, bread, tauco, tape, and kombucha, which are primarily intended to enhance taste and flavor while also providing health benefits for humans. In contrast, modern biotechnology involves genetic engineering and the use of recombinant microorganisms (Dysin et al., 2023).

Traditional biotechnology is a technology that has been used for a long time and continues to be used. Products from traditional biotechnology are more familiar to the general public than products from modern biotechnology. Therefore, products from traditional biotechnology must guarantee the concept of *halal* and *thayyib*. It becomes an important issue if the market share of traditional biotechnology products is in the muslim community.

The development of biotechnology today extends beyond fermentation to include genetic modification of microorganisms, raising concerns among consumers, particularly Muslims, who require that such bioproducts be produced in compliance with fundamental Islamic principles and dietary laws (Karahalil, 2020). Consequently, it is essential to understand the application of the concepts of *halal* and *thayyib* in traditional biotechnology, particularly in fermentation-based food products. The purpose of this paper is to provide an overview of long-consumed fermented foods and to critically evaluate their production processes in terms of *halal* and *thayyib* principles.

Basic Principles of Biotechnology-Based *Halal* Products

To gain a clear understanding of the basic principles of *halal* in fermented products that are part of traditional biotechnology, it is important to recognize that these principles are grounded in the concepts of *halal* (permissible) and *thayyib* (wholesome), which ensure that food products are lawful, safe, and beneficial for consumption. In the fermentation process, products must be carefully maintained during preparation, production, and distribution to ensure they are not exposed to contamination from prohibited substances like alcohol (*khamr*) (Bachtiar, 2025). Even if the original ingredients are *halal*, any contact with non-*halal* materials during processing can compromise the *halal* status of the fermented product.

One of the main concerns in determining the *halal* status of fermented food products lies in the origin of microorganisms and their growth media. In the cultivation of these microorganisms, protein hydrolysates such as peptones, which provide amino acids and nitrogen sources, are often used as key raw materials. These are commonly derived from animals such as pigs or non-*halal*-slaughtered cattle (Rossi et al., 2022). In addition, during the fermentation process, cross-contamination can occur, as in cheese production, which uses the enzyme rennet as a coagulant. Rennet is typically obtained from the stomach lining of young calves, and if the method of slaughter is unknown, its *halal* status becomes questionable (Mazalan et al., 2023).

A distinctive feature of traditional biotechnology, particularly in fermented products, is its ability to provide health benefits and extend the shelf life of food products (Castellone et al., 2021). The application of *halal* principles in products and services is rooted in the Qur'anic verse Al-Baqarah (2:168), in which Allah SWT commands humankind to consume what is lawful (*halal*) and good (*thayyib*) (Jannah et al., 2023). This aligns with the concept of *thayyib*, as it provides benefits to the human body and contributes to overall well-being. As an illustration, a schematic of the basic principles of biotechnology-based *halal* products is shown in Figure 1.

Thayyib

The concept of *halal* in a product, especially food products, cannot be separated from the *thayyib* aspect. *Thayyib* fulfills the health-related needs of the human body, addressing aspects such as the production process, production location, contamination, and related safety issues. The *halal* status of products and services must also encompass the aspect of *thayyib*, which refers to food that is healthy and of good quality. This aspect is influenced not only by the cleanliness and health of the producers but also by the overall design and layout of the production environment (Nurul Farhanah Hamdan & Norkhairiah Hashim, 2022).

The concept of *thayyib* in product processing encompasses the protection of health, food safety, animal welfare, environmental sustainability, and social justice, ensuring well-being throughout the entire production, processing, and distribution chain (Idris et al., 2022). Currently, the term *halalan thayyiban* has gained global attention. It is increasingly recognized not only among Muslims but also in broader consumer markets, particularly in the context of food and beverages. The concept of *thayyib* is often interpreted as "safe" and "wholesome", referring to products that are harmless and suitable for consumption (Anuar et al., 2024). The goal of *thayyib* is to achieve maximum hygiene (clean) and minimum contamination (pure). *Halal*-thayyib food is intended to promote a sense of calm and comfort by ensuring adherence to Islamic law in both the processing and sourcing of raw materials (Alzeer et al., 2018).

Halal and *thayyib* raw materials are regulated from their source to the production process. If the process is not clean, caused by cross-contamination, or contains toxic ingredients, food products cannot pass the *halal* certification process. Food has a role as a potential means of disease transmission. Therefore, Islam emphasizes food safety issues, food contamination, and the application of the concept of *thayyib* (clean and pure) as priorities for human health and improving the quality of life (Alzeer et al., 2020).

Halal Critical Point in Food Biotechnology

To ensure that food products meet the principles of *halalan thayyiban*, it is essential to identify and control *Halal* Critical Points throughout the entire production process. *Halal* Critical Points refer to stages where the risk of contamination or the use of non-*halal* materials may occur, potentially compromising the *halal* integrity of the final product. Unlike most traditional biotechnology products, where the critical point can be identified from the raw materials and additives used, this product has a unique formulation.

Halal integrity in microbial-based food products must be maintained by identifying and monitoring critical points such as the origin of microorganisms, the composition of growth media, and the use of additives, as materials derived from non-*halal* or impure sources like blood, pork, or improperly slaughtered animals can compromise the product's *halal* status, thus requiring strict adherence to Islamic principles throughout production (Fathurrohim, 2022). To accurately identify these critical points in traditional biotechnology products, a deeper understanding of the source microorganisms, additives, and their methods of acquisition is required.

Therefore, this study presents the identification of critical points of food biotechnology products (Atma et al., 2018). The key determinants of *halal* perception in microbially derived bioprocess products involve several critical points, including the origin of microorganisms, the type of microbial isolates used, the growth substrates, the resulting metabolic products, the production environment, and any additional materials incorporated for specific functional purposes (Kurniadi, 2016).

The types of fermentation, microorganisms, raw materials, main metabolites, and health benefits of the product through traditional biotechnology are shown in Table 1.

Halal Critical Points of Tape

Tape production is carried out through a fermentation process that contains several types of microorganisms, such as mold, yeast, and lactic acid bacteria. Fungi produce amylolytic enzymes that break down starch into simpler sugars (disaccharides and monosaccharides). The yeast (*Aspergillus*) hydrolyzes starch into simpler sugars, which are then converted by other yeasts into alcohol, resulting in the characteristic aroma and taste of fermented products such as sticky rice tape and cassava tape (Fathnur, 2019). Locally known as *ragi tape* or *yeast tapay*, this starter culture produces a slightly sour or sweet alcoholic flavor due to the fermentation activity of *Saccharomyces cerevisiae*, which converts starch-derived glucose into alcohol and organic acids (Cempaka, 2021). In addition, this process is influenced by *Acetobacter aceti,* which converts alcohol into acetic acid, resulting in the tape having a sour taste. The reaction of tape fermentation is shown in Figure 2.

Islamic law prohibits the consumption of *khamr*. *Khamr* is the term for any intoxicating substance. An example of *khamr* is liquor. Drinks with a minimum ethanol content of 1% are categorized as *khamr*. *Khamr* contains alcohol, but alcohol is not necessarily included in the *khamr* category. This includes tape, although tape contains alcohol, but the alcohol does not intoxicate people who consume it (Faridah & Sari, 2019).

Halal Critical Points of Kombucha

Tea and sugar are combined to create the fermented beverage known as kombucha. Antioxidants, antimicrobial properties, intestinal purification, blood pressure reduction, and immunity-boosting are just a few of the health advantages of kombucha. Kombucha is a drink that contains alcohol at the end of the fermentation process (Riswanto & Rezaldi, 2021). Kombucha tea is a fermented tea that involves the activity of microorganisms. The Synbiotic Culture of Bacteria and Yeasts (SCOBY) is the initial culture used to make kombucha. SCOBY is a mixture of cultures containing bacteria and yeast (Wistiana & Zubaidah, 2015).

Green tea, black tea, white tea, and oolong tea were the four types of tea that were used as substrates to make kombucha. Before and after fermentation, the four varieties of base tea were contrasted. In general, the final result of kombucha fermentation experienced a lighter color change. The degree of color change in kombucha increases with the length of fermentation (Khaerah & Akbar, 2019). Fermented red and green tea are high sources of antioxidants, namely polyphenols, especially flavonoids (Jakubczyk et al., 2020). In addition, the type of tea can also affect the content of micronutrients in SCOBY. Micronutrient contents of manganese (Mn), copper (Cu), iron (Fe), chromium (Cr), and zinc (Zn) were found in black, red, green, and white tea types (Jakubczyk et al., 2022).

The color of the kombucha will vary depending on the type of tea used. During the fermentation process, the SCOBY will seem darker if the tea is darker in color. Yeast adhering to the SCOBY area, which resembles hanging threads and develops brown or yellow spots, is another factor contributing to the darkening of the SCOBY color. Additionally, the sugar used to make black tea and green tea kombucha has an impact on the SCOBY's color change. If you use yellow sugar, the SCOBY will likewise match the color of the kombucha-produced solution (Crum, et al, 2016).

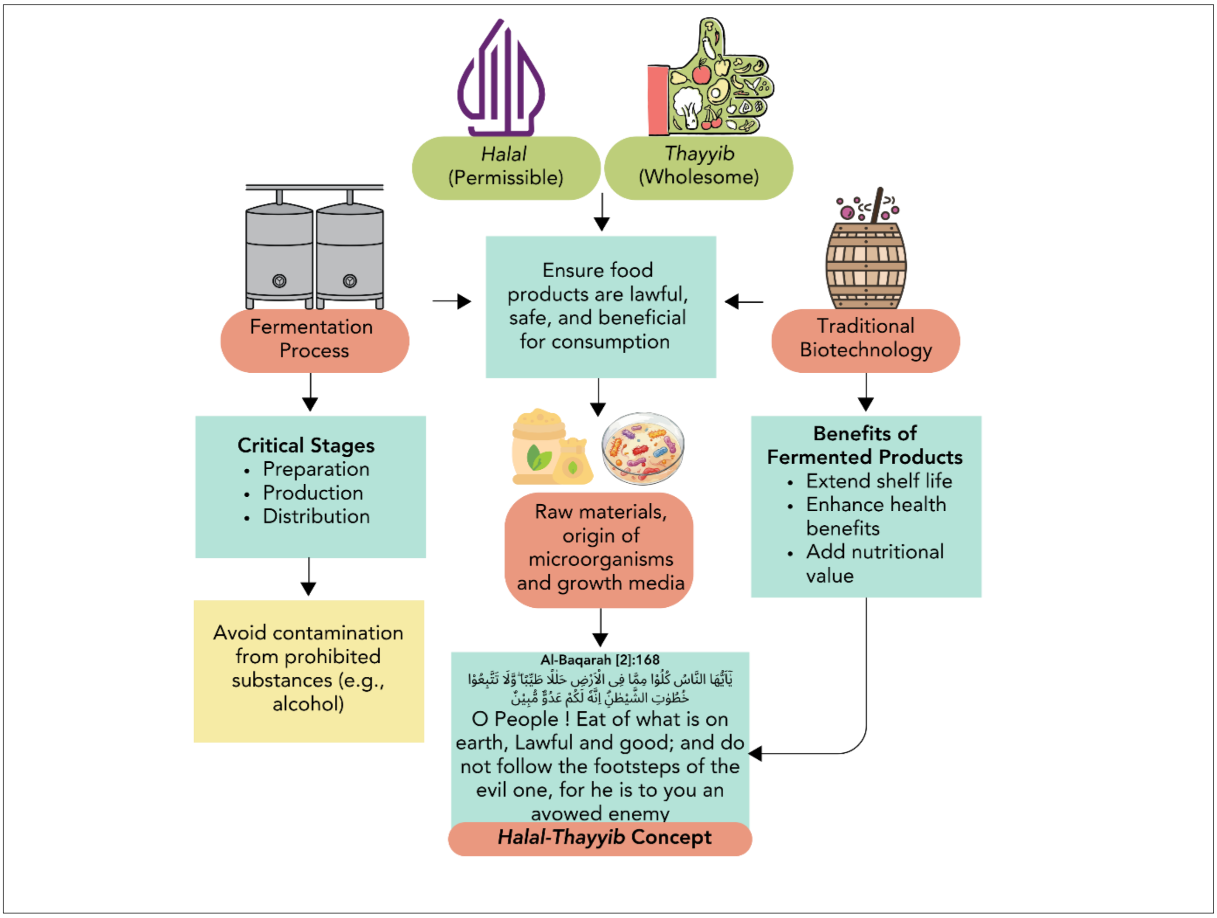

Figure 1. Schema of Basic Principles of Biotechnology-Based *Halal* Products

Figure 3 depicts the fermentation process for kombucha tea, which includes three major stages: alcoholic, lactic acid, and acetic acid. During this process, yeasts begin breaking down sucrose into glucose, which is then used as a substrate for both alcoholic and lactic fermentation. Lactic acid bacteria convert glucose to lactic acid. Acetic acid bacteria within the tea fungus, on the other hand, contribute to the creation of acetic acid, influencing the final beverage's chemical composition and sensory characteristics.

In contrast, during the alcoholic fermentation phase, glucose is converted into ethanol while carbon dioxide is also released. Acetic acid bacteria oxidise the ethanol produed by glucose breakdown, resulting in acetic acid and acetaldehyde (Jakubczyk et al., 2022). Kombucha has a sour taste caused by the presence of bacteria. The fermentation of bacteria causes the distinctive flavor of kombucha to become sour (Villarreal-Soto et al., 2018b).

The focus on Indonesian Muslim consumers, who comprise the bulk of the population, is the critical point of *halal* kombucha drinks. The Indonesian Ulema Council's (MUI) fatwa regulation, which governs the *halal* requirements of food products, serves as the basis for determining whether a food or beverage product is *halal* or haram (Riswanto & Rezaldi, 2021).

The test's outcome demonstrates that the fermented kombucha beverage satisfies the MUI requirement, particularly that its alcohol concentration is less than 0.5%. (Riswanto & Rezaldi, 2021). Thus, it can be said that the fermented kombucha beverage is safe for Muslim consumers to consume and meets MUI *halal* requirements.

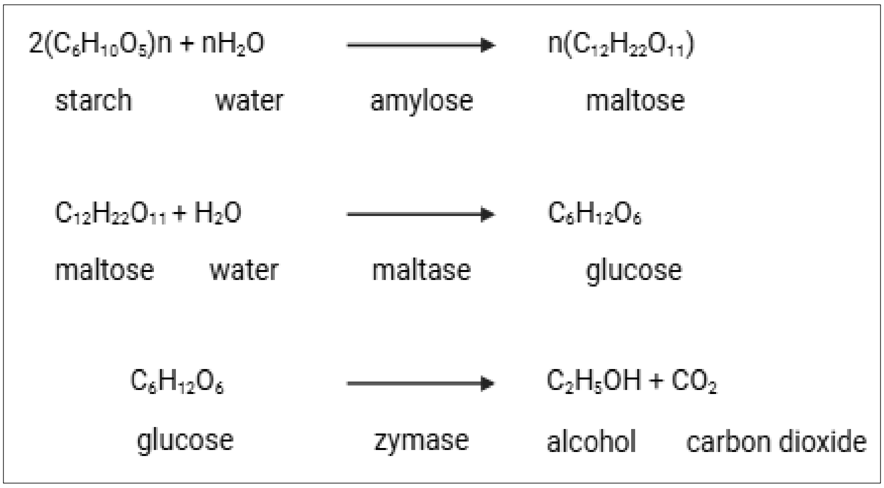

Figure 2. Reaction of Tape Fermentation (Farida & Sari, 2019). Created with BioRender.com

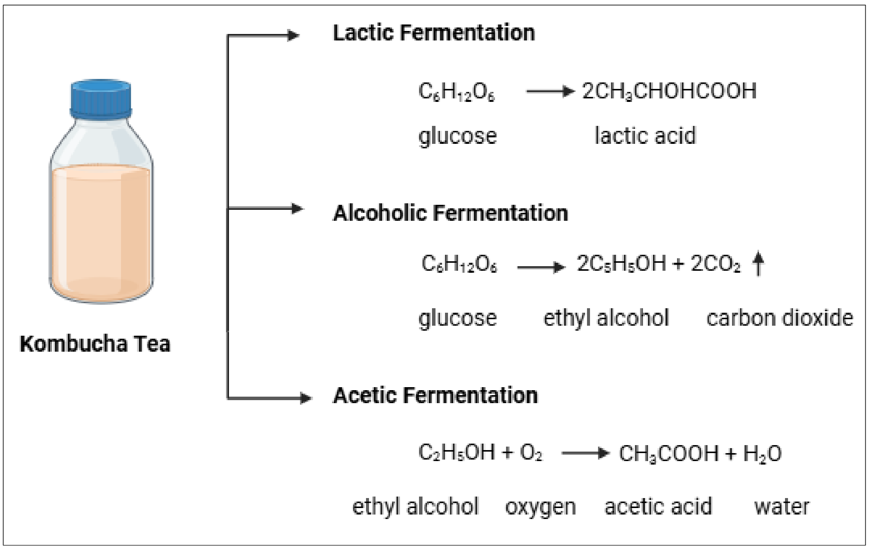

Figure 3. Reaction of Kombucha Tea (Jakubczyk et al., 2022). Created with BioRender.com

Table 1. Products of Traditional Biotechnology

No	Product Name	Type of Fermentation	Microorganisms	Main Raw Materials	Main Metabolite Products	Health Benefits	*Halal* Critical Points	References
1	Tape	Alcoholic and lactic acid fermentation	*Saccharomyces cerevisiae, Lactobacillus sp.* (Yeast and Lactic Acid Bacteria)	Cassava, glutinous rice	Ethanol, lactic acid, acetic acid	Improves digestion, natural probiotic source	Presence ethanol from fermentation	(Hidayat et al., 2020; Indasah & Muhith, 2020; Aini & Khiftiyah, 2021; Laili et al., 2022; Nst et al., 2025)
2	Kombucha	Lactic, alcoholic, and acetic fermentation	*Acetobacter sp., Saccharomyces sp.* (Lactid Acid Bacteria)	Tea, sugar	Acetic acid, ethanol, polyphenols, glucuronate	Antioxidant, liver detoxification	Ethanol residue from fermentation	(Chakravorty et al., 2016; Villarreal-Soto et al., 2018; Nyhan et al., 2022)
3	Yogurt	Lactic acid fermentation	*Lactobacillus bulgaricus, Streptococcus thermophilus* (Lactic Acid Bacteria)	Cow's milk	Lactic acid, bioactive peptides	Lowers cholesterol, improves gut microbiota	Milk source must be *halal*-certified	(Freitas, 2017; Kok & Hutkins, 2018; Savaiano & Hutkins, 2021)
4	Bread	Alcoholic fermentation	*Saccharomyces cerevisiae* (Yeast)	Wheat flour	CO_2, ethanol, aromatic compounds	Improves carbohydrate digestibility	Yeast and emulsifier sources must be *halal*-compliant	(Heitmann et al., 2018; Ismail et al., 2020; Zain et al., 2022; D'Amico et al., 2023)
5	Tauco	Mixed fermentation (Mold & bacteria or Mold & Mold)	*Aspergillus oryzae, Bacillus subtilis, Lactobacillus sp., Rhizopus oligosporus, Rhizopus oryzae* (Mold and Lactic Acid Bacteria)	Soybean, salt	Free amino acids, peptides, organic acids	Antioxidant, hydrolyzed protein source	Possible enzyme or alcohol use in extraction process	(Herlina et al., 2022; Seveline et al., 2025; Pauzi & Astuti, 2025)

Halal Critical Point of Yogurt

Yogurt is a fermented milk product with a sweet and sour taste. Yogurt is a fermented product made with the help of lactic acid bacteria and is considered beneficial for individuals with lactose intolerance because lactose is converted during the fermentation process (Wahyuningsih et al., 2023). The consumption of yogurt containing lactic acid bacteria, particularly from the *Lactobacillus* group, has been shown to increase the diversity of the gastrointestinal microbial community, thereby providing beneficial effects on human health (Lisko et al., 2017). The reaction of yogurt fermentation is shown in Figure 3.

In general, the yogurt manufacturing process begins with determining the total solids content of the milk, followed by pasteurization at 85 °C for 20–30 minutes to eliminate undesirable microorganisms, and subsequently the addition of a bacterial starter (Rashwan et al., 2023). Critical points must be considered at every stage of the process, from choosing the raw materials (input) to processing them until the finished product is ready for consumption, to assess whether the food is *halal* (Ermis, 2017).

First, select the raw materials. Dairy products derived from *halal* sources, such as cows or goats, are considered *halal* as long as the milk originates from animals permitted for human consumption. Conversely, if the milk is obtained from non-halal animals, the resulting dairy products are deemed non-*halal* (Faridah & Sari, 2019).

Second, the determination of total milk solids was carried out by adding skim powder, casein, and whey. These additives can come from non-*halal* animals, so they can cause yogurt to become non-*halal* (Atma et al., 2018). Third, the addition of a bacterial starter, to ensure the *halal* status of fermented products, it is essential that the microorganisms, their genetic sources, and the growth or fermentation media particularly those containing nitrogen and carbon compounds are derived solely from *halal* and hygienic materials, free from non-permissible contaminants such as animal tissues, blood-based components, or genes originating from haram sources (Purnasari & Rusdan, 2023).

Fourth, the addition of additives such as emulsifiers, flavorings, stabilizers, and food coloring is important. These Additives can come from non-*halal* materials (Atma et al., 2018). Fifth, stabilizing agents such as gelatin are commonly incorporated to enhance the visual quality of yogurt, prevent phase separation, and improve its water-holding capacity, particularly when syneresis occurs during storage. The selection of gelatin ingredients needs to be considered because it may come from non-*halal* animals, such as pork (Faridah & Susanti, 2018).

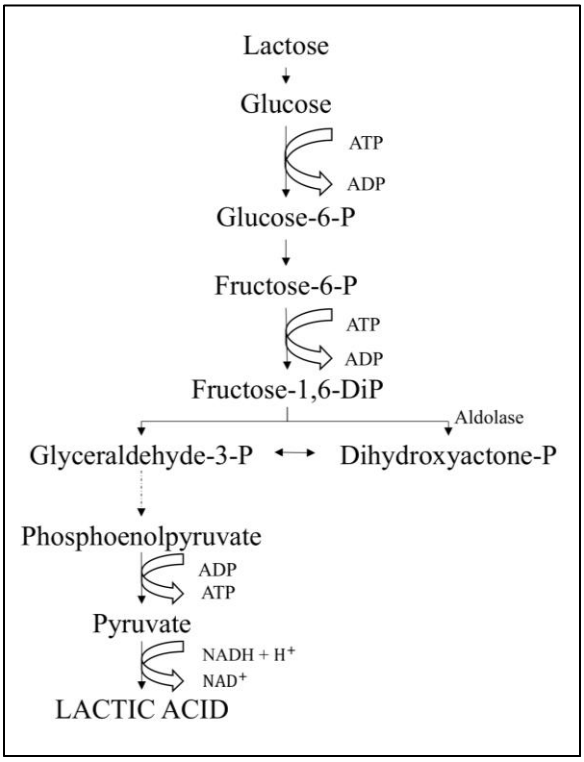

Figure 3. Reaction of Yogurt Fermentation (Hendarto et al., 2019)

Halal Critical Point of Bread

Bread is produced by fermenting a dough made from wheat flour, water, yeast, salt, and various additives, followed by baking. The primary purpose of fermentation in bread making is to generate carbon dioxide, which expands the dough and contributes to a soft texture and characteristic aroma. The primary microorganism involved in bread making is the yeast Saccharomyces cerevisiae. This yeast conducts alcoholic fermentation by converting glucose into ethanol and carbon dioxide (Heitmann et al., 2018).

Fermentation by yeast and lactic acid bacteria increases the bioavailability of minerals such as iron and zinc by reducing the phytate (an antinutrient) content in flour. Additionally, fermented metabolites, including organic acids and bioactive peptides, can enhance digestion and gastrointestinal health (Zain et al., 2022).

In bread production, identifying Halal Critical Points (HCP) involves examining animal-based ingredients like milk, butter, and cheese, which may contain non-Halal enzymes or emulsifiers. It also includes plant-derived components such as margarine, wheat flour, chocolate, and sugar, which can contain additives from animal sources. Attention is also required for microbial media used during fermentation. These potential critical points can be effectively managed by substituting uncertified ingredients with *halal*-certified alternatives to ensure product integrity and maintain quality (Sucipto et al., 2022).

In addition, maintaining the *halalan-tayyiban* status of bakery products requires adherence to good hygiene and safety practices throughout the production and distribution chain. Proper storage conditions, temperature control, and compliance with food quality systems such as HACCP, GMP, and GHP are essential to ensure that bread remains both safe and halal-certified (Nawawi et al., 2018). *Halal* critical points of bread can come from additives used, such as bread improver or dough conditioner, that do not have *halal* certification (Ismail et al., 2020). Bread making requires clean raw materials and equipment, as well as microbiological safety during proofing and baking. High-temperature baking >180°C typically eliminates pathogens. However, it is important to monitor and control acrylamide formation from excessive maillard reactions to ensure product safety (Mollakhalili-Meybodi et al., 2021).

Halal Critical Points of Tauco

Tauco is a traditional fermented food from Indonesia, particularly recognized as a culinary specialty in West Java. It is produced through the fermentation of soybeans, a process that develops complex biochemical transformations leading to the formation of distinctive flavors and aromas. The final product is typically characterized by a yellowish paste-like appearance, with a savory, salty, and umami taste profile that contributes to its wide use as a seasoning or condiment in Indonesian cuisine (Rosida et al., 2014).

The primary raw material of tauco is soybean, which undergoes a fermentation process similar to that of miso (Herlina et al., 2024). The fermentation process of tauco consists of two stages, an initial *koji* fermentation and a subsequent *moromi* or brine fermentation, during which microbial enzymatic activities induce compositional changes that shape its characteristic properties (Nurmilah et al., 2024).

The *halal* critical points in microbiological products can be identified through six stages, starting from microbial culture to the final product. In the case of tauco, these critical points include the source and medium of *Aspergillus* used in the koji stage, the fermentation environment in the moromi process, and the verification of additional materials or condiments to ensure no contamination from non-*halal* or impure sources (Jumiono et al., 2024). The growth media used for microbial starter propagation may also pose a halal concern if animal-based peptones are applied as nitrogen sources. In addition to halal assurance, the *thayyib* aspect in tauco emphasises hygiene, food safety, and the absence of harmful residues or pathogenic microorganisms. Furthermore, maintaining traceability throughout the production chain is crucial to ensure compliance with *halalan thayyiban* principles from upstream to downstream.

Opportunities and Challenges

Traditional biotechnology products, such as bread, tauco, tape, yogurt, and kombucha, have a great opportunity to continue developing because they can provide health benefits while supporting fermentation-based food diversification. The fermentation process can increase nutritional value, produce bioactive compounds such as probiotics and antioxidants, and extend product shelf life. In addition, increasing public awareness of functional foods and healthy lifestyle trends is an important opportunity to expand the market for *halal* and *thayyib* biotechnology products.

However, major challenges arise in ensuring the *halal* integrity of these products. Some stages of the fermentation process still have the potential to cause *halal* issues, such as the use of starter cultures grown on media containing animal components, enzymes derived from pigs or animals that are not *halal* slaughtered, and food additives (such as emulsifiers, flavorings, or stabilizers) whose origins are unclear. In addition, cross-contamination and traceability issues are also important challenges in the modern food industry, especially in products that are mass-produced and involve long supply chains.

In terms of *thayyib*, attention to food safety, process hygiene, and the use of healthy ingredients is equally important. Fermented products must be free from pathogenic microbial contamination, chemical residues, and ingredients that can cause allergic reactions. Therefore, the synergy between biotechnology innovation, *halal* regulations, and a strong *halal* assurance system is the key to presenting fermented products that are not only of high functional value but also fulfill the principles of *halal* and *thayyib* as a whole.

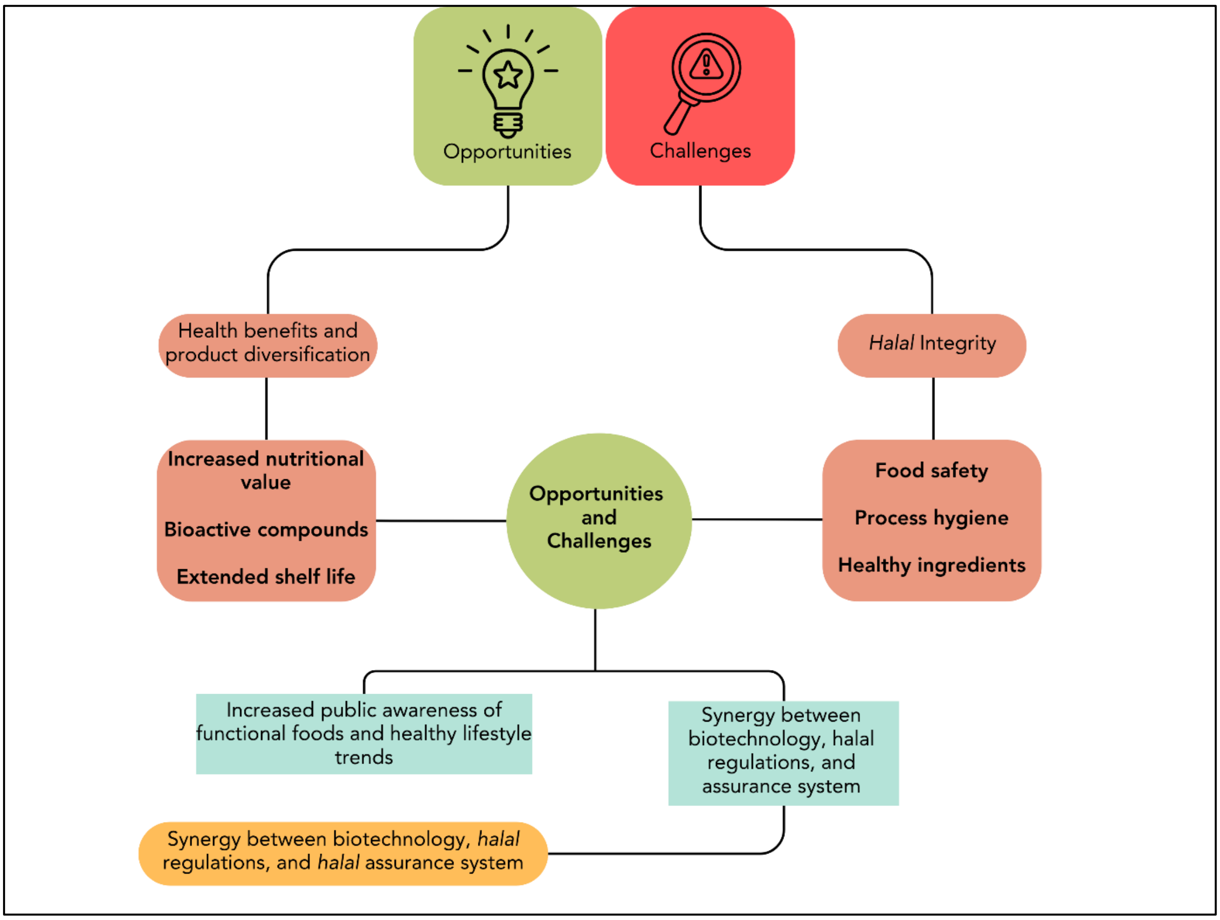

Figure 4. Schema of Opportunities and Challenges Traditional Biotechnology Products

Another opportunity for the development of traditional biotechnology products lies in the application of genetic recombination to improve the functionality of microorganisms used in fermentation. Through controlled genetic modification, microbial strains can be optimized to enhance nutrient bioavailability, improve digestibility, and produce metabolites that promote human health. However, this approach also presents new *halal* challenges, as the origin of the transferred genes and the process of modification must comply with Islamic ethical principles to ensure that the resulting strains and their products remain *halal* and *thayyib*. As an illustration, a schematic of the opportunities and challenges of traditional biotechnology products is shown in Figure 4.

CONCLUSIONS

Various types of consumers have long recognized traditional biotechnology products. One of them is Muslim consumers. Therefore, the concepts of *halal* and *thayyib* must be applied to traditional biotechnology products. Fermented products are examples of traditional biotechnology applications. The fermentation process involves various types of microorganisms, namely bacteria, fungi, and yeast. Five of these are tape, yogurt, kombucha, bread, and tauco. In the concepts of *halal* and *thayyib*, there are critical points for determining the safety of products consumed by Muslims. *Halal* food means avoiding non-*halal* raw materials, media, and food additives.

Meanwhile, *thayyib* is the fulfillment of requirements based on the cleanliness of the location, process, and use of the best quality ingredients. Critical *halal* points in traditional biotechnology products include the source of microorganisms, the growth media used, and the fermentation process. Fundamentally, the concepts of *halal* and *thayyib* in food prioritize human health. Food and beverages that are contaminated or contain non-*halal* ingredients, such as pork, are of course haram. In contrast, food and beverages containing alcohol have a tolerance limit according to the Indonesian Ulema Council (MUI), namely an alcohol content of less than 0.5%, are not classified as *khamr*, and do not have an intoxicating effect. In the future, the development of traditional biotechnology products can apply genetic recombination to improve the function of microorganisms in the fermentation process.

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