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Collagen Products: Issue of *Halalness* and the Consumers' Tendency of Acceptance

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ABSTRACT

Collagen is essential to a human being because it is an important source of amino acids. Lack of collagen may cause health problems such as decreased joint elasticity and aging. Collagen is in high demand, especially in food and beverages, cosmetics, and health industries. Nevertheless, the sources of collagens and gelatins are recently being questioned, particularly among Muslim users, on the status of halãlness. The study's objective is to derive the guiding principles from the Qur'ãnic and Prophetic points of view related to sources of collagen products. This study also aims to explore the tendency that consumers in Malaysia will choose halal collagen in their consumption and its determinants. Both qualitative and quantitative methods are adopted. Analytical, inductive, and deductive approaches are used under the qualitative method. Descriptive and logistic regression are used under the quantitative method in which data are collected from a

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survey. The study finds that any collagen products sourced from bovine bone, bovine hide, porcine skin, and non-slaughtered animals are non-halal. The sources obtained that might affect the ecosystem and environment are highly discouraged in Islam, and the use of recombinant collagen-like protein from selected bacteria is permissible as long as it complies with the related halal and health regulations imposed by the authorities. Empirically, the probability that consumers opt for halal collagen is significantly determined by gender, age, religion, education, and income level. The likelihood of consumers opting for halal collagen is higher among the elderly, females, Muslims, highly educated consumers, and middle-income consumers. The empirical results also reveal that consumers' tendency to choose halal collagen is significantly influenced by the idea that the collagen should support Maqasid Shariah and be approved by JAKIM.

Keywords: *Collagen, Halal, Logit, Regression*

INTRODUCTION

The primary sources of collagen are mainly the land animal such as bovine, porcine, and poultry, and a small portion from marine and others. Collagen is a protein extracted from bones, skin, tendons, and ligaments. There are five common types of collagens, and their structure determines each. Collagen is essential to a human being because it is an important source of amino acids Lack of collagen may cause health problems such as decreased joint elasticity and aging. Collagen could boost the health and nutritional values of the human body, including the ability to control many cellular functions in the human body (Brett, D., 2008), improves skin and heart health, and so promotes the wound healing process (Marrs, Jo., 2020). Collagen is in high demand, especially in food and beverages, cosmetics, and health industries. The market size for collagen in 2015 reached USD860.2 million and has increased over the years (Riaz, M., & Chaudry; M., 2004). Currently, the collagen market exceeded USD3,600 million in 2020 due to the higher level of awareness of the health benefits of collagen. (Kunal Ahuja & Sonal Singh, 2021).

However, the sources of collagens and gelatins are recently being questioned, particularly among Muslim users, on the status of halãlness.

This is because the raw materials used in its manufacture could be sourced from porcine or non-halal slaughtered animals. Given that most collagens are from animal sources, it is still not the best choice because of the growing concerns about the transfer of diseases from land animals. Moreover, land-animal collagen may cause an immunogenic reaction (Schmidt M. M. et al., 2016). Another issue with animal-based collagen is that the vegetarian community is not allowed to use it. Hence, it is essential to provide an alternative source of collagen. Undoubtedly, fish and other marine sources of collagen slowly access the market. However, certain countries have limited fish and marine life supplies to suit manufacturing facilities.

Nonetheless, society is now highly aware of preserving the environment and biodiversity. Thus, many efforts have been carried out to produce recombinant human collagen using plants (Fertala, A., 2020) & (Exposito, F. et al., 2000) and insects and yeast (Myllyharju, J., 2009). However, those efforts experienced difficulty caused by the requirement for post-translational proline hydroxylation. Collagen-like proteins have been identified in bacteria during the last ten years, principally from analysis of genome databases. Collagen-like proteins, especially in bacteria, can form triple-helix structures even though they are lacking. Through research and development, the genes of collagen-like proteins have been identified in various bacteria during the last ten years. Several bacterial collagens have been expressed in bacteria E. coli, and they adopt a triple-helix conformation. Unlike animal collagen, these bacterial collagens are readily produced in large quantities by recombinant methods, either in the original amino acid sequence or in genetically manipulated sequences (Yu, Z. et al., 2014). It is expected that the demand for collagen-like protein will be on par with the popularity of collagen due to its beneficial qualities, such as being safe for Muslim consumers and those with religious considerations.

Thus, this research examines the sources of collagen products based on the Al-Quran and Prophetic guidance. This may help to solve the high demand for collagen, limited supplies of collagen alternatives, and the non-halal-certified collagen issues in Malaysia. Besides, the current study also explores how consumers in Malaysia will choose halal collagen in their consumption and its determinants. This study is organized as follows. Following the introduction are the past studies under the literature review. Next, is the methodology used, followed by the findings and conclusion.

Literature Review

Collagen is the most abundant protein in the human body. It can be found in human bones, muscles, ligaments, tendons, organs and skins (Nor Atikah, 2015). One's cannot measure the level of collagens in their body yet, and they know precisely when the level of collagens is dropping.

Wrinkles, joint pain, and muscle weakening are among the indicators of decreasing collagen levels (Varani, J., 2006). Why do people consume collagens? Collagens can be consumed naturally through healthy diets, yet the human body cannot absorb collagen effectively as people get older. Therefore, a dietary supplement is one of the available alternatives. Studies show that taking collagen is mainly associated with its health benefits, such as relieving joint pain and being best for skin health. While most consumers believe health is precious, collagens are also consumed for cosmetics (Ibrahim, Z., 2015).

Even to be specific, the benefits of collagen vary depending on the types of collagen that consumers consume. Most of the time, collagens are categorized into five types: Type I, Type II, Type III, Type V, and Type X collagen. (Gelse, K. et al., 2003). Type I collagen is best for slowing the effects of aging skin as it provides a structure for healthy skin. Usually, this type of collagen is found in products using bovine or fish collagen. Type II collagens are primarily found in cartilage and are usually represented by products based on chicken bone broth collagen, and therefore are best for healthy joints. Type III collagens support the structures of muscles, arteries, and organs. An example of Type III is bovine collagens from the bone and muscle of cows. Type V and Type X collagens are the minor collagen components that support collagen fibers of connective tissues. This could be found in the eggshell membrane collagen.

The collagens market is concentrated in food and beverages, pharmaceuticals, and cosmetics (Hashim P. et al., 2015). The products available could be ingested through jellies, powder, beverages, and capsule form, or collagen products could be produced for cosmetics in terms of soaps, lotions, and creams (Omar S. et al., 2019). In addition, the source of collagens can be extracted from various sources, and its primary source is coming from pigskin. Therefore, issues arise in providing halalbased

collagen products to meet the demand from halal-awareness consumers, which, without which, constitutes a more significant market share towards the demand for collagen. Apart from the non-halal sources of gelatines, collagen-based products are also could be extracted from poultry animals (halal) and aquatic-based or fish-based gelatines (Rakhmanova, A. et al., 2018).

The usage of collagens as supplements in Malaysia is controlled by the National Pharmaceutical Control Bureau (NPCB). This is to ensure that the products are not only halal but do not have side effects on health. Only approved collagen can be used as a supplement. Besides being supplements, collagens are also in high market demand for drinks, food additives, edible films, and coating. In the food and beverages industry, using collagen improves product quality and boosts the nutritional value of the products (Hashim, P. et al. 2015). The use of gelatin, for example, as the derivative of collagen has been widely used for its characteristics as an emulsifier, thickening agent, food textures stabiliser and protein enrichment (Herpandi, N. Huda & F. Adzitey., 2011). Interestingly, the use of collagen is a significant component of the cosmetics industry as collagen brings the nature of moisture, regenerating, and natural humectant (Sionkowska, A., et al., 2020). Its potential could be seen in commercialising cosmetics based on hair, skin, and oral care.

As the demand for collagen products increases, it is significant for Muslim consumers to ensure that the collagen is extracted from permissible sources, especially those with easy halal certification identity. Even if it is permissible, specific other requirements shall be met. For example, if the collagen is extracted from the source of poultry animal, the animal shall be slaughtered according to the shariah requirements. Next, the usage of collagens should not bring harm one's health. The advancement of technology in the current food industry has set the requirements for the halal authority bodies to ensure that the source of collagen used is permissible (Zamzahaila, M. Z, et al., 2021). Other religion, such as Judaism, practices Kosher. Kosher means food fit for the Jews. Pork and shellfish-based collagen is also banned in Kosher, and not all marine-based collagen is considered Kosher (Mariod, Abdalbasit & Fadul, Hadia., 2013). Concerning culture, people with vegetarian diets, such as Hinduism and Buddhism, cannot consume collagen (Deane, C. et al. 2020) as it is hard to find plant-

based collagen. Though efforts have been made to use genetically engineered microorganisms as recombinant human collagen, the availability is limited.

Consumers' acceptance of collagen products does not merely depend on the factors of religion only. The opposing sides and health risks of porcine and bovine-based collagen, such as the effects of mad cow diseases, gelatin allergic consumption and neurodegenerative diseases, led consumers to find an alternative for collagen products (Zamzahaila, M. Z, et al., 2021). Marine-based gelatin or collagen products have been in the interest of consumers because recombinant collagen is expensive for commercial production (Olsen D. et al., 2003). Omar, S. (2019) highlighted that collagen is consumed depending on the level of knowledge one possesses on the choice of halal collagen. The more the consumers are aware of the halalness of goods, the more selective the source of collagen they consume. Moreover, religious beliefs and family opinions are also crucial in deciding the choice of collagen products. Consumers will always opt for halal products as they are safe, reliable, and hygienic (Sanep Ahmad et al., 2014; Duasa et al., 2020).

METHODOLOGY

The method adopted in the current study is twofold. The first method is qualitative, and the second is quantitative.

Qualitative Method

In this qualitative methodology, the study relies on three-language sources; Arabic, English and Malay texts related to the topic. It is also a combination of three approaches: analytical, inductive and deductive. An analytical technique is primarily applied in this research to investigate the Shariah critical points on the issue of collagen based on the analysis of various institutions and the information available in books, journals, websites, research works, thesis, articles in periodicals and Islamic primary sources such as the Al-Quran and hadith. The inductive and deductive methods are employed in deriving the guiding principles and processes based on those selected Quranic verses and Hadith. Concerning the grading of Hadith, the study mentions the grades of Hadith relying mainly on the analysis of scholars.

Quantitative Method

The tendency to opt for halal collagen among consumers is analysed using the quantitative method in which a survey is conducted. The sample size of respondents needs to be determined, and the simplest methods to apply are sample size rules of thumb. Browne (1995), for example, cites a general flat rule to 'use at least 30 subjects or greater to estimate a parameter, while Julious (2005) suggests a minimum sample size of 12 subjects per treatment arm. Teare et al. (2014), however, recommend a sample size of 70 to reduce the imprecision around the standard deviation estimate. Using convenience sampling, the returned responses from the survey is 1446, which covers four regions of the Peninsula Malaysia: North, South, West and East Peninsula. The distribution of respondents by state is displayed in the Appendix.

Initially, data are analysed descriptively using frequencies and cross-tabulation. The frequencies involve analysis of the number of respondents for each variable or item, such as demographic variables. Cross-tabulation statistics display the analysis of the relationship between two or more variables. A Chi-Squared test is conducted in cross-tabulation to test for relatedness or independence between variables.

Next, a logistic model is developed to analyse the tendency of probability that respondents are opting for the recombinant collagen-like protein as an alternative source of collagen. This is a nonlinear regression model specifically designed for binary dependent variables. Unlike the linear probability model, this model adopts a nonlinear formulation that forces the predicted values between 0 and 1 by using the cumulative probability distribution function (c.d.f.), denoted by F. The logistic c.d.f. could be computed faster than the normal c.d.f. (Stock and Watson 2007). The logistic cumulative distribution function has a specific functional form defined in terms of the exponential function. The population logit model of the binary dependent variable Y with multiple regressors (Xs) could be expressed as:

$$\Pr(Y=1|X_1, X_2.....) = F(\beta_0 + \beta_1 X_1 + \beta_2 X_2 + ...+ \beta_k X_k) = \frac{1}{1+e^{-(\beta_0+\beta_1 X_1+\beta_2 X_2+.....+\beta_k X_k)}} \quad (1)$$

In short, a logistic regression model is estimated to predict a categorical (usually dichotomous) variable from a set of predictor variables. For this study, the dependent or the outcome variable of interest was constructed as a dichotomous indicator based on the response to the survey question: "Do you prefer to use only halal collagen?". Respondents who answered 'Yes' is coded as 1, and those who answered 'No' is coded as 0. The predictor variables consist of dummy variables, categorical variables, and continuous variables. Among the dummy variables included are "gender", "citizenship", and "religion". The categorical variables are "education level", and "monthly income", which relate to the recombinant collagen-like protein. Meanwhile, the continuous variable is "age". To simplify, we develop a Logit Model as follows:

$$L_i = ln\left(\frac{P_i}{1-P_i}\right) = \beta_0 + \beta_1(AGE)_i + \beta_2(DUMMY\ GENDER)_i + \beta_3(DUMMY\ CITIZEN)_I + \cdots + \vartheta_I \quad (2)$$

Where Li is a dummy variable (dependent variable) with a value of 0 or 1, logistic regression allows us to assess how well the predictor variables explain the categorical dependent variable.

A 'Classification Table' is being analyzed to compare the model without independent variables (Block 0) and the model with predictor variables included (Block 1). The overall percentage of correctly classified cases is reported here with the hope that when a set of predictor variables is entered, it will be able to improve the accuracy of the predictions. Third, the Omnibus test of Model Coefficients in 'Block 1' indicates how well the model performs, over and above the results for Block 0, with no predictors entered into the model. This is referred to as a 'goodness of fit test. For this result, we expect a highly significant value (the sig. value should be less than 0.05). Hosmer and Lemeshow test is another test that can be used to describe whether the model used is fit or not to the data. For this test, the poor fit is indicated by a significance value less than 0.05 for the Chisquare statistic. A 'Model Summary' table reports two R-squares, namely the Cox and Snell R square and the Nagelkerke R square, which gives information about the usefulness of the used model. They indicate the amount of variation in the dependent variables explained by the model (from the minimum

value of 0 to a maximum of approximately 1). They are also referred to as pseudo-R square statistics.

The importance of each predictor variable is examined using the Wald test. If sig (p-value) values less than 0.05, the variable contributes significantly to the model's predictive ability. The odd ratio of each predictor is reported under the column "Exp(B)' and the coefficient of each predictor is reported under the column of 'B'. B values can be positive or negative to inform the direction of the relationship between the predictor and dependent variables. In other words, it could inform which factors increase the likelihood of a 'yes' answer and which factors decrease the likelihood of a 'no' answer. The odd ratio represents the change in odds of being in one of the categories of the outcome when the value of a predictor increases by one unit. In equation (2), if we take the antilog of the jth slope coefficients (β's), subtract one from it, and multiply the result by 100, we will obtain the percent change in the odds for a unit increase in the jth regressor. The percentage change could be interpreted as the probability that opting for halal collagen will change (increase or decrease) due to a unit increase in independent variables.

RESULTS & DISCUSSION

The method adopted in the current study is twofold. The first method is qualitative, and the second is quantitative.

Qualitative Results

Collagen supplements are gaining popularity among Muslim consumers. Most commercial collagen and gelatin are obtained from mammals, mainly from bovine bone, bovine hide, and porcine skin, mostly from nonhalãl based. However, there are growing concerns regarding the transfer of diseases from animal sources and halãl issues on the sources and manufacturing processes as well as the limited sources from marine animals. The sources of collagens and gelatines are being questioned, particularly among Muslim users, on their Shariah permissibility (halal) status. This is because the raw materials used in its manufacture could be sourced from porcine or non-halal slaughtered animals (Riaz, M. & Chaudry; M., 2004).

All foods are halal except those that are specifically mentioned as haram in the Qur'an and Hadith. Haram foods are mainly from alcohol, pork, dead animals, blood, and animals slaughtered while reciting a name other than Allah.

> "He has only forbidden you carrion, blood, pig's meat, and animals over which any name other than God's has been invoked. But if anyone is forced to eat such things by hunger, rather than desire or excess, he commits no sin: God is most merciful and forgiving."
>
> (al-Baqarah: 173)

In addition to that, the Prophet (PBUH) is reported to have said:

> "That which is lawful is clear, and that which is unlawful is clear, and between the two are doubtful matters many people do not know. Thus, he who avoids doubtful matters clears himself regarding his religion and his honour, but he who falls into doubtful matters (eventually) falls into that which is unlawful, like the shepherd who pastures around a sanctuary, all but grazing therein. Truly every king has a sanctuary, and truly Allah's sanctuary is His prohibitions. Truly in the body, there is a morsel of flesh, which, if it be whole, all the body is whole, and which, if it is diseased, all of (the body) is diseased. Truly, it is the heart."
>
> (Sahih Muslim, 2006)

To all Muslims, Shariah conveys moral and metaphysical purposes. It resembles the idea that all human beings are subject to justice under the law. Shariah represents a connection to the divine, a set of unchanging beliefs and principles that order life following Allah's will (Feldman, N., 2008). Meanwhile, Shariah principles are also related Shariah-compliant means strictly observing the permissible (halal) and abstaining from the prohibited (haram) as stated in Quran and hadith. (Azhar Rosly, S., 2010). In some cases, these are foods mentioned explicitly as being permissible, while in other cases, it is clear that they fall under the general guidelines laid out in the Qur'an and Sunnah. For example, in one verse of the Quran;

> "This day are (all) good things made lawful for you. The food of those who have received the Scripture is lawful for you, and your food is lawful for them…."
>
> (al-Maidah, 5: 5)

In other cases, expressions like "there is no sin upon you…" appear in the Qur'an, making it clear that something is permissible. In the same way, acts that are forbidden are explicit. For example, Allah says in the Qur'an:

> "Forbidden for you are only carrion and blood and swine-flesh and that which has been slaughtered in the name of other than Allah and that which has been killed by strangling, or by violent blow or by a headlong fall or by the goring of horns and that which has been [partly] eaten by a wild animal unless you are able to slaughter it [before its death] and that which is sacrificed on altars. [Forbidden] also is to use arrows for seeking luck. All that is disobedience to Allah and sin."
>
> (al-Maidah, 5:3)

Thus, in the case of collagen sourced from bovine bone, bovine hide, porcine skin, and non-slaughtered animals are considered non-halāl. After stating that lawful and unlawful matters in Islam are clear, the Prophet (PBUH) mentioned that there are also 'doubtful matters.

> "Between the two of them are doubtful [or ambiguous] matters, about which not many people are knowledgeable."

Only a minority of acts fall into this category, and there are different factors that may make people uncertain about a particular act and whether or not it is permissible. Generally, people may know that there are variances of opinion among scholars about different topics. Related to this topic, lawful and unlawful are clear, and doubtful matters exist. The Prophet Muhammad (PBUH) mentioned that people only understood clearly about lawful and unlawful, but they were not concerned about doubtful matters.

> "Thus, he who avoids these doubtful matters certainly clears himself in regard to his religion and honour."

Prophet Muhammad (PBUH) also said that those who avoid these doubtful matters protect their religion and honour. This hadith explains that if we are suspicious about something, we should avoid using it. These are considered cautious steps to avoid engaging in unlawful or forbidden. Thus, if the raw materials used in collagen manufacture are doubtful in which it could be sourced from porcine or non-halal slaughtered animals, it is better to avoid it.

Another concern on the issue of collagen is when it is sourced from fish and marine life, which might affect the ecosystem and biodiversity. In Islam, every person is entitled to have the right to benefit from natural resources and to own property and wealth individually or in partnership with others, while state ownership of critical resources is allowed if it is in the public interest (Khan, 1994). In other words, each is given its due right in life, but it is governed and controlled by the God-given law. Allah SWT said:

> "It is We Who portion out between them their livelihood in the world"
>
> (al-Zukhruf, 43: 32)

Thus, any act to produce collagen should not simultaneously neglect the task of protecting the environment. Allah has created the earth and its ecosystems; all work within their limits and balance. Islam likewise limits the human desire to work according to Allah's will (Fazlun, 2002). That is why man needs a just and balance system to control his desire which can never be satisfied. He would undoubtedly ask for a third if given two valleys of gold. As soon as he received the third valley, he would beg for the fourth and so on (Sahih al-Bukhari 6439, Book 81, Hadith 28).

Animals, plants, cells and microorganisms are creations of Allah that is included in our responsibility of having mercy. Any resources that can be obtained from this earth should be utilised wisely. Rahmah (mercy) is the soul for the act of adalah (justice) and tawazun (balance); without it, people will either be highly harsh with justice or protect freedom with equality. Mercy promotes balance in the laws that justice is built upon.

The recent development of an alternative source of collagen is collagen-like protein based on bacteria. It is also subjected to the test

of Shariah compliance to ensure that the product will be acceptable for Muslims. Producing an alternatively new protein is like any other new method humans are innovating in this modern world. This is part of the responsibility of being the vicegerent (khalīfah), as Allah has raised humankind as people responsible for caring for the world. As a vicegerent, we were given two crucial things. The first matter is a blessing. Allah SWT, as this earth's Creator, has granted humans blessings on earth from among His creations. He is the one who made skies as roofs and earth as a mattress, made foods from all kinds of crops in different colors, shapes, tastes, and use, and made the ocean a place for man to find sustenance and traveling. All sorts of utility He provided on this earth (al-Ḥajj, 22: 65). His creations were all made into service of humans, which concepts of taskhir (utility) came into the picture, whom Allah has called us as the vicegerents of the earth. Therefore, we must take care and utilize everything permissible on earth as a sign of gratitude for His blessings (alJāthiyah, 45: 12).

A recombinant collagen-like protein from selected bacteria such as Rhodopseudomonas palustris and Mathylobacterium sp can be cloned into an Escherichia coli that is purified and suitable for food and nutraceutical with guidance from Sharī'ah permissible (Halal). The product of recombinant collagen-like protein proposed to comply with the related Halãl and health regulations imposed by the authorities that are on par with the listed food and hygiene guidelines; food safety acts and all Islamic and Sharī'ah principles as gazette by the Religious Department of Islamic Development Malaysia (Jabatan Kemajuan Islam Malaysia, hereafter termed as JAKIM) with established hygienic manufacturing practices.

Quantitative Results

At stage one, a total of 1446 data collected are analyzed descriptively. Later, in stage two, logit regression is applied to the data. As depicted in Table 1, the number of female respondents (69.4 percent) exceeds that of males (30.6 percent). Most of them (61.2 percent) are non-citizens, and most respondents are Muslims (99.0 percent). Observing the respondents' education level, more than 75 percent of them have a higher level of education, with a first degree or postgraduate degree. Regarding income earned, about 56.1 percent of the respondents earn less than RM500 per month. If the income range is widened to less and equal to RM1000 per month, almost 66.3 percent of them are in this income range.

Table 1: Distribution of Respondents by Demographic Variables

Item		Frequency	Valid %
Gender	Male	528	36.6
	Female	915	63.4
	Malaysian	1209	84.0
Citizenship	Non-Malaysian	230	16.0
	Muslim	1284	91.8
Religion	Non-Muslim	114	8.2
	No education	19	1.3
	Primary education	11	0.8
	Secondary education	172	11.9
Educational Level	Diploma/pre-university	311	21.6
	First Degree	679	47.2
	Postgraduate education (Master PhD)	248	17.2
	≤ RM500	529	38.5
	RM501 - RM1,000	125	9.1
	RM1,001 - RM1,500	112	8.2
Monthly income	RM1,501 - RM2,000	115	8.4
	RM2,001 - RM2,500	89	6.5
	RM2,501 - RM3,000	95	6.9
	> RM3,000	308	22.4

Respondents (consumers) are asked about their opinion about using collagen products, and their knowledge and opinion on recombinant collagen-like protein (RCLP) suggested in the current study as an alternative source of the current source of collagen. The responses by sample consumers are displayed in Table 2. More than 90 per cent of respondents agree and strongly agree that the collagen used in the community should be approved by JAKIM, the approval body of Islamic products. Nevertheless, 92.5 per cent agree and strongly agree that collagen produced and consumed should support the objectives of maqasid alsyariah.

Surprisingly, more than 50 per cent of respondents are familiar with the concept of recombinant collagen-like protein, which implies that they are aware of the current method of extracting collagen from bacteria used

in health care and cosmetic industries. About 54.3 per cent of respondents have heard about RCLP in Malaysia. 87.7 per cent agree that RCLP could be an alternative to the existing source of collagen products.

Table 2: Information on Using Collagen & Recombinant Collagen-Like Protein

Item	Strongly Disagree (SDA)	Disagree (DA)	Agree (A)	Strongly Agree (SA)
Whatever is used as collagen in our community, should be approved by JAKIM	34 (2.4)	89 (6.2)	508 (35.3)	808 (56.2)
The collagen should support the objectives of *maqasid alsyariah*	24 (1.7)	84 (5.8)	691 (48.1)	639 (44.4)
I am familiar with concept of recombinant collagen-like protein	91 (6.3)	556 (38.7)	679 (47.3)	110 (7.7)
I have heard about recombinant collagen-like protein in Malaysia	99 (6.9)	558 (38.8)	691 (48.1)	89 (6.2)
The recombinant collagenlike protein can be an alternative for the existing collagen product.	28 (1.9)	150 (10.4)	1060 (73.7)	201 (14.0)

Notes: Valid Percentage in parentheses. The frequencies displayed do not include missing data.

Cross tabulations provide a way of analysing and comparing the results for one or more variables with the results of another (or others). For some responses, it is possible to determine statistically significant differences between sub-groups using a Chi-Squared test. A cross-tabulation of preference for halal collagen by gender, citizenship, education level, religion and monthly income is shown in Table 3.

The statistics indicate that the number of females (93.17 per cent) exceeds that of males (89.02 per cent) in the 'yes' category of choosing halal collagen. As for citizenship, several citizens and non-citizens are almost similar in preferring halal collagen (91.55 and 92.58 per cent, respectively). Comparing responses by education level, except for the category of no education, the other levels of education of respondents score more than 80 per cent preference for halal collagen. This implies that higher education knowledge enables consumers to have more awareness about collagen and

halal collagen available in the market. It is also found that at all levels of income in the study, except for category RM2,001 – RM2,500, the number of respondents who choose halal collagen exceeds 90 per cent. Regardless of income levels, consumers prefer to opt for halal collagen.

Table 3: Cross-Tabulation of 'Choosing Halal Collagen' by Gender, Citizenship, Education Level, Religion and Monthly Income

		'Do you prefer to use only *halal* collagen?		**Total N (%)**	Pearson ***ChiSquare***
		Yes N(%)	**No N(%)**		
Gender	Male	462 (89.02)	57 (10.98)	519 (10.98)	7.457 (sig.= 0.006)
	Female	846 (93.17)	62 (6.83)	908 (100.00)	
Citizenship	Malaysian	1094 (91.55)	101 (8.45)	1195 (100.00)	0.267 (sig.= 0.605)
	Non-Malaysian	212 (92.58)	17 (7.42)	229 (100.00)	
Religion	Muslim	1216 (95.75)	54 (4.25)	1270 (100.00)	340.15 (sig.= 0.000)
	Non-Muslim	51 (45.54)	61 (54.46)	112 (100.00)	
Educational Level	No education	15 (78.95)	4 (21.05)	19 (100.00)	6.294 (sig.= 0.279)
	Primary education	10 (90.91)	1 (9.09)	11 (100.00)	
	Secondary education	152 (89.41)	18 (10.59)	170 (100.00)	
	Diploma/ preuniversity	282 (93.07)	21 (6.93)	303 (100.00)	
	First Degree	617 (91.54)	57 (34.54)	674 (100.00)	
	Postgraduate (Master/PhD)	229 (92.71)	18 (7.29)	247 (100.00)	
Monthly Income	≤ RM500	478 (90.34)	51 (9.64)	529 (100.00)	6.369 (sig.=0.383)
	RM501 – RM1,000	113 (91.13)	11 (8.87)	124 (100.00)	

RM1,001 – RM1,500	100 (90.91)	10 (9.09)	110 (100.00)
RM1,501 – RM2,000	107 (93.04)	8 (6.96)	115 (100.00)
RM2,001 – RM2,500	77 (87.5)	11 (12.5)	88 (100.00)
RM2,501 – RM3,000	87 (91.58)	8 (8.42)	95 (100.00)
> RM3,000	286 (94.39)	17 (5.61)	303 (100.00)

Furthermore, the Chi-square test is conducted to explore the relationship between two categorical variables. The test compares the observed frequencies or proportions of cases that occur in each of the categories with the values that would be expected if there was no association between the two variables being measured. The hypotheses which could be developed for this test are:

H_o: The preference for halal collagen is independent of gender, citizenship, education level, religion and monthly income.

H_a: The preference for halal collagen is dependent on gender, citizenship, education level, religion and monthly income.

The test results are displayed in the last column of Table 3. Since the pvalue or sig. of Pearson Chi-square values are more than 0.05 for citizenship, education level and monthly income, it could be inferred that there is no association between the preference for halal collagen and citizenship, education level, and monthly income. The p-value is, however less than 0.05 for variables of gender and religion. The result implies that the selection of halal collagen among respondents highly depends on their gender and religion. Females significantly prefer halal collagen to males, and Muslim consumers prefer halal collagen over non-Muslim consumers.

Furthermore, the results of logistic regression are presented in Table 5. Five regressions are performed where all equations include all demographic variables in the model. The difference of the equations lies in the final independent variable, where dummy variables on variables using collagen and RCLP are included one by one for sensitivity analysis. Data of variables

of information using collagen and RCLP (items on Table 2) are computed as binary numbers, 1 and 0, from a scale 1(strongly disagree) to 4(strongly agree) of the original data. The scores of 1 and 2 are computed as 0, and the scores of 3 and 4 are computed as 1.

Logit regression results show that for all equations, a consistently significant predictor in the models is 'age' with a positive sign. Positive and significant β values for the 'age' variable suggest that elderly consumers are more likely to prefer halal collagen in consumption, other things equal. Observing the odd ratios of this variable, they represent the change in odds of being in one of the outcome categories when the value of each predictor increases by one unit. The odds of a person choosing halal collagen is 1.05 times higher among older consumers than young ones, all other factors equal (for equations 1, 3, 4, and 5). The odd ratio of the variable is slightly higher for equation 2 with 1.067. Aging consumers are expected to consume more collagen, particularly halal collagen, than young ones in maintaining skin health, improving immunity, activating muscles and treating joint pain due to depletion in the body as age increases.

There are three cases where the coefficient of gender is traced to be significant with a negative sign. Those are in equations 2, 3, and 4. The negative sign simply implies that females are more likely to prefer halal collagen than males. The odd ratio of this variable is between 0.621 and 0.657, which implicitly means that the odds of a person opt for halal collagen is 0.621-0.657 times lower among males as compared to females, all other factors being equal.

Dummy religion is found to be significant at 1 percent level in all equations. The positive sign of coefficients suggests that Muslim consumers have more tendency to choose halal collagen than non-Muslim consumers. Referring to equation 1, the odds of a person select halal collagen is 17.14 times higher among Muslims than non-Muslims, given other factors constant. The odd ratios are much higher in other equations with the highest one is 30.18 in equation 4.

Table 4: Logistic regression results

Independent variables	Binary logistic *Dependent variable*: 'Prefer to use halal collagen' (yes =1, no = 0)									
	Equation 1		Equation 2		Equation 3		Equation 4		Equation 5	
	B Ex	***B Ex***	***B Ex***	***B Ex***	***B Ex***	***p(B)***	***p(B)***	***p(B)***	***p(B)***	***p(B)***
Constant	-	0.0	-	0.0	-	0.1	-	0.1	-	0.0
	3.90 *** (0.9 74)	34	4.05 4*** (0.9 96)	17	2.24 1 (0.9 34)	06	2.26 1** (0.9 24)	04	2.67 4***	69
Dummy_ Gender	- 0.38 4 (0.2 61)	0.6 81	- 0.47 6* (0.2 57)	0.6 21	- 0.42 0* (0.2 49)	0.6 57	- 0.42 1* (0.2 50)	0.6 57	- 0.39 5 (0.2 50)	0.6 74
Age	0.05 7*** (0.0 19)	1.0 58	0.06 5*** (0.0 20)	1.0 67	0.05 4*** (0.0 18)	1.0 55	0.05 3*** (0.0 18)	1.0 55	0.05 1*** (0.0 18)	1.0 52
Dummy_ citizenship	0.16 5 (0.3 77)	1.1 79	0.03 3 (0.3 82)	1.0 33	0.15 8 (0.3 70)	1.1 71	0.16 3 (0.3 69)	1.1 77	0.17 8 (0.3 68)	1.1 95
Dummy_ religion	2.84 1*** (0.2 90)	17. 138	3.15 8*** (0.2 81)	23. 51	3.40 2*** (0.2 70)	30. 018	3.40 7*** (0.2 69)	30. 175	3.38 5*** (0.2 70)	29. 519
Education_n one										
Education_pr imary	- 1.30 8 (0.8 06)	0.2 70	- 0.86 6 (0.8 54)	0.4 21	- 1.26 5 (0.7 97)	0.2 82	- 1.26 5 (0.7 97)	0.2 82	- 1.23 0 (0.8 03)	0.2 92
Education_s econdary	2.22 4 (1.2 37)	1.2 51	0.48 8 (1.2 62)	1.6 29	0.62 4 (1.3 20)	1.8 66	0.62 3 (1.3 23)	1.8 65	0.54 7 (1.3 07)	1.7 27
Education_di ploma/pre-U	- 0.47 5 (0.4 68)	0.6 22	- 0.46 5 (0.4 69)	0.6 28	- 0.47 3 (0.4 55)	0.6 23	- 0.48 1 (0.4 57)	0.6 18	- 0.43 2 (0.4 55)	0.6 49

Education_degree	0.062 (0.442)	1.064	0.328 (0.451)	1.387	0.084 (0.432)	1.087	0.082 (0.4 33)	1.086	0.075 (0.432)	1.078
Education_postgraduate	0.541 (0.382)	1.717	0.663* (0.389)	1.941	0.492 (0.374)	1.635	0.49 1 (0.3 75)	1.635	0.468 (0.373)	1.645
Income_<RM 500										
Income_up to RM1000	0.509 (0.463)	1.663	0.644 (0.460)	1.904	0.478 (0.443)	1.613	0.477 (0.4 43)	1.611	0.510 (0.447)	1.665
Income_up to RM1500	0.523 (0.571)	1.687	0.81 (0.579)	2.258	0.55 (0.547)	1.749	0.551 (0.548)	1.736	0.553 (0.549)	1.739
Income_up to RM2000	0.287 (0.570)	1.333	0.455 (0.570)	1.576	0.212 (0.542)	1.237	0.213 (0.542)	1.238	0.241 (0.544)	1.273
Income_up to RM2500	1.04 (0.654)	2.828	1.501** (0.676)	4.485	1.055 (0.649)	2.873	1.046 (0.6 50)	2.847	1.072 (0.651)	2.921
Income_up to RM3000	-0.320 (0.522)	0.726	-0.178 (0.524)	0.837	-0.442 (0.498)	0.643	-0.455 (0.4 98)	0.634	-0.414 (0.496)	0.661
Income_>RM 3000	0.014 (0.571)	1.014	0.133 (0.554)	1.142	-0.101 (0.538)	0.904	-0.080 (0.5 37)	0.923	-0.067 (0.534)	0.935
Dummy_ support maqasid	1.755*** (0.302)	5.785								
Dummy_ approved by JAKIM			1.849*** (0.298)	6.350						
Dummy_familiar concept RCLP					0.009 (0.242)	1.009				

Dummy_heart RCLP in Msia				0.066 (0.239)	1.068	
Dummy_RCLP can be alternative.					0.566* (0.309)	1.761
% correct classification (Block 1)	92.8	92.5	92.0	97.6	97.8	
Omnibus Chi-square stat.	233.6 (sig = 0.000)	241.0 (sig. = 0.000)	207.2 (sig. = 0.000)	207.2 (sig. =0.000)	206.9 (sig. = 0.000)	
Hosmer & Lemeshow Test stat.	4.075 (sig.= 0.850)	5.877 (sig. = 0.661)	6.144 (sig. = 0.631)	8.773 (sig. = 0.362)	4.851 (sig. = 0.773)	
Cox &Snell R-square	0.166	0.171	0.149	0.149	0.149	
Negelkerke R-square	0.379	0.388	0.336	0.336	0.338	

Note: Standard errors are in parentheses; ***statistically significant at the 1% level; **5% level; *10% level.

The independent variables of the categorical variables, such as income level and education level, are interpreted so that the coefficients or betas are the difference between the focus category as compared to the base category. As for education level, the coefficients of this variable are positive in all equations. However, it is only significant in equation 2 at 10 percent level. The positive value of beta (β) is 0.663 in this equation 2, which indicates that an increase in an independent variable score as compared to the base category (no education) will increase the probability of the case recording a score of 1 or 'yes' in the dependent variable. The odd ratio of 1.941 implies that the odds of a person answering 'yes' that the person chooses halal collagen is 1.941 times higher for someone who has postgraduate education as compared to those who have no education, all other factors being equal. The tendency of consumers to select halal collagen in the study is among the higher educated consumers.

Similarly, the income variable is only significant in equation 2. The income coefficient is a positive sign in all equations though. The positive value of beta (β) for 'income level between RM2000 to RM2500', that is 1.501, indicates that an increase in the independent variable score as compared to the base category (income level less than RM500 per month)

will result in an increase in the probability of the case recording a score of 1 or 'yes' in the dependent variable. The odd ratio (Exp (β)) for this variable is 4.485 which means that the odds of a person answering 'yes' in choosing halal collagen is 4.485 times higher for someone who earns income between RM2000 and RM2500 per month as compared to those who earn less than RM500 per month, all other factors constant. The middle-income consumers are therefore more likely to opt for halal collagen than lower-income consumers.

From the results in Table 4, the dummy variable "the collagen should support maqasid al-syariah" (coded as 1 for agree and strongly agree, 0 otherwise) is significant at 1 percent level in equation 1. Similarly, the dummy variable "collagen should be approved by JAKIM" is also significant at 1 percent level. Both coefficients are positive. Positive and significant β values for these dummy variables suggest that those who agree and strongly agree that collagen should support maqasid al-syariah and JAKIM should approve it are more likely to state that they select halal collagen, other things equal. The odd ratios of these variables represent the change in odds of being in one of the categories of the outcome when the value of each predictor increases by one unit. The odds of a person choosing halal collagen is 5.785 times higher among those who agree that collagen products should support maqasid alsyariah. The odds are 6.350 times higher among those who agree that collagen produced should be approved by JAKIM, all other factors being equal. Other independent variables are not significantly contributing to the likelihood that consumers choose halal collagen.

The robustness of the models is examined, and the statistics are shown in the lower part of Table 5. In the classification table, when a set of predictor variables is entered, it improves the accuracy of the prediction to more than 92% (range between 92.0% to 97.8%) for overall equations 1 and 5. The Omnibus tests of Model coefficients (the Chi-square statistic) are significant (p-value < 0.05), and the Hosmer & Lemeshow tests support the 'goodness of fit of the models with the Chi-square statistic having a significance level of more than 0.05 for all equations. The pseudo-R-square statistics (Cox & Snell R-square and Nagelkerke R-square) show that between 14.9% and 38.8% of the variability in the dependent variable is explained by the set of predictor variables. In general, the models developed are considered exemplary models.

CONCLUSION

The sources of collagens and gelatins are recently being questioned because the raw materials used in its manufacture could be sourced from porcine or non-halal slaughtered animals. There are also growing concerns regarding the transfer of diseases from animal sources of collagen to human users. Though currently collagen can be extracted from marine life, the sources are very limited and recently, there is new innovation attempted to use collagen-like protein from bacteria. The present study aims to examine the current sources of collagen products based on the Qur'ãnic and Prophetic guidance and to explore the tendency that consumers in Malaysia will choose halal collagen in their consumption and its determinants. Qualitative and quantitative approaches are used in the methodology of the study.

The study finds that any collagen products sourced from bovine bone, bovine hide, and porcine skin as well as non-slaughtered animals are considered non-halãl. In fact, the sources obtained that might affect ecosystem and environment is highly discouraged in Islam to avoid injustice and unbalance between human and other creations. The use of recombinant collagen-like protein from selected bacteria is permissible as long as it complies with the related halãl and health regulations imposed by the authorities that are on par with the listed food and hygiene guidelines, food safety acts and all Islamic and Sharī'ah principles. Using survey data, the probability consumers opt for halal collagen is significantly determined by gender, age, religion, education and level of income. The likelihood of the consumers to opt for halal collagen is higher among elderly, females, Muslims, highly educated consumers and middleincome consumers. The empirical results also reveal that the tendency to choose halal collagen among consumers are significantly influenced by the idea that the collagen should support maqasid al-syariah and should be approved by JAKIM. It can be concluded that there is a high level of awareness concerning halal collagen products among Muslim users. Thus, an ethical Halal policy should be outlined based on the Qur'an and Sunnah of the Prophet Muhammad (PBUH) as the guiding principles to the producers in producing collagen that could provide value for Muslim consumers.

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CONFLICT OF INTERESTS

The authors declare no competing interests such as financial or personal relationships with regard to the writing of this article.

AUTHORS' CONTRIBUTIONS

Jarita Duasa designed the study, wrote the article, conducted the survey and analyzed the results empirically. Norhazirah Burhanuddin conducted the qualitative study and analyzed the qualitative result. Nur Hidayah Zainal wrote the introduction and gathered the literature review.

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APPENDIX

Distribution of respondents by states in Malaysia

State	Frequency	Percent
Johor	133	9.2
Kedah	184	12.7
Kuala Lumpur	199	13.8
Kelantan	102	7.1
Melaka	15	1.0
Pahang	106	7.3
Pulau Pinang	341	23.6
Perak	99	6.8
Perlis	51	3.5
Selangor	135	9.3
Terengganu	81	5.6
Total	**1446**	**100.0**