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# The multiplicity of *halal* standards: a case study of application to slaughterhouses

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## Abstract

Food products suitable for Muslim consumers should be *halal* certified, particularly when their origins or production processes are doubtful. However, there is a multiplicity of *halal* standards. This situation may generate confusion, particularly for producers in Western countries who would like to certify their products in order to export them to Islamic countries. This study analyzed the reasons underlying the multiplicity of standards and reviewed the attempts of harmonization over time. Then, the case study of application to slaughterhouses was considered, by comparing four different *halal* standards (namely GSO 993:2015, OIC/SMIIC 1:2019, HAS 23103:2012, and MS 1500:2019) representative of different geographic areas. Animal stunning was critically examined, comparing tradition with modernity. The study evidenced that the basic requirements related to slaughtering are common to all the *halal* standards considered, but several differences occur in more specific details. Only a close collaboration between the authorities of all the countries involved in issuing *halal* certifications will lead to a homogeneous regulatory framework with unified certification and accreditation procedures, increasingly required in a globalized market.

**Keywords:** *Halal* certification, Geographic variability, Food quality, Food standards, Animal welfare

## Introduction

Religions and customary beliefs contribute to, and strongly influence, food habits, particularly through food laws imposing or prohibiting the consumption of certain food products. Religion is therefore a fundamental component of the dietary culture that communities develop as it typically symbolizes its heritage and the socio-cultural aspects of its ethnicity [1]. Islam is no exception to this, only permitting for the consumption of clean, safe, and fully lawful food and beverages that adhere to Islamic rules. Such food and beverages are named *halal*, which is the Arabic word for “lawful”, “permissible”, “approved”, and “legal”, with the opposite being *haram*, which means “forbidden”.

With 1.8 billion Muslim consumers worldwide [2], the global Muslim spend on food and beverages accounted for \$1.4 trillion in 2018 and is expected to reach \$2.0

trillion by 2024. According to the 2019/2020 Report on the State of the Global Islamic Economy (SGIE), the 57 countries of the Organisation of Islamic Cooperation (OIC) imported \$184 billion in *halal* food and beverages, with intra-OIC trade accounting for \$34 billion [2].

Muslim awareness for *halal* products has increased in recent years. According to a survey carried out in 2016, 96% of Muslim travelers considered *halal* food to be critical, 85% rated *halal* food at the facility around them as important, and 81% rated having no alcoholic drinks at restaurants/food outlets as important [3]. This high level of awareness is due to the availability of apps which link consumers to *halal* products/restaurants, as well as to the development of *halal* hubs [2]. Moreover, the *halal* market is not constrained to Muslim countries alone: the highest *halal* food expenditure per capita is in European and North American Muslim minority countries [4]. Therefore, the *halal* markets of Western countries are also worthy of attention.

Food products suitable for Muslim consumers should be *halal* certified, particularly when their origins or

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production processes are doubtful. However, there is a multiplicity of *halal* standards. While standardization would seem to suggest regularity and homogeneity, with a reduction in diversity, a multiplicity in the world of standards has emerged with globalization [5], particularly for those standards that have a strong cultural and geographical basis linked to ethno-religious factors, such as *halal*. This situation may generate confusion, particularly for producers in Western countries who would like to certify their products as *halal* in order to be able to export them to Islamic countries.

Therefore, this research aimed at (i) reviewing the basic principles on how food technologists certify food products or raw materials as *halal*, (ii) analyzing the attempts of *halal* standard harmonization over time, and (iii) comparing the application of four different *halal* standards established in different geographical areas. The case study of slaughterhouses was considered, with critical considerations on animal stunning between tradition and modernity.

### Sources for *halal* precepts and schools of Islamic thought

The primary sources for *halal* precepts are the *Quran* and the *Sunnah* of the Prophet (the traditions of the Prophet, set forth in the *hadith*) but, with the evolution of legislation in Islamic history, secondary sources have been added over time. Indeed, when the primary source does not provide an adequate answer to the question, Islamic judges along with religious scholars (*ulama*) intervene to solve the issue in three different ways: (i) by looking at similar situations or principles (*qiyas*, i.e., reasoning by analogy), (ii) by independent critical reasoning (*ijtihad*), and (iii) by consensus of commentators on a controversial point of the law (*ijma*) [6, 7].

By the end of the 11th century, Muslim scholars were focused on developing thorough methodologies in order to clarify and understand every aspect of the Islamic law, the *shari'ah*, composed of the sum of laws, orders, faith, and acts given to mankind via the Prophet. Later, these methodologies became known as “school of Islamic thought” (*mazhab* or *madhab*) within the Muslim jurisprudence (*fiqh*) [8]. A wide cultural variation in early Muslim jurisprudence occurred, but four jurists of Sunni Islam emerged: Abu Hanifa al-No'man bin Thabit, Abu 'Abd-Allah Malik bin Anas, Mohammad ibn Idris al-Shafi'i, and Ahmad bin Hanbal. Named after their leading interpreter, four juridical schools were established: *Hanafi*, *Maliki*, *Shafi'i*, and *Hanbali*, with a different geographical distribution [9, 10]. The followers of the *Hanafi* school are mostly prominent in Turkey, Pakistan, Afghanistan, Muslim region of China, and states of the former Soviet Union; the *Maliki* school is concentrated in North Africa, northern Nigeria, and Arabian Gulf

States; followers of the *Shafi'i* school are found in Palestine, Lebanon, part of Egypt, Iraq, Yemen, Malaysia, and Indonesia; the *Hanbali* school has most of its followers in Saudi Arabia [10]. In the Shia branch of Islam, meanwhile, other schools of law were established, such as *Isma'ili*, *Jaafari*, and *Zaidi*, but they are much less represented than the Sunni schools [11].

The *halal* precepts establish permitted behaviors in many aspects of daily life including social justice, public relations, work, religious worship, interpersonal conflicts, and economic transactions (*Quran* verses 2:188, 2:282-283, 3:130, 4:29, 6:152, 83:1-14). In between *halal* and *haram*, there are situations which are not clearly defined, termed as “*mashbooh*” (doubtful or questionable actions or deeds), and “*makrooh*” (disapproved, disliked or hated) [6].

### *Halal* precepts in the food sector

For non-Muslims, the word *halal* is usually associated with the food that Muslims are allowed to eat. The *halal* precepts related to food are defined in the *Quran* verses 2:168, 2:172, and 2:173.

Food hygiene measures vary from one country to another, and also depend on the availability of resources; the situation was more difficult in the past, but food hygiene standards are still low today in some areas of the world. Dietary prohibitions dictated by religious laws helped to reduce mortality rates and to limit the spread of endemic diseases in various populations. The *halal* precepts concerning food predominantly focus on the following issues: ban on toxic substances and blood, slaughter methods, and permitted and prohibited animals. Therefore, the term *halal* was primarily linked to meat, but starting from the 1990s, the application of *halal* principles has been set out in greater detail, covering 6 different food categories (Table 1) [12]. In 1997, the FAO and the WHO drafted general guidelines for the use of the term *halal*, recognizing *halal* food in a broader sense than related only to meat [13].

Muslims are prohibited to consume alcohol, as indicted clearly in the *Quran surah* 5:90. Alcohol in *halal* food refers to ethanol: therefore, all fermented or distilled alcoholic drinks, which alter the consciousness, are forbidden. Many *halal* standards allow alcohol if its concentration in the finished product is less than 0.1%, when the source of alcohol is not from *khamr* (fermented or distilled beverage) [14]. An interesting case is vinegar. Despite deriving from wine, which is *haram*, vinegar is *halal* because alcohol is converted to acetic acid. This chemical conversion, which removes the impure nature of a forbidden substance by producing a different one, is named *istihala* [14].

Regarding the permitted and prohibited animals, the meat of domesticated animals with split hooves, such as

**Table 1** *Halal* product categories according to the GSO 2055-2:2015 standard “*Halal* foods. Part 2: Guidelines for *halal* foods certification bodies”

Category code	Categories	Process and product
A	Farming 1 (animals)	Animal farming, fish farming, egg production, milk production, beekeeping, fishing, hunting
B	Farming 2 (plants)	Fruits, vegetables, cereals, spices, horticultural products
C	Processing 1 (perishable animal products)	Meat, poultry, eggs, dairy, and fish products, includes animal slaughtering
D	Processing 2 (perishable vegetable products)	Fresh fruit, fresh juices, fresh vegetables
E	Processing 3 (products with long shelf life at room temperature)	Canned products, preserved vegetables, preserved fruits, biscuits, snacks, oil, drinking water, beverages, pasta, flour, sugar, salt
F	Feed production	Animal feed, fish feed
G	Food service	Hotels, restaurants

goats, camels, buffaloes, sheep and cattle, is allowed. From the bird category, chicken, ducks, turkeys, pigeons, and sparrows are all allowed. In contrast, the meat of swine (*Quran*, 6: 121), boars, and carnivorous animals including birds of prey (eagles, ospreys, and falcons) is prohibited, for “the eating of all fanged beasts of prey, and all the birds having talons” is forbidden (Sahih Muslim, 821–875 AD) [15]. All Muslims can eat fish with scales. Some groups do not accept fish without scales such as catfish [16]. There are significant differences when it comes to seafood such as mollusks and crustaceans, depending on the religious school [14]. Animals that live both on land and water such as crocodiles, seals, and frogs are all forbidden.

As for the slaughter, the Islamic *shari’ah* defines the specific conditions for the prescribed method of ritual slaughtering (described in detail later in this review), named *dhabihah* or *zabiha*, which means “slaughtered animal”. To meet the *halal* requirements, meat has to derive from the permitted animal species, and must be slaughtered by a Muslim, nominating Allah’s name while slaughtering (*Quran*, 6: 118). The neck has to be cut by a sharp knife, to allow for the rapid and full draining of blood, while ensuring the quickest possible death of the animal.

There are three methods of slaughtering according to Muslim jurisprudence (*fiqh*). The first is *al-Zabih*, which is for domestic animals such as cows, sheep, chickens, geese, and ducks. The second is *al-Nahr*, for long-necked animals, such as camels and horses, cutting the throat between the start of the neck and the chest. The third is *al-Aqr*, causing a wound by an arrow or sharp tool in any part of the body of a wild animal which is out of control or animals that fall in a well [17].

According to the *Hanafi* school, slaughtering must be carried out by a sharp knife from the front of the neck by cutting the trachea (*halqum*), the esophagus (*marii*), and both the carotid arteries and jugular veins (*wadajain*), or at least one of the jugulars. According to the

*Maliki* school, the trachea and both the carotid arteries and jugular veins must all be cut, while cutting the esophagus is not essential.

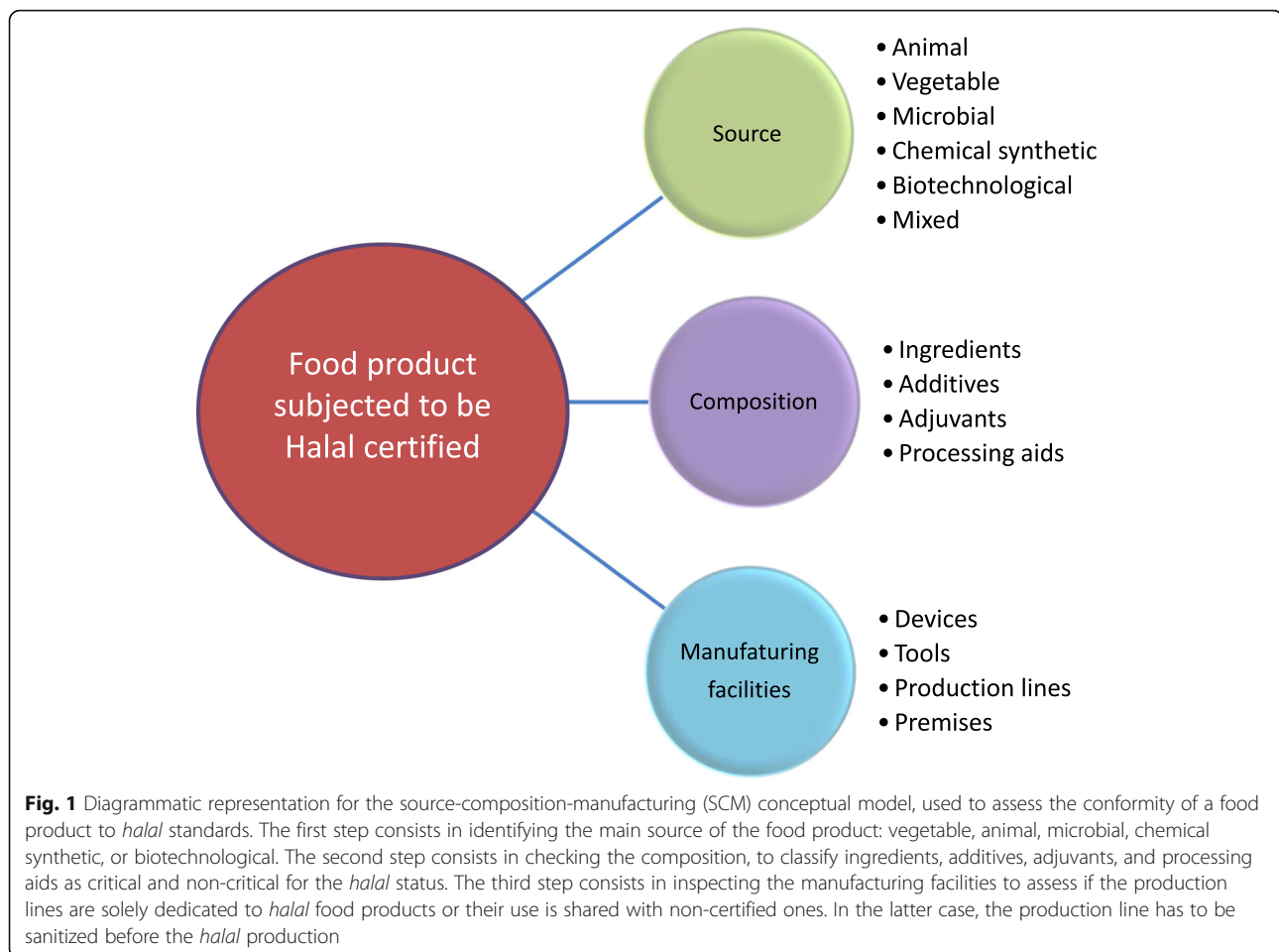
For *Shafi’i* and *Hanbali*, meanwhile, cutting the trachea and the esophagus is required, without specifying anything about the carotids and jugulars (whose cut is recommended according to *Sunnah*). Cutting the head of the animal is disliked (*makrooh*) [17].

Muslims are also prohibited from consuming blood (*Quran* 6: 121). Ingredients and additives derived from blood, such as albumin, are *haram*. A combination of prohibited ingredients (pork and blood) occurs in some traditional food products where pig blood is the main ingredient, such as the Italian dessert known as “*sanguinaccio*” [18], “black pudding” in the UK and Ireland, and the Vietnamese dish known as “*tiet canh*”.

### **Halal certification procedure**

*Halal* food is produced according to Islamic law but should also comply with Hazard Analysis Critical Control Points (HACCP) and Good Manufacturing practices (GMP). The certification body must have the technical competence to assure that religious requirements and food safety standards are both met. Any food product can be subjected to *halal* certification, including processing aids. For example, activated carbon, used in the food industry as a clarifying agent [19], has a source that is not exclusively vegetable-based, which means that it is not always *halal*: therefore, the certifier must be an expert in the field of food technology in order to undergo a correct *halal* compliance check.

The key point in certifying a food product is to ensure its suitability for the selected *halal* standard, by following a conceptual model that can be defined as “Source-Composition-Manufacturing” (SCM), shown in Fig. 1. According to this model, the main food *source* has to be clearly identified in order to verify whether it is vegetable, animal, microbial, chemical, synthetic or biotechnological [14]. Then, the *composition* has to be

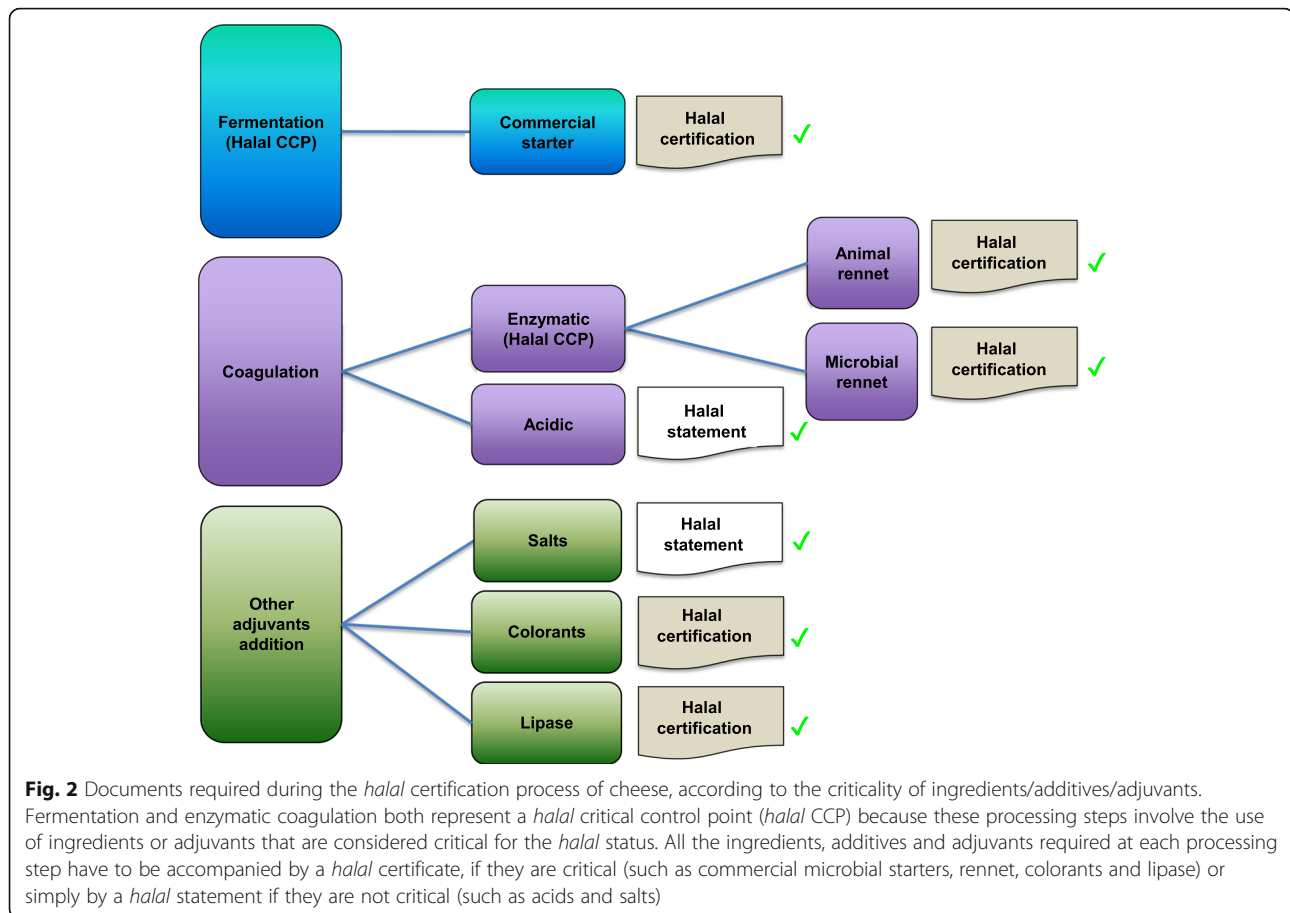


considered to verify if each critical ingredient, additive, adjuvant, or processing aid, holds a *halal* certification. For the non-critical ingredients, a *halal* statement filled out by the supplier/producer is sufficient, as illustrated in Fig. 2 for the cheese industry for example. Lastly, the *manufacturing facilities* have to be inspected to assess if the production lines are solely dedicated to *halal* products or if their use is shared with non-certified ones. In the latter case, the criticality of the non-certified food products for which the line is used must also be checked. For example, being produced exclusively by mechanical means, without any chemical intervention, nor the addition of processing aids or preservatives, extra virgin olive oil (EVOO) can be considered “naturally *halal*” [4]. EVOO is, therefore, a product without criticalities, and the production line does not need to be sanitized in a *halal* specific way during the production of EVOO.

The previous concepts can also be applied to rennet, used in the dairy industry for enzymatic coagulation of milk. Coagulation is a processing phase associated with a *halal* critical control point (*halal* CCP) (Fig. 2). Rennet, in fact, is generally obtained from a young animal’s

stomach (usually a calf) or, alternatively, from a microbial source [14, 20]. In order to certify the *halal* suitability of rennet, the food technologist has to check its source. This criticality remains high because porcine rennet was used in some cheeses in the past, and is still used today in the production of the Italian “Pecorino di Farindola” [21]. Besides, even if the source is a permitted animal, it must be *halal* slaughtered to be acceptable. Meanwhile, if rennet comes from a microbial source, produced through the transcription of bovine chymosin genes [22], the *halal* certifier should check the substrate used for microbial growth, as it may contain proteins or other materials of animal origin. The substrate also has to be checked for the commercial starters used for fermentation (*halal* CCP). Therefore, fermentation is another processing phase associated with a *halal* CCP, and initial commercial producers must be *halal* certified (Fig. 2).

Furthermore, rennet composition has to be accurately checked to verify the conformity of all additives and adjuvants used to produce it. Chemicals might be used to release enzymes from tissues: such chemicals have to be *halal* approved. Some additives might be used for the



standardization of rennet, such as emulsifiers and preservatives, in order to increase its shelf life. These additives too must be *halal* [14]. A similar situation occurs for lipase and colorants used for some cheeses, which again must be *halal* certified. Salts and acids, however, are not in any way linked to animal sources; therefore, a *halal* statement is sufficient.

As for the production lines (i.e., the “manufacturing” step of the SCM conceptual model), they must be *halal* and thoroughly cleaned, for generally speaking, the manufacturers of animal enzymes keep various animal sources on their premises. Therefore, a *halal*-approved cleaning procedure is required to avoid any risk of cross-contamination. It is also important to check that the first production site of the food product, has been *halal* certified. When food companies buy the product in bulk and just pack it, then, the *halal* audit must also be performed where the production takes place, i.e., the producer should be subject to checks, as well as the packing company. The food technologist should also determine the final use of an ingredient, defining whether it is intended for direct consumption or not, whether it is a semi-finished or finished product, in order to determine the technical documents necessary to ensure compliance with *halal* requirements.

### **Halal standards in different geographic areas**

Over time, and spreading far and wide from its initial center of origin, several different traditions have emerged within Islam which, while maintaining the unity of believers, at the same time caused a certain diversification. The spread of Islam was accompanied by a cultural transfer from the areas of origin, but met with the juxtaposition of local culture, which led to distinctive characteristics [23].

In Southeastern Asia, the presence of Islam was recorded as early as the seventh century A.D., with a more significant spread starting from the end of the thirteenth century [23, 24]. There are also sources of evidence that point to an Arabic origin, though via the Persian and Indian coasts, thanks to feasible sea routes. Indeed, maritime trading links existed between Southeastern Asia and Southern India, where there was a significant Muslim presence [24].

Southeastern Asian countries, such as Malaysia and Indonesia, with large but not exclusive Muslim populations, were the first to develop *halal* standards and certification procedures, in order to ensure that the Muslim consumers would trust and accept food produced in these countries by non-Muslim manufacturers [4].



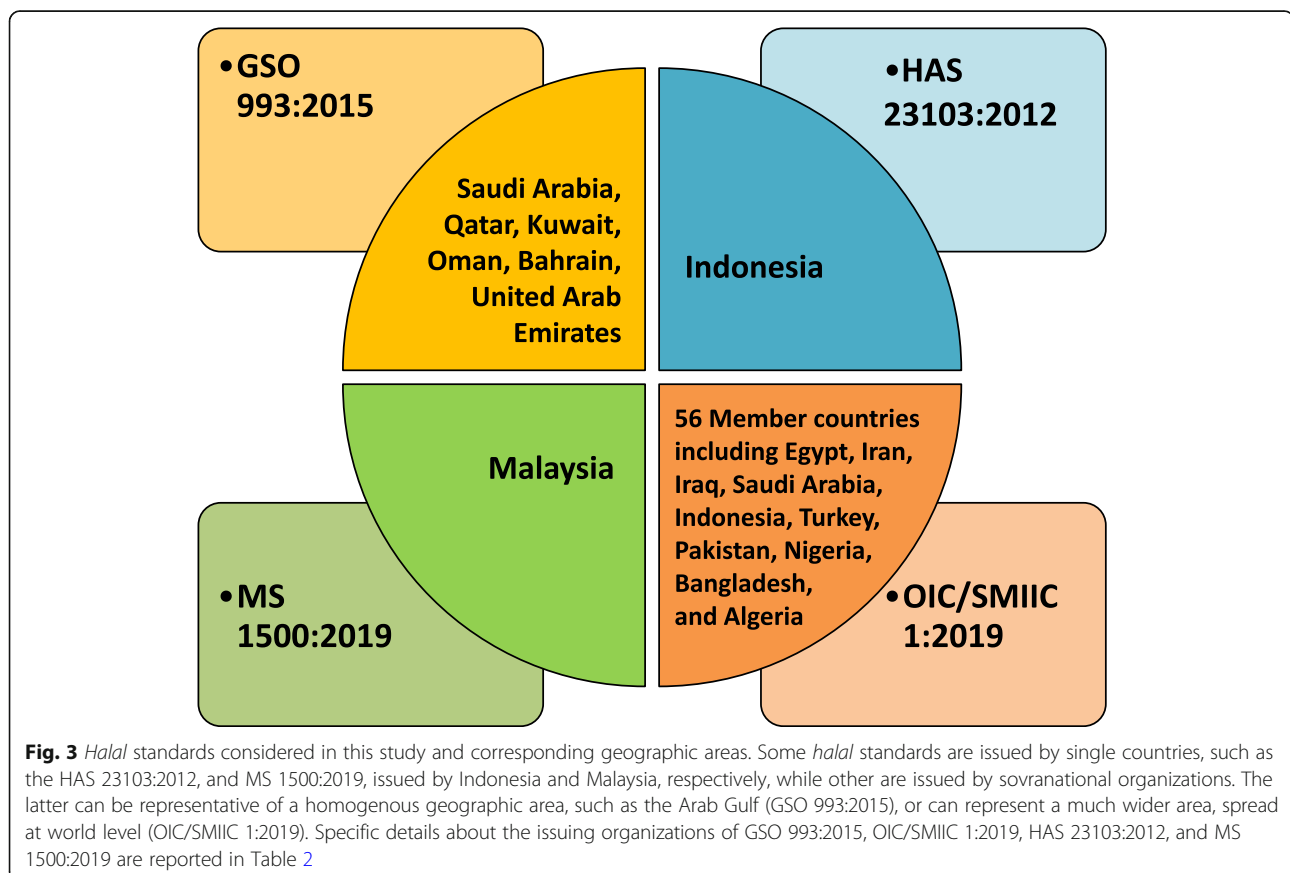
Nowadays, the Muslim population in Malaysia is around 61% [25], and around 87% in Indonesia [26]. With much of the food produced by the non-Muslim Chinese community, the need for *halal* verification was of paramount importance in these countries. The establishment of *halal* standards was therefore promoted by the government to guarantee manufacturers' compliance with *halal* rules.

In the areas where Islam originated, meanwhile, the almost entirely Muslim populations who resided there, traditionally held the view that food was naturally *halal*, without the need of specific certification procedures. Later on however, the increase of food imports changed this situation, and so Muslim-majority countries also developed their own *halal* standard [4].

The regulatory frameworks in the *halal* sector are therefore somewhat complex, as they vary from one geographic area to another. The differences between the Islamic schools originated in the early Islamic era, and are much more complicated nowadays in a wider geographic perspective and in a globalized world. The regulation of the *halal* market is still evolving. Different *halal* standards have been established among different countries and, sometimes even within each country, due to the presence of several issuing organizations and authorities.

Consequently, there is currently no consensus on a single *halal* standard. This generates uncertainty for producers, who may not know exactly which authority to consult in order to get their product certified for the selected market. In addition, another consequence of the multiplicity of *halal* standards is that producers from either non-Muslim countries, or from Muslim countries where a different standard is recognized, are required to obtain additional *halal* certifications according to each geographic area where they intend to export. Therefore, a global *halal* standard would be very much welcomed by the food industry. Last but not least, the multiplicity of standards (and consequently the multiplicity of different *halal* marks to be included in the food label) causes confusion among consumers too and might decrease their overall trust in certifications.

Some of the major *halal* international standards, representing different geographic areas (Fig. 3), include (Table 2) (i) the *halal* assurance system (HAS) Indonesian standards HAS 23000:2012 [27], HAS 23103:2012 [28], and HAS 23201:2012 [29], issued by the Assessment Institution for Foods, Drugs and Cosmetics of the Indonesian Council of Ulama; (ii) the MS 1500:2019 Malaysian standard [30], issued by the Department of Islamic Development Malaysia (JAKIM); (iii) the GSO



**Table 2** *Halal* International standards representative of different geographic areas, and their issuing organizations

Issuing organization	Standard code	Standard title
Lembaga Pengkajian Pangan, Obat-obatan, dan Kosmetika — Majelis Ulama Indonesia (LPPOM MUI), i.e., “The Assessment Institution for Food, Drugs and Cosmetics of the Indonesian Council of Ulama”	HAS 23000: 2012	Requirements of <i>halal</i> certification
	HAS 23103: 2012	Guidelines of <i>halal</i> assurance system criteria on slaughterhouses
	HAS 23201: 2012	Requirements of <i>halal</i> food material
Jabatan Kemajuan Islam Malaysia (JAKIM), i.e., “Department of Islamic Development Malaysia” — Department of Standard Malaysia (DSM)	MS 1500: 2019	<i>Halal</i> food. Production, preparation, handling and storage. General requirements.
GCC Standardization Organization (GSO) (being GCC = Gulf Cooperation Council)	GSO 2055-1: 2015	<i>Halal</i> foods. Part 1: General requirements.
	GSO 2055-2: 2015	<i>Halal</i> foods. Part 2: Guidelines for <i>halal</i> foods certification bodies.
	GSO 993: 2015	Animal slaughtering requirements according to Islamic law.
Organization of Islamic Cooperation (OIC) — Standards and Metrology Institute for Islamic Countries (SMIIC)	OIC/SMIIC 1:2019	General requirements for <i>halal</i> food

993:2015 standard [31] issued by Gulf Cooperation Council (GCC) Standardization Organization (GSO); and (iv) the OIC/SMIIC 1:2019 standard [32], issued by the Organization of Islamic Cooperation (OIC) and the Standards and Metrology Institute for the Islamic Countries (SMIIC).

The LPPOM MUI is an Indonesian institution aimed at carrying out *halal* certification processes in the sector of foods, drugs, and cosmetics. The LPPOM, whose members are qualified in chemistry, biochemistry, food science and technology, and agro-industry, was established in 1989 to assist MUI as a *halal* certifying body in Indonesia, the biggest market of *halal* food products in Asia [33]. To get the *halal* certificate, a company must implement a *halal* assurance system that ensures the continuity of *halal* production processes during the validity period of the certificate [34].

The MS 1500 standard, first issued in 2000, obtained its third revision in 2019. This standard provides practical guidance for the food industry on the preparation and handling of *halal* food in Malaysia. The *halal* certification is issued by a federal authority, specifically by a religious department of the government, the JAKIM. The Malaysian standards have been considered as a model for *halal* certification by the Codex Alimentarius Commission [34] and have been used as the basis of *halal* standards in many other countries [6].

The GSO, established in 2001 and having operated since 2004, has the national departments for standards and specifications of the Arab Gulf states (Saudi Arabia, Qatar, Kuwait, Oman, Bahrain, United Arab Emirates),

among its members. One of GSO’s main functions is to issue Gulf Standards/Technical *halal* regulations through specialized technical committees (TCs) [35].

It has to be considered that each National Standardization Body in GSO member countries is obliged to adopt the GSO standards, eliminating any conflicting national standards. Therefore, GSO Standards become the national standards in all the Arab Gulf countries [35].

In the case of importing meat and meat products (or other food products) in any of the Arab Gulf countries, the *halal* certificate accompanying these products must be checked by the consulate of the importer country. The check is fundamental to verify that the issuer of the certificate is accredited by the concerned agencies, according to the requirements mentioned in the GSO standard. Such certificate shall reflect that slaughtering and production have been done as prescribed by the GSO standard and in accordance with national laws and regulations. Meat and meat products must have a food grade stamp affixed by the issuer of the certificate or by an Islamic center or institution, so that it cannot be counterfeited [31].

The OIC is an alliance of countries in which Islam plays a significant role, including countries where Islam is the state religion, those in which Muslims represent the majority of the population, and those in which Muslims are only a minority but play a significant role for the country. In the latter category are countries such as Uganda, Benin, Togo, Mozambique, the Ivory Coast, Gabon, Cameroon, Suriname, and Guyana. The OIC has

currently 56 member countries (Fig. 4), spread over four continents, primarily in North Africa, Middle East, and Central Asia [36]. The 10 biggest food markets in the OIC countries are: Egypt, Saudi Arabia, Iran, Iraq, Turkey, Pakistan, Bangladesh, Nigeria, Algeria, and Indonesia [4]. Under the OIC, the designated organization for the development of standards is the SMIIC, established in 2010. The OIC/SMIIC has the objective of providing a unified framework whereby all the OIC member states use the same standards and methodologies for certification, accreditation, and laboratory services, in order to facilitate commercial exchanges [37]. Various other bodies actively collaborate with SMIIC, such as the Emirates Standards and Metrology Authority (ESMA) and the Turkish Accreditation Agency. However, the OIC/SMIIC standards may not be recognized by the member countries that had already issued and adopted their own *halal* food standard, such as Indonesia and Malaysia.

#### Attempts to harmonize the *halal* standards

Several attempts have been made to harmonize the existing *halal* standards, along with their certification and accreditation procedures. However, although these attempts should be duly credited with conceiving the idea of a transnational cooperative organization, no unification has yet been achieved because of the very reason that several of these organizations (named, depending on each individual case, “council”, “forum”, or “alliance”) have been constituted. There is still a long way to go to achieve a unified *halal* standard.

The idea of establishing a reliable system for the harmonization of standards among Islamic states can be

traced back to the 1st Meeting of the Economic and Commercial Cooperation Standing Committee (COM-CEC) of OIC in 1984 [38]. The Standardization Experts Group for Islamic States (SEG) was established in 1985 for this purpose, and its work led to the approval of the SMIIC Statute at the 14th COMCEC Meeting in 1998 [38].

The World *Halal* Food Council (WHFC), founded in 1999 upon the initiative of the LPPOM MUI, represented another attempt to harmonize the *halal* market, with the aim of defining a global *halal* standard [39]. In 2011, around 20 *halal* certifying bodies around the world had joined the WHFC [39]. The establishment of a Minimum Core Standard including a number of basic issues (such as pork and alcohol prohibition) was suggested, with specific additional requirements applied to each individual country [40]. The WHFC is currently still working on controversial topics pertaining *halal* dietary laws.

During the 2006 World *Halal* Forum, a similar attempt was made by establishing the International *Halal* Integrity (IHI) Alliance, an international association aimed at the development of a global *halal* standard to uphold the integrity of the *halal* industry [40].

The harmonization of the accreditation practices in the *halal* sector worldwide was also considered. A step forward in this direction was the establishment, of the International *Halal* Accreditation Forum (IHAF) in 2016, a network of *halal* accreditation bodies (HABs) [41]. Accreditation of *halal* certification bodies (HCBs) is a fundamental step in ensuring their reliability and objectivity during the certifying process. Acting as both a certifier and an accreditation agency may, in fact, lead to



**Fig. 4** Map of the 56 countries members of the Organization of Islamic Cooperation (OIC) (from [WorldData.info](https://www.worlddata.info/alliances/oic-organization-of-islamic-cooperation.php), <https://www.worlddata.info/alliances/oic-organization-of-islamic-cooperation.php>). The OIC is a worldwide organization of Islamic countries, with the main objective of promoting socio-cultural and economic cooperation among them. The majority of member countries is located in North Africa, Middle East, and Central Asia, but there are also a few members from South America (Suriname and Guyana) and Europe (Albania)



conflicts of interest. However, a number of HCBs have not fully embraced the concept of accreditation and operate as unofficial HABs [4]. The first meeting of IHAF was attended by 10 constituent members including several western countries, such as Australia, New Zealand, the UK, the USA, and Spain [41]. The number of members then increased to 27 HABs, operating both in the OIC member countries and in non-Islamic countries [41].

### **A case study: comparison of different *halal* standards applied to slaughterhouses**

*Dhabiḥah* are techniques that are acceptable in the *halal* slaughtering of all permitted animals and birds. The basic requirements related to slaughtering are common to all the major *halal* standards. For example, the size of the knife used for slaughtering should be proportionate to the neck, and there should be as little back and forth strokes as possible. The slaughterer must be trained to minimize damage to the skin and carcass while cutting the front of the neck, in order to sever the jugular and carotid, esophagus, and trachea, without reaching the nerves and bones [14]. However, some aspects of slaughtering may vary according to the *halal* standard considered [42]. For example, the requirements related to slaughtering according to the GSO 993:2015 [31], OIC/SMIIC 1:2019 [32], HAS 23103:2012 [28], and MS 1500:2019 [30] *halal* standards, listed in Table 3, show several differences. Even the Codex Alimentarius Commission, when defining the general guidelines for the use of the term *halal*, recognized that “there may be minor differences in opinion in the interpretation of lawful and unlawful animals and in the slaughter act, according to the different Islamic schools of thought” [13]. Therefore, slaughterhouses looking to obtain a *halal* certificate for their meat products have to fulfill specific requirements depending on the standard they choose to adhere which, in turn, depends on the specific geographic area where the products are to be marketed.

According to MS 1500:2009 [30] and HAS 23103:2012 [28] standards, the location of the manufacturing site must be separated from pig farms. The HAS 23103:2012 standard specifies that the closest pig farm, if present, must be at least 5 km from the *halal* premises [28]. Due to the high concentration of pig farms in Europe compared to the countries where these standards were set up, it may be difficult to fulfill these requirements for slaughterhouses in Western countries, not to mention that most of them usually slaughter pigs as well as other animals. On the other hand, the OIC/SMIIC 1:2019 standard states that the slaughtering site must be dedicated exclusively to *halal* animals and *halal* slaughter [32], whereas the GSO 993:2015 standard does not

mention any specific requirement regarding the location of the manufacturing site [31].

Slaughtering tools must cut by sharpness of their edge, and not by weight or pressure, but this point is considered only by GSO 993:2015 [31] and OIC/SMIIC 1:2019 [32]. All the considered *halal* standards agree that the *halal* and non-*halal* animals shall not be slaughtered on the same production line. *Halal* food must not come into direct contact with tools or food products that are non-*halal*, for these are considered a contaminant. Specific procedures (i.e., “ritual cleaning”, described in the next paragraph) are required by the OIC/SMIIC 1:2019 [32], MS 1500:2009 [30], and HAS 23103:2012 [28] standards to convert all production lines or tools that have come into contact with contaminants (*najis*) to *halal* status. The GSO 993:2015 standard, meanwhile, considers the general (not ritual) cleaning rules as sufficient and does not require the conversion process to be repeated on a continual basis [31].

There are three categories of *najis*, which vary in severity, with the more extreme *najis* being considered particularly serious by Islamic law (Table 4). In case of severe *najis*, appropriate cleansing (called *samak* or *dibagh*) must be done, which involves 7 steps of washing including one with water mixed with soil/clay [30]. These requirements are somewhat difficult to apply in European slaughterhouses, where personnel are not familiar with the *halal* precepts. Furthermore, the use of clay or soil may well be rejected by the HACCP internal quality control. With the purpose of facilitating *halal* cleansing, the use of a cleaning product containing soil is permitted [28, 30, 32], and liquid clay-based products which can be used as ritual detergents are widely sold and marketed in Indonesia [43]. The particle size of clay must be small in order to avoid damaging equipment surfaces [44]. The ritual cleansing by using clay is an example of *qiyās* (analogical reasoning) based on the following procedure mentioned in *Sunnah*: “The purification of the utensil belonging to any one of you, after it is licked by a dog, lies in washing it seven times, using sand for the first time” (Sahih Muslim, 821–875 AD).

It should be noted that the ritual cleansing procedure imposed by three of the four standards examined, namely OIC/SMIIC 1:2019, HAS 23103:2012, and MS 1500:2009, is the procedure defined by the *Shafi'i* school, without taking into account other *fiqh* schools, such as the *Hanafi* and the *Maliki*, who consider washing it seven times with running water without clay or soil [17] sufficient, or the *Hanbali* school, which recognizes a detergent, namely “soap”, as an equivalent substitute to clay/soil [17], this being an approach that is more practically applicable to today's modern lifestyle.

**Table 3** Differences among animal slaughtering requirements in four *halal* standards

Criteria	<i>Halal</i> standard			
	GSO 993: 2015	OIC/SMIIC 1:2019	HAS 23103: 2012	MS 1500: 2019
<b>Slaughtering site, tools, utensils, devices, machinery</b>				
The slaughterhouse productive site shall be effectively segregated and well insulated from pig farms or their processing activities to prevent contamination through personnel and equipment			×	×
The closest pig farm, if present, has to be distant at least 5 km from the <i>halal</i> premises			×	
The slaughtering site shall be dedicated only to <i>halal</i> animals and <i>halal</i> slaughter		×		
Slaughtering lines, food grade tools and utensils shall be clean and used for the purpose of <i>halal</i> slaughter only	×	×	×	×
Slaughtering tools used for cutting shall be sharp and free from blood and other impurities	×	×	×	×
Slaughtering tools shall cut by sharpness of their edge, not by weight or pressure	×	×		
Bones, nails and teeth shall not be used as slaughtering tools	×	×	×	×
Slaughtering tools shall be free and not from any materials which are categorized as <i>najs</i> or <i>haram</i>	×	×	×	×
Devices, utensils, machines and processing aids which were previously used or in contact with <i>najs al-mughallazah</i> shall be washed and ritually cleansed		×	×	×
In the case of converting <i>najs al-mughallazah</i> processing line into <i>halal</i> production line, the line shall be washed and ritually cleansed. This procedure shall be supervised and verified by the competent authority. Upon conversion, the line shall be operated for <i>halal</i> food only. Alternate conversion of the <i>najs al-mughallazah</i> line to <i>halal</i> line and back shall not be permitted		×	×	×
<b>Permitted animals</b>				
<i>Halal</i> animals	×	×	×	×
The animal must be alive or deemed to be alive before slaughtered	×	×	×	×
The animal must be healthy (approved by a veterinary authority) and the principles of animal welfare must be respected	×	×	×	×
<b>Stunning</b>				
Stunning must not kill or cause a permanent physical injury to the animal	×	×	×	×
Stunning should be made only to reduce animal pain and make slaughtering easier	×	×	×	×
The stunned animal should be alive or deemed to be alive before slaughtering starts	×	×	×	×
The veterinary authority must supervise the stunning process		×		×
Stunning tools must be free from any non- <i>halal</i> material	×	×	×	×
Stunning should follow specific instructions in terms of intensity (stunning type, duration, voltage, and position of stunner)	×	×	×	×
Stunning tools must be calibrated and validated periodically by the competent authority		×	×	×
The only permitted stunning methods for bovines are electrical or pneumatic percussive stunning (non-penetrative captive bolt stunning, ax/hammer, or air blowing)	×	×	×	×
The only permitted stunning method for poultry is electrical stunning (water-bath stunning)			×	×
Stunning should be avoided except for violently resisting animals		×		
<b>Stunning operator</b>				
The stunning operator must be skilled and pass the training conducted by <i>halal</i> certification bodies or other competent authorities			×	
<b>Slaughtering</b>				
Right before slaughtering the animals, the slaughterer shall utter "In the name of Allah" ( <i>tasmiyah "Bismillah"</i> ) and he shall not mention any name other than Allah, otherwise this will make meat non- <i>halal</i>	×	×	×	×
The slaughter act shall be done intentionally and in the name of Allah		×		×
The slaughter act shall sever the trachea ( <i>halqum</i> ), esophagus ( <i>mari</i> ) and both the carotid arteries and two jugular veins ( <i>wadajain</i> ) to enhance the bleeding and death of the animals. The bleeding shall be spontaneous and complete	×	×	×	×

**Table 3** Differences among animal slaughtering requirements in four *halal* standards (Continued)

Criteria	<i>Halal</i> standard			
	GSO 993: 2015	OIC/SMIIC 1:2019	HAS 23103: 2012	MS 1500: 2019
The slaughter act shall be done after having been raised the animal's head or laid the animal on its left side facing the direction of Mecca ( <i>qibla</i> )	×	×	×	×
Care shall be given to reduce animal pain while being raised or laid, without keeping it in that position for too long	×	×	×	×
Slaughtering shall be done only once	×	×	×	×
The "sawing action" of the slaughtering is permitted as long as the slaughtering knife or blade is not lifted by the animal during slaughter		×		
<b>Slaughterman</b>				
The slaughterer shall fully understand the fundamental Islamic rules and conditions related to the slaughter of animals		×	×	×
The slaughterer shall practice Islam as a good Muslim		×	×	×
The slaughterer can be either Muslim, or Jewish or Christian	×			
The slaughterer shall be minimum 18 years old			×	×
The slaughterer shall be healthy and mentally sound, as proven by medical record			×	×
The slaughterer shall be certified by a competent <i>halal</i> authority	×	×	×	×
The number of slaughtermen who work per day shall be adequate to the number of animals being slaughtered			×	×
<b>Halal supervisor</b>				
The supervisor shall be minimum 18 years old			×	×
The supervisor shall practice Islam as a good Muslim			×	×
The supervisor shall pass a training by <i>halal</i> certification body or competent authority			×	×
The supervisor shall ensure that the stunning process (if any) does not cause permanent physical injury or death; that the slaughtering process meets the <i>halal</i> requirements; that the animals are dead before further handling; that non- <i>halal</i> products are not mixed with <i>halal</i> products, either in chiller, deboning room, cold storage, and transportation; that appropriate records of all the activities are kept			×	×
There must be an adequate number of supervisors per day, adjusted with the number of animals being slaughtered			×	×
The supervisor is responsible for the effectiveness of the <i>halal</i> internal control system			×	
<b>Halal head checker</b>				
The <i>halal</i> head checker must be a practicing Muslim and technically competent				×
The <i>halal</i> head checker must be trained and supervised by a <i>halal</i> certification body				×
The <i>halal</i> head checker must verify the <i>halal</i> carcass status by examining the level of damage			×	×
The <i>halal</i> head checker must assess the skull damage after stunning and record for any non-compliance carcass			×	×
<b>Halal checker</b>				
The <i>halal</i> checker shall be minimum 18 years old				×
The <i>halal</i> checker shall be healthy and mentally sound, as proven by medical record				×
The <i>halal</i> checker shall practice Islam as a good Muslim				×
The <i>halal</i> checker must be trained and supervised by a <i>halal</i> certification body				×
The <i>halal</i> checker must check all the activities related with stunning and/or slaughtering				×

Regarding the permitted animals, there are no differences among the standards considered: animals must be healthy, alive (or deemed to be alive) prior to the slaughtering act, and from permitted species.

Regarding pre-slaughter stunning, aimed at inducing unconsciousness in order to minimize the pain associated with slaughter [45], the major *halal* standards permit stunning but do not encourage it. Stunning is permissible as long as the animals and poultry do not

**Table 4** Classification of contaminants and cleaning procedures (from DSM, 2019) [30]

	Degree of severity of contamination		
	Light ( <i>Mukhaffafah</i> )	Medium ( <i>Mutawassitah</i> )	Severe ( <i>Mughallazah</i> )
<b>Type of contaminant</b>	This category includes exclusively urine of babies less than two years old who have not consumed any other food except his mother's milk	Contaminants not included in the other two categories, such as tools or food products that are non- <i>halal</i> This category includes also vomit, pus, blood, <i>khamar</i> , carrions, liquid and objects discharged from the orifices of humans or animals	Dogs and pigs ( <i>khinzir</i> ) including any liquid and objects discharged from their orifices, descendants and derivatives
<b>Cleaning procedure</b>	Remove the contaminant and sprinkle water over the contaminated area	Remove the contaminant and wash with running water until odor or visible traces of contaminant disappear	Remove the contaminant and wash seven times with running water, one of which shall be with water mixed with soil. The first wash shall clear the najas. The water from first cleaning shall not remain behind and the successive wash shall be counted as the second wash. The amount of soil used is just enough to make a suspension.

die instantly as a result of stunning itself. Stunning should therefore be “reversible”, i.e., non-lethal [46]. Stunning should be performed at a certain degree of intensity approved by health and Islamic authorities.

There are several means and methods of stunning used for different animals and poultry species. In particular, two of the examined *halal* standards accept electrical stunning (water-bath stunning) for poultry and mechanical stunning (pneumatic percussive stunning and non-penetrative captive bolt stunning) for other animals [28, 30, 32]. Stunning is an effective method to ensure the animal avoids feeling pain, but some studies claim that it has adverse effects on carcass, meat quality, and public health [47, 48]. In contrast, other studies [49, 50] found that the physicochemical and quality properties of goat meat from electrically stunned animals were comparable to those of animals slaughtered without stunning. Moreover, no differences in bleeding were observed comparing stunned sheeps with non-stunned ones [51].

At a European level, a number of regulations have been implemented over the years to protect the welfare of animals during slaughter. This issue was given importance for the first time in 1974 with the 74/577/EEC Directive [52], setting out measures for animal protection at the time of slaughtering or killing. This framework was further developed by the 88/306/EEC Directive [53], and the 93/119/EC Directive [54], the latter repealed by the Council Regulation (EC) 1099/2009 [55].

The first measure introduced was aimed at ensuring that animal death was as rapid as possible after stunning, in order to avoid any cruelty to animals [52]. Art. 3 of EC Reg. 1099/2009 [55] reiterates that animals shall be spared any avoidable pain, distress, or suffering during their killing and related operations. Stunning, which causes animals to be unconscious, should last until they are slaughtered, thus avoiding any unnecessary suffering.

Pre-slaughter stunning, however, has divided the opinion of scholars within the Muslim community [56, 57]. Many scholars in the UK, for example, consider reversible electrical stunning to be compatible with *halal* slaughter [56], but many people will not accept meat from stunned animals [57]. In general, all forms of stunning and unconsciousness of animals are disliked because the severity of stunning might kill the animals before bleeding, which is unacceptable for *halal*. The issue of stunning for religious slaughtering is well known and even EU rules are on board with this. According to the Council Regulation (EC) 1099/2009 (art. 4.4) [55], in the case of animals subjected to particular slaughtering methods prescribed by religious rites, stunning is not obligatory, provided that the slaughter takes place in a slaughterhouse. Some countries, however, such as Sweden, Norway, Iceland, Denmark, and Slovenia prohibit any ritual slaughtering without stunning [58].

According to OIC/SMIIC 1:2019 [32] stunning and concussion (loss of consciousness) should be avoided except for animals who are violently resistant. MS 1500:2009 [30] does not recommend stunning but, if it has to be carried out, specific conditions are set by this standard. HAS 23103:2012 [28] allows for stunning, specifying that its sole objective is to ease the slaughter process and minimize animal pain.

The four *halal* standards set out guidelines on the intensity and duration of stunning to ensure that animals remain alive during and after stunning. If animals die before slaughtering, they shall be deemed as fatally beaten (*mawqouza*) and, therefore, considered *haram*. With regards to this, however, it should be considered that the verse 05.03 of Surat Al-Maeda (the table) states that “Forbidden to you (for food) are: Al-Maitah (the dead animals), blood, the flesh of swine, that on which Allâh’s Name has not been mentioned while slaughtering, the strangled, the (Mawqouza) dead through beating, the

dead through falling from a height, that which had been killed by (the goring of) horns, and the devoured of wild beasts, unless you are able to slaughter it". According to this verse, the specification "unless you are able to slaughter it" poses an exception, i.e., the case of a freshly dead animal (who has died in front of the person). This point should therefore encourage revision of the current opinion about stunning, i.e., even in cases that make the animal die, provided that the slaughtering process is completed within few minutes from stunning and complies with the requirements on bleeding, the animal can still be consumed. EU legal framework, specifically 64/433/EEC Directive [59], 93/119/EC Directive [54], and EC Reg. 1099/2009 [55] also states how bleeding must be complete and operations of stunning, shakling, hoisting, and bleeding must be carried out consecutively on one animal before carrying out any of them on another animal. This situation is similar to that of animals hunted by means of trained animals: in verse 05.04 of Surat Al-Maeda; it is stated that you must still pronounce the name of Allah over these hunted animals, even though, in many cases, the prey is already dead. The most important issue is that the animal is healthy, not rotten or diseased, and immediately slaughtered, as mentioned in the *hadith* "If you shoot with your arrow and (the Prey) goes out of your sight and you find it (later on), then eat if it has not gone rotten" (Sahih Muslim, 821-875 AD).

Slaughter is designed to remove all blood from the carcass by a complete bleeding process. There are several factors which are responsible for bleeding efficiency after slaughtering, such as the physical state of the animal before slaughter, the stunning method, and the interval between stunning and bleeding. During Islamic slaughter, it is very important to maintain the connection between the brain and the rest of the body via the spinal cord, by ensuring the prevention of neck separation, in order to send the nerve signals and hormonal alerts needed to complete the bleeding process [14].

Regarding the slaughterman, all the considered standards require this person to be Muslim, with the exception of GSO 993:2015 [31], which also allows Jews and Christians to fill this role. In the past, Muslims living in Europe did not question the *halal* status of meat, even slaughtered after stunning, because they regarded meat slaughtered by Christians and Jews, i.e., "People of the Book", as *halal* [60]. The HCBs should keep a record of the names of the *halal* slaughterers (*muthakeen*) and supervisors, and a record of the supervision procedures [6]. The roles of the *halal* supervisor and head checker are only specified in the HAS 23103:2012 [28] and MS 1500:2019 [30] standards. The role of the *halal* checker is only stated in the MS 1500:2019 standard [30].

## Conclusion

The growing demand for *halal* products motivates manufacturers to comply with *halal* standards, in view of potential commercial benefits. *Halal* certifications, however, are released by a number of bodies which may differ in the requirements imposed, as shown in the case study of slaughterhouses. Therefore, a specific *halal* certification is not recognized worldwide. The implementation of a harmonized monitoring system and establishment of a unified global *halal* standard would facilitate trade and increase the confidence of both producers and consumers. This study evidences that several attempts have been made to harmonize the existing *halal* standards. However, no unification has been achieved so far, and further efforts by standardization organizations are still needed to overcome this challenge. Only close collaboration between authorities from all the different countries involved in issuing *halal* certifications can lead to a homogeneous regulatory framework with unified certification and accreditation procedures, increasingly required in a globalized market.

## Supplementary Information

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**Additional file 1: Supplementary Table S1.** List of some Arabic terms used in the article, commonly related to halal certification.

## Authors' contributions

AA conceptualized the research, reviewed the literature, interpreted the data, wrote the article, and edited, read, and approved the final manuscript; MAR revised, read, and approved the final manuscript; AP reviewed the literature, wrote the article, and revised, edited, read and approved the final manuscript.

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All data and materials have been presented in the paper.

## Declarations

### Competing interests

The authors declare that they have no competing interests.

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## References

1. Kwon DY, Tamang JP. Religious ethnic foods. *J Ethn Foods*. 2015;2(2):45–6. <https://doi.org/10.1016/j.jef.2015.05.001>.



2. Dinar Standard. State of the global Islamic economy. Report 2019/20; 2020. <https://cdn.salaamgateway.com/special-coverage/sgie19-20/full-report.pdf> Accessed 24 Feb 2021.
3. COMCEC. Muslim-friendly tourism: developing and marketing MFT products and services in the OIC Member Countries; 2016. [https://sbb.gov.tr/wp-content/uploads/2018/11/Muslim\\_Friendly\\_Tourism\\_MFT\\_Developing\\_and\\_Marketing\\_MFT\\_Products\\_and\\_Services\\_in\\_the\\_OIC\\_Member\\_States%E2%80%8B.pdf](https://sbb.gov.tr/wp-content/uploads/2018/11/Muslim_Friendly_Tourism_MFT_Developing_and_Marketing_MFT_Products_and_Services_in_the_OIC_Member_States%E2%80%8B.pdf) Accessed 10 Jan 2021.
4. ITC. From niche to mainstream. *Halal* goes global. Geneva: International Trade Centre; 2015.
5. Djelic ML, Den Hond F. Introduction: multiplicity and plurality in the world of standards. *Bus Polit.* 2014;16(1):67–77. <https://doi.org/10.1515/bap-2013-0034>.
6. Al-Teinaz YR, Spear S, El-Rahim IH. The *halal* food handbook. Hoboken: Wiley; 2020. <https://doi.org/10.1002/9781118823026>.
7. Gray T. Islam and international criminal law and justice. Brussels: Torkel Opsahl Academic Epublsher; 2018.
8. Burton J. The sources of Islamic law: Islamic theories of abrogation. Edinburgh: Edinburgh University Press; 1990.
9. Al-Karasneh SM, Saleh AM. Islamic perspective of creativity: a model for teachers of social studies as leaders. *Procedia Soc Behav Sci.* 2010;2(2):412–26. <https://doi.org/10.1016/j.sbspro.2010.03.036>.
10. Okon E. The sources and schools of Islamic jurisprudence. *Am J Soc Manag Sci.* 2012;3:106–11.
11. Abdal-Haqq I. Islamic law: an overview of its origin and elements. *J Islamic L Culture.* 2002;7:27–81.
12. GSO. Halal products. Part 2: general requirements for *Halal* certification bodies (GSO 2055-2:2015). Riyadh: GCC Standardization Organization; 2015.
13. FAO. Codex alimentarius. General guidelines for use of the term "*halal*" (CAC/GL 24 1997). Rome: Food and Agriculture Organisation; 1997.
14. Riaz MN, Chaudry MM. Halal food production. Boca Raton: CRC Press; 2003. <https://doi.org/10.1201/9780203490082>.
15. Khattak JZ, Mir A, Anwar Z, Wahid HM, Abbas G, Khattak HZ, et al. Concept of *halal* food and biotechnology. *Adv J Food Sci Technol.* 2011;5:385–9.
16. Zulkifli. The Madhhab. In: The struggle of the Shi'is in Indonesia: ANU Press; 2013. [https://www.jstor.org/stable/j.ctt5hg234.11?seq=1#metadata\\_info\\_tab\\_contents](https://www.jstor.org/stable/j.ctt5hg234.11?seq=1#metadata_info_tab_contents). Accessed 24 Feb 2021.
17. Al JA. Al-fiqh alla al-madhabih Al-arabaa. 2th ed. Beirut: Dar Al Kotob. Al-ilmiah; 2003.
18. Wilson C, Trotter C. The whole hog: recipes and lore for everything but the oink. London: Pavilion Books; 2012.
19. van der Poel PW, Schiweck H, Schwartz TK. Sugar technology: deet and cane sugar manufacture. Berlin: Bartens, A; 1998.
20. Wei Z-Y, Zhang Y-Y, Wang Y-P, Fan M-X, Zhong X-F, Xu N, et al. Production of bioactive recombinant bovine chymosin in tobacco plants. *Int J Mol Sci.* 2016;17(5):624. <https://doi.org/10.3390/ijms17050624>.
21. Tofalo R, Schirone M, Fasoli G, Perpetuini G, Patrignani F, Manetta AC, et al. Influence of pig rennet on proteolysis, organic acids content and microbiota of pecorino di Farindola, a traditional Italian ewe's raw milk cheese. *Food Chem.* 2015;175:121–7. <https://doi.org/10.1016/j.foodchem.2014.11.088>.
22. Cardoza RE, Gutiérrez S, Ortega N, Colina A, Casqueiro J, Martín JF. Expression of a synthetic copy of the bovine chymosin gene in *Aspergillus awamori* from constitutive and pH-regulated promoters and secretion using two different pre-pro sequences. *Biotechnol Bioeng.* 2003;83(3):249–59. <https://doi.org/10.1002/bit.10666>.
23. Houben VJH. Southeast Asia and Islam. *Ann Am Acad Pol Soc Sci.* 2003;588:149–70.
24. Hooker MB. Islam in south-East Asia. Leiden: Brill; 1988.
25. Hirschmann R. Perceived and actual percentage of Muslim population in Malaysia as of 2018; 2019. <https://www.statista.com/statistics/953765/malaysia-perceived-and-actual-share-of-muslim-population/> Accessed 24 Feb 2021
26. Hirschmann R. Share of Indonesian population in 2010, by religion; 2020. <https://www.statista.com/statistics/1113891/indonesia-share-of-population-by-religion/> Accessed 24 Feb 2021
27. LPPOM MUI. Assessment institution for foods, drugs and cosmetic of the Majelis Ulama Indonesia. Requirements of *halal* certification (HAS 23000: 2012). Kota Bogor: LPPOM MUI; 2012.
28. LPPOM MUI. Assessment institution for foods, drugs and cosmetic of the Majelis Ulama Indonesia. Guidelines of *halal* assurance system criteria on slaughterhouses (HAS 23103:2012). Kota Bogor: LPPOM MUI; 2012.
29. LPPOM MUI. Assessment institution for foods, drugs and cosmetic of the Majelis Ulama Indonesia. Requirements of *halal* food material (HAS 23201: 2012). Kota Bogor: LPPOM MUI; 2012.
30. DSM. Halal food. Production, preparation, handling and storage. General guidelines (MS 1500:2019). Putrajaya: Department of Standard Malaysia; 2019.
31. GSO. Animal slaughtering requirements according to Islamic rules (GSO 993: 2015). Riyadh: GCC Standardization Organization; 2015.
32. SMIIC - The Standards and Metrology Institute for Islamic Countries. General requirements for halal food (OIC/SMIIC 1:2019). Istanbul: SMIIC; 2019.
33. Ratanamaneichat C, Rakkarn S. Quality assurance development of *halal* food products for export to Indonesia. *Procedia Soc Behav Sci.* 2013;88:134–41.
34. Khan MI, Haleem A. Understanding *halal* and *halal* certification and accreditation system: a brief review. *Saudi J Bus Manag Stud.* 2016;1:32–42.
35. GSO. About GSO; 2019. <https://www.gso.org.sa/en/about-gso/> Accessed 3 Jan 2021
36. WorldData.info. OIC countries. Organization of Islamic Cooperation. <https://worlddata.info/alliances/oic-organization-of-islamic-cooperation.php> Accessed 2 May 2021.
37. Halim MA, Mahyeddin MS. The possibility of uniformity on *halal* standards in organization of Islamic countries. *World Appl Sci J.* 2012;17:6–10.
38. SMIIC - The Standards and Metrology Institute for Islamic Countries. History of SMIIC. <https://www.smiic.org/index.php/en/history-of-smiic> Accessed 24 Feb 2021
39. WHFC. History. World halal food council; 2014. <https://www.whfc-halal.com/about-us/history> Accessed 24 Feb 2021
40. Wan Hassan WM. Globalising *halal* standards: issues and challenges. *Halal J.* 2007;38–40.
41. International Halal Accreditation Forum. IHAF Establishment; 2018. <http://www.ihaf.org/ae/en/establishment-of-ihaf/> Accessed 20 Feb 2021.
42. Aghwan ZA, Regenstein JM. Slaughter practices of different faiths in different countries. *J Anim Sci Technol.* 2019;61(3):111–21. <https://doi.org/10.5187/jast.2019.61.3.111>.
43. Wati DS, Rohman AM. Optimization of bentonite liquid detergent for cleansing of extreme najis using simplex lattice design. *Int J Appl Pharm.* 2019;11:186.
44. Kassim N, Hashim P, Hashim DM, Jol H. New approach of Samak clay usage for *halal* industry requirement. *Procedia Soc Behav Sci.* 2014;121:186–92. <https://doi.org/10.1016/j.sbspro.2014.01.1119>.
45. European Food Safety Authority (EFSA). Opinion of the scientific panel on animal health and welfare on a request from the commission related to the welfare aspects of the main systems of stunning and killing applied to commercially farmed deer, goats, rabbits, ostriches, ducks, geese and quail. *EFSA J.* 2006;326:1–18.
46. Fuseini A, Knowles TG, Lines JA, Hadley PJ, Wotton SB. The stunning and slaughter of cattle within the EU: a review of the current situation with regard to the *halal* market. *Anim Welf.* 2016;25(3):365–76. <https://doi.org/10.7120/09627286.25.3.365>.
47. Farouk MM, Al-Mazeedi HM, Sabow AB, Bekhit AED, Adeyemi KD, Sazili AQ, et al. *Halal* and *kosher* slaughter methods and meat quality: a review. *Meat Sci.* 2014;98(3):505–19. <https://doi.org/10.1016/j.meatsci.2014.05.021>.
48. Abd El-Rahim IH. Recent slaughter methods and their impact on authenticity and hygiene standards. In: Al-Teinaz YR, Spear S, El-Rahim IH, editors. The *halal* handbook. Hoboken: Wiley; 2020. p. 81–9. <https://doi.org/10.1002/9781118823026.ch7>.
49. Lokman NS, Sabow AB, Abubakar AA, Adeyemi KD, Sazili AQ. Comparison of carcass and meat quality in goats subjected to preslaughter head-only electrical stunning or slaughtered without stunning. *CyTA - J Food.* 2016;15:99–104.
50. Sabow AB, Adeyemi KD, Idrus Z, Meng GY, Ab Kadir MZA, Kaka U, et al. Carcass characteristics and meat quality assessments in goats subjected to slaughter without stunning and slaughter following different methods of electrical stunning. *Ital J Anim Sci.* 2017;16(3):416–30. <https://doi.org/10.1080/1828051X.2017.1291287>.
51. Mckinstry TJL. Comparison of religious slaughter of sheep with methods that include pre-slaughter stunning, and the lack of differences in exsanguination, packed cell volume and meat quality parameters. *Anim Welf.* 2004;13:387–92.
52. European Council. Council directive 74/577/EC on stunning of animals before slaughter. *OJ Eur Comm.* 1974;L316:10–1.
53. European Council. Council directive 88/306/EC on conclusion of the European convention for the protection of animals for slaughter. *OJ Eur Comm.* 1988;L137:25–6.

54. European Council. Council directive 93/119/EC on the protection of animals at the time of slaughter or killing. OJ Eur Comm. 1993;L340:21–34.
55. European Council. Council regulation (EC) 1099/2009 of 24 September 2009 on the protection of animals at the time of killing. OJ Eur Union. 2012;L303:1–30.
56. Fuseini A, Wotton SB, Hadley PJ, Knowles TG. The perception and acceptability of pre-slaughter and post-slaughter stunning for *halal* production: the views of UK Islamic scholars and halal consumers. *Meat Sci.* 2017;123:143–50. <https://doi.org/10.1016/j.meatsci.2016.09.013>.
57. Fuseini A, Wotton SB, Hadley PJ, Knowles TG. The compatibility of modern slaughter techniques with halal slaughter: a review of the aspects of “modern” slaughter methods that divide scholarly opinion within the Muslim community. *Anim Welf.* 2017;26(3):301–10. <https://doi.org/10.7120/09627286.26.3.301>.
58. Law Library of Congress, Global Legal Research Center. Legal restrictions on religious slaughter in Europe; 2018. <https://www.loc.gov/law/help/religious-slaughter/religious-slaughter-europe.pdf> Accessed on 21 Jan 2021
59. European Council. Council directive of 26 June 1964 on health problems affecting intra-community trade in fresh meat. OJ Eur Comm. 1964;L2012/64:185–97.
60. Miele M. Killing animals for food: how science, religion and technologies affect the public debate about religious slaughter. *Food Ethics.* 2016;1(1):47–60. <https://doi.org/10.1007/s41055-016-0004-y>.

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