



## Nutrition & Food Science

Quality assurance and halal control points for the food industry  
An Nee Lau Mohd Hafiz Jamaludin Jan Mei Soon

### Article information:

To cite this document:

An Nee Lau Mohd Hafiz Jamaludin Jan Mei Soon , (2016), "Quality assurance and halal control points for the food industry", Nutrition & Food Science , Vol. 46 Iss 4 pp. -

Permanent link to this document:

<http://dx.doi.org/10.1108/NFS-03-2016-0026>

Downloaded on: 01 July 2016, At: 03:23 (PT)

References: this document contains references to 0 other documents.

To copy this document: [permissions@emeraldinsight.com](mailto:permissions@emeraldinsight.com)

The fulltext of this document has been downloaded 35 times since 2016\*

### Users who downloaded this article also downloaded:

(2015), "Halal supply chain critical success factors: a literature review", Journal of Islamic Marketing, Vol. 6 Iss 1 pp. 44-71 <http://dx.doi.org/10.1108/JIMA-07-2013-0049>

(2015), "Drivers of halal orientation strategy among halal food firms", British Food Journal, Vol. 117 Iss 8 pp. 2143-2160 <http://dx.doi.org/10.1108/BFJ-01-2015-0027>

(2012), "Principles in halal supply chain management", Journal of Islamic Marketing, Vol. 3 Iss 3 pp. 217-243 <http://dx.doi.org/10.1108/17590831211259727>

Access to this document was granted through an Emerald subscription provided by emerald-srm:405310 []

### For Authors

If you would like to write for this, or any other Emerald publication, then please use our Emerald for Authors service information about how to choose which publication to write for and submission guidelines are available for all. Please visit [www.emeraldinsight.com/authors](http://www.emeraldinsight.com/authors) for more information.

### About Emerald [www.emeraldinsight.com](http://www.emeraldinsight.com)

Emerald is a global publisher linking research and practice to the benefit of society. The company manages a portfolio of more than 290 journals and over 2,350 books and book series volumes, as well as providing an extensive range of online products and additional customer resources and services.

Emerald is both COUNTER 4 and TRANSFER compliant. The organization is a partner of the Committee on Publication Ethics (COPE) and also works with Portico and the LOCKSS initiative for digital archive preservation.

\*Related content and download information correct at time of download.

# 1                   **Quality assurance and halal control points for the food industry**

2  
3

## 4   **Introduction**

5   Islam has outlined the rules and regulations for food preparation which suggest the  
6   source, process and people should conform to the principles of Islam faith (Samori *et*  
7   *al.*, 2014) and covers the aspects of nurturing, slaughtering, storage, display,  
8   preparation, hygiene and sanitation. Halal (lawful) foods are free from any  
9   components that Muslims are prohibited from consuming. Most foods are halal except  
10   those that have been specifically prohibited by Qur’ānic guidance (Qur’an, 2:168,  
11   cited in Chandia, 2015) and the Sunnah (the life, actions and teachings of the Prophet  
12   Muhammad [Peace be upon him (PBUH)]) Riaz and Chaudry, 2004a). In addition, the  
13   Qur’ān verses regarding eating and food are “Toyyiban” – an Arabic word translated  
14   as “good or wholesome” (Hashimi *et al.*, 2010).

15           Previous studies on understanding of halal concepts had been conducted  
16   among general Muslim consumers (Ambali and Bakar, 2014), respondents from  
17   higher education institutions (Yusuf and Ab Yajid, 2016), British Muslims (Jamal and  
18   Sharifuddin, 2015) and non-Muslims (Mathew *et al.*, 2014). For Muslim consumers,  
19   halal food and drinks means products that meet the requirements as laid down by the  
20   Shariah law whereas for a non-Muslim consumer, it represents hygiene, cleanliness,  
21   quality and the safety of the product (Ambali and Bakar, 2014; Mathew *et al.*, 2014).

22           Hygiene control and sanitation are the top priorities in the manufacturing and  
23   distribution of food products. The effectiveness of sanitation procedures had been  
24   evaluated using immediate visual assessments or microbiological methods such as  
25   hygiene swabs or agar contact plates (Griffith *et al.*, 2000). Rapid hygiene monitoring  
26   methods such as adenosine triphosphate (ATP) bioluminescence are available to  
27   provide an estimate of total surface contamination in real time has been well  
28   documented (Hawronskyj and Holah, 1997). This technique does not require  
29   laboratory and specialized staff and can be used effectively in field conditions  
30   (Aycicek *et al.*, 2006).

31           Hazard Analysis and Critical Control Points (HACCPs) concept was designed  
32   to prevent microbial, physical and chemical hazards in food for the space missions  
33   (Janevska *et al.*, 2010). The HACCP system is a recommended approach to enhance  
34   food safety from farm to fork. There are suggestions that it could be used to assure

35 halal compliance (Bonne and Verbeke, 2008; Kohilavani *et al.*, 2012; Kohilavani *et*  
36 *al.*, 2013; Riaz and Chaudry, 2004a; van der Spiegel *et al.*, 2012). With the help of  
37 HACCP, Halal Control Points (HCPs) can be identified to eliminate potential  
38 presence of haram (unlawful) components in the manufacturing of halal food products.  
39 Halal Control Points plan can be utilized to ensure both food safety and halal analysis  
40 of food products. This is based on the view that safe food and hygienic production is  
41 the base for halal production (Riaz and Chaudry, 2004a). Food safety is the assurance  
42 that food will not cause harm to the consumer when it is prepared and/or eaten  
43 according to its intended use (CAC, 1997). As such, the term halal encompasses  
44 cleanliness and hygiene in food preparation because cleanliness is part of religion and  
45 Allah (S.W.T.) only permits hygiene, safe and halal foods or products for Muslims  
46 consumptions (Ambali and Bakar, 2014). Utensils, equipment and machinery  
47 (including all food contact surfaces) must be cleaned, sanitized and untainted by  
48 contact with haram materials (Henderson, 2015). For the identification of haram  
49 substance, zero tolerance practice is adopted to ensure that the religious requirements  
50 are stringently followed (Kohilavani *et al.*, 2013). This study aims to determine the  
51 understanding of halal concept among food production workers, evaluate the hygiene  
52 and sanitation (via adenosine triphosphate (ATP) swabbing) and to develop a generic  
53 Halal Control Point (HCP) Plan for food processing.

54

## 55 **Methods**

### 56 *Development of Questionnaires and Interview Questions*

57 A semi-structured questionnaire (with both opened and close-ended questions)  
58 (Burgess, 2001) which include demographic profile, understanding and attitude  
59 towards halal food sections was designed. Statements such as ‘I understand what is  
60 Halal’; ‘Halal focuses on slaughtering only’; ‘Halal focuses on slaughtering and food  
61 quality’; ‘Halal food does not contain pork and alcohol’ and ‘Halal food must be  
62 prepared by Muslims’ were included to capture a snapshot of understanding of halal  
63 concepts among food production workers. In-depth interviews related to the quality  
64 assurance and halal practices in food manufacturing plants were conducted among  
65 Quality Assurance staff. A pilot sample of 30 participants from a food manufacturing  
66 company was carried out. A sample of 30 participants from the population of interest  
67 is a reasonable minimum recommendation for a pilot study where the purpose is  
68 preliminary survey or scale development (Johanson and Brooks, 2009). Cronbach’s

69 alpha is used as a measure of the reliability ( $\geq 0.70$ ) of a set of questions in a survey  
70 instrument as it can measure the interrelatedness of a set of items (Cronbach, 1951).

71

## 72 *Sampling*

73 Two hundred respondents were targeted as the minimum sample size to ensure  
74 reliability (Yurdugul, 2008). Respondents (ethnic origins and religions were not taken  
75 into consideration to reduce biasness) were randomly selected from four different  
76 halal food manufacturing plants: Company A (soy sauce), Company B (frozen  
77 chicken roll), Company C (oat) and Company D (coffee powder). 150 respondents  
78 were from companies A and B and the remaining 50 from firms C and D. Although  
79 survey and interviews were conducted among workers from Company A, no  
80 swabbing tests were allowed. All organisations had been renamed as A – D to ensure  
81 anonymity.

82

## 83 *Real Time ATP Hygiene Monitoring System and Microbiological Tests*

84 Hygiena's SystemSURE Plus (Hygiena, Camarillo, CA, United States) ATP hygiene  
85 monitoring system was used to detect the level of hygiene in workers' and associated  
86 food preparation surfaces in the processing plants. Food contact surfaces and workers'  
87 hands (from lower palm to each fingertips) were swabbed during production and  
88 results were expressed numerically as Relative Light Units (RLU) (Hygiena, 2013).  
89 End products were collected from each food processing plants and transported back to  
90 the laboratory. Short shelf life product i.e. frozen chicken roll were transported in a  
91 carrier box containing ice packs and analyses were performed upon receipt of samples  
92 at the laboratory. However, if a laboratory analysis was postponed due to delayed  
93 arrival of samples, the samples were refrigerated at 0 – 4°C until examination but  
94 were not kept longer than 36 hours (Al Mamun *et al.*, 2013). 25 g of each sample  
95 were homogenised in 1% buffered peptone water in a Stomacher 400 Circulator  
96 (Seward, UK) blender for 2 minutes. Following homogenization, all samples were  
97 tested for total plate count.

98

## 99 *Halal Control Points (HCPs)*

100 In this study, HACCP and Halal Critical Control Points decision tree (Kohilavani *et*  
101 *al.*, 2013; MS 1500: 2009) were adapted to identify and eliminate potential presence  
102 of haram components (Figure 1).

103

104 **Figure 1.** Decision tree to identify Halal Critical Control Points (HCCPs) in  
 105 ingredients and process controls (Kohilavani *et al.*, 2013; MS 1500: 2009)

106

## 107 **Results and Discussion**

### 108 *Validation of Questionnaire*

109 The pilot test questionnaires were analyzed and the value of Cronbach's alpha was  
 110 0.801. The higher the Cronbach's alpha coefficient is, the more correlated the items  
 111 are within the relevant variable which theoretically should be higher than 0.700  
 112 (Pallant, 2005).

113

### 114 *Demographics*

115 Majority of the participants came from the age group of 31 to 40 years (40.00%)  
 116 (Table 1). According to the Department of Statistics Malaysia (2015), the percentage  
 117 of employed persons in 2014 showed that 76.20% of the persons employed were from  
 118 the age group of 25 to 54 years old whereas minority (8.20%) were employees from  
 119 age 55 to 64 years old. Furthermore, majority of the respondents (87%) had  
 120 completed secondary education whilst 19% studied at upper secondary schools and  
 121 above.

122

123 **Table 1.** Demographics of food production workers (N = 200)

124

### 125 *Understanding and Attitude towards Halal Food Products*

126 The respondents' understanding of halal principles is important in providing an  
 127 insight into Malaysian consumers' attitudes toward halal products. In this case, 77  
 128 respondents (38.50%) claimed that they understand the concept of halal. In contrast, a  
 129 minority of them claimed that halal foods must only be prepared by Muslims ( $\chi^2 =$   
 130 50.95;  $df = 4$ ;  $P < 0.05$ ) (Table 2). Previous findings suggested that consumers  
 131 generally perceive pork and alcohol to be haram (Salman and Siddiqui, 2011).  
 132 Although participants have various responses towards this statement, these do not  
 133 indicate that they have a poor understanding or misconception towards the concept of  
 134 halal. (Nawai *et al.*, 2007). In fact halal has now become a universal concept as

135 demonstrated in other similar studies (Ambali and Bakar, 2014; Henderson, 2015;  
136 Mohd Shariff and Abd Lah, 2014).

137

138 **Table 2.** Participants' single response towards the concept of halal (N=200)

139

140 Based on Table 3, 76.5% of the respondents (regardless of religion)  
141 demonstrated a positive attitude towards halal food products. Religious beliefs, food  
142 safety, animal welfare, environmentally friendly, age, education level and area of  
143 residence are significant determinants of the consumers' attitude towards  
144 understanding and awareness of halal principles and halal food products (Rezai *et al.*,  
145 2010). However, the behaviors of Muslims consumers are largely predisposed by their  
146 Islamic ideology (Salman and Siddiqui, 2011).

147

148 **Table 3.** Attitude of respondents towards halal food products (N=200)

149

150 *ATP Swabbing Tests*

151

152 **Table 4.** Adenosine Triphosphate (ATP) swabbing tests (N =12)

153

154 Company B revealed the highest average RLUs ( $233.5 \pm 2.1$ ) due to the presence of  
155 food debris and this is particularly related to the chemical composition of the organic  
156 residues present (Moore and Griffith, 2002). Investigation conducted in vegetable  
157 processing plant revealed that the surface of chopping board possessed 209 RLU  
158 (Kuisma *et al.*, 2014). In contrast, the lowest average RLUs were recorded in  
159 Company C. This might be due to the implementation of HACCP and International  
160 Organisation for Standardisation (ISO) 22000 Food Safety Management Systems in  
161 the manufacturing plant. Food production workers' left and right hands (from lower  
162 palm to each fingertips) were swabbed as these areas can provide a suitable and  
163 sufficient surface area for swabbing (Yaambut *et al.*, 2016). The highest mean RLU  
164 ( $96.5 \pm 2.1$ ) was recorded in workers from Company D. It is probable that the daily  
165 cleaning is not following the standard procedures. Similar ATP swabs were conducted  
166 domestically by Larson *et al.* (2003) with acceptable values ( $2.6 \pm 0.8$  RLU) (Larson  
167 *et al.*, 2003) while Sudheesh *et al.* (2013) reported that all tested food contact surfaces  
168 failed the sanitation quality test with readings as high as 100,000 RLU. Aprons were

169 provided for food production workers which were changed on a daily basis. The  
 170 highest mean RLU was found among workers from Company B. The lowest mean  
 171 RLU reading was from Company C which has an integrated automated system to  
 172 facilitate mechanical production of goods, and workers' aprons were less likely to be  
 173 contaminated with food residues. In another similar study, Worsfold and Griffith  
 174 (2001) found 96469.00 RLU on aprons and the ATP might had be derived from dead  
 175 microorganisms, food residues or hand ATP. Primary or secondary packaging  
 176 materials (plastic) were also swabbed. In this case, the recorded RLU readings for  
 177 three companies were same, which was 0 RLU.

178

### 179 *Halal Control Points (HCPs)*

180 Hazard Analysis and Critical Control Points (HACCPs) is a Food Safety Management  
 181 System (Al-Kandari and Jukes, 2011) which is widely acknowledged as the best  
 182 method of assuring product safety whilst becoming internationally recognized as a  
 183 tool for controlling food borne safety hazards (Khandke and Mayes, 1998; Wallace *et*  
 184 *al.*, 2005). In this study, HACCP was adapted with Halal Control Points (HCPs) to  
 185 identify and eliminate potential presence of haram components. Based on Kohilavani  
 186 *et al.* (2013) decision tree, survey and the interview results from the four food  
 187 manufacturing plants, four specific HCPs plans were developed (SeeAppendix for  
 188 Supplementary File Tables 1-4). The supplementary tables provide a halal analysis  
 189 and justification for inclusion of the HCPs. This concept is similar to hazard analysis  
 190 in HACCP.

191

192 Based on the four specific HCPs plans generated, a generic HCPs Plan was developed  
 193 (Figure 2). It is useful as it can be used as a guideline in halal food industries with the  
 194 purpose of identifying the possible sources of haram contamination.

195

196 **Figure 2.** Generic Halal Control Points for food industries

197

### 198 *HCP 1: Halal Certification*

199 When importing raw materials from foreign countries, the manufacturer sends  
 200 representative to the supplier's site to conduct audit. This includes inspecting the  
 201 implementation of halal practices in the premises, quality of the raw materials and

202 halal certification. Today, many Muslims countries require food products imported to  
203 their countries be certified halal (van der Spiegel *et al.*, 2012). In order to get halal  
204 certification, inspection of the facility, review of sanitation, ingredients and labels and  
205 training the company personnel are important (Riaz and Chaudry, 2004b).

206

#### 207 *HCP2: Equipment*

208 For the company producing non-meat products, it is sufficient to clean equipment and  
209 determine cleanliness by visual observation. If food premises producing halal food  
210 carry out haram operations, it is required to perform a mandatory ritual cleansing  
211 (Man and Sazili, 2010). Besides, chemicals used for cleaning should be screened to  
212 avoid animal fat origin (Riaz and Chaudry, 2004a) and the brushes should be halal  
213 certified as it can be made out of pigs' hair (Fischer, 2015).

214

#### 215 *HCP3: Raw materials/ingredients*

216 The halal status of ingredients derived from plant origins is rarely an issue except it is  
217 from animals (Riaz and Chaudry, 2004a). Flavours and flavourings contain several  
218 ingredients that can be derived from microorganisms, plants, minerals, petroleum,  
219 animals and synthetic sources. So, the manufacturer has to make sure that any  
220 flavours, proprietary mixes or secret formulas are halal and free from doubtful  
221 materials (Riaz and Chaudry, 2004a).

222

#### 223 *HCP4: Transportation and storage*

224 Often, the manufacturer takes charge of the shipping and storage condition or they  
225 rely on the vehicles of buyers in the distribution of goods. The vehicles used to  
226 transport goods must be cleansed thoroughly and avoided from shipping food  
227 products which could emit pungent odor such as onion or garlic. The storage  
228 condition should also be inspected by the related staff to ensure the freshness of the  
229 food products. During transportation, halal foods must be handled properly to avoid  
230 cross-contamination with haram products.

231

#### 232 *Microbiological Analysis*

233 No microorganisms were detected in food samples such as frozen chicken roll, oat  
234 and coffee powder but the TPC found in soy sauce was  $4.8 \pm 5.1$  log CFU/mL. Yan *et*  
235 *al.* (2013) conducted an enumeration of microbiota present during koji-making in soy

236 sauce production found that the total mesophilic aerobic bacteria (TMAB) was 8.8 log  
 237 CFU/g. In this study, the microbial load was much lower compared to Yan *et al.*  
 238 (2013) which may be attributed to the heat treatment applied on the soy sauce after  
 239 passing through the koji-making process. Soy sauce was found to initiate the growth  
 240 of purple mucoid colonies on Eosin and Methylene Blue (EMB) Agar. The absence of  
 241 green metallic sheen suggested that *Escherichia coli* was absent as Eosin methylene  
 242 blue agar provides a rapid and accurate method to identify *Escherichia coli* (Leininger  
 243 *et al.*, 2001; Macfadden, 1985) Primary screening test was performed and the  
 244 suspected colonies were from the family of Enterobacteriaceae (Singh *et al.*, 2015).  
 245 Previous studies revealed that nine species belonging to the family Enterobacteriaceae  
 246 were identified in the fermentation of inyu (Wei *et al.*, 2013) and koji (Yan *et al.*,  
 247 2013).

248

#### 249 *Conclusion*

250 The findings indicated that food production workers in general demonstrated an  
 251 understanding and positive attitude towards halal food products. In terms of hygiene  
 252 and sanitation of the manufacturing plants, the ATP swabbing tests of food contact  
 253 surfaces (tabletops) revealed that only two companies passed the swabbing tests ( $\leq 10$   
 254 RLU). The ATP swabbing tests for all workers' hands and aprons did not meet the  
 255 hygiene requirements ( $> 30$  RLU). Based on the interviews conducted with quality  
 256 control staff, Halal Control Points (HCPs) were identified in the manufacturing  
 257 process of food products, and one generic HCPs plan and four specific HCP plans  
 258 were developed for the manufacturing process of halal food products for each food  
 259 company.

260

#### 261 **References**

- 262 Al-Kandari, D. and Jukes, J.D. (2011). "Incorporating HACCP into National Food  
 263 Control Systems - Analyzing Progress in the United Arab Emirates", *Food*  
 264 *Control*, Vol. 22, 851-861.
- 265 Al Mamun, M., Rahman, S.M.M. and Turin, T.C. (2013). "Microbiological quality of  
 266 selected street food items vended by school-based street food vendors in  
 267 Dhaka, Bangladesh", *International Journal of Food Microbiology*, Vol. 166  
 268 No. 3, 413-418.
- 269 Ambali, A.R. and Bakar, A.N. (2014). "People's awareness on halal foods and  
 270 products: Potential issues for policy-makers", *Procedia – Social and*  
 271 *Behavioral Sciences*, Vol. 121, 3-25.
- 272 Aycicek, H., Oguz, U. and Karci, K. (2006). "Comparison of results of ATP  
 273 bioluminescence and traditional hygiene swabbing methods for the

- determination of surface cleanliness at a hospital kitchen”, *International Journal of Hygiene and Environmental Health*, Vol. 209 No. 2, 203-206.
- Bonne, K. and Verbeke, W. (2008). “Religious values informing halal meat production and the control and delivery of halal credence quality”, *Agriculture and Human Values*, Vol. 35, 35-47.
- Burgess, T.F. (2001). A General Introduction to the Design of Questionnaires for Survey Research. *Information Systems Services University of Leeds*. Retrieved 20 March 2015, from <http://iss.leeds.ac.uk/downloads/top2.pdf>
- CAC (1997). *CAC/GL 24-1997 General Guidelines for use of the term "Halal"*, s.l.: Codex Alimentarius Commission.
- Chandia, M. (2015). *Translation of the Holy Qur'an*. London: Azhar Academy.
- Cronbach, L.J. (1951). “Coefficient alpha and the internal structure of tests”, *Psychometrika*, Vol. 16 No. 3, 297-334.
- Department of Statistics Malaysia, Official Portal. (2015). Labour Force Survey Report, Malaysia, 2014. Retrieved 19 November 2015, from [https://www.statistics.gov.my/dosm/index.php?r=column/cthemendmenu\\_id=U3VPMldoYUxzVzFaYmNkWXZteGduZz09andbul\\_id=NHUxTlk1czVzMGYwS29mOEc5NUtOQT09](https://www.statistics.gov.my/dosm/index.php?r=column/cthemendmenu_id=U3VPMldoYUxzVzFaYmNkWXZteGduZz09andbul_id=NHUxTlk1czVzMGYwS29mOEc5NUtOQT09)
- Fischer, J. (2015). Manufacturing halal in Malaysia. *Contemporary Islam*, 1-18.
- Griffith, C., Cooper, R., Gilmore, J., Davies, C. and Lewis, M. (2000). “An evaluation of hospital cleaning regimes and standards”, *Journal of Hospital Infection*, Vol. 45 No. 1, 19-28.
- Hashimi, D., Saifuddeen, M. and Salleh, M. (2010). “A background on Halal industry and principles. In: *International Workshop for Islamic Scholars on Agribiotechnology: Shariah Compliance*. Georgetown: Malaysia Biotechnology Information Center (MABIC), The International Service for the Acquisition of Argi-biotech Applications (ISAAA), pp. 12-20.
- Hawronskyj, J., and Holah, J. (1997). “ATP: A universal hygiene monitor”, *Trends in Food Science and Technology*, Vol. 8 No. 3, 79-84.
- Henderson, J.C. (2015). “Halal food, certification and halal tourism: Insights from Malaysia and Singapore”, *Tourism Management Perspectives*, doi: 10.1016/j.tmp.2015.12.006
- Hygiena. (2013). *A Guide to ATP Hygiene Monitoring*. Retrieved 10 March 2015, from [http://www.hygiena.net/doc\\_download/97-atp-hygiene-monitoring-guide](http://www.hygiena.net/doc_download/97-atp-hygiene-monitoring-guide)
- Jamal, A. and Sharifuddin, J. (2015). “Perceived value and perceived usefulness of halal labelling: The role of religion and culture”, *Journal of Business Research*, Vol. 68 No. 5, 933-941.
- Janevska, D.P., Gospavic, R., Pacholewicz, E. and Popov, V. (2010). “Application of a HACCP–QMRA approach for managing the impact of climate change on food quality and safety”, *Food Research International*, Vol. 43 No. 7, 1915-1924.
- Johanson, G. and Brooks, G. (2009). “Initial scale development: Sample size for pilot studies. *Educational and Psychological Measurement*, Vol. 70 No. 3, 394-400.
- Khandke, S., and Mayes, T. (1998). “HACCP Implementation: A practical guide to the implementation of the HACCP plan”, *Food Control*, Vol. 9 No. 2-3, 103-109.
- Kohilavani, Yang, T. A., Febrianto, N. A., Abdullah, W. and Tajul Aris, A. (2012). “A decision tree based approach for the identification of Halal Critical Control Point for slaughtering according to Islamic dietary law”, *Internet Journal of Food Safety*, Vol. 14, 48-53.

- 324 Kohilavani, Zzaman, W., Febrianto, N., Zakariya, N., Abdullah, W. and Yang, T.  
325 (2013). “Embedding Islamic dietary requirements into HACCP approach”,  
326 *Food Control*, Vol. 34 No. 2, 607-612.
- 327 Kuisma, R., Pienmunne, E., Lehto, M. and Kymalainen, H.R. (2014). “Surface  
328 hygiene in vegetable processing plants: Results of a repeated hygiene survey.  
329 *Journal of Hygienic Engineering and Design*, Vol. 7, 53-60.
- 330 Larson, E., Aiello, A., Gomez-Duarte, C., Lin, S., Lee, L., Della-Latta, P. and  
331 Lindhardt, C. (2003). “Bioluminescence ATP monitoring as a surrogate  
332 marker for microbial load on hands and surfaces in the home”, *Food  
333 Microbiology*, Vol. 20 No. 6, 735-739.
- 334 Leininger, D., Roberson, J. and Elvinger, F. (2001). “Use of Eosin Methylene Blue  
335 agar to differentiate *Escherichia coli* from other gram-negative mastitis  
336 pathogens”, *Journal of Veterinary Diagnostic Investigation*, Vol. 13 No. 3,  
337 273-275.
- 338 MacFadden, J.F. (1985). Eosin Methylene Blue Agars. *Media for the isolation-  
339 cultivation-identification-maintenance of medical bacteria*. Volume 1.  
340 Baltimore, MD: Williams and Wilkins. pp. 292–297.
- 341 Man, Y.B.C. and Sazili, A.Q. (2010). Food Production from the Halal Perspective. In  
342 Isabel, G. and Hui, Y. H. (eds). *Handbook of Poultry Science and Technology,  
343 Volume 1: Primary Processing*. John Wiley and Sons, Inc, pp. 184-214.
- 344 Mathew, V.N., Amir Abdullah, A.M.R. and Mohamad Ismail, S.N. (2014).  
345 “Acceptance on halal food among non-Muslim consumers”, *Procedia – Social  
346 and Behavioral Sciences*, Vol. 121, 262-271.
- 347 Mohd Shariff, S. and Abd Lah, N.A. (2014). “Halal certification on chocolate  
348 products: A case study”, *Procedia – Social and Behavioral Sciences*, Vol. 121,  
349 104-112.
- 350 Moore, G. and Griffith, C. (2002). “A comparison of traditional and recently  
351 developed methods for monitoring surface hygiene within the food industry:  
352 An industry trial”, *International Journal of Environmental Health Research*,  
353 Vol. 12 No. 4, 317-329.
- 354 MS 1500: 2009 (Malaysian Standard) (2009). Halal food – Production, preparation,  
355 handling and storage – General guidelines. (Second Revision). Department of  
356 Standards Malaysia. Retrieved 3 December 2015, from  
357 <https://law.resource.org/pub/my/ibr/ms.1500.2009.pdf>
- 358 Nawai, N., Nooh, M.N., Dali, N.R.S.M. and Mohammad, H. (2007). “An exploratory  
359 study on halal branding among consumers in Malaysia: Factor analysis  
360 technique”, *Journal of Muamalat and Islamic Finance Research*, Vol. 4 No. 1,  
361 19-44.
- 362 Pallant, J. (2005). *SPSS Survival Manual*, Open University Press, Berkshire, United  
363 Kingdom.
- 364 Rezai, G., Mohamed, Z., Shamsudin, M.N. and Chiew, E.F.C. (2010). “Non-Muslims’  
365 awareness of halal principles and related food products in Malaysia”,  
366 *International Food Research Journal*, Vol. 17, 667-674.
- 367 Riaz, M.N., and Chaudry, M.M. (2004a). *Halal Food Production*. Boca Raton, FL:  
368 CRC Press. pp. 1-28.
- 369 Riaz, M.N., and Chaudry, M.M. (2004b). “The value of halal food production”,  
370 *International News on Fats, Oils and Related Materials*, Vol. 15 No. 11, 698-  
371 700.

- 372 Salman, F. and Siddiqui, K. (2011). "An exploratory study for measuring consumers  
373 awareness and perceptions towards halal food in Pakistan", *Interdisciplinary*  
374 *Journal of Contemporary Research in Business*, Vol. 3 No. 2, 639-651.
- 375 Samori, Z., Ishak, A., and Kassan, N. (2014). "Understanding the development of  
376 halal food standard: Suggestion for future research", *International Journal of*  
377 *Social Science and Humanity*, Vol. 4 No. 6, 482-486.
- 378 Singh, J., Sharma, S. and Nara, S. (2015). "Evaluation of gold nanoparticle based  
379 lateral flow assays for diagnosis of Enterobacteriaceae members in food and  
380 water", *Food Chemistry*, Vol. 170, 470-483.
- 381 Sudheesh, P.S., Al-Ghabshi, A., Al-Aboudi, N., Al-Gharabi, S., and Al-Khadhuri, H.  
382 (2013). "Evaluation of food contact surface contamination and the presence of  
383 pathogenic bacteria in seafood retail outlets in the Sultanate of Oman",  
384 *Advance Journal of Food Science and Technology*, Vol. 5 No. 2, 77-83.
- 385 van der Spiegel, M., van der Fels-Klerx, H., Sterrenburg, P., van Ruth, S., Scholtens-  
386 Toma, I. and Kok, E. (2012). "Halal assurance in food supply chains:  
387 Verification of halal certificates using audits and laboratory analysis", *Trends*  
388 *in Food Science and Technology*, Vol. 27 No. 2, 109-119.
- 389 Wallace, C., Powell, S. and Holyoak, L. (2005). "Development of methods for  
390 standardized HACCP assessment", *British Food Journal*, Vol. 107 No. 10,  
391 723-742.
- 392 Wei, C., Chao, S., Tsai, W., Lee, P., Tsau, N., Chen, J., Lai, W., Tu, J. and Tsai, Y.  
393 (2013). "Analysis of bacterial diversity during the fermentation of inyu, a  
394 high-temperature fermented soy sauce, using nested PCR-denaturing gradient  
395 gel electrophoresis and the plate count method", *Food Microbiology*, Vol. 33  
396 No. 2, 252-261.
- 397 Worsfold, D. and Griffith, C. (2001). "An assessment of cleaning regimes and  
398 standards in butchers' shops", *International Journal of Environmental Health*  
399 *Research*, Vol. 11 No. 3, 245-256.
- 400 Yaambut, N., Ampornaramveth, R.S., Pisanrturakit, P.P. and Subbalekha, K. (2016).  
401 "Dental student hand hygiene decreased with increased clinical experience",  
402 *Journal of Surgical Education*, doi: 10.1016/j.jsurg.2015.12.007
- 403 Yan, Y., Qian, Y., Ji, F., Chen, J. and Han, B. (2013). "Microbial composition during  
404 Chinese soy sauce koji-making based on culture dependent and independent  
405 methods", *Food Microbiology*, Vol. 34 No. 1, 189-195.
- 406 Yurdugul, H. (2008). "Minimum sample size for Cronbach's coefficient alpha: A  
407 Monte-Carlo study", *Hacettepe University Journal of Education*, Vol. 35, 397-  
408 405.
- 409 Yusuf, E. and Ab Yajid, M.S. (2016). "Halal pharmaceuticals and cosmeceuticals  
410 from the perspective of higher education", *Asian Journal of Pharmaceutical*  
411 *Sciences*, Vol. 11, 18-19.
- 412
- 413 Appendix
- 414 Insert Supplementary file tables 1-4 (four tables)

**Table 1.** Demographics of food production workers (N = 200)

Demographic items	N (%)
Age	
≤ 20	None
21-30	73 (37)
31-40	80 (40)
41-50	36 (18)
≥ 51	11 (6)
Position	
Manager	4 (2)
Production worker	140 (70)
Quality assurance/executive	9 (5)
Research and development executive	8 (4)
Supervisor	9 (5)
Others	30 (15)
Number of years working in food industry	
≤ 5	103 (52)
6-10	59 (30)
11-20	33(17)
≥ 21	5 (3)
Academic qualification	
Primary level	None
Lower secondary level	40 (20)
Secondary level (O levels)	87 (44)
Upper secondary level (A levels)	2 (1)
Diploma/Degree/Master/PhD	36 (18)
Others	35 (18)

Notes: N represents the number of respondents; (%) represents their share in the sample.

**Table 2.** Participants' response towards halal concepts (N=200)

Understanding of halal concepts:	<i>N</i> (%)
I understand what is Halal	77 (39)
Halal focuses on slaughtering only	24 (12)
Halal focuses on slaughtering and food quality	32 (16)
Halal foods do not contain pork and alcohol	45 (23)
Halal foods must be prepared by Muslims	22 (11)

Notes: N represents the number of respondents; (%) represents their share in the sample. Chi-square test has been performed ( $\chi^2 = 50.95$ ) and all statements are significantly different at the level of 5%.

**Table 3.** Attitude of respondents towards halal food products (N=200)

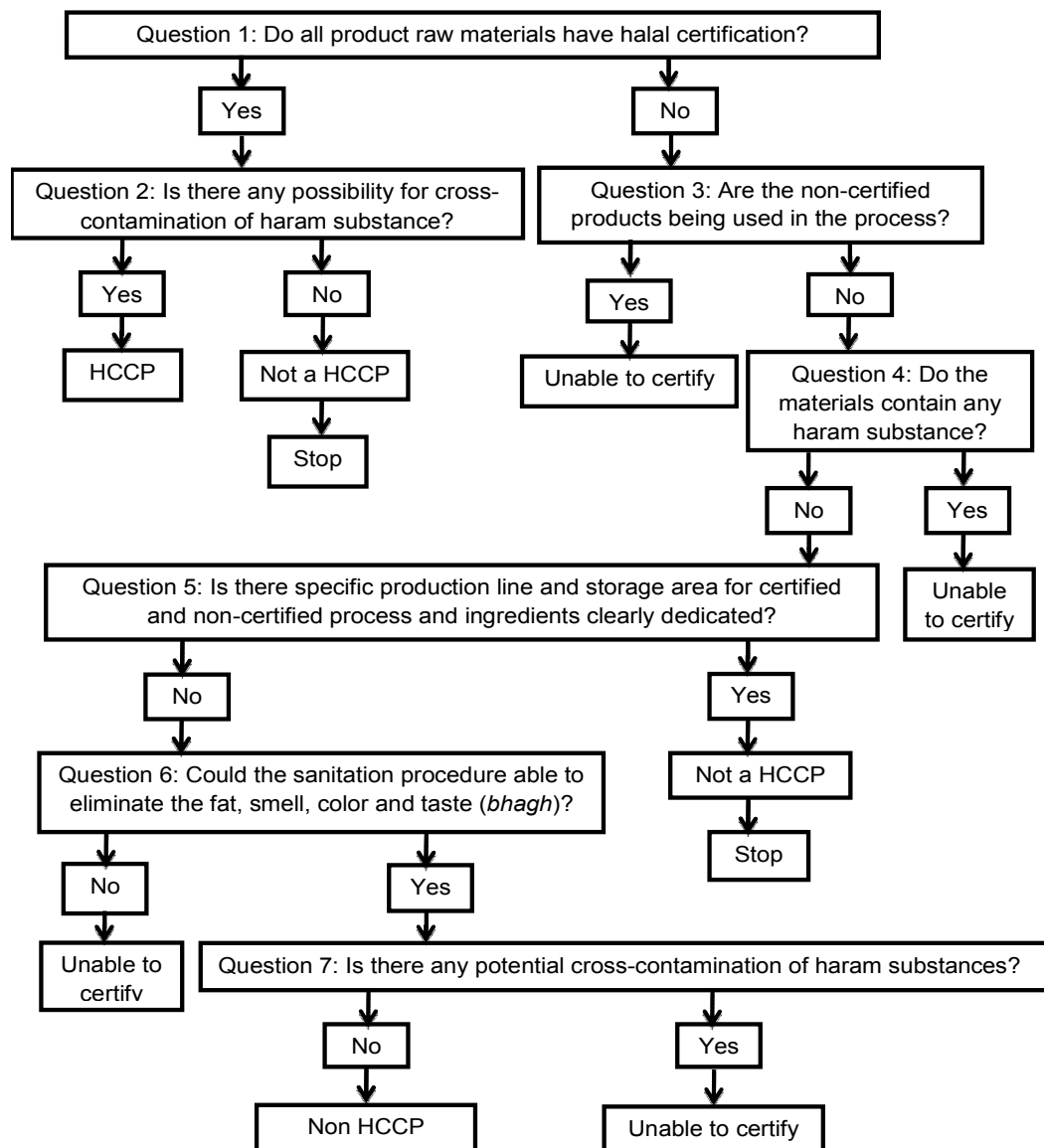
<b>Statement</b>	<b>N (%)</b>
I emphasized the halal status of food products that I purchased <sup>a</sup>	
Strongly disagree	0
Disagree	0
Neither agree nor disagree	47 (24)
Agree	95 (48)
Strongly agree	58 (29)
Religious obligation is a major concern of mine when purchasing food products <sup>b</sup>	
Strongly disagree	0
Disagree	0
Neutral	54 (27)
Agree	97 (49)
Strongly agree	49 (25)
Halal principle is related to hygiene and food safety <sup>c</sup>	
Strongly disagree	0
Disagree	0
Neutral	50 (25)
Agree	93 (47)
Strongly agree	57 (29)
Knowing how halal food is produced or processed is very important <sup>d</sup>	
Strongly disagree	0
Disagree	0
Neutral	55 (28)
Agree	100 (50)
Strongly agree	45 (23)

Notes: N represents the number of respondents; (%) represents their share in the sample (five-point Likert scale: 1 = “strongly disagree”, 3 = “neutral”, 5 = “strongly agree”). Chi-square test has been performed to compare the statements of respondents towards halal food products. Items denoted with superscripts represent the  $\chi^2$  values (a = 18.97; b = 20.89; c = 15.97; d = 25.75) and all statements are significantly different at the level of 5%.

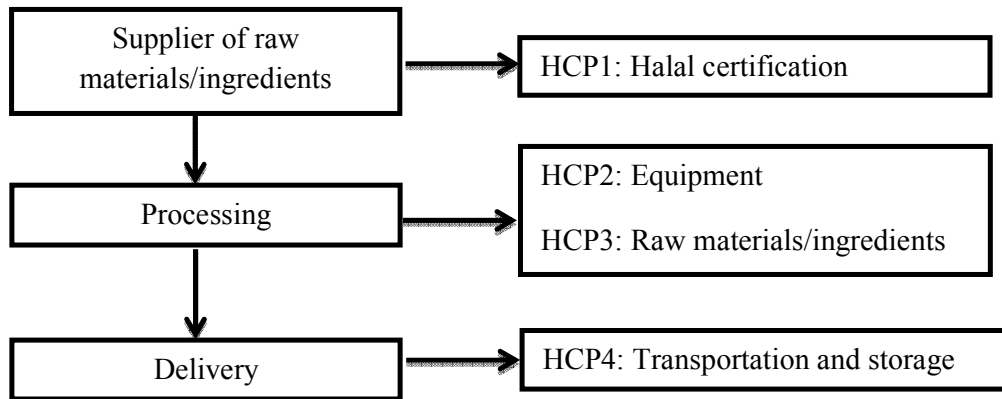
**Table 4.** Adenosine Triphosphate (ATP) swabbing tests (N =12)

Area being swabbed	Company (Reflective Light Unit [RLUs] of contact surfaces)			
	A (soy sauce)	B (chicken roll)	C (oat)	D (coffee powder)
Preparation tables	-	Fail (233.5 ± 2.1)	Pass (1.0 ± 0)	Pass (2.5 ± 0.7)
Workers' hands (left and right hands – swabbed from lower palm to each fingertips)	-	Fail (82.0 ± 2.8)	Fail (73.0 ± 1.4)	Fail (96.5 ± 2.1)
Workers' aprons	-	Fail (84.5 ± 0.7)	Fail (56.5 ± 2.1)	Fail (67.0 ± 1.4)
Packaging materials	-	Pass (0)	Pass (0)	Pass (0)

Notes: N represents the number of swab samples. The calculated values are expressed as mean values of triplicate samples ± standard deviation. Swabbing tests were not permitted in Company A. Pass: Any score of 10.00 RLU or less; Caution: Scores from 11.00 to 30.00 RLU; Fail: Any score greater than 30.00 RLU



**Figure 1.** Decision tree to identify Halal Critical Control Points (HCCPs) in ingredients and process controls (Kohilavani *et al.*, 2013; MS 1500: 2009)



**Figure 2.** Generic Halal Control Points (HCPs) for food industries (See Supplementary Files Tables 1 – 4 for halal analysis and identification of HCPs)

**Supplementary File Table 1.** Halal analysis and identification of Halal Control Points (HCPs) in production of soy sauce

<b>Process steps</b>	<b>Halal Control Points (HCPs)</b>	<b>Justifications</b>	<b>Preventive measures</b>
Selection	HCP 1	Potential for transport or storage contamination with non-halal products	Suppliers to provide halal certifications or conduct suppliers' second party audit to verify storage of soy beans and incoming goods check
Koji / Moromi	HCP 2	Potential for mixing with non-halal products such as alcohol to enhance the flavour and taste of soy sauce	Quality control performed by related trained staff in halal certification
Refined soya sauce	HCP 3	Potential of entrance of non-halal products into the final product	Quality control performed by related trained staff in halal certification
Delivery	HCP 4	Potential for transport contamination with non-halal products	Transports were cleaned and inspected by related trained staff in halal certification

**Supplementary File Table 2.** Halal analysis and identification of Halal Control Points (HCPs) in production of frozen chicken roll

<b>Process steps</b>	<b>Halal Control Points (HCPs)</b>	<b>Justifications</b>	<b>Preventive measures</b>
Receipt of halal chicken	HCP 1	Potential for transport or storage contamination with non-halal products	Supplier to provide halal certification
Production	HCP 2	Potential for mixing with non-halal ingredients such as lard which has been commonly used to replace oil	Quality control performed by related trained staff in halal certification
Delivery	HCP 3	Potential for transport contamination with non-halal products	Transports were cleaned and inspected by related trained staff in halal certification

**Supplementary File Table 3.** Halal analysis and identification of Halal Control Points (HCPs) in production of oats

<b>Process steps</b>	<b>Halal Control Points (HCPs)</b>	<b>Justifications</b>	<b>Preventive measures</b>
Receiving	HCP 1	Potential for transport or storage contamination with non-halal products	Supplier to provide halal certification or conduct supplier second party audit to verify storage of oat and incoming goods check
Kilning	HCP 2	Potential for mixing with non-halal products (cheaper raw materials and ingredients)	Quality control performed by related trained staff in halal certification
Delivery	HCP 3	Potential for transport contamination with non-halal products	Transports were cleaned and inspected by related trained staff in halal certification

**Supplementary File Table 4.** Halal analysis and identification of Halal Control Points (HCPs) in production of coffee powder

<b>Process steps</b>	<b>Halal Control Points (HCPs)</b>	<b>Justifications</b>	<b>Preventive measures</b>
Receiving	HCP 1	Potential for transport or storage contamination with non-halal products	Supplier to provide halal certification
Roasting 1 / 2	HCP 2	Potential for mixing with non-halal products (cheaper raw materials and ingredients) in the open roaster	Quality control performed by related trained staff in halal certification
Delivery	HCP 3	Potential for transport contamination with non-halal products	Transports were cleaned and inspected by related trained staff in halal certification