**Review article**

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# Halal assurance systems in enzyme market

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**Abstract**

**Background and objective:** Enzymes are kind of food additive which are widely used in food industry. They are derived from different origins including plants sources, animals and microorganisms. There are a growing demand for Halal ingredients due to the people 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, edible Halal ingredients should be derived from permitted sources in view of Islam. 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 culture media consist Halal ingredients. In addition, there is an additional restriction for genetically modified microorganisms so that they should have recombinant DNA derived from Halal origins. As conclusion, attention to the ingredients up to molecular level and the processes makes the Halal food products more popular among the 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 and 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 megatrend in developing countries specially for among Muslims due to their increasing demand for novel Halal products [2,4,5]. Halal assurance builds the principles according to Islamic guidance and approves the Halal authenticity of food products and the integrity of Halal food supply chain from farm to 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

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and mislabeling of Halal food products containing prohibited (haram) ingredients such as pork have become common issues in Halal food industry in many countries [6,8].

Because of the extensive application of chemical additives, synthetic components and food processing aids such as enzymes, their source and processing details may pose risks to Halal status [5,9-11]. Enzymes have been used as vital molecules in the processing of various foodstuffs to catalyze and speed up specific reactions. Biophysical and biochemical process, which occur subsequently, can influence the molecular structure and regulation or 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 improvement of 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. It has led to rapid growth of Halal market and provided several businesses especially profit-making business by production of Halal enzymes for several industries producing different kinds of detergents, foods, beverages, textiles, biofuels, animal feeds, etc. [6,7].

To achive an exteneded range of food products' specification, the common enzymes are derived from natural sources such as plant materials, animal tissues, or biological systems through fermentation by various microorganisms [12]. For instance, enzymes that derived from pigs or other animals not exposed to kosher slaughter ritual or come from non-Halal sources and doubtful materials may deteriorate the Halal status even if the 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 industry [9,18,19]. Considering the type and source of enzymes (which are not required to be appeared on the label) is a critical step in food certification process [5,12]. Investigation of quality assurance of the sources of products and production system of the enzymes used in food industry is crucial to meet the Halal requirements needed for delivery of safe food to the customers. However, the differences existed in standardization, certification, and accreditation will be a kind of barrier to trade. So, the inter-governmental organizations such as the Standards and Metrology Institute for the Islamic Countries (SMIIC) and 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 across the globe by releasing general guidelines [10]. SMIIC's general guidelines on Halal food refers the enzymes and their labeling requirements, which shows a step forward in enzyme regulation in Halal assurance. It declars that the enzymes used as raw material, food additives or processing aid should be originated from Halal sources and should be mandatory declared on the products' 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 increase the rate of chemical reactions 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 by 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, high speed, and high stability [13,14].

Progress in industrial biotechnology and fermentation leads to providing desired enzymes by optimal activity under different ranges of variables. Enzymes identification is performed by EC (Enzyme Commission) numbers which 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 breakage 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) Translocases: 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 frequently used for a long time. The most enzymes used in this regard are amylases, catalases, lactases, lipases, proteases, and rennet [21]. Examples of popular enzymes in food industries include rennet which is derived from calve stomach and used in cheese making, and also proteases and amylases in production of soy-based foods [15]. The major enzymes used in different food categories are listed in Table 1.

Table 1- Enzymes in food products

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

In baked products, enzymes play a critical role as a food additive. Enzymes are added to flour and dough to modify rheology, develop a desired softness, and help in gas retention [17]. Furthermore, enzymes are widely used in 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 is 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 that has lower crystals and retains the product's freshness [25].

### 3. Halal assurance steps in enzyme manufacturing

Similar to the all industries, food industry fulfils the demands and discretions of the consumer. Today, people are greatly aware of the health benefits of foods worldwide. The ethnic and religious diversity in the U.S. and Europe has motivated the industries to prepare products with high diversity appropriate for people by different nationalities such as 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. As mentioned earlier, Muslims follows the Islamic rules for the food products called Halal [26]. Muslims are supposed to make an effort to obtain a good quality of Halal food. It is their religious obligation to intake just Halal food. Interestingly, for non-Muslim consumers, the Halal products are often perceived as specially selected and processed to achieve the highest level of quality as well as being healthy and safe for edible consumption [6].

The Halal assurance system (HAS) includes systematic planning and implementation process by documenting the actions conducted in management of Halal integrity in 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]. Evaluation of halal status includes both the sources involved and the synthesis/fabrication process of active ingredients and excipients. In this regard, if the source is halal and the process does not involve haram agents, then the product is categorized as Halal [6,10,28]. Figure 1 demonstrates the steps that could be used in setting up the HAS, 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, improvement of technologies have resulted in more ambiguities in Halal status of materials and the matter gets significantly complicated [29].

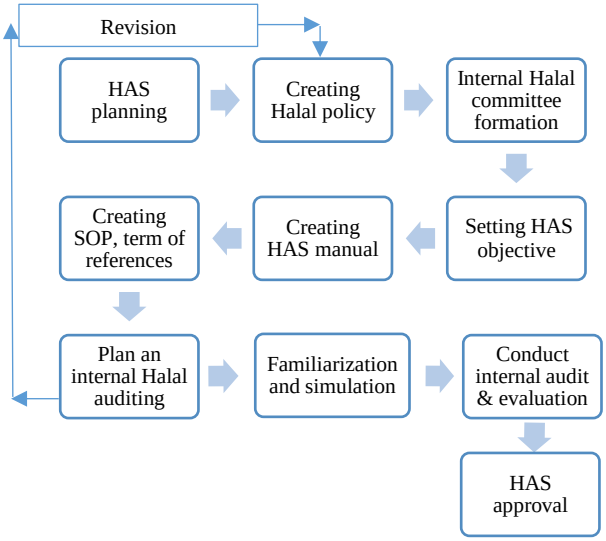


Figure 1- Steps in setting up the HAS

To obtain a better conclusion, it is necessary that both 'scientists' and 'ulama' debate every step in enzyme manufacturing. Three major points should be taken into account in evaluating the Halal status of the enzymes: (a) whether the components used as processing aid or raw material in enzyme production are prohibited or doubtful by Islam, (b) if the enzymes obtained from animals not-allowed for eating such as pork, and (c) if the enzymes originated from animals not slaughtered according to Islamic liabilities [30].

The critical points in production of halal enzymes, which may occur during fermentation process are listed in Table 2. Microorganisms produce the majority of enzymes and are used in food processing; therefore, special attention is needed for techniques such as fermentation in terms of processing aids and raw materials to ensure that the final product followed Islamic law to get Halal certification. Some crucial actions should be carried out before the fermentation process begins. Cleaning the all equipments, especially if they were used for manufacture of

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 biological organism was exposed to biotechnological manupulation, the original genetic material used for this purpose becomes important [2].

Table 2- Potential halal assurance risks (HAR) in production of enzyme through conventional fermentation

| Type | Process stages | Potential risks | Actions to be taken |
|---|---|---|---|
| HAR1 | Preparation of growth media | Raw materials prepared from non-Halal origins or using non-Halal enzymes and/or components in preparation of raw materials | Raw materials should be approved as Halal |
| HAR2 | Selection of microorganisms as starter culture | Isolation of microorganisms from non-Halal origins or genetic materials from non-Halal origins in genetic manipulation works | The biological organisms should be approved as Halal |
| HAR3 | Seed/inoculum preparation | Ingredients of the culture media or other substances originated from non-Halal sources | Ingredients and growth media should be approved as Halal |
| HAR4 | Addition of processing aids | Emulsifiers and antifoaming agents from non-Halal sources | Processing aids and ingredients should be approved as Halal |
| HAR5 | Standardization of the enzymes produced by biological organisms | Preservatives, emulsifiers, or other standardizing agents originated from non-Halal sources, use of alcohol as preservative | Alcohol residue is generally acceptable if existed less than 0.5% by volume in the final product |
| HAR6 | Packaging and labeling | Stearates, waxes and coating agents used in packaging practices from non-Halal origins, packaging materials contaminated by animal fats from non-Halal origins | Avoid cross-contamination during packaging; approved containers should be used for enzyme packaging; reused packages should be cleaned appropriately |

All processing aids and emulsifiers should be free of prohibited 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 protection of enzyme activity as a preservative. The standardization process used for enzyme manufacturing as well as packaging and labeling materials should 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 wihtin the process and not needed 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 on the 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 trans-

formation of physicochemical properties of a component, resulting in another product with no physiochemical 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].

There is a big debate about genetically modified foods (GMO) regarding ethical and religious issues, which the consumers are not aware of and should be clarified and declared so that do not threat the Halal assurance [28,35]. Genetically modified microorganisms, which produce enzymes should not contain any Haram ingredients in the inoculums and are allowed when derived from Halal origins [18]. Although, there is no strict statement about genetically modified foods and substances in holy Quran, because these technologies are novel and greatly interested in recent decades. However, genetically modified foods prepared from not-allowed animals are forbidden for eating. Despite the fact that the enzymes produced by non-GMO microorganisms are extensively used, the genetically modified organisms have 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. On the other hand, convincing the Muslim consumers about advantages of these genetically modified organisms is so difficult and it is better the industries avoid such products [36]. Both the Muslim consumers and halal authorities in several countries are concerned about the source of produced enzymes. The suppliers are recommended to explain about origin and process of the enzymes especially when the products are considered as Halal.

## 4. Conclusion

Several enzymes have been extensively used in production of various food products due to their advantages during the process such as quality improvement and also reduction of processing time and costs. Therefore, it is necessary to track the components, which might threat the Halal assurance. As far as many Muslims are concerned about using enzymes in food and food products, the Halal authorities have been trying to declare the Halal status of enzymes and their origins. Following the recent advances in biotechnology and the approved benefits of the enzymes derived from microbes, fermentation is becoming the primary way of production. Therefore, it is important to evaluate the culture media, substrates, components, and their treatment to assess any inconformities with Halal assurance. Furthermore, some enzymes are produced by genetically modified microorganisms and further investigation is required to identify their utilization by Halal food industries if non-Halal animal genes were used. As part of Halal assurance, Halal status of additives and processing aids should be clarified to ensure that the Halal requirements are met. Using Halal approved materials and processing aids produced by appropriate techniques confirms that the produced enzyme is completely Halal. It builds trust among the consumers.

## 5. Conflict of interest

The authors declared no conflict of interest.

## References

1. Bergeaud-Blackler F, Fischer J, Lever J. Halal Matters: Taylor & Francis; 2015.

2. Man Y, Sazili AQ. Food production from the halal perspective Handbook of Poultry Science and Technology: Primary Processing (Vol. 1, pp. 183-215). John Wiley & Sons, Inc. New Jersey, USA; 2010.
https://doi.org/10.1002/9780470504451.ch11

3. Chaudry MM, Regenstein JM. Implications of biotechnology and genetic engineering for kosher and halal foods. Trends in Food Science & Technology. 1994; 5(5): 165-168. https://doi.org/10.1016/0924-2244(94)90122-8

4. Shariff SM, Lah NAA. Halal certification on chocolate products: A case study. Procedia-Social and Behavioral Sciences. 2014; 121: 104-112. https://doi.org/10.1016/j.sbspro.2014.01.1112

5. Al-Mazeedi HM, Regenstein JM, Riaz MN. The issue of undeclared ingredients in halal and kosher food production: A focus on processing aids. Comprehensive Reviews in Food Science and Food Safety. 2013; 12(2): 228-233. https://doi.org/10.1111/1541-4337.12002

6. Riaz MN, Chaudry MM. Enzymes in Halal Food Production. Handbook of Halal Food Production. 2018: 167-176. CRC Press. https://doi.org/10.1201/9781315119564-13

7. Yunus NSNM, Rashid WEW, Ariffin NM, Rashid NM. Muslim's purchase intention towards non-Muslim's Halal packaged food manufacturer. Procedia-Social and Behavioral Sciences. 2014; 130: 145-154. https://doi.org/10.1016/j.sbspro.2014.04.018

8. Bisswanger H. Enzyme assays. Perspectives in Science. 2014; 1(1-6): 41-55. https://doi.org/10.1016/j.pisc.2014.02.005

9. Khattak JZK, Mir A, Anwar Z, Abbas G, Khattak HZK, Ismatullah H. Concept of halal food and biotechnology. Advance Journal of Food Science and Technology. 2011; 3(5): 385-389.

10. Dag H, Erbasi-Gonc E. SMIIC and halal food standards. Journal of Chemical Metrology. 2013; 7(1): 1-6.

11. Fernandes P. Enzymatic processing in the food industry. Reference Module in Food Science. 2018. https://doi.org/10.1016/b978-0-08-100596-5.22341-x

12. Robinson PK. Enzymes: principles and biotechnological applications. Essays in biochemistry. 2015; 59: 1-41. https://doi.org/10.1042/BSE0590001

13. Subin SR, Bhat SG. Enzymes: concepts, nomenclature, mechanism of action and kinetics, characteristics and sources of food-grade enzymes. Enzymes in Food and Beverage Processing. 2015: 3-38. https://doi.org/10.1201/b19408-3

14. Oort MV. Enzymes in food technology–introduction. In: Whitehurst RJ, Oort MV. Enzymes in food technology. First edition. 2010. Wiley-Black well. https://doi.org/10.1002/9781444309935.ch1

15. Dhillon GS, Kaur S. Agro-industrial wastes as feedstock for enzyme production: apply and exploit the emerging and valuable use options of waste biomass. 2016. Academic Press.

16. Reuters T, Standard D. State of the global Islamic economy report 2016/17. 2016. Dubai. Thomson Reuters.

17. Collar C, Martinez J, Andreu P, Armero E. Effects of enzyme associations on bread dough performance. A response surface analysis/Efectos de las asociaciones enzimaticas sobre la calidad funcional de masas panarias. Analisis de superficies de respuesta. Food Science and Technology International. 2000; 6(3): 217-226. https://doi.org/10.1177/108201320000600304

18. Chaudry M, Riaz M. Safety of food and beverages: Halal food requirements. Encyclopedia of Food Safety. 2014; 3: 486-491. https://doi.org/10.1016/B978-0-12-378612-8.00400-5

19. Alzeer J, Hadeed KA. Ethanol and its Halal status in food industries. Trends in Food Science & Technology. 2016; 58: 14-20. https://doi.org/10.1016/j.tifs.2016.10.018

20. Ako H, Nip W. Enzyme classification and nomenclature. In: Simpson BK. Food Biochemistry and Food Processing. First edition. 2012: 107-124. Wiley. https://doi.org/10.1002/9781118308035.ch6

21. Shinde V, Deshmukh S, Bhoyar M. Applications of major enzymes in food industry. Indian Farmer. 2015; 2(6): 497-502. https://doi.org/10.1080/10408399609527735

22. Khan U, Selamoglu Z. Use of Enzymes in Dairy Industry: A Review of Current Progress. Archives of Razi Institute. 2020; 75(1): 131-136. https://doi.org/10.22092/ari.2019.126286.1341

23. Singh K, Singh R. Role of Enzymes in Fruit juices clarification during Processing: A review. International Journal of Biological Technology. 2015; 6(1): 1-12.

24. Singh PK, Shrivastava N, Ojha B. Enzymes in the meat industry. Enzymes in Food Biotechnology: Elsevier; 2019. 111-128. https://doi.org/10.1016/B978-0-12-813280-7.00008-6

25. Veana F, Flores-Gallegos AC, Gonzalez-Montemayor AM, Michel-Michel M, Lopez-Lopez L, Aguilar-Zarate P, et al. Invertase: An Enzyme with Importance in Confectionery Food Industry. Enzymes in Food Technology. 2018. Springer.

26. Regenstein JM, Chaudry MM, Regenstein CE. The kosher and halal food laws. Comprehensive Reviews in Food Science and Food Safety. 2003; 2(3): 111-127. https://doi.org/10.1111/j.1541-4337.2003.tb00018.x

27. Jahangir M, Mehmood Z, Bashir Q, Mehboob F, Ali K. Halal status of ingredients after physicochemical alteration (Istihalah). Trends in Food Science & Technology. 2016; 47: 78-81. https://doi.org/10.1016/j.tifs.2015.10.011

28. Khattak Z. Halal Dairy Ingredients Now Available for Muslim Food. Halal Consumer. 2007: 20-22.

29. Satiawihardja B. A Review on the Halalness of Fermentation Products: From the Ancestor Era until Present Day. 2012 .Jakarta: Pustaka Iman.

30. Shafii Z, Khadijah W. Halal traceability framework for halal food production. World Applied Sciences Journal. 2012; 17(12): 1-5.

31. Yaakob B, Sazili AQ. Food production from the halal perspective. Handbook of poultry science and technology. 2010: 183. https://doi.org/10.1002/9780470504451.ch11

32. Ermis E. Halal status of enzymes used in food industry. Trends in Food Science & Technology. 2017; 64: 69-73. https://doi.org/10.1016/j.tifs.2017.04.008

33. Ab Talib MS, Mohd Johan M. Issues in halal packaging: a conceptual paper. International Business and Management. 2012; 5(2): 94-98. https://doi.org/10.3968/j.ibm.1923842820120502.1080

34. Halim MA, Salleh MM. The possibility of uniformity on halal standards in organization of Islamic countries (OIC) country. World Applied Sciences Journal. 2012; 17(17): 6-10.

35. Sondergaard HA, Grunert KG, Scholderer J. Consumer attitudes to enzymes in food production. Trends in Food Science & Technology. 2005; 16(10): 466-474. https://doi.org/10.1016/j.tifs.2005.06.003

36. Malaysia S. Halal food-production, preparation, handling and storage—general guidelines (second revision). Department of Standards, Selangor Darul Ehsan, Malaysia, MS1500. 2009.