Halal assurance systems in enzyme market

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Abstract

Background and objective: Enzymes are a kind of food additive which are widely used in food industry. They are extracted from different sources including plants, animals and microorganisms. There are a growing demand for Halal ingredients because of people's awareness of disadvantages of Haram foods. The aim of this review is listing the main enzymes used in food industry by focusing on control measures in evaluation of halal status.

Results and conclusion: According to Islamic regulations, Halal food ingredients must come from halal sources. Specifically, the enzymes utilized in Halal foods must be extracted from Halal sources. In this regard, the enzymes produced by microorganisms are considered as Halal if the cultivation medium consists of Halal ingredients. In addition, there is an additional restriction for genetically modified microorganisms so that they should have recombinant DNA derived from Halal sources. As conclusion, attention to ingredients up to molecular level and the processes makes the Halal food products more popular among consumers.

Keywords: Enzymes; Fermentation processing; Halal assurances system (HAS); Processing aids

1. Introduction

The word “Halal”, which means allowed, permitted or lawful, enshrined in the holy Quran emphasizes purity and cleanliness of food sources to protect the religious adherence [1-3]. During past decade, the necessity to be aware of advantages of Halal (permissible) or disadvantages of Haram (prohibited) has become a common mega-trend in developing countries specially for Muslim due to the increasing demand for new and differentiated Halal products in food manufacturing and Muslim consumption [2,4,5]. Halal assurance builds the principles according to Islamic guidance and makes assuring the Halal authenticity of food products and the integrity of Halal food supply chain, from farm to the table of consumers to confirm that the final product has not been contaminated with prohibited materials [6,7]. For instance, Mixing, counterfeiting, adulteration, cross-contamination and mislabeling of

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Halal food products with forbidden (haram) substances such as porcine have become common issues in Halal food industry in many countries [6,8]. Because of the extensive application of chemical additives, synthetic ingredients and food processing aids such as enzymes, sources of food materials and their processing details, might pose risks to Halal status [5,9-11]. Enzymes have been used as biological molecules in the processing of various foodstuffs to catalyze and speed up specific reactions. Biophysical and biochemical process, which occur subsequently, can influence the modification of molecular structure and regulation and performance of living cells and tissues [12-14]. Besides, they carry out vital functions for many purposes, such as extending shelf life, freshness, retaining high nutritive values, and improving stability and safety in food industries [13-15]. The global industrial enzyme market invested around 160 million USD in 2019 [16]. In comparison, based on a report presented by the global Islamic economy, Halal food market spent 1.8 tn USD in 2019 across the food, pharmaceutical and lifestyle sectors. This leads to the rapid growth of the Halal market, which has provided businesses with a great opportunity in profit-making business through producing Halal approved enzymes for different industries that manufacture a variety of detergents, foods, beverages, textiles, biofuels, animal feeds, etc [6,7]. To produce a complete range of food product’s specifications, common enzymes used, which harvested or extracted from natural biological sources such as plant materials, animal tissues, or microbial sources through fermentation utilizing a variety of microorganisms [12]. For instance, enzymes that derived from pigs or animals that have not been through kosher slaughter ritual or come from non-Halal sources and doubtful material may cause deterioration in the Halal status of the product even if a company is a Halal certified producer [17]. Henceforth, according to Halal authenticity issues, quick and reliable analytical methods are required to oversee accreditation of products, ingredient labeling, and clarify the Halal status of food enzymes used in the food processing industry [9,18,19]. Considering the type and source of enzymes found in products, which are not required to appear on the product’s ingredient label is a critical component of the food’s certification process [5,12]. Based on a report presented by the global Islamic economy, Halal food market size spent 1.8tn US$ in 2019 across food, pharmaceutical and lifestyle sectors. In comparison, the global industrial enzyme market invested around 160 million USD in 2019 [16]. Therefore, this annual estimated market value leads to the rapid growth of the Halal market, which has provided businesses with a great opportunity in profit-making business through producing Halal approved enzymes for different industries that manufacture a variety of detergents, foods, beverages, textiles, biofuels, animal feeds, etc. [6,7]. Investigation of both qualities of the sources of products and the system of production processing of enzymes used in the food industry is crucial to meet the Halal requirement to maintain quality assurance of safe food to customers. However, the differences existing in standardization, certification, and accreditation will be a kind of barrier to trade. So, the inter-governmental organization, the Standards and Metrology Institute for the Islamic Countries (SMIIC), the affiliated institution to the Organization of Islamic Cooperation (OIC), harmonize the regulations, assess the conformity, eliminates trade barriers and establish a strong Halal certification system in the world through releasing general guidelines [10]. SMIIC’s general guidelines on Halal food highlights enzymes and their labeling, which indicates a step forward in enzyme regulation in Halal assurance. It states that enzymes used as raw material, food additives or as processing aid must come from Halal sources and must be declared on product label.
Therefore, their main function is to benefit public health and to protect the consumers. This review listed the main enzymes commonly used in the food industry and relevant challenges in their halal status in-process and post-process.

2. Enzymes in food industry

Enzymes are natural catalysts that accelerate the reaction rate via reducing the required energy for activation. Generally enzymes catalyze the conversion of specific substrate to product. Several factors can affect the activity and stability of enzymes such as pH, temperature, substrate to enzyme ratio, and metal ions which, each enzyme needs optimal condition for highest performance [11]. A large number of enzymes are proteins but there is some exception including ribozymes, which are rRNA [12]. Among sources of enzyme production, microbial fermentation route is the most desirable because of its high efficiency, cost-effectiveness, fast process, and high stability [13, 14]. Progress in industrial biotechnology and fermentation leads to providing desired enzymes that having optimal activity under different ranges of variables. Enzymes identification perform by EC (Enzyme Commission) numbers, has been developed by the International Union of Biochemistry and Molecular Biology (IUBMB). In this method, the letter EC comes with four numbers that are separated with dots. The first number shows the enzymes classification based on the reaction they catalyze. It includes seven classes as [6, 15, 20]: 1) Oxidoreductases: catalyze oxidation-reduction reactions that includes 22 subclasses, 2) Transferases: catalyze transfer of functional groups among molecules that includes 10 sub-classes, 3) Hydrolases: catalyze a chemical reaction in water. They include 13 subclasses, 4) Lyases: catalyze break-age of chemical bonds without oxidation or hydrolysis. They include eight subclasses, 5) Isomerases: catalyze the isomerization process of a compound, which further included seven subclasses, 6) Ligases: catalyze the joining of molecules and include six subclasses, 7) Trans-locases: catalyze the movement of ions or molecules across membranes, which further divided to six subclasses. Each of subclasses classified into further subclasses and sub-sub classes that specify the EC number of enzyme [12].

In food processing, enzymes have been used for centuries. The most enzymes used in the food industry are amylases, catalases, lactases, lipases, proteases, and rennet [21]. The common examples for enzymes in the food industry are the use of rennet that was derived from calves' stomach, in cheese making, and proteases and amylases in production of soy-based foods [15]. The major enzymes used in different food categories are gathered in Table 1.

Table 1- Enzymes in food products

<table>
<thead>
<tr>
<th>Foods</th>
<th>Enzymes</th>
<th>References</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baked goods</td>
<td>Amylases; Cellulase; Laminarase; Lichenase;</td>
<td>[16]</td>
</tr>
<tr>
<td></td>
<td>endo β(1,4)-D-Xylanase; α-L-Arabinosidase; β-D-Xylosidase; Proteases; Lipase; Glicose Oxidase; Lipoxygenase; Laccase; Sulfhydryl Oxidase</td>
<td></td>
</tr>
<tr>
<td>Dairy products</td>
<td>Rennet; Catalase; Proteases; Lipases; Transglutaminase; Lactase; Amylases</td>
<td>[12, 17]</td>
</tr>
<tr>
<td>Fruit and vegetable juices</td>
<td>Pectinases; α-Amylase; Cellulases; Amyloglucosidase; Xylanases,</td>
<td>[13, 18]</td>
</tr>
<tr>
<td>Meat, fish, and seafood</td>
<td>Transglutaminase; Proteases; Lipases; Peptidases; Glutaminase</td>
<td>[14, 19]</td>
</tr>
<tr>
<td>Confectionery products</td>
<td>Polyphenol Oxidase; Invertase; Protease; Carboxypeptidase</td>
<td>[20]</td>
</tr>
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</table>

In baked products, enzymes play a critical role as a food additive. Enzymes are added to flour and
dough in order to rheology modification, development of desired softness, and gas retention [17]. Furthermore, enzymes are widely used in the manufacture of dairy products. Several enzymes are utilized for different processing of milk and milk products. The function of enzymes in dairy products is milk clotting, accelerating cheese aging, flavor enhancement, and reduction of lactose intolerance [22]. Furthermore, enzymes are the most important component in the fruit and vegetable juice industry. Enzymatic treatment is a helpful method for extraction, modification, and clarification of juices from different fruits and vegetables [23]. In the meat industry, protein-degrading enzymes (proteases and peptidases) are among the most widely used enzymes. Lipases are used as flavor enhancement in sausages and Transglutaminase utilized as structure modification in meat products [24]. In confectionery, Invertases are widely used because they produce inverted sugar and this sugar retains the product freshness and has lower crystals [25].

3. The study of Halal assurance steps in enzyme manufacturing

The food industry, like any other big industry, responds to the demands and desires of the consumer. People all over the world are nowadays more aware about health benefits of foods. The ethnic and religious diversity in the U.S. and Europe has encouraged the food industry to prepare products, which are suitable for different groups of people such as the Chinese, Italian, Indian, Mexican, Vegetarian, Jewish, and Muslim communities [6]. In Islam, eating is considered a matter of worship of God, just like religious prayers. Muslims obey the Islamic rules for food products that are called Halal [26]. Muslims are supposed to make an effort to obtain a good quality of Halal food. Interestingly, for non-Muslim consumers, Halal products are often perceived as specially selected and processed to achieve the highest standards of quality as well as being healthier [6]. The Halal assurance system (HAS) is the systematic planning, implementation of documentation in managing Halal integrity to food production. Among all enzymes intended for human consumption, those extracted from animal organs such as the stomach may lead to a severe argument between Muslims if those animals were Haram or doubtful [27]. The assessment of halal status does not only apply to the sources involved but also the synthetic process of active ingredients and excipients. If the sources are halal and the process did not involve haram substances, then the product would be categorized as Halal [6,10,28]. Figure 1 demonstrates the steps that could be used in setting up Halal assurance system, which sourced from Halal guidelines. The Halal and Haram are entirely distinct and clear, and everything in between is doubtful and must be evaluated [27]. Recently with the advance in technology, the debate on the Halal status of many substances gets increasingly complicated [29].

![Figure 1- Steps in setting up Halal assurance system](image-url)
To obtain the better conclusion, it is necessary that both ‘scientists’ and ‘ulama’ debate every step in enzyme manufacturing. Three major aspects should be taken into consideration in evaluating the Halal status of the enzymes. (a) whether the components used as processing aid or raw material in enzyme production are forbidden or doubtful by Islamic law, (b) if the enzymes obtained from animals not-allowed for eating such as pork and (c) if the enzymes are derived from animals which are not slaughtered by Islamic requirements [30].

The potential risks to Halal status of enzymes, which may occur during fermentation are listed in Table 2. Microorganisms produce the majority of enzymes and are used in food processing; therefore, special attention should be given to techniques such as fermentation in terms of processing aids and raw materials to make sure that the final product followed Islamic law to get Halal certification. Some crucial actions need to be carried out before the fermentation process begins. Cleansing of all equipment, especially if they used for the manufacturing non-Halal products before Halal production is necessary. Finding of risks, which are related to cross-contamination with any non-Halal components, personal hygiene and waste management needed to be appropriately conducted [5,31]. Besides, having Halal certification for any ingredients or processing aids used during production is vital [29]. Through the fermentation process, microbial cultures or bacteria can be indigenous or genetically modified. If the culture medium is Halal, all the indigenous sources of cultures are acceptable. However, if the bacteria or other microorganisms have been modified through biotechnology, the source of the genetic material used for the original gene becomes important [2].

Table 2- Potential halal assurance risks (HAR) in enzyme production by conventional fermentation process

<table>
<thead>
<tr>
<th>Type</th>
<th>Process stages</th>
<th>Potential risks</th>
<th>Actions to be taken</th>
</tr>
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<tbody>
<tr>
<td>HAR1</td>
<td>Preparation of growth media</td>
<td>Raw materials from non-Halal sources or using non-Halal enzymes and/or ingredients to prepare raw materials</td>
<td>Raw materials need to be Halal approved</td>
</tr>
<tr>
<td>HAR2</td>
<td>Selecting microorganisms as culture</td>
<td>Isolation of microorganisms from non-Halal sources, genetic materials from non-Halal sources in genetic modification technology</td>
<td>Microorganisms need to be Halal approved</td>
</tr>
<tr>
<td>HAR3</td>
<td>Seed/inoculum preparation</td>
<td>Ingredients of growth media and other substances from non-Halal sources</td>
<td>Ingredients and growth media need to be Halal approved</td>
</tr>
<tr>
<td>HAR4</td>
<td>Adding processing aids</td>
<td>Emulsifiers and antifoaming agents from non-Halal sources</td>
<td>Processing aids and ingredients need to be Halal approved</td>
</tr>
<tr>
<td>HAR5</td>
<td>Standardization of enzyme produced by microorganisms</td>
<td>Preservatives, emulsifiers, and other standardizing materials from non-Halal sources, using alcohol as preservative</td>
<td>Alcohol is generally acceptable if below 0.5% by volume in the final enzyme preparation</td>
</tr>
<tr>
<td>HAR6</td>
<td>Packaging and labeling</td>
<td>Stearates, waxes and coatings applied to packaging materials from non-Halal sources, packaging materials contaminated with animal fats from non-Halal sources</td>
<td>Cross-contamination during packaging should be avoided; enzymes should be packed in acceptable and Halal approved containers; reused packages must be properly cleaned</td>
</tr>
</tbody>
</table>
All processing aids and emulsifiers should be free of forbidden materials, especially when they obtained from pork fat [32]. If the culture is lyophilized, the cryoprotectant agents must be from Halal sources and Halal approved. In some cases, alcohol may be used for the protection of enzyme activity as a preservative. The standardization process used for enzyme manufacturing as well as packaging and labeling materials need to meet Halal requirements. Acceptable labeled containers with Halal marking should be used for produced enzymes. Enzymes, which are used as functional catalysts or processing aids are usually inactivated and not need to be labeled, but in some products such as cheese and bakery, enzymes remain active in the final product and in that case it should be written in the final product label [33]. Indeed, the big deal is that there is no specific rule or consensus in some cases. For example, In Islam a big confusion is where the whole properties of a matrix are altered. They may be categorized as transformation of state or Istihalah. The term of Istihalah is well expressed in Islamic rules and refers to complete transformation of physicochemical properties of a component, resulting in another product with no physicochemical resemblance to the original or any other non-Halal material [27].

There are two types of Istihalah including natural and synthetic transformation. The natural transformation such as vinegar production from grape is globally accepted and the certification based on this transformation of matrix (as Halal) is agreed by all groups. But if the Halal organization give a Halal certificate for synthetic transformation, the organization should be taking a good decision from its own interpretation and such certificate may not have a global acceptance [27,34]. Also there is a big debate about genetically modified foods (GMO) regarding ethical and religious issues, which is not well known by consumers and need to be clarified and declared carefully not to threaten Halal assurance [28,35]. Genetically modified microorganisms, which produce enzymes should not contain any Haram sources in the inoculums and are allowed when derived from Halal sources [18]. There is no specific mention of altered or genetically modified foods and substances in Quran, because these technologies are very recent and novel. However, genetically modified products from not-allowed animals for eating are forbidden. Despite the fact that non-GMO produced microbial enzymes are extensively used, the genetically modified organism has not been accepted in Islamic laws as long as their process does not follow Halal requirements. Obtaining halal status for the genes derived from haram animals which are intended for halal animals or plants, is going to be completely difficult. It is also difficult to convince Muslim consumers about the advantages of these genetically modified organisms and it is better for the industries to avoid such products [36]. Muslim consumers as well as halal authorities in several countries are concerned about the source of produced enzymes. It is better to mentioned not only the descriptions of the enzymes but also their sources, even when the products are accounted as Halal.

4. Conclusion

Several enzymes have been used in different kinds of food products due to their benefits, such as improving quality while decreasing processing time and costs. Nowadays, with the increasing use of enzymes in food processing, it is necessary to keep track of the possible components, which might threaten Halal assurance. As far as many Muslims are concerned about using enzymes in food and food products, Halal authorities have been trying to declare the Halal status of enzymes and their sources. According to the recent developments in biotechnology and various benefits of enzymes derived microbes, fermentation is becoming the primary way of production, and therefore, it is crucial to evaluate the culture medium, substrates, components, and their treatment to determine possible non-compliances with Halal assurance. Furthermore, most of enzymes have been produced by using
genetically modified microorganisms and if non-Halal animal genes were used, further examination is needed to identify their utilization by Halal food industry. As part of Halal assurance, Halal status of additives and processing aids must be clarified to ensure that Halal requirements are met. Using Halal approved materials and processing aids with performing of suitable technology and techniques will ensure that the final produced enzyme is completely Halal and it will generate trust amongst consumers.

5. Conflict of interest
The authors have declared no conflict of interest.

References


