

# PROCESSING AND PRODUCTS

## Developing control points for *halal* slaughtering of poultry

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**ABSTRACT** *Halal* (permissible or lawful) poultry meat production must meet industry, economic, and production needs, and government health requirements without compromising the Islamic religious requirements derived from the *Qur'an* and the *Hadiths* (the actions and sayings of the Prophet Muhammad, peace and blessings be upon him). *Halal* certification authorities may vary in their interpretation of these teachings, which leads to differences in *halal* slaughter requirements. The current study proposes 6 control points (CP) for *halal* poultry meat production based on the most commonly used *halal* production systems. CP 1 describes what is allowed and prohibited, such as blood and animal manure, and feed ingredients for *halal*

poultry meat production. CP 2 describes the requirements for humane handling during lairage. CP 3 describes different methods for immobilizing poultry, when immobilization is used, such as water bath stunning. CP 4 describes the importance of intention, details of the *halal* slaughter, and the equipment permitted. CP 5 and CP 6 describe the requirements after the neck cut has been made such as the time needed before the carcasses can enter the scalding tank, and the potential for meat adulteration with fecal residues and blood. It is important to note that the proposed *halal* CP program is presented as a starting point for any individual *halal* certifying body to improve its practices.

**Key words:** halal, shackling, poultry slaughtering, poultry industry, water bath stunning

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## INTRODUCTION

By 2050, Muslims will make up 30% of the global population, with 2.8 billion adherents. Muslim populations in Europe also will increase from 5.9 to 10% by 2050 (Audi, 2015). The growing number of Muslims creates substantial marketing opportunities for *halal* (Arabic: “Permissible” is the more accurate translation although the more commonly used term is “lawful”) food products. The demand for *halal* meat and meat products serves to challenge the food industry to expand its production without compromising the *halal* integrity of products being certified (Farouk, 2013). *Halal* (along with kosher) slaughtering without inducing unconsciousness has been alleged to be inhumane compared to secular slaughter although many of the reports are difficult to evaluate because of a failure to describe the actual details of the religious slaughter, assuming that all *halal* (or kosher) slaughters are the same. To meet these criticisms, some Muslims have adopted electrical head-only stunning (**ES**) (Nakyin-

sige et al., 2013). However, the use of pre-slaughter ES prior to the neck cut has been linked to blood splash (ecchymosis) in a range of muscles of slaughtered animals (Hindle et al., 2010). On the other hand, some members of the religious communities are concerned about the “spiritual quality” of the meat because of concerns about noncompliance with the religious requirements for *halal* and kosher meat production and are thus strongly committed to traditional slaughter methods (Farouk et al., 2014).

Many countries and non-governmental agencies have adopted guidelines and standards for *halal* poultry meat production (Table 1) applicable to different steps in the slaughter process. Among the listed *halal* monitoring authorities, only Australia and Malaysia have *halal* monitoring systems that are overseen by their respective governments. While Malaysia’s JAKIM monitors the *halal* integrity for both local and export products, the Australian government becomes involved only with products for export. In many countries, including the United States, there is no single standard for *halal* certification guidelines. One of the *halal* certifying agencies in the United States, the *Halal* Food Standards Alliance of America (HFSAA), provides education, monitoring, and certification for *halal* farmers and slaughter

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**Table 1.** Available guidelines from different countries or agencies for *halal* poultry slaughtering.

| Country/<br>Agency | <i>Halal</i> monitoring authority/<br>relevant guidelines | Available guidelines at various steps of<br>poultry meat slaughtering and processing |       |   |        |
|--------------------|---|--|-------|---|--------|
|                    |   | Farm   | Pre-S | S | Post-S |
| Australia          | Australian Quarantine and Inspection Service (AQIS)       | ×  | ×     | ✓ | ×      |
| Arab Gulf          | Arab Gulf Cooperation Council (GCC)/GCC Standard 993/2998 | ×  | ×     | ✓ | ×      |
| Indonesia          | Indonesian Council of Ulama (MUI)                         | ×  | ×     | ✓ | ✓      |
| Malaysia           | Department of Islamic Development Malaysia (JAKIM)        | ×  | ×     | ✓ | ✓      |
|                    | Malaysian Standard/ MS 1500:2009                          |  |       |   |        |
| Singapore          | Islamic Religious Council of Singapore (MUIS)             | ×  | ×     | ✓ | ✓      |
| Thailand           | Central Islamic Committee of Thailand/THS 24000:2552      | ×  | ✓     | ✓ | ✓      |
| UK                 | <i>Halal</i> Monitoring Committee                         | ×  | ×     | ✓ | ✓      |
| US                 | <i>Halal</i> Food Standards Alliance of America (HFSAA)   | ✓  | ×     | ✓ | ✓      |
| WTO                | CODEX Alimentarius CAG/GL 24-1997                         | ×  | ×     | ✓ | ×      |

× = not available, ✓ = available, S = slaughtering (neck cutting).

plants although it is not clear whether this is widely accepted by the community beyond companies under their certification. The U.S. Department of Agriculture (USDA) also recognizes the CODEX Alimentarius and the Arab Gulf Cooperation Council's standard for regulating *halal* slaughter as part of their general meat export functions.

The religious guidelines for *halal* meat production are primarily based on the fundamental principles derived from the *Qur'an* and the *Hadiths* (Arabic: Actions and sayings of the Prophet Muhammad, peace and blessings be upon him [PBUH]). However, variations are observed in *halal* requirement/standards for current practices in industrial *halal* meat production among the different schools of thought. For example, while the pre-slaughter ES is permissible according to the *halal* requirements of certain *halal* certifying bodies, others might not accept such practices. In all cases, the actual system used for *halal* slaughtering requires more careful monitoring and more detailed standards, ideally quantitative standards, to avoid compromising the *halal* integrity of meat products. These can be organized around control points for *halal* slaughtering (CPHS). The objective of this paper is to suggest a preliminary listing of such control points (CP) for *halal* poultry meat production. The proposed CP incorporate all possible steps/components for *halal* slaughtering, and therefore are applicable irrespective of the number of chickens being slaughtered. In the current study, a starting model CPHS program for poultry meat production is proposed that will integrate religious principles with the most common current industrial practices from farm to slaughter (Figure 1). Depending on the need, large or small scale, the steps/components of the respective CP can be adapted. However, modified CP should not contradict the basic principles of *halal* slaughtering. Identification of these CP for the *halal* poultry meat production industry requires an in-depth analysis of potential alternatives and their consequences.

## MATERIALS AND METHODS

The methodology used for this study is summarized in Figure 2. In brief, the Islamic guidelines for *halal*

slaughter and the commercial practices during poultry slaughter were reviewed. The steps along the meat production chain where the *halal* requirements impacted the poultry processing were then identified so that CPHS could be determined based on a *halal* decision tree (Figure 3).

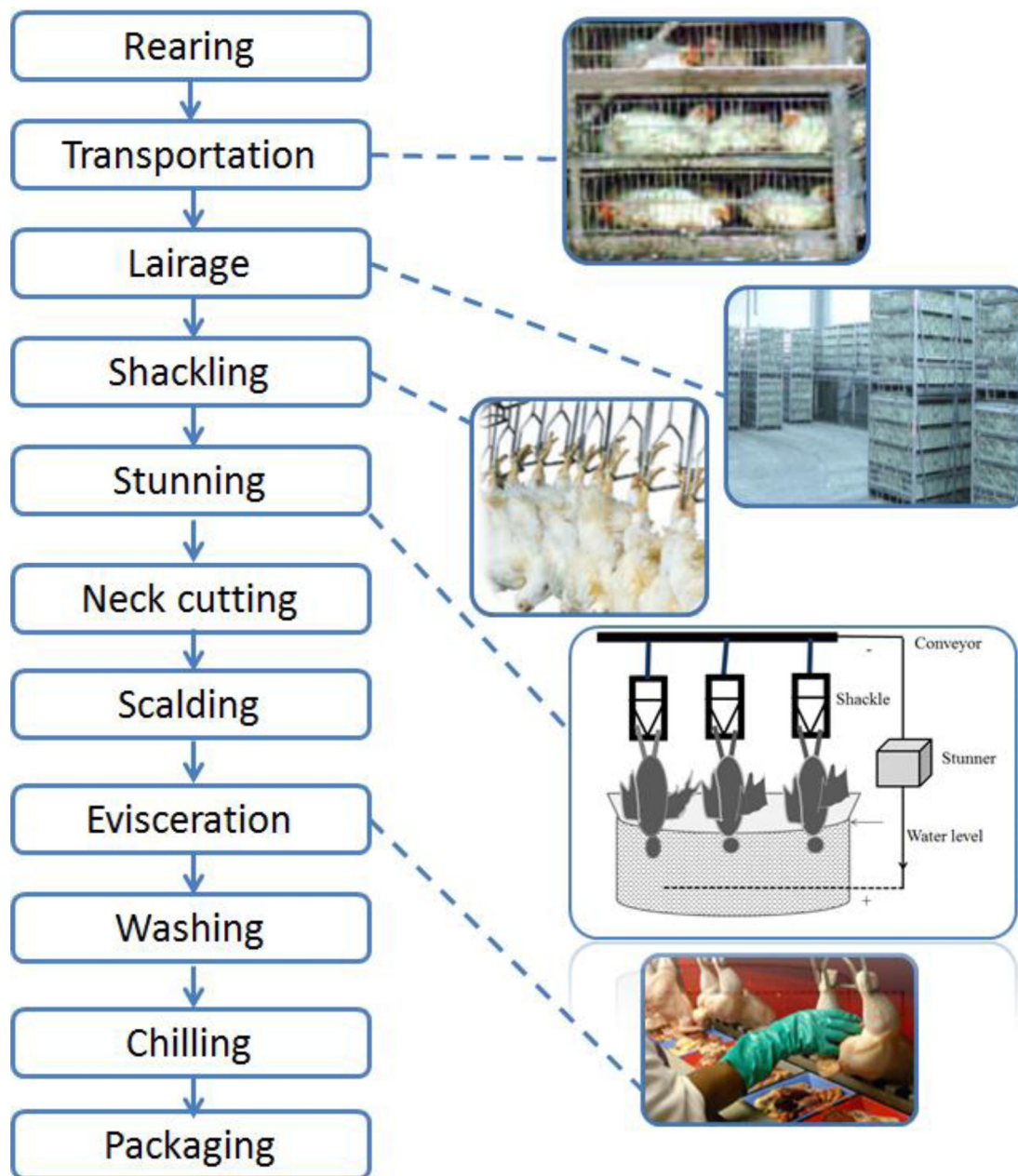
As with other aspects of human life, poultry production can be evaluated based on the 5 categories of Islamic law, which are in the order of best to worst: obligatory (*fardh*), desirable or recommended (*mandub*), neither prohibited nor recommended (*jaiz* or *mubah*), detested (*makrooh*), or prohibited (*haram*) (Table 2).

### Identification of the Islamic Halal Poultry Slaughter Guidelines

The relevant *Qur'anic* verses and *Hadiths* for *halal* meat production were compiled and reviewed (Supplementary Table S1) after a search of the key word terms of *halal*, *haram* (Arabic: prohibited), *shubhah* (Arabic: doubtful), *tayeeb* (Arabic: wholesome), poultry, slaughter, food, meat, and blood. The resultant verses were linked to the corresponding act/component of current poultry practices (Figure 1). The *Qur'anic* translations used in this study were based on the Saheeh International (<http://www.saheehinternational.com>) version of the *Qur'an*. The relevant *Hadiths* were compiled from 7 collections of *Hadiths* by *Bukhari*, *Muslim*, *Abu Dawood*, *An-Nasa'i*, *At-Tirmidhi*, *Ibn Majah*, and *Malik*. These are recognized as the authentic collections of *Hadiths*. An English translation of these *Hadiths* is available at <http://www.sunnah.com>.

### Identification of Current Halal Poultry Slaughter Practices

The components for industrial production of *halal* poultry were identified by undertaking a literature survey, visiting *halal* poultry slaughter plants in Malaysia, and interviewing personnel involved in different sectors of *halal* poultry production and monitoring in Malaysia. Thus, the results may be biased towards Malaysia and may require adjustments in other countries. Interviews



**Figure 1.** Typical events in the commercial production of poultry meat.

were conducted with personnel (1) at the *halal* poultry slaughter plants, (2) at the Department of Islamic Development Malaysia (JAKIM) who were involved in the inspection, monitoring, and certification of *halal* poultry meat production, (3) the religious departments for 2 Malaysian states: the Selangor Department of Islamic Religious Affairs and the Pahang Department of Islamic Religious Affairs, and (4) veterinarians involved in poultry plant inspection.

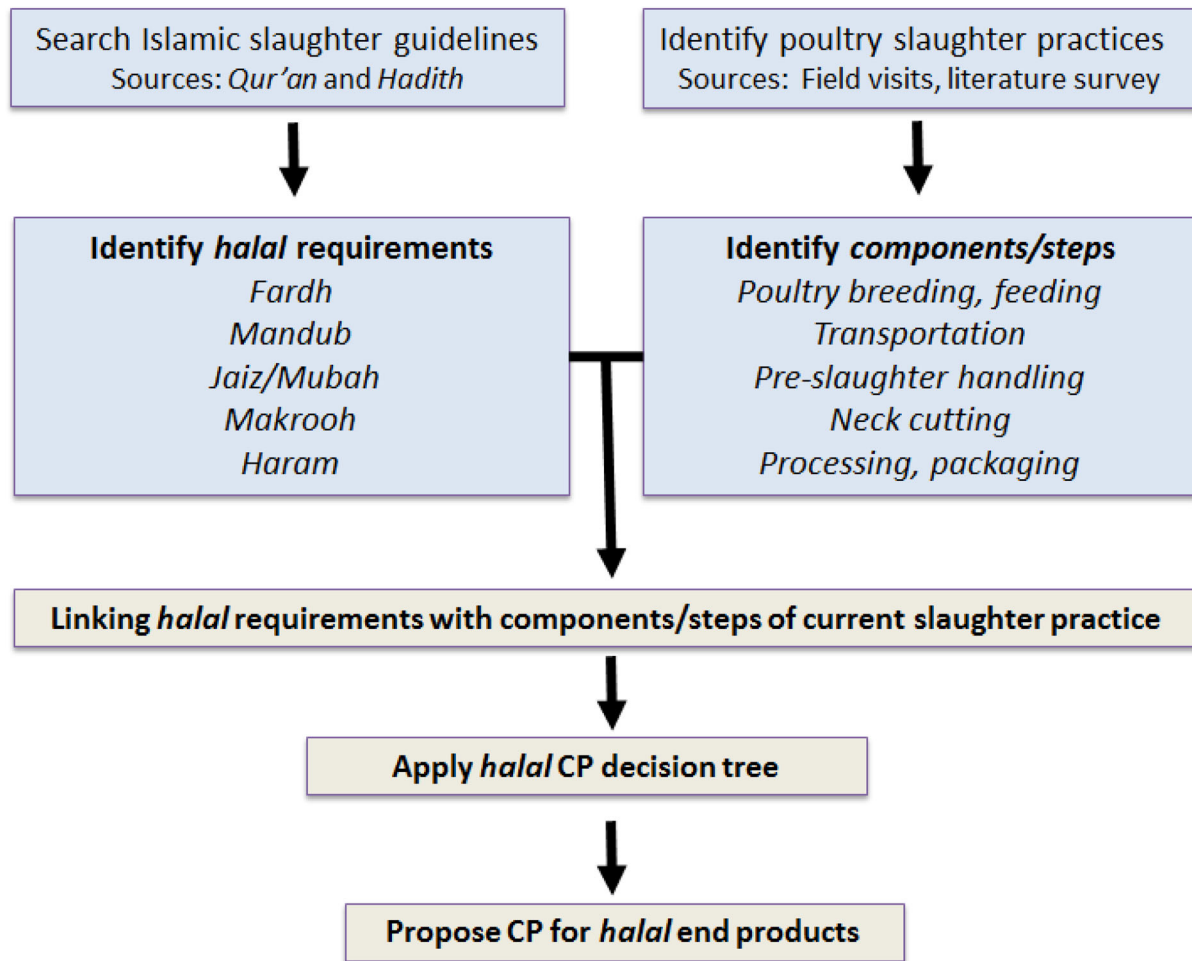
### Linking Halal with Current Halal Poultry Slaughter Practices

Guidelines for *halal* meat production were established and arranged in accordance with the chronological steps

for commercial poultry meat production (Figure 1). All relevant information regarding slaughtering including the slaughtering of animals during the *Eid al-Adha* (Arabic: Festival of the Sacrifice) were included. At this point in the process only religious verses applicable to poultry were used.

### Proposing CP for Halal Poultry Meat Production

Each act and component of poultry processing (Figure 1) was evaluated using the CPHS decision tree (Figure 3). Eventually, the 6 CP for *halal* poultry meat production were developed.



**Figure 2.** Methodology for the development of control points (CP) in *halal* poultry meat production. All the guidelines related to various steps of poultry meat production are collected from the *Qur'an* and the *Hadiths* to develop the CP for the *halal* meat production chain. Finally, 3 CP were proposed by applying the decision tree for CP identification.

## RESULTS

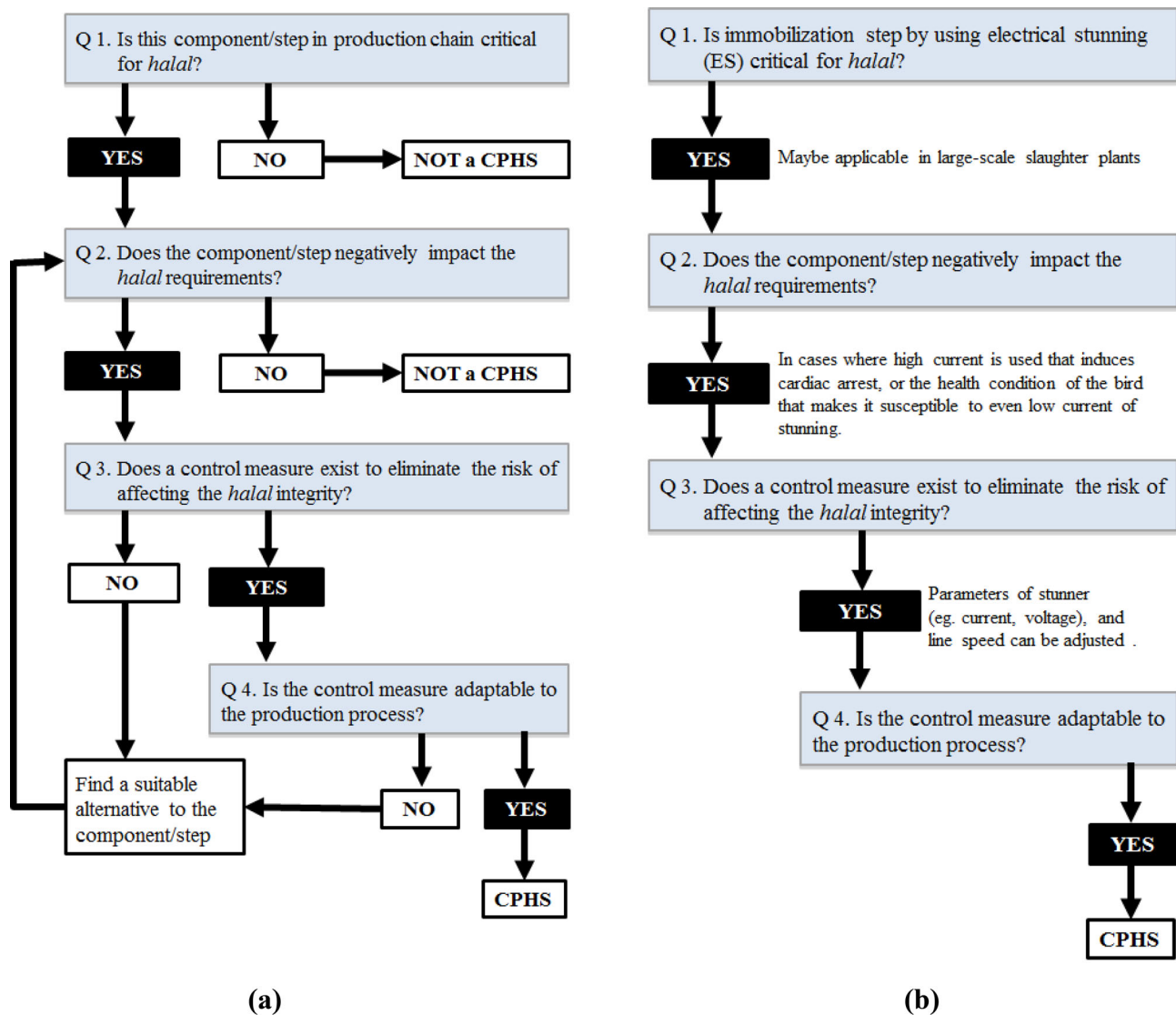
### The 3 Considerations for Halal Poultry Production

The general rule of consuming *halal* food is based on the *Qur'anic* verse number 2:168 (No. 1, Supplementary Table S1). The CPHS program is developed to encourage meat producers to adopt the best practices for *halal* meat slaughtering, and to educate them that meeting *halal* requirements is not difficult. Regardless of the differences of the various schools of thought, the acts and components of *halal* meat production can be analyzed as falling within 3 different areas of consideration: (1) acts of sacrifice (slaughtering), which are also considered as acts of worship and obedience in Islam; (2) the species, ages, and physical conditions of the animals; and (3) animal handling before, during, and after the slaughter. These considerations frame *halal* meat poultry production. Hence, further development of *halal* meat processing and slaughtering guidelines should focus on these 3 considerations when setting up a standard for *halal* poultry production.

### Categorization and Certification of Halal Poultry

For an item to be *halal* it must normally be at least *jaiz* or *mubah* although some items may be *makrooh* to some and acceptable to others. Once the acts/components of poultry production are categorized, the end product can be defined or labeled as *halal*, *haram*, or *shubhah*. The *halal* and *haram* concepts are clearly defined in the *Qur'an* and the *Hadiths*. On the other hand, examples of items that could be labeled as *shubhah* are lacking from these 2 sources. What is important is that any acts/components that could be suspected as being *haram*, or that have a doubt on their *halal* integrity, should be labeled as *shubhah*. For this reason, the descriptions of the labels *halal*, *haram*, and *shubhah*, with respect to *halal* poultry meat slaughtering, is developed in Table 3. If an act is categorized by the responsible authority as an obligatory act, missing that act will render the end product *haram*. Similarly, addition of any prohibited act/component would render the end product *haram*. By definition, missing an optional or recommended requirement





**Figure 3.** Decision tree to identify CPHS (a) and an assessment on the use of water bath electrical stunning as a CP for *halal* poultry meat production (b).

**Table 2.** The 5 categories of Islamic law.

| Category          |                                    | Description/Definition   |
|-------------------|------------------------------------|--|
| Arabic            | English translation                |  |
| <i>Fardh</i>      | Obligatory/Compulsory              | Something must be done, and rewards will be given.   |
| <i>Mandhub</i>    | Desirable                          | If something is done, it would be commendable.   |
| <i>Jaiz/mubah</i> | Neither recommended nor prohibited | One can choose to perform or not to perform an act.  |
| <i>Makrooh</i>    | Detested                           | Something that is not recommendable to do, but if one does it, no punishment is imposed on the doer. |
| <i>Haram</i>      | Prohibited                         | Something must not be done, and punishment will be imposed on the doer.                              |

**Table 3.** Possible label/status of the end product.

| Label/Status   |                       | Description/Definition   |
|----------------|-----------------------|--|
| Arabic         | English translation   |  |
| <i>Halal</i>   | Permissible or lawful | Processed or produced following all obligatory requirements and prohibitions   |
| <i>Haram</i>   | Prohibited            | Missing at least one obligatory requirement or containing at least one item that is prohibited   |
| <i>Shubhah</i> | Doubtful              | Presence of any act/component during processing, the status of which is recognized as <i>makrooh</i> or is not clearly described as <i>halal</i> or <i>haram</i> |

may not compromise the *halal* integrity of the end product.

Once again, whether a particular act/component should be categorized as *fardh*, *mandub*, *jaiz/mubah*, *makrooh*, or *haram* may vary depending on the interpretation of a government or *halal* certifying body, which will base its decision on the schools of thought it follows and possibly of the current best available technical information. An example of differences in categorizations is the prohibition of sharpening the slaughtering tool in front of the animal to be slaughtered [*Hadith* no. 21, Supplementary Table S1]. Some Muslims may consider the act of slaughtering using a knife that was sharpened in front of the animal as *makrooh*, hence the meat might be defined as either *halal* or *shubhah*. Thus each step or event in the production chain must be defined and categorized according to the *halal* requirements and standards of the respective authority. Nonetheless, it is possible to develop a model CPHS program to include the most common CP involved in *halal* poultry meat production.

The reason for developing the CPHS program for *halal* poultry slaughtering and processing is to provide guidelines for common CP that are acceptable to most countries and *halal* certifying bodies. However, different schools of thought may have different categorizations (i.e., *fardh*, *mandub*, *jaiz/mubah*, *makrooh*, or *haram*) for these CP, which will affect their acceptance.

### The 6 Proposed CPHS of Poultry Meat

A systematic approach to the production of *halal* foods that meets the criteria of *halal*, *tayeeb*, and safety was initially suggested by Riaz and Chaudry (2004). In the current study, a preliminary list of common CP was proposed based on the guiding principles (Supplementary Table S1) and further evaluated for their necessity, possible impact on animal welfare and human health, and potential alternatives of each act/component in the case of noncompliance. The proposed 6 CP for the *halal* poultry meat production chain are highlighted in relation to the current commercial practices in poultry meat processing (Table 4).

## DISCUSSION

The following section will discuss the 6 CP for the CPHS program. Each CP is discussed by: (1) defining the CP; (2) providing comparative analysis with current practice in the industry, if available, (3) applying the appropriate religious verses (from the *Qur'an* and the *Hadith*) to identify the concerns with the current practice, and (4) proposing the possible measures that are needed to be in compliance with *halal* requirements.

### CP 1: On Farm: Poultry Breed, Rearing, and Poultry Feed

**Priority to Reduce Stress During Rearing: Optimum Space and Natural Growth Rate** Commercial broilers are reared in closed, controlled-atmosphere environments and fed with diets that aim to reduce the cost of production by shortening the time for growth (Kilgour, 1978). As a result of the modern farming systems and excessive breeding for production traits, many chicken broilers suffer leg weaknesses (Kilgour, 1978). Since Islam prohibits unnecessary stress on animals [*Hadiths* no. 14–16, Supplementary Table S1], it is critical to meet modern poultry welfare standards such as those of the National Chicken Council (United States), which includes monitoring leg weakness. Thus, how poultry is bred and reared is part of CP 1.

#### Processed Animal Byproducts in Poultry Feed

Processed animal proteins (PAP) are a source of protein and calcium in poultry feed. They can be obtained using the dry-rendering of mammalian and avian tissues, such as the internal organs, bones, tendons, ligaments, and skeletal muscle (Ravindran et al., 1999). Animal protein-based feeds also may contain animal waste such as litter from poultry, ruminants, and swine (Haapapuro et al., 1997). The use of PAP optimizes the beneficial use of processed poultry feed but concerns for disease transmission, especially bovine spongiform encephalopathy (Hodges, 2009) has led many countries to restrict or carefully specify the proper use of PAP. The permissibility of animal byproduct (excluding animal litter) materials in poultry feed is based on *Hadiths* no. 10 in Supplementary Table S1, which allows the use of these materials from animals slaughtered for consumption. The unacceptability of litter in PAP may be based on the prohibition of consuming meat and milk of animals that were fed on filth [*Hadith* no. 11, Supplementary Table S1]. Thus eating meat from animals that were fed on manure may be viewed by many Muslims as *haram* or *makrooh*. However, animals choosing to eat such materials in their natural environment are acceptable as there are no discussions among Muslim scholars suggesting otherwise. Other possible *haram* ingredients in poultry feed may include blood and pork [*Qur'an* 2:173, 5:3, 16:115, no. 12, Supplementary Table S1], which are both *haram* for Muslim consumption. Ideally poultry should be obtained from specific *halal* compliant farms that avoid any of these *haram* or even *shubhah* materials.

#### Antibiotics, Growth Promoters, and Drugs in Poultry Feed

Studies have linked antibiotics in poultry feed as a secondary cause of gait problems in broilers (Bradshaw et al., 2002). Traces of antibiotics also have been found in chicken meat (Jafari et al., 2007; Mottier et al., 2003) consumption of which might result in inappropriate antibiotic exposure potentially resulting in antibiotic resistance (Wolfgang, 1998; Levy and Bonnie, 2004). Before 2011, organoarsenical drugs, specifically Roxarsone, had been widely used in the

**Table 4.** Comparison between the control points for *halal* slaughtering (CPHS) program and the current practice in the poultry industry, identified by the 6 CP in this study (third column).

| Basic considerations to monitor the CPHS program   | Current practices in the commercial poultry meat industry   | Proposed CP  |
|--|---|--|
| i. Restriction on composition of poultry feed ingredients  | i. Excessive breeding for production traits   | CP 1   |
| ii. Prohibition of any form of stress to animal  | ii. Physical weakness due to rapidly induced growth<br>iii. Animal waste, toxic ingredients, and components of blood and pork in poultry feed | Poultry breeding, rearing, and poultry feed              |
| i. Prohibition of abusive and inhumane handling of animals   | i. Crowded crates   | CP 2   |
| ii. Provisions to supply food and water to animals during travel                                       | ii. Heat stress and poor ventilation  | Welfare of the poultry during transportation and lairage |
| i. Prohibition on restraining the animal after neck cutting  | iii. Prolonged starvation<br>i. Chickens remain shackled after neck cutting   | CP 3   |
| ii. Promotes gentle and kind handling while the animal is being slaughtered                            | ii. Metallic shackle can be painful for the poultry (legs bruises due to shackling)   | Immobilization to facilitate slaughtering                |
| iii. Prohibition of killing by other means except neck cutting such as stunning (stun-to-kill)         | iii. Stunning can cause death in chickens   |  |
| iv. Ensuring profuse blood flow following the neck cutting   |   |  |
| i. Obligation to recite <i>tasmiyah</i>  | i. Obstacle of background noise to hear <i>tasmiyah</i>   | CP 4   |
| ii. Prohibition to sacrifice in the name of anyone/anything except <i>Allah</i>                        | ii. Knife may be blunt and have nicks   | Act of slaughter   |
| iii. Obligation to use a sharp knife   | iii. Shackled chickens are slaughtered in sequence  |  |
| iv. Prohibition of sharpening the knife in front of other chickens to be slaughtered                   | iv. Use of automated knife and rapid line speeds Improper neck alignment affects proper neck cutting  |  |
| v. Cutting major veins for maximum blood loss  | v. Involving slaughter man whose faith or religion is other than one accepting the Scriptures   |  |
| vi. Permission of followers of other scriptures and women to slaughter                                 | vi. Facing <i>kaaba</i> ?   |  |
| vii. Obligation to face the <i>Kaaba</i> while neck cutting  |   |  |
| i. Prohibition of killing by other means except neck cutting such as by suffocation in a scalding tank | i. Chickens are alive (either conscious or unconscious) as they enter the scalding tank (due to short time between neck cutting and scalding) | CP 5<br>Time for full bleed-out                          |
| i. Package clean meat without any <i>haram</i> , toxic, or harmful ingredients and materials           | i. Possible adulteration with other meats if different animal species are processed in the same plant   | CP 6   |
|  | ii. Use of blood and swine casings to make secondary meat products  | Washing and packaging                                    |

production of chicken broilers in many countries including the United States, Canada, Indonesia, Vietnam, and Malaysia (Harris and Grady, 2011) to treat coccidiosis, a common parasitic disease in poultry, and to improve feed conversion, which allows poultry to gain weight faster (Silbergeld and Nachman, 2008). Arsenic exposure is believed to increase the risks of cancer, diabetes, and cardiovascular disease (Nachman et al., 2012). However, the contribution of poultry to the human arsenic burden is currently not known.

Probiotics are live, non-pathogenic gut flora obtained from healthy poultry or other sources, administered through the feed and are considered beneficial to the host's health. If added to the poultry feed, probiotics and prebiotics can potentially enhance productivity (Lutful Kabir, 2009) and reduce enteric diseases by improving the immune response in the chicken (Huang et al., 2004). Thus, the use of pre- and probiotics could

be viewed as beneficial both for meat production and for animal welfare without any damaging impact on human health. In addition to pro- and prebiotics, anticoccidials, biochemically known as ionophores, are used to allow low-pathogenicity coccidia in the intestines of the bird to aid in developing immunity against the disease coccidiosis. Although generally considered beneficial, the use of ionophores in poultry feed might have a long term impact on the environment since its presence is detected in poultry litter (Biswas et al., 2012). There is no evidence that these materials can be found in the edible parts of poultry and therefore these do not raise any *halal* issues.

The presence of any components, as mentioned above, in animal feed, which might eventually appear in the edible part for human consumption, is inconsistent with the preparation of wholesome food [*Qur'an* 2:168, no. 1, Supplementary Table S1]. This notion is

consistent with the teaching of the *Qur'anic* verse that prohibits consumption of toxic ingredients that are injurious to human health [*Qur'an* 2:195, no. 13, Supplementary Table S1]. Thus, the misuse of antibiotics, drugs, and ionophores in feed and failure to allow a proper withdrawal time should be considered as part of CP 1.

**Concerns on Changing the Fair Nature of Allah's Creation** As stated in the *Qur'an*, changing the fair nature of Allah's creation is an act of *satan* and those who follow *satan* are considered as losers [*Qur'an* 4:119, No. 8, Supplementary Table S1]. Each living species has its natural growth, morphology, and physiology. The natural order of growth and development of animal species including chickens depends on their genetic makeup as well as the feed they consume (Julian, 1998). Commercial broilers are bred and fed to induce faster growth for higher productivity (Knowles et al., 2008; Pauwels et al., 2015) which in turn may lead to various physiological consequences such as lameness (Dransfield and Sosnicki, 1999; Kestin et al., 2001; Sanotra et al., 2001; Bradshaw et al., 2002; Knowles et al., 2008). While the meat from a lame chicken can be considered *halal*, the processes involved that lead to lameness may be questionable. Islam and its adherents are concerned with ethical issues such as animal welfare that are exemplified in CP 2 (handling of the poultry during transportation and lairage). However, Muslim consumers may need to determine the acceptable limits for the modification of natural growth and development and its consequences, such as lameness, from an animal welfare point of view. *Halal* certification authorities might wish to evaluate to what extent the modifications in natural growth and development are acceptable to maintain the *halal* status of the poultry.

The recent advances of the technology for genetic modification might also raise some *halal* issues, especially if the genetic makeup of the poultry is altered by the addition of genes of *haram* animals such as porcine genes. Similarly, use of radiation or mutagens at the germplasm stage, if used for poultry breeding in the future, might raise *halal* concerns. It is to be noted here that selective poultry breeds used in current industrial slaughtering are widely accepted as *halal*. Nonetheless, those involved with *halal* poultry need to continue to pay attention to these issues, but because they are not current issues for poultry, they are not proposed as a CP at this time.

## CP 2: Welfare of Poultry During Transportation and Lairage

Feed withdrawal prior to commencing the journey is a common practice that allows for evacuation of intestinal contents; the latter can lead to cross-contamination of poultry during processing, particularly in the scalding tank (Petracci et al., 2010). According to the OIE

(2012), the maximum time allowed without feed is 12 h starting with the catching of the birds on the farm.

Transportation of live chickens is stressful from the animal welfare point of view and is potentially complicated by excess number of animals being loaded onto the transportation vehicle and by temperature stress (Duncan, 2001; Warriss et al., 2005; Petracci et al., 2006; Terlouw et al., 2008; Petracci et al., 2010). Moreover chickens are commonly deprived of food and water while being transported, and the duration of food and water withdrawal can be between 6 to 12 h (Petracci et al., 2010). Ideally poultry will be off-loaded and slaughtered upon arrival. If necessary, during periods of heat stress, animals will be held in an area with forced air movement to assure good ventilation.

Lairage is defined as a place where livestock are held temporarily before slaughter (OIE, 2012). The period of lairage can be used to allow animals to recover from stress from transportation between farms and the slaughter plants (Zhang et al., 2009, 2010).

Any abusive and inhumane handling of animals such as unnecessary stressful conditions while transporting and during lairage is not permissible in Islam. This principle can be based on (1) the instruction of Prophet Muhammad (PBUH) for his companions to provide food for the animals while travelling [*Hadith* no. 14, Supplementary Table S1], (2) kindness to animals is rewardable in Islam [*Hadith* no. 15, Supplementary Table S1], and (3) causing suffering to animals is condemnable [*Hadith* no. 16, Supplementary Table S1].

It is notable that Islam prohibits the act of starving animals and animal cruelty under any circumstances. Moreover, in particular before slaughter, animals should be treated with mercy to ensure good slaughter, as well as from the viewpoint of providing wholesome meat (Tankson et al., 2001). Thus, humane best practices for handling of poultry become CP 2.

## CP 3: Immobilization to Facilitate Slaughtering

In industrial meat processing, chickens are restrained prior to stunning, neck cutting, and further processing using shackles or cones.

**Shackling and Cones** Shackling of chickens is done by placing the legs of live chickens on metallic shackles with their heads in a downward position. This can be painful as it stimulates the cutaneous nociceptors in the legs (Gentle, 2011). Generally, chickens remain shackled even after the neck cutting, until they become unconscious. This condition may be considered by some to be equivalent to tying a chicken by its legs, an act that is forbidden by the Prophet Muhammad (PBUH) [*Hadith* no. 17, Supplementary Table S1]. Cones allow the chicken to be placed in an upside down position with its whole body supported (Hillebrand et al., 1996). The use of cones for restraint was shown to reduce the convulsion effect during stunning and consequently



improved meat quality (Hillebrand et al., 1996). It might be considered that the use of cones is not practical for the large-scale slaughter plants. Nonetheless, if shackling is proven to be stressful and painful for the chickens, it is obligatory to adapt alternative techniques to minimize (or eliminate) the stress and pain to comply with the basic principles of *halal* slaughtering. Thus, if adopted, chickens slaughtered in cones could be hung in shackles after becoming unconscious for further processing.

**Water Bath Electrical Stunning** Stunning was introduced in poultry meat processing to render chickens unconscious before slaughter (Bilgili, 1992). The ability to detect pain inflicted during slaughter was thought to be abolished when the chicken becomes unconscious by stunning. A wide variation is found in water bath ES parameters such as voltage, current, duration of stunning, and number of chickens in a stunner at one time (Heath et al., 1994), which makes it difficult to judge whether the conditions used are humane and whether the resulting animals are *halal*. Currents as high as 200 mA have been suggested as necessary to induce epileptic seizures and cardiac arrest (Raj, 2004). Stunning at 120 mA was shown to abolish the somatosensory evoked potentials (SEP) in the brain, which is an indicator of reduced response to pain (Gregory and Wotton, 1989, 1991). However, when compared with the electroencephalogram or with the sensibility test (response to comb pinch), the impact of reduced SEP on pain remains inconsistent and inconclusive. Furthermore, stunning at 105 mA proved to have a lower risk of the animal regaining conscious, while 90% of the stunned chickens at that current experienced heart fibrillation (Kettlewell and Hallworth, 1990) resulting in cardiac arrest and death. In addition, stunning at high current (125 mA) has been shown to produce less blood loss during exsanguination than chickens stunned with low voltage (11 V) (Craig and Fletcher, 1997). In the study, the former setting was done using a constant current stunner in accordance to the EU recommendation for stunning, while the latter setting was based on the commercial constant voltage stunner used in the poultry industry (Craig and Fletcher, 1997). The blood loss was measured 150 s after exsanguination, which may represent the initial (or active) blood loss, rather than total blood loss.

In *halal* meat processing plants, pre-slaughter ES, if accepted, needs critical attention to the parameters of the ES so that it should not (1) interfere with a swift killing by the neck cut; (2) interfere with the flowing of blood following the neck cutting; (3) cause the animal's death (heart stoppage) prior to neck cutting; and (4) cause any additional stress or pain. Although stunning is a modern invention, it may be used as long as the process remains consistent with religious teachings.

According to Islamic teachings, slaughtering must ensure a swift killing of the animals [*Hadith* no. 21,

Supplementary Table S1]. The fastest time to cause brain failure was 90 s when using stunning induced by cardiac arrest (Kettlewell and Hallworth, 1990). This was followed by decapitation (136 s). However, neither method is in compliance with the Islamic slaughtering guidelines. When the chickens were stunned, followed by exsanguination, the time for brain failure varied between 163 to 332 s. But no information on exsanguination alone without stunning was available for that study.

A number of *Qur'anic* verses and *Hadiths* [*Qur'an* 6:145, no. 12; *Hadith* no. 19–20, Supplementary Table S1] endorse the importance of the active flow of blood during slaughtering. Stunning using high current (60 to 125 mA) showed less blood loss compared to low current (20 to 50 mA) (Contreras and Beraquet, 2001). They concluded that at high current, the low blood loss could be due to ventricular fibrillation. Un-stunned birds, however, had the lowest blood loss in the study. This suggests that the stunning parameters for *halal* meat production must be controlled so that they do not interfere with active blood flow during the subsequent bleeding after neck cutting.

Since *halal* slaughter of poultry necessitates bleeding from the neck cut as mentioned in the *Qur'an* and in several *Hadiths* [*Qur'an* 6:145, no. 12; *Hadith* no. 19–20, Supplementary Table S1] and killing by strangulation is prohibited [*Qur'an* 5:3, no. 12, Supplementary Table S1], stunning should not cause the death of the chickens. Chickens have been reported to die even at a stunning current of less than 100 mA (FAWC, 1982; Hindle et al., 2010; Kettlewell and Hallworth, 1990). Stunning can be considered to be equivalent to strangulation if the animal is experiencing cardiac arrest and lack of oxygen resulting in suffocation. Taken together, it can be concluded that reversible ES (stun-to-stun) might be acceptable for *halal* slaughter if properly operated and monitored although irreversible ES (stun-to-kill) is clearly prohibited.

The importance of being merciful to the animals to be slaughtered [*Hadith* no. 18, Supplementary Table S1] must be evaluated so as to be in compliance with *halal* slaughter requirements. In water bath ES, birds had to be hanged and shackled in an upside down position, and this is an uncomfortable position for the birds. Some birds also may experience pre-stun shocks due to the improper design of the line processing and ramp of the stunner's entrance (Shields and Raj, 2010). Thus, the stress and discomfort in the birds due to the ES system need to be minimized so they can be in compliance with merciful slaughter.

Therefore, acceptable parameters for water bath ES, if used, must be critically evaluated and thus this step becomes a part of CP 3.

**Controlled Atmospheric Stunning/Killing (CAS/CAK)** CAS is an alternative to water bath ES. It eliminates the transporting, shackling, and stunning of conscious broilers (Raj, 1998). In CAS,

**Table 5.** Hand slaughter versus machine slaughter: concerns for *halal* slaughtering.

| Concern                       | Hand slaughter  | Machine slaughter  |
|-------------------------------|---|--|
| Recitation of <i>tasmiyah</i> | Possible for the Muslim slaughter man to say <i>tasmiyah</i> for each chicken | Possible at the time of switching the machine on by a Muslim operator for a group of chickens  |
| Position of the neck cut      | Possible for the slaughter man to adjust for each chicken                     | May vary depending on the length of the neck and movement of the chicken   |
| Precision in cutting          | May vary from one chicken to another  | Can be maintained for a group of chickens by pre-adjustment of parameters of the automated cutter and selection of birds of equal size |
|                               | Variation can be reduced in skilled slaughter man                             |  |

chickens are introduced to a mixture of carbon dioxide, oxygen, nitrogen, and/or argon gases prior to neck cutting (Raj, 1998).

Chickens exposed to aversive gaseous environments during the induction of unconsciousness show gasps, head shakes, and wing flapping that start before loss of posture, and may cause some distress (Raj, 2006). Gasping occurs even after the loss of posture, which may last for more than a min (Raj, 2006). Unlike ES, CAS is not associated with carcass defects such as red wing tips, broken bones, and haemorrhages (Abeyesinghe et al., 2007). Systems used for *halal* must not be subject to such stress and the birds must be alive at the time of neck cutting.

#### **CP 4: Act of Slaughtering: Intention, Instrument Used, Personnel, and Premises**

**Intention of Slaughtering: In the Name of Allah (recitation of the *Tasmiyah*)** (Arabic: The invocation of the name of Allah; Allah, Arabic: Commonly translated as God in English): *Tasmiyah* signals the intention of doing the act of slaughtering. Recitation of the *tasmiyah* is an obligation (according to most authorities) as the reminder of an important teaching in Islam: Allah as the Creator gives life and death, and only He provides provisions. A number of *Qur'anic* verses and *Hadiths* refer to the obligation of reciting *tasmiyah* [*Qur'an* 6:121, no. 3, *Hadiths* no. 4–5, Supplementary Table S1] as well as forbidding any sacrifice in the name of anyone else besides and except Allah [*Qur'an* 2:173; 5:3; 6:145; 16:115, no. 12, Supplementary Table S1]. *Tasmiyah* can be recited as the chickens are lined up on the shackles or the cones prior to having their necks cut [*Qur'an* 22:36, no. 5, Supplementary Table S1]. Therefore, it is important to provide time to allow the slaughter man to recite *tasmiyah* for each bird independently. Provisions for reciting the *tasmiyah* might vary when an automated slaughter instrument (machine slaughter) is used and is discussed in the following section.

**Instrument for Slaughtering: Sharp Knife (Manual and Automated)** For meat to be considered *halal*, any sharp instrument is permissible for slaughtering animals [*Hadith* no. 18 and 21, Supplementary Table S1], except the use of a tooth or a bone, which were prohibited [*Hadith* no. 19, Supplementary Table S1]. While a sharp instrument is necessary, sharpening the instrument in front of the animal being slaughtered or any

other animal awaiting slaughter was prohibited by the Prophet (PBUH) [*Hadith* no. 21, Supplementary Table S1]. When an incision on the skin during neck cutting is made using a sharp knife, the number of vascular endothelial cells (**VES**) injured would be less compared to those if cutting is made using a blunt tool (Inoue et al., 1998). The number of injured VES may determine the degree of blood clotting (Chambers and Grandin, 2001). Therefore, neck cutting using a sharp knife is important to guarantee maximum and rapid blood loss for humane slaughtering.

In many commercial slaughter plants, killing of the chickens by neck cutting uses a rotating blade (machine slaughter) that severs major blood vessels allowing the loss of blood. Unlike the manual neck cutting (hand slaughter), machine slaughter does not involve a slaughter man. A number of aspects in neck cutting by machine slaughter need to be critically evaluated for the use of machine slaughter (Table 5). A majority of the schools of thought are in consensus that *tasmiyah* must be recited during slaughter and preferably on each individual bird. The use of recorded *tasmiyah* played during machine slaughter has been reported but this cannot be supported by the fundamental principles of *halal* slaughtering. The chickens' necks must be in the correct position for the rotating blade and thus continuous calibration is necessary to ensure proper neck cutting. This can be monitored either using a closed-circuit television or hiring a person to observe the whole process. The use of machine slaughter can promote efficiency and precision in neck cutting; however, it has to be in parallel with a proper monitoring system that can offer corrective measures on a real-time basis.

It is imperative that the act of neck cutting be done properly by ensuring the right position and the right instrument to maximize blood loss as well as to prevent additional suffering during slaughtering. Therefore, the proper use of the instrument for neck cutting along with the intention of slaughtering become part of proposed CP 4.

**Personnel and Direction While Slaughtering** The believers in the Scriptures are generally considered to be the ones to act accordingly and this has been addressed in the *Qur'an* [*Qur'an* 5:5, no. 7, Supplementary Table S1]. It is important to reiterate that the recitation of the *tasmiyah* is one of the obligatory requirements of *halal* slaughtering. Therefore, it is imperative that those who believe in *Allah* would perform the act of slaughtering

in His name and at the same time it is prohibited to slaughter animals in the name of anyone except *Allah* such as different forms of gods worshiped in different religions. Therefore, if the followers of any of the current versions of the Scriptures other than the *Qur'an* fail to comply with this obligatory requirement of *halal* slaughtering, the status of such slaughter needs to be critically evaluated. Among the followers of the Scriptures, the Jewish slaughter man is permitted to say the *tasmiyah* at the time of slaughter, according to some Orthodox Rabbinical decisors (Regenstein, personal communication). Nonetheless, just like other CP, whether or not believers in the Scriptures can be the personnel who slaughter animals for *halal* meat must be decided by the *halal* certifying authorities. Under most circumstances, *halal* certifying authorities can avoid this issue by simply hiring Muslim slaughter men.

It has been exemplified by the Prophet himself (PBUH) that his act of sacrifice is solely intended for the sake of *Allah* (*Hadith* no.2, Supplementary Table S1). To fulfill the purpose of sacrifice and to distinguish himself from the polytheists, he faced the *Kaaba* (the center of the Masjid-al-Haram (mosque) in Mecca, Saudi Arabia) (*Hadith* no. 2, Supplementary Table S1). Thus both the direction of the personnel involved in slaughtering and the direction that the animal is facing while being slaughtered could be included as part of CP 4 for *halal* slaughtering.

### CP 5: Time for Full Bleed-Out

Based on current industrial slaughter practices, after neck cutting, chickens are allowed to bleed out between 2.5 to 3 min, before the carcasses enter the scalding tank. In the scalding tank chickens are immersed in hot water (50 to 55°C) for subsequent de-feathering. It is important to note that improper neck cutting might result in less blood loss hence elongating the time to death (Alvarado et al., 2007). In such a case it is possible that the chicken would enter the scalding tank alive and die from suffocation under water. These chickens appear redder (Sams and McKee, 2010) than properly killed chickens and are condemned in most countries by the secular authorities and would be considered *haram*.

Among the prohibited methods for slaughtering, the *Qur'an* gives specific examples, such as slaughtering animals by strangling, with a violent blow, due to a head-long fall, or by being gored to death (*Qur'an* 5:3, no. 12, Supplementary Table S1). Therefore, it is important to ensure that the optimum time is provided after neck cutting before entering the scalding tank. Hence the bleed-out time is considered critical for CP 5.

### CP 6: Washing and Packaging to Maintain Good Hygiene and Halal Integrity

Packaging of deboned meat or whole carcasses is generally the last stage of processing in the slaughter plant.

At this stage, caution must be taken to prevent the meat from becoming adulterated with meat from other species. Meat can become adulterated with forbidden materials such as pork or other non-*halal* slaughtered animals (Nakyinsige et al., 2012). This is likely if the same slaughter plant processes non-*halal* animals or does non-*halal* slaughter of *halal* animals. Meat from pig and/or other animals that are not slaughtered according to the Islamic teaching is considered unlawful [*Qur'an* 2:173, 5:3, 16:115 and 6:145, no. 12, Supplementary Table S1]. Some religious authorities do not permit *halal* slaughtering in plants that slaughter pigs.

Traces of alcohol and feces also have been found in '*halal*' meat (Nakyinsige et al., 2012). Traces of alcohol may have originated from the disinfectants used to clean benches and processing equipment. Improper evisceration and washing of the meat can result in fecal residues being found in packaged meat. Inclusion of fecal matter would render the meat product unwholesome under most secular inspection systems, which is consistent with the *Qur'anic* verse regarding the requirements to consume only wholesome food [*Qur'an* 2:168, no. 1, Supplementary Table S1]. If the feces can be isolated from the meat product, either by physically removing it or by washing, then the meat is acceptable. This is related in *Hadith* no. 22 in Supplementary Table S1, which describes that if the forbidden substances can be physically removed, the rest of the food is *halal*.

## CONCLUSION

The current study proposes a model systematic monitoring system for *halal* poultry meat production based on guidelines derived from the *Qur'an* and the *Hadiths*. The proposed CPHS identified 6 critical points that need to be controlled and monitored for *halal* poultry meat production. Such a systematic approach to ensure the *halal* integrity of the end product is meant to facilitate the production of *halal* poultry meat. This model can be adapted to other circumstances by adding or modifying the proposed control points. Finally, it is hoped that the current study will improve the practice of industrial *halal* poultry meat production.

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## Conflict of interest

Authors declare no conflict of interest.



## Author contributions

IAS worked on the field visits, literature review, and compilation from the *Qur'an* and collection of the *Hadiths*. IAS, ASMS, and JMR contributed to the analysis of the Islamic guidelines and the steps at industrial scale. MTR led and conceptualized the project and supervised the project. IAS, ASMS, JMR, and MTR all participated in writing the materials for this study.

## SUPPLEMENTARY DATA

**Table S1.** Guiding principles to develop CPHS for poultry meat production based on the *Qur'anic* verses and the *Hadiths* related to the conditions and criteria in the Islamic slaughter and the Islamic approach to handling animals.

Supplementary data is available at *PSA Journal* online.

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