

16. Technology, Innovation and Supply Chain Management
Competitive Session

**Determining Critical Factors of Halal Food Supply Chain using the Analytic
Hierarchy Process (AHP)**

Wan Marhaini Wan Omar

School of Business IT and Logistics, RMIT University, Melbourne, Australia

Email: wanmarhaini.wanomar@rmit.edu.au

Shams Rahman

School of Business IT and Logistics, RMIT University, Melbourne, Australia

Email: shams.rahman@rmit.edu.au

16. Technology, Innovation and Supply Chain Management Competitive Session

Determining Critical Factors of Halal Food Supply Chain using the Analytic Hierarchy Process (AHP)

ABSTRACT: *Research in halal food supply chain is relatively new. Most previous studies are either conceptual or descriptive. This study presents a conceptual hierarchical model for halal food supply chain with four factor-categories and thirteen factors and investigates the critical factors of halal food supply chain using the Analytic Hierarchy Process (AHP). Data and information are collected through in-depth interviews from senior executives of ten halal processed food and beverage companies in Malaysia. Expert choice[®] software is used to analyse the data and to determine relative weights of each factor-category. The results indicate that process capability is the most critical factor-category and environmental friendliness, material handlings and physical segregation are the top three critical factors.*

Keywords: AHP, halal supply chain, processed food, beverage.

1.0 INTRODUCTION

The global halal food industry is developing and growing at a rapid pace. It worth hundreds of billions of dollars and is increasing. A recent estimate suggests that the global halal trade values at US\$2.3 trillion (HDC, 2014). The rapid increase in halal food business is not only because of the growth and spread of Muslim population in Muslim countries and territories, but also due to the growth of Muslim population in the non-Muslim regions such as Europe, North America and China. This has provided a huge business opportunity, however, made the global halal food supply chains more complex. The complexity arised not only due to the increased number of halal products, their sourcing centres and distribution lead time, but also due to special characteristics associated with halal foods.

Halal is an Arabic term which means an act or product that is lawful and permitted (Al-Qaradawi, 2007). According to Malaysian Standard (MS1500:2009, p. 1), halal food means ‘food and drink and/or their ingredients permitted under the Shariah law and fulfil the following conditions: a) does not contain any parts or products of animals that are non-halal by Shariah law or any parts or products of animals which are not slaughtered according to Shariah law; b) does not contain najis (*Arabic terminology means filth or unclean*) according to Shariah law; c) safe for consumption, non-poisonous, non-intoxicating or non-hazardous to health; d) not prepared, processed or manufactured

using equipment contaminated with najis (*Arabic terminology means filth or unclean*) according to Shariah law.’ Halal is a sensitive issue for Muslims especially when it comes to food consumption. As food chains are becoming longer and complex, Muslims are increasingly becoming concern about the content of the foods they consume and how such foods are produced (Bonne & Verbeke, 2008). Advances in food technology and global distribution have exposed Muslims to various ingredients and manufactured foods. Given this context, Muslim consumers require greater assurance of the risk of contamination of the halal food they consume. Studies by Lada, Tanakinjal & Amin (2009), Omar, Jaafar & Osman (2013) and Tieman, Vorst & Ghazali (2012) argue that halal requires a contamination free supply chain that conforms to the halal requirements from the point of origin to the point of consumer purchase.

For efficient distribution and fulfillment of the global demand, the focus of halal food management has shifted from the organization-centered perspective to the supply chain perspective. Studies suggest stringent requirements in halal standards, uniqueness of product attributes and integrity requirements have made the halal food supply chain more vulnerable. In addition, there are also the issues such as of lack of control of halal food norms, protecting of halal food’s authenticity and avoiding halal food adulteration (Tieman et al., 2012; Bonne & Verbeke, 2008; Tieman, 2011; Wilson & Liu, 2010; Fadzlillah, Che Man, Jamaludin, Ab.Rahman & Al-Kahtani, 2011). Given this context, this research investigates the critical factors of halal food supply chain in the context of Malaysian processed food and beverage industry. The development and implementation of strategies based on the critical factors may assist organizations engaged in halal food business to improve their performance and competitiveness.

The rest of the paper is structured as follows. Section 2 presents a brief review of related literature on critical factors of halal food supply chain and proposed a hierarchical conceptual framework. An outline of research methodology is given in section 3, followed by analysis and results in section 4. Finally, the paper concludes with a brief discussion on major findings in section 5.

2.0 LITERATURE REVIEW

Through an extensive review of literature, we identified thirteenth factors which were then clustered into four factor-categories. A brief discussion of the factor under each factor-category is provided below.

2.1 Factor-categories and Factors of Halal Food Supply Chain

Halal food supply chain (HFSC) is vital to food manufacturers in order to deliver credibility and trust to Muslim consumers. The term halal food supply chain refers to the process of managing halal food products, starting from the point of origin to the point of consumption and involving different parties from suppliers to end-users (Zulfakar, Anuar & Talib, 2012). Furthermore, related activities under halal supply chain include sourcing, warehousing, transporting, handling of product, inventory management, procurement, marketing and order management must all comply with the general principles of Shariah law.

Though there are some studies conducted on halal food supply chains, however, this area is still under-researched. These factors-categories are discussed as follows.

2.1.1 Physical attributes

Physical attributes referring to the characteristics or features of halal food products where they must be safe for consumption, need to be clean, healthy and nutritional and generally everything is allowed except what has been specifically forbidden according to Quran. In the manufacture of halal products, it is imperative that all possible sources of contamination are eliminated and this can be accomplished by ensuring the production lines and equipment used are thoroughly cleansed and sanitized (Riaz & Chaudry, 2004). The halal food manufacturers should not only focus on Islamic processing techniques, but also on quality assurance processes. Quality assurance also reflects the safety and quality for both products and processes (Abdul Talib, Mohd Ali & Jamaludin, 2008). Focusing on physical attributes is part of halal as a holistic concept and it should reflect halal products in terms of cleanliness, safety, health and nutrition (Mohamad & Hassan, 2011). Religion also plays an important

role in people's lives through shaping their beliefs, knowledge, attitudes and even food habits (Ireland & Rajabzadeh, 2011; Kordnaeij, Askaripoor, & Bakhshizadeh, 2013; Wilson & Liu, 2010). For a Muslim, the basic guidance for laws concerning food are revealed in the Holy Quran and explained and recorded in the Hadith (the compilation of the traditions of the Prophet Muhammad) (Bonne & Verbeke, 2008) and these constitute the two major sources of Islamic dietary law. According to Islamic dietary law all food products are permitted except those that are forbidden such as alcohol, pork, blood, meat from cadavers, and meat of animals that has not been slaughtered according to Shariah law (Riaz & Chaudry, 2004; van der Spiegel, van der Fels-Klerx, Sterrenburg, van Ruth, Scholtens-Toma, & Kok, 2012). Based on the discussion above, cleanliness, health and nutritious, safety of the products and understanding the Islamic dietary law are considered to be four important factors of halal food physical attributes.

2.1.2 Process capability

Process capability covers how the halal food products are segregated from non-halal, how the food shall be processed using dedicated equipment and facilities, how they are stored and transported and how halal food shall be suitably packed, labelled and advertised. Food products manufactured for Muslim consumers must comply with halal criteria. The criteria are the nature, origin and processing method of the food product (Bonne & Verbeke, 2008; van der Spiegel et al., 2012). For Muslim consumers, trust in halal food relates to how the food being processed. During the processing stage, such as storage and display, halal products must be segregated from non-halal products to prevent cross contamination (Nakyinsige, Man & Sazili, 2012). The process of packaging and labelling products must also be considered in order to create a genuine and wholesome halal product (Ab Talib & Mohd Johan, 2012). There should be no mixing between halal and non-halal goods on a load carrier or in a common transportation vehicle (Ngah & Zainuddin, 2012). Furthermore, dedicated equipment and facilities used for non-halal products cannot be used for halal products (DoS, 2009). Thus, the issues such as physical segregation, material handlings, storage and transportation,

and packaging and labelling are the factors considered under the process capability factor-category.

2.1.3 Ethical issues

The development of a halal product must be ethical and thus consistent with Shariah principles. Studies suggest that features are: being environmentally friendly, considered animal welfare, having an organic character, being respectful to Islamic financing and fair trade attributes are the common features of ethical practices (Mohamad & Hassan, 2011). In this study, we only focus on the two elements of the ethical issues which are environmental friendliness and fair trade practices. Al-Qaradawi (2007) emphasizes that the principle of permissibility is not only limited to the things and objects being used but also includes all human actions and behaviours. Additionally, having ethical producers who are involved in fair trade and are socially responsible within the whole production chain do constitutes a major concern in the halal industry (Irfan, 2010). In practice, a sale transaction is regarded as legal if it is made through the mutual consent of the parties concerned, and where no undue advantage is taken and charged high prices (Mohammed, 2013). Also, manufacturers are not allowed to use harmful ingredients or engage in unethical conduct that may possibly undermine consumers. Hence, the ethical issue is considered as one of the factor-categories.

2.1.4 Management capability

In this study, management capability is referred to the organizational capability to be competent in halal food industry. These may include such as making sure that the staff and personnel are trained in the halal principles, allocating adequate resources in order to implement halal food chain and having the capability to involve in innovation. To develop a sustainable pool of knowledge workers and professionals in the halal industry, training is vital and management should ensure that everyone is trained (Tieman et al., 2012). In Malaysian Standard:MS1500:2009, it is stated that personnel should be trained in halal to ensure compliance with Shariah precepts. Management also needs to involve in innovation such as venturing in the development of a halal traceability and tracking system. These can be

established for the purpose of improving halal transparency in supply chains (Zailani et al., 2010). At the same time, management needs to ensure that resources are adequate such as manpower, infrastructure, machinery and equipment and finances are provided (DoS, 2009). In this study, the factors such as halal training and personnel, resource adequacy and capability to innovate are considered under management capability factor-category for halal food supply chain.

2.2 Hierarchical Conceptual Framework

Based on the discussion above, we proposed a hierarchical conceptual framework with the goal of determining critical factors of halal food supply chain in the Malaysian context. The framework which is shown in Figure 1 is described by four higher-level factors-categories and thirteenth factors of halal food supply chain. The four higher-level factors-categories are physical attributes, process capability, the ethical issues and management capability. The factors included in the physical attributes comprise of cleanliness, safety, health and nutritious and understanding of Islamic dietary law. Process capability covers the processing aspects at different stages which are the aspects of physical segregation of products, how the materials are handled using dedicated equipment and facilities, how the products are stored and loaded on a transport and how the product is been packaged and labelled. The ethical issues include the factors which are environmental friendliness and fair trade practices and management capability represents the factors such as adequate halal training and personnel, having adequate resources and capable to involve in innovation activities.

Insert Figure 1 about here

3.0 RESEARCH METHODOLOGY

3.1 Method of Analysis – Analytic Hierarchy Process (AHP)

This research employed the analytical hierarchy process (AHP) methodology for analysis. AHP is a multi-criteria decision making approach which integrates simultaneously qualitative and quantitative information in which the factors are arranged in a hierarchic structure. AHP has been applied to a

wide variety of contexts including identifying critical success factors for ISO implementation (Sambasivan & Fei, 2008), automobile selection (Byun, 2001), web sites selection (Ngai, 2003), supplier selection in fast changing fashion market (Chan & Chan, 2010) as well as in the food and beverage industry (Bandeira, Becker & Waquil, 2011). Eventually, AHP is providing the consistency in managers’ judgement, obtaining managers preferences such as through Likert scales and forces them to make explicit comparisons between priorities (Rahman et al., 2014). Furthermore, AHP analysis not only clarifies the ranking of the priorities, but also measures how much more/less important a given priority is. AHP employs a scale with the exact numbers between 1 – 9 to measure the judgements (Table 1) which has been validated for its effectiveness (Saaty, 1990). The modelling process of AHP consists of four steps:

- 1. Identification of key factors of halal food supply chain studies;
- 2. Structuring the problem and model building;
- 3. Collection and compilation of decision makers’ opinions and application of prioritisation procedure to determine normalised priority weights of individual factors;
- 4. Analysing the priority weights and deriving solutions to the problem.

| Insert Table 1 about here |

3.2 Profile of the Respondents

The research adopted an in-depth interview as a method of data collection. The interviewed were conducted with senior executives from ten selected leading halal processed food and beverage companies. These respondents hold vital positions in their organizations and work closely with the manufacturing and distribution of products. Respondents were chosen on the basis of their capacity to generate the information needed. The responding companies are located across Malaysia and over the years they have contributed significantly to the growth of Malaysian halal food industry. A two part questionnaire was employed for data collection. Part A consists of questions (in AHP format) designed to capture respondents’ opinions on the relative importance of factor-categories and factors, whereas Part B contained questions related to company and respondents’ background. The

respondents were briefed on the procedure required in the AHP methodology. The researcher went through every question with the respondents and further clarification was given upon each of the question asked.

Table 2 provides respondent-related information. The respondents' position, education level, working experience, working experience in halal food industry and frequency of attended halal course vary from one respondent to another. Among the interviewees one is a director, three are senior executive officers and the rest are managers. One respondent hold post graduate qualification while others have bachelor degrees. The working experience ranged between 5 to 20 years with an average of thirteenth years. All respondents have extensive experience of working in halal food industry with an average of nine years. Attending halal courses such as workshops and seminars organized by Department of Islamic Development Malaysia (JAKIM) and Halal Industry Development Corporation (HDC) are highly encouraged to all halal manufacturers. Both JAKIM and HDC have been entrusted by the Malaysian government to issue halal certificate and provide global halal support systems. Of the ten respondents, two respondents have attended halal courses more than ten times and the rest have attended the courses between four to nine times.

Table 3 summarizes organization related information. All selected organizations belong to either large or medium-sized. Of the ten organizations, five are large organizations employing over 200 employees and the remaining five are medium-sized organizations. Of the ten responding companies, seven are involved in the processed food, two are in beverage product and one is involved in manufacturing of both processed food and beverage. Five companies are in operation for more than 30 years and others are in operation between 19 and 26 years.

Insert Table 2 about here

Insert Table 3 about here

4.0 ANALYSIS AND RESULTS

4.1 Determination of the Critical Factors

Expert choice[®] software was used to analyse the data and to determine relative weights of each factors. The final weights obtained by AHP method for the ten selected organizations are shown in Table 4. From the analysis, it is evident that process capability is the most critical factor-category of halal food supply chain with a weight of 0.4344 (Inconsistency ratio (IR) = 0.00966 which is within the acceptable level of ≤ 0.1). Ethical factor-category is found to be the second most critical factor-category with weight = 0.2545 (IR = 0.00); whereby management capability is ranked as the least critical factor-category in halal food supply chain (weight = 0.1469; IR = 0.00016).

At the factor level, safety (weight = 0.5103), material handlings (weight = 0.3889), environmental friendliness (weight = 0.7684) and halal training and personnel (weight = 0.5820) are found to be the most critical factors under physical attributes, process capability, ethical issues and management capability factor-categories respectively. The factors such as Islamic dietary law (weight = 0.0659), storage and transports (weight = 0.1347), fair trade practices (weight = 0.2316) and innovative capability (weight = 0.1052) are found to be the least critical factors for each of the factor categories. Overall weights for all factors are shown in Table 4 and Figure 2. It is evident that the top five most critical factors for halal food supply chain are environmental friendliness (weight = 0.1956), material handlings (weight = 0.1689), physical segregation (weight = 0.1373), halal training and personnel (weight = 0.0855) and safety (weight = 0.0838).

Insert Table 4 about here
Insert Figure 2 about here

4.2 Determination of Critical Factors based on the type of Products

To assess whether or not critical factors are different in the type of product such as processed food and beverage, analysis are conducted separately for the two category of product. The results are summarized in Table 5. The overall IR for processed food and beverage ranged from 0.01 and 0.02 respectively. In both of the cases the IR are within the acceptable level.

4.2.1 *Processed food*

At the 1st level of AHP model, the findings from processed food indicate that process capability (weight = 0.4143) is the most critical factor category for defining halal food supply chain in the context of Malaysian halal food industry. Physical attributes (weight = 0.1402) is identified as the least critical factor-category under processed food category. Based on the results at factor level, environmental friendliness factor is considered as the most critical factor under processed food with a weight of 0.02022 whereas Islamic dietary law was found to be the least critical factor for processed food with a weight of 0.0089. The top five most critical factors in processed food are environmental friendliness (0.02022), physical segregation (0.1498), material handlings (0.1439), halal training and personnel (0.1118) and safety (0.0746).

4.2.2 *Beverage*

In the context of beverage, the results show slightly different in the range of factor-categories and factors. Process capability remains as the most critical factor-category under beverage with a weight of 0.4695. However, the least critical factor-category goes to management capability with a weight of 0.0600. At the 2nd level of AHP model, the results indicate that material handlings (weight = 0.2339) is the most critical factor. Environmental friendliness comes to the second most critical factor under manufacturing of beverage. Capability to innovate was found to be the least critical factor under beverage with a weight of 0.0051. The top five most critical factors under beverage are material handlings (0.2339), environmental friendliness (0.1578), packaging and labelling (0.1233), safety (0.1127) and cleanliness (0.1083).

Insert Table 5 about here
Insert Figure 3 about here

4.3 Sensitivity Analysis

Sensitivity analysis is carried out to investigate whether small variations in the model parameters would change the ranking of the enabling factors and lead to different outcome. The model is tested with two scenarios based on the two most critical factors-categories such as process capability and ethical issues. As part of the sensitivity analysis, two scenarios are generated: (i) One by increasing the weight of process capability and ethical issues, and (ii) Second by decreasing the weight of process capability and ethical issues. The results are discussed below:

4.3.1 Sensitivity analysis based on process capability

First, the weight of the process capability factor-category was varied. Figure 4 shows dynamic sensitivity analyses of the thirteenth factors perform with respect to the change in process capability factor-category. Figure 4(a) demonstrates that when weight is increased from 0.4344 to 0.4730, the priority of the sub-factor is changed, i.e., Environmental friendliness becomes the second most important factor. Material handlings turned up to be the most important factor. When the weight is decreased from 0.4344 to 0.2940, halal training and personnel becomes the second most important factor instead of material handlings (see Figure 4(b)). However, environmental friendliness remains as the top most important factor.

Insert Figure 4 about here

4.3.2 Sensitivity analysis based on ethical issues

Second, the weight of ethical issues factor-category was varied. Figure 5(a) shows that when weight is increased from 0.2525 to 0.4520, the priority of the enabling sub-factors is changed, i.e., fair trade practices becomes the third most important factors instead of physical segregation. The ranking of environmental friendliness and material handlings remain the same. When the weight is decreased from 0.2525 to 0.2250, material handlings becomes the

most important factor and environmental friendliness shifts to the second position. Figure 5(b) illustrates these results.

Insert Figure 5 about here

5.0 DISCUSSION & CONCLUSIONS

This study determines the critical factors required for halal food supply chain in the context of Malaysian halal food industry. The information gathered from the senior executives through an in-depth interview of both halal processed food and halal beverage companies. The research employed AHP, a multi-criteria decision making methodology for formulating and analysing the gathered information. In factor-category, the findings depicted that process capability is the most critical factor-category of halal food supply chain. Ethical issues factor is found to be the second most critical factor-category whereby management capability is ranked as the least critical factor-category in halal food supply chain. The results are matched with the series of interview conducted where most of the manufacturers agreed process capability is extremely important in developing halal food supply chain. For them, having a proper manufacturing process can produce a good quality of halal product. The research found that to determine whether the food is halal or haram, it depends on its nature, how it is processed and how it is obtained. In the case of factor level, safety and cleanliness are the two most critical factors in physical attributes factor-category and material handlings together with physical segregation turn out to be the two most critical factors in process capability factor-category. In the ethical issues factor-category, environmental friendliness is the most critical factor in developing halal food supply chain whereby halal training and personnel become the most critical factor for management capability factor-category. Overall, the top five factors are environmental friendliness, material handlings, physical segregation, halal training and personnel and safety.

On the other hand, the results of the critical factors in defining the halal food supply chain are different with regard to the type of products. Obviously, the factors which are physical segregation, material handlings, packaging and labelling, cleanliness and halal training and personnel are shown

different ranking in both of processed food and beverage. Physical segregation is found to be more critical factor in the manufacturing of processed food compared to beverage. In the context of material handlings, beverage manufacturer ranked this factor as more critical compared to processed food manufacturer with the rank of 1 and 3 respectively. Processed food manufacturers think that halal training and personnel are more critical in their production but for beverage manufacturer this factor is less concerned in their production. Furthermore, packaging and labelling becomes more important in beverage production rather than processed food production when both of the manufacturers ranked it at 3 and 8 respectively. Cleanliness is more concerned in the manufacturing of beverage when it was ranked at 5 whereby in the manufacturing of processed food it was ranked at 10.

Based on the overall findings, it can be suggested that the manufacturers should emphasize on those critical factors if they want to device the strategies in order to have an efficient halal food supply chain. The findings also indicate that processed food and beverage have a different set of critical factors in defining their halal supply chain. For that reason, manufacturers should take into consideration of those set of critical factors if they want to produce a credence quality attributes of halal processed food and beverage products. Finally, the results provide valuable insights that can assist the managers in strengthening and improvise their own strategies and capabilities particularly in the context of halal food industry as to remain competitive in the market.

REFERENCES

- Ab Talib, M.S. & Mohd Johan, M.R. (2012). Issues in halal packaging: A conceptual paper. *International Business and Management*, 5(2), 91-5.
- Abdul Talib, H. H., Mohd Ali, K. A., & Jamaludin, K. R. (2008). *Quality Assurance in Halal Food Manufacturing in Malaysia: A Preliminary Study*. Paper presented at the International Conference on Mechanical & Manufacturing Engineering (ICME2008), Johor Bahru, Malaysia.
- Al-Qaradawi, Y. (2007). *The Lawful and the Prohibited in Islam*. Kuala Lumpur, Islamic Book Trust.
- Bandeira, D.L., Becker, J.L., & Waquil, H.D. (2011). *Applying Ahp To The Selection Of Suppliers Of Marketing Materials To A Large Brazilian Company In The Food And Beverage Industry*. Paper presented at The International Symposium on the Analytic Hierarchy Process.
- Bonne, K., & Verbeke, W. (2008). Religious values informing halal meat production and the control and delivery of halal credence quality. *Agriculture and Human Values*, 25(1), 35-47.
- Byun, D.-H. (2001). The AHP approach for selecting an automobile purchase model. *Information & Management*, 38(5), 289-297.
- Chan, F. T., & Chan, H. K. (2010). An AHP model for selection of suppliers in the fast changing fashion market. *The International Journal of Advanced Manufacturing Technology*, 51(9-12), 1195-1207.
- Malaysia, D. o. S. (2009). *Halal food - production, preparation, handling and storage - general guidelines (second revision) MS 1500:2009* (pp. 1-16). Malaysia: Department of Standards Malaysia.
- Fadzlillah, N.A., Che Man, Y., Jamaludin, M.A., Ab.Rahman, S. & Al-Kahtani, H.A. (2011). *Halal Food Issues From Islamic And Modern Science Perspective*. Paper presented at 2011 2nd International Conference on Humanities, Historical and Social Sciences, Singapore.
- HDC 2014, *Opportunities in Halal Economy*, Halal Industry Development Corporation, retrieved by 20 January 2014, <<http://www.hdcglobal.com>>.
- Ireland, J., & Rajabzadeh, S. A. (2011). UAE consumer concerns about Halal products. *Journal of Islamic Marketing*, 2(3), 274-283.
- Irfan, S. (2010). Consumer awareness: Thoughts and trends across the globe. *Halal J*, 2, 10-11.
- Kordnaeij, A., Askaripoor, H., & Bakhshizadeh, A. (2013). Studying affecting factors on customers' attitude toward products with Halal brand (case study: Kuala Lumpur, Malaysia). *International Research Journal of Applied and Basic Sciences*, 4(10), 3138-3145.
- Lada, S., Tanakinjal, G. H., & Amin, H. (2009). Predicting intention to choose <IT>halal</IT> products using theory of reasoned action. *International Journal of Islamic and Middle Eastern Finance and Management*, 2(1), 66-76.
- Lodhi, A-u-H. (2009). *Understanding Halal Food Supply Chain*. London, HFRC UK Ltd.
- Mohamad, A.B., & Hassan, H., (2011). The influences of halal integrity on product adaptation strategy for global trade. *International Business Management*, 5(6), 421-426.

- Mohammed, J.A., (2013). Business Precepts of Islam: The Lawful and Unlawful Business Transactions According to Shariah. *Handbook of the Philosophical Foundations of Business Ethics*, Springer, 883-97.
- Nakyinsige, K., Man, Y.C., & Sazili, A.Q. (2012). Halal authenticity issues in meat and meat products. *Meat Sci*, 91(3), 207-14.
- Ngah, A.H., & Zainuddin, Y. (2012) *Barriers to supply chain adoption among Malaysian halal manufacturers with general barriers as a moderating factor*. Paper presented at International Halal Conference 2012, Putra World Trade Centre Kuala Lumpur, Malaysia, 4th-5th September 2012.
- Ngai, E. (2003). Selection of web sites for online advertising using the AHP. *Information & Management*, 40(4), 233-42.
- Omar, E.N., Jaafar, H.S., & Osman, M.R. (2013). Halalan toyyiban supply chain of the food industry. *Journal of Emerging Economies and Islamic Research*, 1(3).
- Othman, P., Sungkar, I., & Hussin, W.S.W. (2009). Malaysia as an international halal food hub: Competitiveness and potential of meat-based industries. *Asean Economic Bulletin*, 26(3), 306-20.
- Rahman, S., Rashid, N., Yadlapalli, A., & Yiqun, L. E. (2014). *Determining Factors Of E-Government Implementation: A Multi-Criteria Decision-Making Approach*. Paper presented at Pacific Asia Conference on Information systems (PACIS) 2014, Chengdu, China, 24th-28th June 2014.
- Riaz, M.N., & Chaudry, M.M. (2004). *Halal Food Production*. United States of America, CRC Press.
- Saaty, T.L. (1990). Physics as a decision theory. *European Journal of Operational Research*, 48, 98-104.
- Sambasivan, M., & Fei, N.Y. (2008). Evaluation of critical success factors of implementation of ISO 14001 using analytic hierarchy process (AHP): a case study from Malaysia. *Journal of Cleaner Production*, 16(13), 1424-33.
- Tieman, M. (2011). The Application of Halal in Supply Chain Management : in-depth interviews. *Journal of Islamic Marketing*, 2(2), 186-195.
- Tieman, M., Vorst, JGAJvd., & Ghazali, M.C. (2012). Principles in halal supply chain management. *Journal of Islamic Marketing*, 3(3), 217-43.
- Van der Spiegel, M., van der Fels-Klerx, H.J., Sterrenburg, P., van Ruth, S.M., Scholtens-Toma, I.M.J., & Kok, E.J. (2012). Halal assurance in food supply chains: Verification of halal certificates using audits and laboratory analysis. *Trends in Food Science & Technology*, 27(2), 109-19.
- Wilson, J. A. J., & Liu, J. (2010). Shaping the <IT>Halal</IT> into a brand? *Journal of Islamic Marketing*, 1(2), 107-123.
- Zailani, S., Arrifin, Z., Abd Wahid, N., Othman, R., & Fernando, Y. (2010). Halal traceability and halal tracking systems in strengthening halal food supply chain for food industry in Malaysia (A Review). *Journal of Food Technology*, 8(3).

Zulfakar, M.H., M Anuar, M., & Ab Talib, M.S. (2012). *Conceptual Framework on Halal Food Supply Chain Integrity Enhancement*. Paper presented at International Halal Conference 2012, Putra World Trade Centre Kuala Lumpur, Malaysia, 4th-5th September 2012.

Appendix

Figure 1: A Hierarchical Conceptual Framework of Halal Food Supply Chain

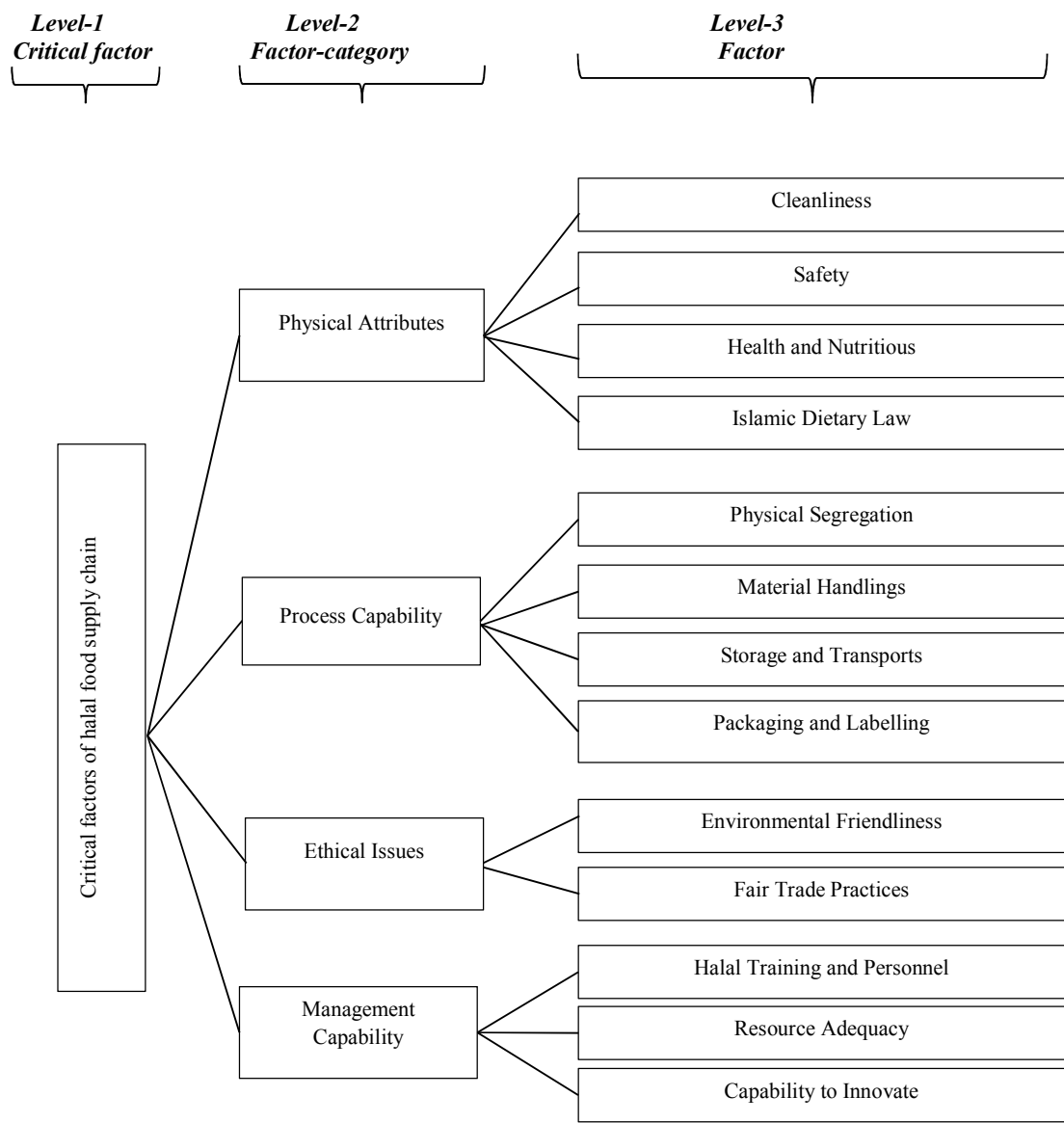


Table 1: The Fundamental Scale of AHP

Intensity of Importance on an absolute scale	Definition	Explanation
1	Equal importance	Two activities contribute equally to the objective
3	Moderate importance of one over another	Experience and judgment strongly favour one activity over another
5	Essential or strong importance	Experience and judgment strongly favour one activity over another
7	Very strong importance	An activity is strongly favoured and its dominance demonstrated in practice
9	Extreme importance	The evidence favouring one activity over another is of the highest possible order of affirmation
2, 4, 6, 8	Intermediate values between the two adjacent judgments	When compromise is needed

Table 2: Respondents Profile

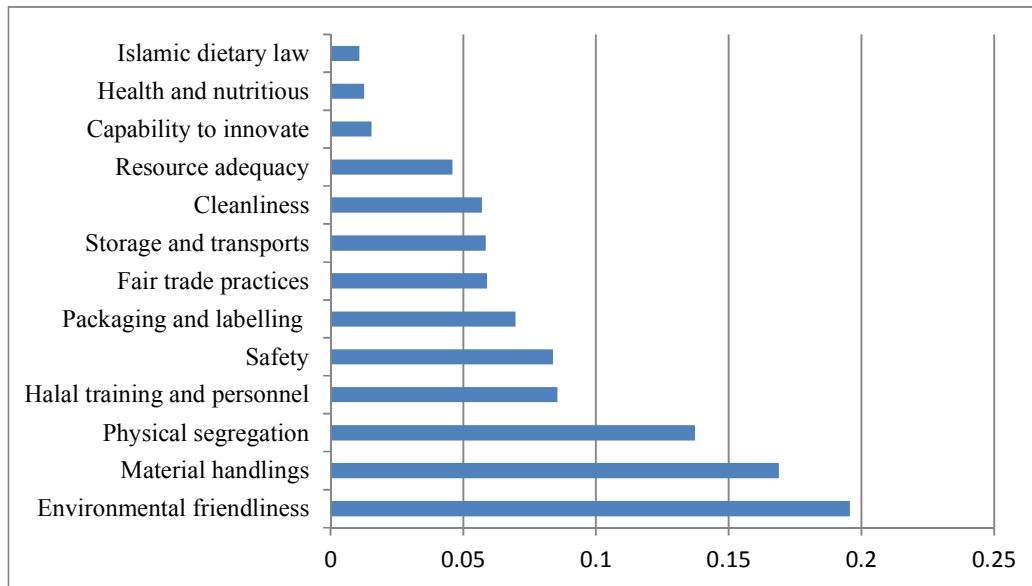
Respondent	Position	Education level	Working experience	Working experience in halal food industry	Frequency of halal course attendance
Company A	Manager	Graduate	5	5	4
Company B	Senior Executive Officer	Graduate	15	10	3
Company C	Manager	Graduate	9	9	7
Company D	Senior Executive Officer	Graduate	15	5	5
Company E	Manager	Graduate	12	7	6
Company F	Senior Executive Officer	Graduate	20	17	12
Company G	Manager	Graduate	13	8	7
Company H	Manager	Post-graduate	18	12	9
Company I	Manager	Graduate	6	6	5
Company J	Director	Graduate	17	11	11

Table 3: Organizations Profile

Organization	No of Employee	Product	Organization size	Operation Years
Company A	75 - 200	Processed Food	Medium	19 years
Company B	75 - 200	Processed Food	Medium	42 years
Company C	201 - 500	Processed Food	Large	19 years
Company D	201 - 500	Processed Food	Large	26 years
Company E	75 - 200	Beverage	Medium	21 years
Company F	501 - 1000	Processed Food & Beverage	Large	31 years
Company G	201 - 500	Processed Food	Large	34 years
Company H	>1000	Processed Food	Large	34 years
Company I	75 - 200	Processed Food	Medium	19 years
Company J	75 - 200	Beverage	Medium	37 years

Table 4: Relative Weights for Factor-category and Factor

Factor Category	Relative weight	Factor	Relative weight	Ranking	Overall weight	Ranking
Physical Attributes CR = 0.00847	0.1642	Cleanliness	0.3471	2	0.0570	9
		Safety	0.5103	1	0.0838	5
		Health and nutritious	0.0767	3	0.0126	12
		Islamic dietary law	0.0659	4	0.0108	13
Process Capability CR = 0.00966	0.4344	Physical segregation	0.3160	2	0.1373	3
		Material handlings	0.3889	1	0.1689	2
		Storage and transports	0.1347	4	0.0585	8
		Packaging and labelling	0.1604	3	0.0697	6
Ethical Issues CR = 0.00	0.2545	Environmental friendliness	0.7684	1	0.1956	1
		Fair trade practices	0.2316	2	0.0590	7
Management Capability CR = 0.00016	0.1469	Halal training and personnel	0.5820	1	0.0855	4
		Resource adequacy	0.3128	2	0.0459	10
		Capability to innovate	0.1052	3	0.0154	11

Figure 2: Overall Priority Ranks for Halal Food Supply Chain**Table 5: Ranking of Factors with Regards to the Type of Product**

AHP Level	Factor-Category	Type of product							
		Processed food				Beverage			
		Weight		Ranking		Weight		Ranking	
Level 1	Physical attributes	0.1402		4		0.2601		2	
	Process capability	0.4143		1		0.4695		1	
	Ethical issues	0.2614		2		0.2104		3	
	Management capability	0.1841		3		0.0600		4	
AHP Level	Factor	Type of product							
		Processed food				Beverage			
		Relative Weight	Ranking	Overall weight	Ranking	Relative Weight	Ranking	Overall weight	Ranking
Level 2	Cleanliness	0.3277	2	0.0459	10	0.4163	2	0.1083	5
	Safety	0.5321	1	0.0746	5	0.4333	1	0.1127	4
	Health and nutritious	0.0770	3	0.0108	12	0.0751	4	0.0195	12
	Islamic dietary law	0.0632	4	0.0089	13	0.0753	3	0.0196	11
	Physical segregation	0.3615	1	0.1498	2	0.1716	3	0.0806	6
	Material handlings	0.3474	2	0.1439	3	0.4984	1	0.2339	1
	Storage and transports	0.1573	3	0.0652	6	0.0674	4	0.0316	8
	Packaging and labelling	0.1339	4	0.0555	8	0.2626	2	0.1233	3
	Environmental friendliness	0.7734	1	0.2022	1	0.7500	1	0.1578	2
	Fair trade practices	0.2266	2	0.0592	7	0.2500	2	0.0526	7
	Halal training and personnel	0.6072	1	0.1118	4	0.4831	1	0.0289	9
	Resource adequacy	0.2823	2	0.0519	9	0.4313	2	0.0259	10
	Capability to innovate	0.1104	3	0.0203	11	0.0856	3	0.0051	13
Consistency ratio (CR)		0.01				0.02			

Figure 3: Priority Ranks for Halal Food Supply Chain based on the type of Products

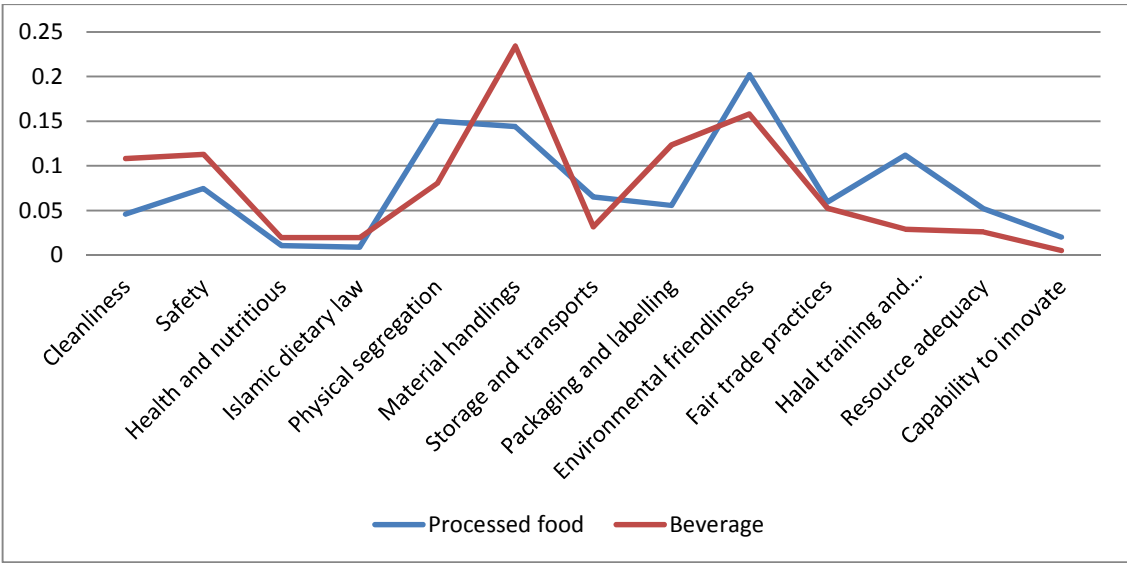


Figure 4: Sensitivity Analysis when Process Capability is varied

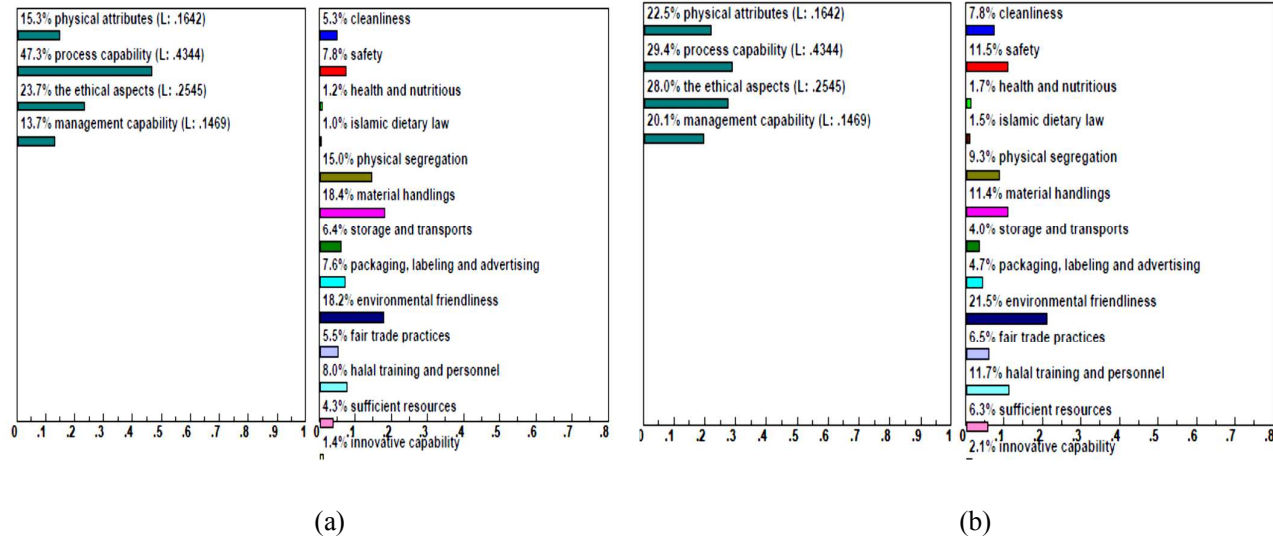
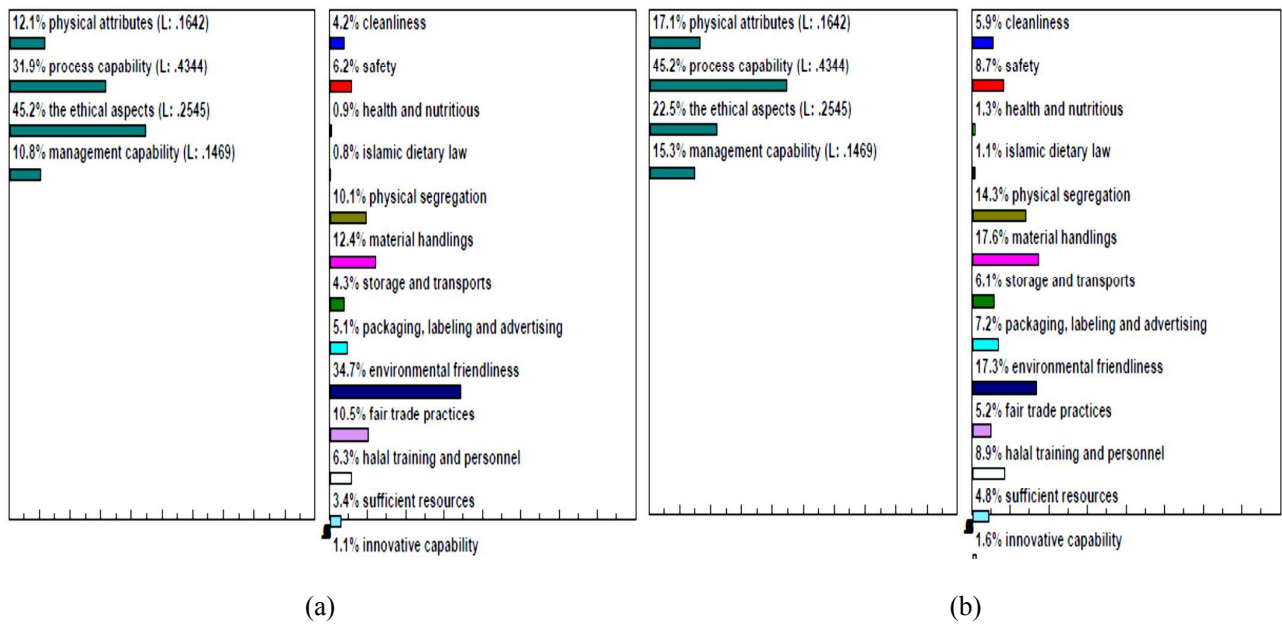


Figure 5: Sensitivity Analysis when Ethical Issues are varied



16. Technology, Innovation and Supply Chain Management Competitive Session

Determining Critical Factors of Halal Food Supply Chain using the Analytic Hierarchy Process (AHP)

ABSTRACT: *Research in halal food supply chain is relatively new. Most previous studies are either conceptual or descriptive. This study presents a conceptual hierarchical model for halal food supply chain with four factor-categories and thirteen factors and investigates the critical factors of halal food supply chain using the Analytic Hierarchy Process (AHP). Data and information are collected through in-depth interviews from senior executives of ten halal processed food and beverage companies in Malaysia. Data was analysed to determine relative weights of each factor-category. The results indicate that process capability is the most critical factor-category and environmental friendliness, material handlings and physical segregation are the top three critical factors.*

Keywords: AHP, halal supply chain, processed food, beverage.

1.0 INTRODUCTION

The global halal food industry is developing and growing at a rapid pace. It worths hundreds of billions of dollars and is increasing. A recent estimate suggests that the global halal trade values at US\$2.3 trillion (HDC, 2014). The rapid increase in halal food business is not only because of the growth and spread of Muslim population in Muslim countries and territories, but also due to the growth of Muslim population in the non-Muslim regions such as Europe, North America and China. This has provided a huge business opportunity, however, made the global halal food supply chains more complex. The complexity arises not only due to the increased number of halal products, their sourcing centres and distribution lead time, but also due to special characteristics associated with halal foods.

Halal is an Arabic term which means an act or product that is lawful and permitted (Al-Qaradawi, 2007). According to Malaysian Standard (MS1500:2009, p. 1), halal food means ‘food and drink and/or their ingredients permitted under the Shariah law and fulfil the following conditions: a) does not contain any parts or products of animals that are non-halal by Shariah law or any parts or products of animals which are not slaughtered according to Shariah law; b) does not contain najis (*Arabic terminology means filth or unclean*) according to Shariah law; c) safe for consumption, non-

poisonous, non-intoxicating or non-hazardous to health; d) not prepared, processed or manufactured using equipment contaminated with najis (*Arabic terminology means filth or unclean*) according to Shariah law.’ Halal is a sensitive issue for Muslims especially when it comes to food consumption. As food chains are becoming longer and complex, Muslims are increasingly becoming concern about the content of the foods they consume and how such foods are produced (Bonne & Verbeke, 2008). Advances in food technology and global distribution have exposed Muslims to various ingredients and manufactured foods. Given this context, Muslim consumers require greater assurance of the risk of contamination of the halal food they consume. Studies by Lada, Tanakinjal & Amin (2009), Omar, Jaafar & Osman (2013) and Tieman, Vorst & Ghazali (2012) argue that halal requires a contamination free supply chain that conforms to the halal requirements from the point of origin to the point of consumer purchase.

The management of halal food is an emerging research field. Prior studies have focused mainly on consumer studies such as consumer awareness of halal products, purchasing behavior of Muslim consumers, product adoption and branding (Bonne et al. 2007; Omar, Muhammad & Omar 2008; Suddin, Harvey & Hanudin 2009; Golnaz et al. 2010; Alam & Sayuti 2011; Wilson & Liu 2010; Hanzae & Ramezani 2011). Since, halal food has become a global issue; the management of halal food supply chain has become an integral part of the halal food business. However, only limited study have been conducted in the context of halal food supply chain, and that too are either case studies or general descriptive essays. The aim of this research is to investigate the critical factors of halal food supply chain model in processed food and beverage industry using a multi-criteria decision making method. Understanding and identification of critical factors of halal food supply chain will help the researcher to develop conceptual framework for future research. The assessment of the critical factors also will assist the halal food manufacturers develop strategies which may improves their performance and competitiveness. The rest of the paper is structured as follows. Section 2 presents a brief review of related literature on critical factors of halal food supply chain and proposed a hierarchical conceptual framework. An outline of research methodology is given in section 3, followed by analysis

and results in section 4. Finally, the paper concludes with a brief discussion on major findings in section 5.

2.0 LITERATURE REVIEW

Through an extensive review of literature, we identified thirteen factors which were then clustered into four factor-categories. A brief discussion of the factor under each factor-category is provided below.

2.1 Factor-categories and Factors of Halal Food Supply Chain

Halal food supply chain (HFSC) is vital to food manufacturers in order to deliver credibility and trust to Muslim consumers. The term halal food supply chain refers to the process of managing halal food products, starting from the point of origin to the point of consumption and involving different parties from suppliers to end-users (Zulfakar, Anuar & Talib, 2012). Furthermore, related activities under halal supply chain include sourcing, warehousing, transporting, handling of product, inventory management, procurement, marketing and order management must all comply with the general principles of Shariah law. Though there are some studies conducted on halal food supply chains, however, this area is still under-researched. These factors-categories are discussed as follows.

2.1.1 *Physical attributes*

Physical attributes referring to the characteristics or features of halal food products where they must be safe for consumption, need to be clean, healthy and nutritional and generally everything is allowed except what has been specifically forbidden according to Quran. In the manufacturing of halal products, it is imperative that all possible sources of contamination are eliminated and this can be accomplished by ensuring the production lines and equipment used are thoroughly cleansed and sanitized (Riaz & Chaudry, 2004). The halal food manufacturers should not only focus on Islamic processing techniques, but also on quality assurance processes. Quality assurance also reflects the safety and quality for both products and processes (Abdul Talib, Mohd Ali & Jamaludin, 2008). Focusing on physical attributes is part of halal as a holistic concept and it should reflect halal products in terms of cleanliness,

safety, health and nutrition (Mohamad & Hassan, 2011). Religion also plays an important role in people's lives through shaping their beliefs, knowledge, attitudes and even food habits (Ireland & Rajabzadeh, 2011; Kordnaeij, Askaripoor, & Bakhshizadeh, 2013; Wilson & Liu, 2010). For a Muslim, the basic guidance for laws concerning food are revealed in the Holy Quran and explained and recorded in the Hadith (the compilation of the traditions of the Prophet Muhammad) (Bonne & Verbeke, 2008) and these constitute the two major sources of Islamic dietary law. According to Islamic dietary law all food products are permitted except those that are forbidden such as alcohol, pork, blood, meat from cadavers, and meat of animals that has not been slaughtered according to Shariah law (Riaz & Chaudry, 2004; van der Spiegel, van der Fels-Klerx, Sterrenburg, van Ruth, Scholtens-Toma, & Kok, 2012). Based on the discussion above, cleanliness, health and nutritious, safety of the products and understanding the Islamic dietary law are considered to be four important factors of halal food physical attributes.

2.1.2 Process capability

Process capability covers how the halal food products are segregated from non-halal, how the food shall be processed using dedicated equipment and facilities, how they are stored and transported and how halal food shall be suitably packed, labelled and advertised. Food products manufactured for Muslim consumers must comply with halal criteria. The criteria are the nature, origin and processing method of the food product (Bonne & Verbeke, 2008; van der Spiegel et al., 2012). For Muslim consumers, trust in halal food relates to how the food being processed. During the processing stage, such as storage and display, halal products must be segregated from non-halal products to prevent cross contamination (Nakyinsige, Man & Sazili, 2012). The process of packaging and labelling products must also be considered in order to create a genuine and wholesome halal product (Ab Talib & Mohd Johan, 2012). There should be no mixing between halal and non-halal goods on a load carrier or in a common transportation vehicle (Ngah & Zainuddin, 2012). Furthermore, dedicated equipment and facilities used for non-halal products cannot be used for halal products (DoS, 2009). Thus, the issues such as physical segregation, material handlings, storage and transportation,

and packaging and labelling are the factors considered under the process capability factor-category.

2.1.3 Ethical issues

The development of a halal product must be ethical and thus consistent with Shariah principles. Studies suggest that features are: being environmentally friendly, considered animal welfare, having an organic character, being respectful to Islamic financing and fair trade attributes are the common features of ethical practices (Mohamad & Hassan, 2011). In this study, we only focus on the two elements of the ethical issues which are environmental friendliness and fair trade practices. Al-Qaradawi (2007) emphasizes that the principle of permissibility is not only limited to the things and objects being used but also includes all human actions and behaviours. Additionally, having ethical producers who are involved in fair trade and socially responsible within the whole production chain do constitute a major concern in the halal industry (Irfan, 2010). In practice, a sale transaction is regarded as legal if it is made through the mutual consent of the parties concerned, and where no undue advantage is taken and charged high prices (Mohammed, 2013). Also, manufacturers are not allowed to use harmful ingredients or engage in unethical conduct that may possibly undermine consumers. Hence, the ethical issue is considered as one of the factor-categories.

2.1.4 Management capability

In this study, management capability is referred to the organizational capability to be competent in halal food industry. These may include such as making sure that the staff and personnel are trained in the halal principles, allocating adequate resources in order to implement halal food chain and having the capability to involve in innovation. To develop a sustainable pool of knowledge workers and professionals in the halal industry, training is vital and management should ensure that everyone is trained (Tieman et al., 2012). In Malaysian Standard MS1500:2009, it is stated that personnel should be trained in halal to ensure compliance with Shariah precepts. Management also needs to involve in innovation such as

venturing in the development of a halal traceability and tracking system. These can be established for the purpose of improving halal transparency in supply chains (Zailani et al., 2010). At the same time, management needs to ensure that resources are adequate such as manpower, infrastructure, machinery and equipment and finances are provided (DoS, 2009). In this study, the factors such as trained-personnel in halal, resource adequacy and innovative capability are considered under management capability factor-category for halal food supply chain.

2.2 Hierarchical Conceptual Framework

Based on the discussion above, we proposed a hierarchical conceptual framework with the goal of determining critical factors of halal food supply chain in the Malaysian context. The framework which is shown in Figure 1 is described by four higher-level factors-categories and thirteenth factors of halal food supply chain. The four higher-level factors-categories are physical attributes, process capability, the ethical issues and management capability. The factors included in the physical attributes comprise of cleanliness, safety, health and nutritious and understanding of Islamic dietary law. Process capability covers the processing aspects at different stages which are the aspects of physical segregation of products, how the materials are handled using dedicated equipment and facilities, how the products are stored and loaded on a transport and how the product is been packaged and labelled. The ethical issues include the factors which are environmental friendliness and fair trade practices and management capability represents the factors such as adequate trained-personnel in halal, having adequate resources and capable to involve in innovation activities.

Insert Figure 1 about here

3.0 RESEARCH METHODOLOGY

3.1 Method of Analysis – Analytic Hierarchy Process (AHP)

This research employed the analytical hierarchy process (AHP) methodology for analysis. AHP is a multi-criteria decision making approach which integrates simultaneously qualitative and quantitative

information in which the factors are arranged in a hierarchic structure. AHP has been applied to a wide variety of contexts including identifying critical success factors for ISO implementation (Sambasivan & Fei, 2008), automobile selection (Byun, 2001), web sites selection (Ngai, 2003), supplier selection in fast changing fashion market (Chan & Chan, 2010) as well as in the food and beverage industry (Bandeira, Becker & Waquil, 2011). Eventually, AHP is providing the consistency in managers’ judgement, obtaining managers preferences such as through Likert scales and forces them to make explicit comparisons between priorities (Rahman et al., 2014). Furthermore, AHP analysis not only clarifies the ranking of the priorities, but also measures how much more/less important a given priority is. AHP employs a scale with the exact numbers between 1 – 9 to measure the judgements (Table 1) which has been validated for its effectiveness (Saaty, 1990). The modelling process of AHP consists of four steps:

- 1. Identification of key factors of halal food supply chain studies;
- 2. Structuring the problem and model building;
- 3. Collection and compilation of decision makers’ opinions and application of prioritisation procedure to determine normalised priority weights of individual factors;
- 4. Analysing the priority weights and deriving solutions to the problem.

| Insert Table 1 about here |

3.2 Profile of the Respondents

This study used critical case sampling method to identify the cases. This method is used by looking for the cases that are ‘particularly information rich’ in relationship to the questions under consideration (Yin 2003). Ten leading halal processed food and beverage organizations were identified for the study. These are large-scale organizations and operating for more than a decade and some of them been awarded halal champion in the industry (see Table 3). Ten senior executives from the identified organizations were interviewed. The respondents were selected on the basis of the vital positions that they hold in the organizations and their capacity to provide the required information. Due to the nature of the method, AHP approach does not require a large sample (Wong & Li 2008).

The used of a small sample size is a norm in AHP for analysis which may vary below 3 to 15 respondents (Cheng & Li 2002; Lam & Zhao 1998). Thus, ten respondents are sufficient as sample size for the study. The responding organizations are located across Malaysia and over the years they have contributed significantly to the growth of Malaysian halal food industry.

A two part questionnaire was employed for data collection. Part A consists of questions (in AHP format) designed to capture respondents' opinions on the relative importance of factor-categories and factors, whereas Part B contained questions related to company and respondents' background. The respondents were briefed on the procedure required in the AHP methodology. The researcher went through every question with the respondents and further clarification was given upon each of the question asked.

Table 2 provides respondent-related information. The respondents' position, education level, working experience, working experience in halal food industry and frequency of attended halal course vary from one respondent to another. Among the interviewees one is a director, three are senior executive officers and the rest are managers. One respondent holds post graduate qualification while others have bachelor degrees. The working experience ranged between 5 to 20 years with an average of thirteen years. All respondents have extensive experience of working in halal food industry with an average of nine years. Attending halal courses such as workshops and seminars organized by Department of Islamic Development Malaysia (JAKIM) and Halal Industry Development Corporation (HDC) are highly encouraged to all halal manufacturers. Both JAKIM and HDC have been entrusted by the Malaysian government to issue halal certificate and provide global halal support systems. Of the ten respondents, two respondents have attended halal courses more than ten times and the rest have attended the courses between four to nine times.

Table 3 summarizes organization related information. All selected organizations belong to either large or medium-sized. Of the ten organizations, five are large organizations employing over 200 employees and the remaining five are medium-sized organizations. Of the ten responding companies,

seven are involved in the processed food, two are in beverage product and one is involved in manufacturing of both processed food and beverage. Five companies are in operation for more than 30 years and others are in operation between 19 and 26 years.

Insert Table 2 about here
Insert Table 3 about here

4.0 ANALYSIS AND RESULTS

4.1 Determination of the Critical Factors

Expert choice[®] software was used to analyse the data and to determine relative weights of each factors. The final weights obtained by AHP method for the ten selected organizations are shown in Table 4. From the analysis, it is evident that process capability is the most critical factor-category of halal food supply chain with a weight of 0.4344 (Inconsistency ratio (IR) = 0.00966 which is within the acceptable level of ≤ 0.1). Ethical factor-category is found to be the second most critical factor-category with weight = 0.2545 (IR = 0.00); whereby management capability is ranked as the least critical factor-category in halal food supply chain (weight = 0.1469; IR = 0.00016).

At the factor level, safety (weight = 0.5103), material handlings (weight = 0.3889), environmental friendliness (weight = 0.7684) and trained-personnel in halal (weight = 0.5820) are found to be the most critical factors under physical attributes, process capability, ethical issues and management capability factor-categories respectively. The factors such as Islamic dietary law (weight = 0.0659), storage and transports (weight = 0.1347), fair trade practices (weight = 0.2316) and innovative capability (weight = 0.1052) are found to be the least critical factors for each of the factor categories. Overall weights for all factors are shown in Table 4 and Figure 2. It is evident that the top five most critical factors for halal food supply chain are environmental friendliness (weight = 0.1956), material handlings (weight = 0.1689), physical segregation (weight = 0.1373), trained-personnel in halal (weight = 0.0855) and safety (weight = 0.0838).

Insert Table 4 about here

Insert Figure 2 about here

4.2 Determination of Critical Factors based on the type of Products

To assess whether or not critical factors are different in the type of product such as processed food and beverage, analysis are conducted separately for the two category of product. The results are summarized in Table 5. The overall IR for processed food and beverage ranged from 0.01 and 0.02 respectively. In both of the cases the IR are within the acceptable level.

4.2.1 *Processed food*

At the 1st level of AHP model, the findings from processed food indicate that process capability (weight = 0.4143) is the most critical factor category for defining halal food supply chain in the context of Malaysian halal food industry. Physical attributes (weight = 0.1402) is identified as the least critical factor-category under processed food category. Based on the results at factor level, environmental friendliness factor is considered as the most critical factor under processed food with a weight of 0.2022 whereas Islamic dietary law was found to be the least critical factor for processed food with a weight of 0.0089. The top five most critical factors in processed food are environmental friendliness (0.2022), physical segregation (0.1498), material handlings (0.1439), trained-personnel in halal (0.1118) and safety (0.0746).

4.2.2 *Beverage*

In the context of beverage, the results show slightly different in the range of factor-categories and factors. Process capability remains as the most critical factor-category under beverage with a weight of 0.4695. However, the least critical factor-category goes to management capability with a weight of 0.0600. At the 2nd level of AHP model, the results indicate that material handlings (weight = 0.2339) is the most critical factor. Environmental friendliness

comes to the second most critical factor under manufacturing of beverage. Innovation capability was found to be the least critical factor under beverage with a weight of 0.0051. The top five most critical factors under beverage are material handlings (0.2339), environmental friendliness (0.1578), packaging and labelling (0.1233), safety (0.1127) and cleanliness (0.1083).

Insert Table 5 about here
Insert Figure 3 about here

4.3 Sensitivity Analysis

Sensitivity analysis is carried out to investigate whether small variations in the model parameters would change the ranking of the enabling factors and lead to different outcome. The model is tested with two scenarios based on the two most critical factors-categories such as process capability and ethical issues. As part of the sensitivity analysis, two scenarios are generated: (i) One by increasing the weight of process capability and ethical issues, and (ii) Second by decreasing the weight of process capability and ethical issues. The results are discussed below:

4.3.1 Sensitivity analysis based on process capability

First, the weight of the process capability factor-category was varied. Figure 4 shows dynamic sensitivity analyses of the thirteen factors perform with respect to the change in process capability factor-category. Figure 4(a) demonstrates that when weight is increased from 0.4344 to 0.4730, the priority of the sub-factor is changed, i.e., Environmental friendliness becomes the second most important factor. Material handlings turned up to be the most important factor. When the weight is decreased from 0.4344 to 0.3320, trained-personnel in halal becomes the second most important factor instead of material handlings (see Figure 4(b)). However, environmental friendliness remains as the top most important factor.

Insert Figure 4 about here

4.3.2 *Sensitivity analysis based on ethical issues*

Second, the weight of ethical issues factor-category was varied. Figure 5(a) shows that when weight is increased from 0.2525 to 0.4520, the priority of the enabling sub-factors is changed, i.e., fair trade practices becomes the third most important factors instead of physical segregation. The ranking of environmental friendliness and material handlings remain the same. When the weight is decreased from 0.2525 to 0.2250, material handlings becomes the most significant factor and environmental friendliness shifts to the second position. Figure 5(b) illustrates these results.

Insert Figure 5 about here

5.0 DISCUSSION & CONCLUSIONS

This study determines the critical factors required for halal food supply chain in the context of Malaysian halal food industry. The information gathered from the senior executives through an in-depth interview of both halal processed food and halal beverage companies. The research employed AHP, a multi-criteria decision making methodology for formulating and analysing the gathered information. In factor-category, the findings depicted that process capability is the most critical factor-category of halal food supply chain. Ethical issues factor is found to be the second most critical factor-category whereby management capability is ranked as the least critical factor-category in halal food supply chain. The results are matched with the series of interview conducted where most of the manufacturers agreed process capability is extremely important in developing halal food supply chain. For them, having a proper manufacturing process can produce a good quality of halal product. The research found that to determine whether the food is halal or haram, it depends on its nature, how it is processed and how it is obtained. In the case of factor level, safety and cleanliness are the two most critical factors in physical attributes factor-category and material handlings together with physical segregation turn out to be the two most critical factors in process capability factor-category. In the ethical issues factor-category, environmental friendliness is the most critical factor in developing halal food supply chain whereby trained-personnel in halal become the most critical factor for management

capability factor-category. Overall, the top five factors are environmental friendliness, material handlings, physical segregation, trained-personnel in halal and safety.

On the other hand, the results of the critical factors in defining the halal food supply chain are different with regard to the type of products. Obviously, the factors which are physical segregation, material handlings, packaging and labelling, cleanliness and trained-personnel in halal are shown different ranking in both of processed food and beverage. Physical segregation is found to be more critical factor in the manufacturing of processed food compared to beverage. In the context of material handlings, beverage manufacturer ranked this factor as more critical compared to processed food manufacturer with the rank of 1 and 3 respectively. Processed food manufacturers think that trained-personnel in halal are more critical in their production but for beverage manufacturer this factor is less concerned in their production. Furthermore, packaging and labelling becomes more important in beverage production rather than processed food production when both of the manufacturers ranked it at 3 and 8 respectively. Cleanliness is more concerned in the manufacturing of beverage when it was ranked at 5 whereby in the manufacturing of processed food it was ranked at 10.

To comply with all halal requirements in a halal food chain has become a huge challenge to the manufacturer especially when the risk of cross-contamination is substantial (Bonne & Verbeke 2008). The integrity of halal food can only be secured by ensuring that halal products are not contaminated with non-halal products throughout the whole supply chain. Contaminated halal food will ultimately lead to an increase in supply chain cost due to food wastage. The food will be no longer consumable. For that reason, halal supply chain is vital to be applied by halal product manufacturers in order to deliver credibility and trust to consumers as well as the halalness of the food.

Based on the overall findings, it can be suggested that the manufacturers should emphasize on those critical factors if they want to device the strategies in order to have an efficient halal food supply chain. The findings also indicate that processed food and beverage have a different set of critical factors in defining their halal supply chain. For that reason, manufacturers should take into

consideration of those set of critical factors if they want to produce a credence quality attributes of halal processed food and beverage products. Finally, the results provide valuable insights that can assist the managers in strengthening and improvise their own strategies and capabilities particularly in the context of halal food industry as to remain competitive in the market.

REFERENCES

- Ab Talib, M.S. & Mohd Johan, M.R. (2012). Issues in halal packaging: A conceptual paper. *International Business and Management*, 5(2), 91-5.
- Abdul Talib, H. H., Mohd Ali, K. A., & Jamaludin, K. R. (2008). *Quality Assurance in Halal Food Manufacturing in Malaysia: A Preliminary Study*. Paper presented at the International Conference on Mechanical & Manufacturing Engineering (ICME2008), Johor Bahru, Malaysia.
- Al-Qaradawi, Y. (2007). *The Lawful and the Prohibited in Islam*. Kuala Lumpur, Islamic Book Trust.
- Bandeira, D.L., Becker, J.L., & Waquil, H.D. (2011). *Applying Ahp To The Selection Of Suppliers Of Marketing Materials To A Large Brazilian Company In The Food And Beverage Industry*. Paper presented at The International Symposium on the Analytic Hierarchy Process.
- Bonne, K., & Verbeke, W. (2008). Religious values informing halal meat production and the control and delivery of halal credence quality. *Agriculture and Human Values*, 25(1), 35-47.
- Byun, D.-H. (2001). The AHP approach for selecting an automobile purchase model. *Information & Management*, 38(5), 289-297.
- Chan, F. T., & Chan, H. K. (2010). An AHP model for selection of suppliers in the fast changing fashion market. *The International Journal of Advanced Manufacturing Technology*, 51(9-12), 1195-1207.
- Cheng, E.W.L., & Li, H. (2002). Construction partnering process and associated critical success factors: Quantitative investigation. *Journal of Management in Engineering*, 18(4), 194-202.
- Malaysia, D. o. S. (2009). *Halal food - production, preparation, handling and storage - general guidelines (second revision) MS 1500:2009* (pp. 1-16). Malaysia: Department of Standards Malaysia.
- Fadzlillah, N.A., Che Man, Y., Jamaludin, M.A., Ab.Rahman, S. & Al-Kahtani, H.A. (2011). *Halal Food Issues From Islamic And Modern Science Perspective*. Paper presented at 2011 2nd International Conference on Humanities, Historical and Social Sciences, Singapore.
- HDC 2014, *Opportunities in Halal Economy*, Halal Industry Development Corporation, retrieved by 20 January 2014, <<http://www.hdcglobal.com>>.
- Ireland, J., & Rajabzadeh, S. A. (2011). UAE consumer concerns about Halal products. *Journal of Islamic Marketing*, 2(3), 274-283.
- Irfan, S. (2010). Consumer awareness: Thoughts and trends across the globe. *Halal J*, 2, 10-11.
- Kordnaeij, A., Askaripoor, H., & Bakhshizadeh, A. (2013). Studying affecting factors on customers' attitude toward products with Halal brand (case study: Kuala Lumpur, Malaysia). *International Research Journal of Applied and Basic Sciences*, 4(10), 3138-3145.
- Lada, S., Tanakinjal, G. H., & Amin, H. (2009). Predicting intention to choose <IT>halal</IT> products using theory of reasoned action. *International Journal of Islamic and Middle Eastern Finance and Management*, 2(1), 66-76.
- Lam, K., & Zhao, X. (1998). An application of quality function deployment to improve the quality of teaching. *International Journal of Quality & Reliability Management*, 15(4), 389-413.

- Lodhi, A-u-H. (2009). *Understanding Halal Food Supply Chain*. London, HFRC UK Ltd.
- Mohamad, A.B., & Hassan, H., (2011). The influences of halal integrity on product adaptation strategy for global trade. *International Business Management*, 5(6), 421-426.
- Mohammed, J.A., (2013). Business Precepts of Islam: The Lawful and Unlawful Business Transactions According to Shariah. *Handbook of the Philosophical Foundations of Business Ethics*, Springer, 883-97.
- Nakyinsige, K., Man, Y.C., & Sazili, A.Q. (2012). Halal authenticity issues in meat and meat products. *Meat Sci*, 91(3), 207-14.
- Ngah, A.H., & Zainuddin, Y. (2012) *Barriers to supply chain adoption among Malaysian halal manufacturers with general barriers as a moderating factor*. Paper presented at International Halal Conference 2012, Putra World Trade Centre Kuala Lumpur, Malaysia, 4th-5th September 2012.
- Ngai, E. (2003). Selection of web sites for online advertising using the AHP. *Information & Management*, 40(4), 233-42.
- Omar, E.N., Jaafar, H.S., & Osman, M.R. (2013). Halalan toyyiban supply chain of the food industry. *Journal of Emerging Economies and Islamic Research*, 1(3).
- Othman, P., Sungkar, I., & Hussin, W.S.W. (2009). Malaysia as an international halal food hub: Competitiveness and potential of meat-based industries. *Asean Economic Bulletin*, 26(3), 306-20.
- Rahman, S., Rashid, N., Yadlapalli, A., & Yiqun, L. E. (2014). *Determining Factors Of E-Government Implementation: A Multi-Criteria Decision-Making Approach*. Paper presented at Pacific Asia Conference on Information systems (PACIS) 2014, Chengdu, China, 24th-28th June 2014.
- Riaz, M.N., & Chaudry, M.M. (2004). *Halal Food Production*. United States of America, CRC Press.
- Saaty, T.L. (1990). Physics as a decision theory. *European Journal of Operational Research*, 48, 98-104.
- Sambasivan, M., & Fei, N.Y. (2008). Evaluation of critical success factors of implementation of ISO 14001 using analytic hierarchy process (AHP): a case study from Malaysia. *Journal of Cleaner Production*, 16(13), 1424-33.
- Tieman, M. (2011). The Application of Halal in Supply Chain Management : in-depth interviews. *Journal of Islamic Marketing*, 2(2), 186-195.
- Tieman, M., Vorst, JGAJvd., & Ghazali, M.C. (2012). Principles in halal supply chain management. *Journal of Islamic Marketing*, 3(3), 217-43.
- Van der Spiegel, M., van der Fels-Klerx, H.J., Sterrenburg, P., van Ruth, S.M., Scholtens-Toma, I.M.J., & Kok, E.J. (2012). Halal assurance in food supply chains: Verification of halal certificates using audits and laboratory analysis. *Trends in Food Science & Technology*, 27(2), 109-19.
- Wilson, J. A. J., & Liu, J. (2010). Shaping the <IT>Halal</IT> into a brand? *Journal of Islamic Marketing*, 1(2), 107-123.

- Wong, J.K.W., & Li, H. (2008). Application of the analytic hierarchy process (AHP) in multi-criteria analysis of the selection of intelligent building systems. *Building and Environment*, 43, 108-125.
- Yin, R.K. (2003). *Application of Case Study Research*. Thousand Oaks California, Sage.
- Zailani, S., Arrifin, Z., Abd Wahid, N., Othman, R., & Fernando, Y. (2010). Halal traceability and halal tracking systems in strengthening halal food supply chain for food industry in Malaysia (A Review). *Journal of Food Technology*, 8(3).
- Zulfakar, M.H., M Anuar, M., & Ab Talib, M.S. (2012). *Conceptual Framework on Halal Food Supply Chain Integrity Enhancement*. Paper presented at International Halal Conference 2012, Putra World Trade Centre Kuala Lumpur, Malaysia, 4th-5th September 2012.

Appendix

Figure 1: A Hierarchical Conceptual Framework of Halal Food Supply Chain

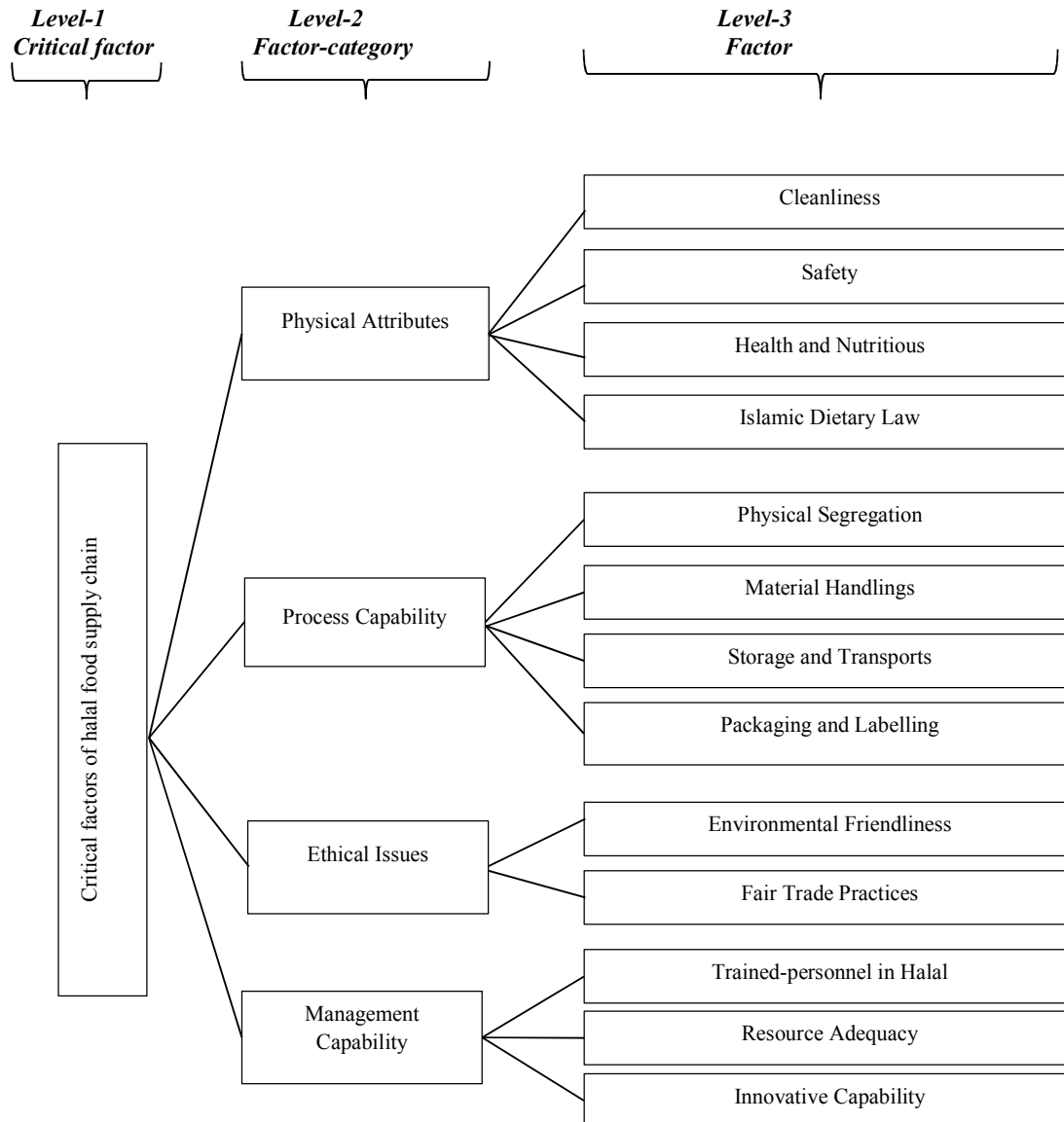


Table 1: The Fundamental Scale of AHP

Intensity of Importance on an absolute scale	Definition	Explanation
1	Equal importance	Two activities contribute equally to the objective
3	Moderate importance of one over another	Experience and judgment strongly favour one activity over another
5	Essential or strong importance	Experience and judgment strongly favour one activity over another
7	Very strong importance	An activity is strongly favoured and its dominance demonstrated in practice
9	Extreme importance	The evidence favouring one activity over another is of the highest possible order of affirmation
2, 4, 6, 8	Intermediate values between the two adjacent judgments	When compromise is needed

Table 2: Respondents Profile

Respondent	Position	Education level	Working experience	Working experience in halal food industry	Frequency of halal course attendance
Company A	Manager	Graduate	5	5	4
Company B	Senior Executive Officer	Graduate	15	10	3
Company C	Manager	Graduate	9	9	7
Company D	Senior Executive Officer	Graduate	15	5	5
Company E	Manager	Graduate	12	7	6
Company F	Senior Executive Officer	Graduate	20	17	12
Company G	Manager	Graduate	13	8	7
Company H	Manager	Post-graduate	18	12	9
Company I	Manager	Graduate	6	6	5
Company J	Director	Graduate	17	11	11

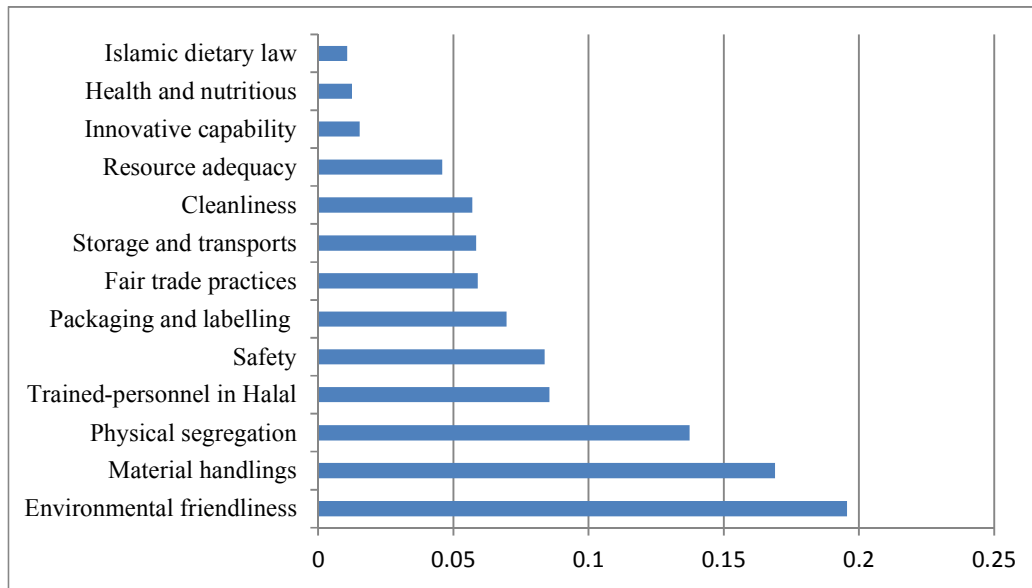
Table 3: Organizations Profile

Organization	No of Employee	Product	Organization size	Operation Years
Company A	75 - 200	Processed Food	Medium	19 years
Company B	75 - 200	Processed Food	Medium	42 years
Company C	201 - 500	Processed Food	Large	19 years
Company D	201 - 500	Processed Food	Large	26 years
Company E	75 - 200	Beverage	Medium	21 years
Company F	501 - 1000	Processed Food & Beverage	Large	31 years
Company G	201 - 500	Processed Food	Large	34 years
Company H	>1000	Processed Food	Large	34 years
Company I	75 - 200	Processed Food	Medium	19 years
Company J	75 - 200	Beverage	Medium	37 years

Table 4: Relative Weights for Factor-category and Factor

Factor Category	Relative weight	Factor	Relative weight	Ranking	Overall weight	Ranking
Physical Attributes CR = 0.00847	0.1642	Cleanliness	0.3471	2	0.0570	9
		Safety	0.5103	1	0.0838	5
		Health and nutritious	0.0767	3	0.0126	12
		Islamic dietary law	0.0659	4	0.0108	13
Process Capability CR = 0.00966	0.4344	Physical segregation	0.3160	2	0.1373	3
		Material handlings	0.3889	1	0.1689	2
		Storage and transports	0.1347	4	0.0585	8
		Packaging and labelling	0.1604	3	0.0697	6
Ethical Issues CR = 0.00	0.2545	Environmental friendliness	0.7684	1	0.1956	1
		Fair trade practices	0.2316	2	0.0590	7
Management Capability CR = 0.00016	0.1469	Trained-personnel in halal	0.5820	1	0.0855	4
		Resource adequacy	0.3128	2	0.0459	10
		Innovative capability	0.1052	3	0.0154	11
Overall Consistency ratio (CR) = 0.01						

Figure 2: Overall Priority Ranks for Halal Food Supply Chain



Overall consistency ratio (CR) = 0.01

Table 5: Ranking of Factors with Regards to the Type of Product

AHP Level	Factor-Category	Type of product							
		Processed food				Beverage			
		Weight	Ranking			Weight	Ranking		
Level 1	Physical attributes	0.1402	4			0.2601	2		
	Process capability	0.4143	1			0.4695	1		
	Ethical issues	0.2614	2			0.2104	3		
	Management capability	0.1841	3			0.0600	4		
AHP Level	Factor	Type of product							
		Processed food				Beverage			
		Relative Weight	Ranking	Overall weight	Ranking	Relative Weight	Ranking	Overall weight	Ranking
Level 2	Cleanliness	0.3277	2	0.0459	10	0.4163	2	0.1083	5
	Safety	0.5321	1	0.0746	5	0.4333	1	0.1127	4
	Health and nutritious	0.0770	3	0.0108	12	0.0751	4	0.0195	12
	Islamic dietary law	0.0632	4	0.0089	13	0.0753	3	0.0196	11
	Physical segregation	0.3615	1	0.1498	2	0.1716	3	0.0806	6
	Material handlings	0.3474	2	0.1439	3	0.4984	1	0.2339	1
	Storage and transports	0.1573	3	0.0652	6	0.0674	4	0.0316	8
	Packaging and labeling	0.1339	4	0.0555	8	0.2626	2	0.1233	3
	Environmental friendliness	0.7734	1	0.2022	1	0.7500	1	0.1578	2
	Fair trade practices	0.2266	2	0.0592	7	0.2500	2	0.0526	7
	Trained-personnel in halal	0.6072	1	0.1118	4	0.4831	1	0.0289	9
	Resource adequacy	0.2823	2	0.0519	9	0.4313	2	0.0259	10
	Innovative capability	0.1104	3	0.0203	11	0.0856	3	0.0051	13
Consistency ratio (CR)		0.01				0.02			

Figure 3: Priority Ranks for Halal Food Supply Chain based on the type of Products

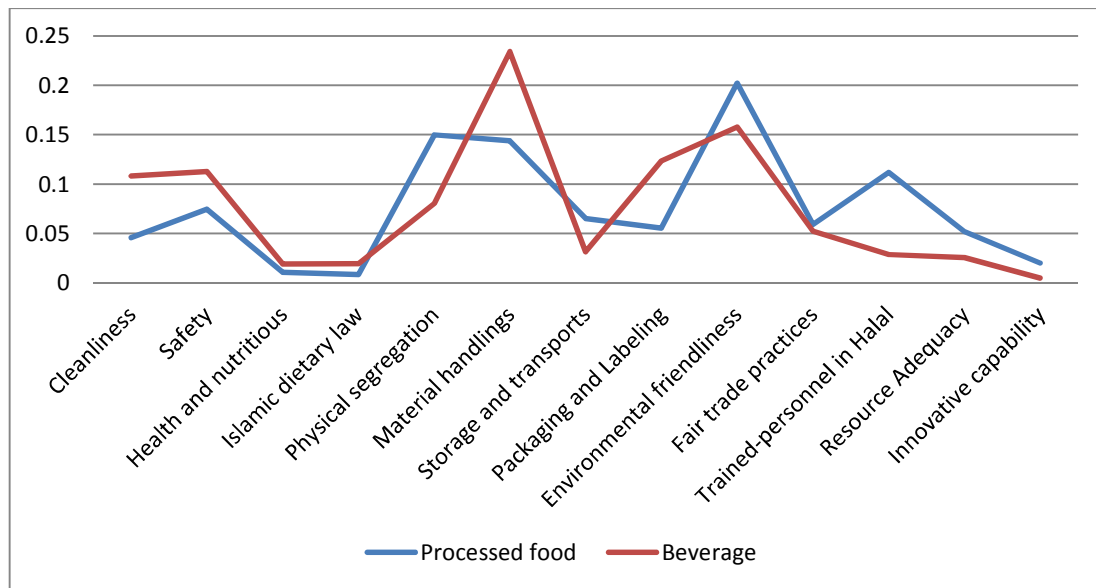


Figure 4: Sensitivity Analysis when Process Capability is varied

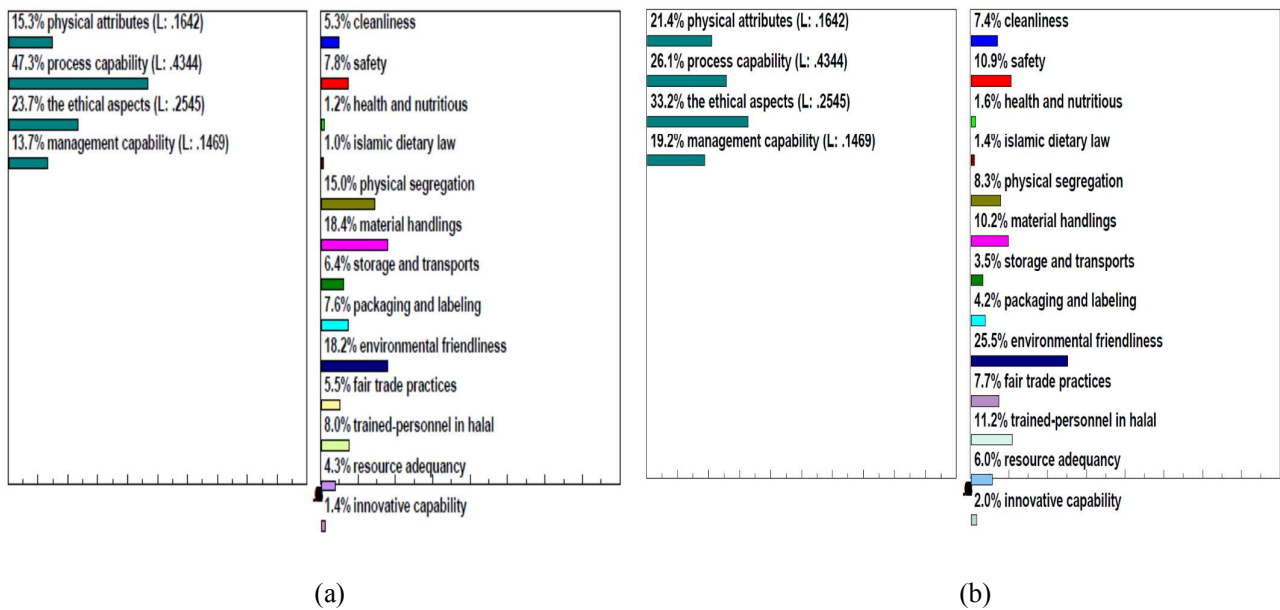
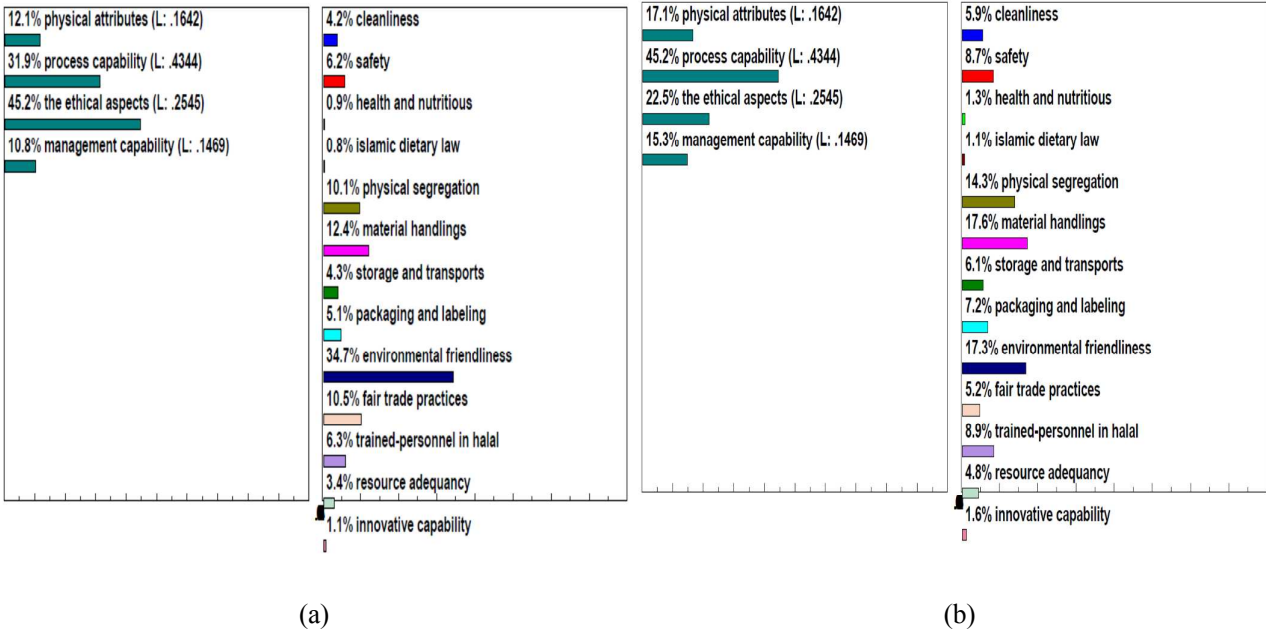


Figure 5: Sensitivity Analysis when Ethical Issues are varied



29th ANZAM Conference 2015

Manuscript ID: ANZAM-2015-122

Manuscript Title: Determining Critical Factors of Halal Food Supply Chain using the Analytic Hierarchy Process (AHP)

Author: Wan Marhaini Wan Omar and Shams Rahman

Date: 7 September 2015

Reviewer 1	Response	Reviewer 2	Response
In abstract the word “thirteenth” may be replaced with thirteen. The name of the software used need not be mentioned.	Corrected in the revised paper	The later part of the introduction needs to be revamped to focus on the contribution of this study in theory and practice.	The later part of introduction has been revamped with more details elaboration on the theoretical and practical contribution of the study. <ul style="list-style-type: none"> Understanding and identification of critical factors of halal food supply chain will help the researcher to develop conceptual framework for future research. The assessment of the critical factors also will assist the halal food manufacturers develop strategies which may improves their performance and competitiveness.
In Introduction section, first line “It worth” may be replaced by “it worths”.	Corrected in the revised paper	The research questions/objectives need to be explicitly articulated.	The aim of this research is to investigate the critical factors of halal food supply chain model in processed food and beverage industry.
For efficient distribution and fulfilment of the global demand, the focus of halal food management has shifted from the organization cantered perspective to the supply chain perspective.	Corrected in the revised paper	The methodology is very simple and the application is simple.	The methodology part has been extended on the method used and the rationale why the respondents and the organizations were selected for the study.

Page 2. There are also the issues. Omit "the".	Corrected in the revised paper	Bring in the uncertainty and risk factors in your sensitivity analysis part.	The sensitivity analysis is carried out just to check whether small variations in the parameters would change the ranking of the enabling factors and is it will impact on the outcome. Thus, we don't think elaboration on the uncertainty and risk factors are required for the study.
First line of section 2, "we identified thirteenth factors". It should be thirteen factors.	Corrected in the revised paper	The discussion sections needs to be more focused on the study's result in supply chain issues.	The discussion section has been elaborated and more focused on the study's result with the current halal supply chain issues.
"In the manufacture of Halal products"- grammatical error. The noun form manufacturing should be used in place of manufacture.	Corrected in the revised paper		
"Additionally, having ethical producers who are involved in fair trade and are socially responsible within the whole production chain do constitutes a major concern in the halal industry (Irfan, 2010)"-----Grammatical errors in sentence construction. Omit the second "are". Write "do constitute".	Corrected in the revised paper		
The phrase "Halal training and personnel" does not bear any meaning. Does the author want to say adequate no of personnel and training imparted by halal food chains? The meaning should come out by the usage of proper phrase.	The phrase "halal training and personnel" has been changed to "trained-personnel in halal"		
Page 6----- it should be "capability to involve in innovation activities"	The phrase "capability to involve in innovation activities" has been changed to "innovative capability"		

Page 7 ---- typing error. “The interviewed were”. Please correct this.	Corrected in the revised paper		
Page 8----- “One respondent hold” should be replaced by “One respondent holds”.	Corrected in the revised paper		
Page 8----- “an average of thirteenth years” should be replaced by “an average of thirteen years”.	Corrected in the revised paper		
I want to know, what is the overall consistency ratio (CR) of the model.	The overall consistency ration (CR) is 0.01.		
How does the author ensure that the thirteen factors chosen are non-overlapping?	The factors were identified through extensive review of literature and we ensure that the factors chosen are not overlapping.		
What is the rationale of choosing these organisations?	The rationale of choosing these organizations because they are large-scale organizations and operating for more than a decade and some of them been awarded halal champion in the industry.		
How does the author ensure that this is a good sample size to generalize his finding?	<ul style="list-style-type: none"> • Due to the nature of the method, AHP approach does not require a large sample (Wong & Li 2008). • The used of a small sample size is a norm in AHP for analysis which may vary below 3 to 15 respondents (Cheng & Li 2002; Lam & Zhao 1998). • Thus, ten respondents are sufficient as sample size for the study. 		

What is the rationale behind selecting the individual respondents?	<ul style="list-style-type: none">• Ten senior executives from the identified organizations were interviewed.• The respondents were selected on the basis of the vital positions that they hold in the organizations and their capacity to provide the required information.		
--	---	--	--