ASSESSING CONSUMERS' RISK PERCEPTION ON THE INTENTION TO PURCHASE THE PRODUCT CONTAINING THE RECOMBINANT COLLAGEN-LIKE PROTEIN: THE MODERATING ROLE OF KNOWLEDGE

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ABSTRACT

Collagen is a valuable substance with numerous applications. It is blessed with large protein molecules make it suitable for use in a variety of industries, including cosmetics, food and drinks, medicine, and others. Nonetheless, the source of collagen is a topic that concerns customers, particularly Muslims. Many industries produce collagen from cattle and pork, which raises halal problems. As a result, the recombinant collagen-like protein (CLP) was developed to replace animal-based collagen with halal collagen. The CLP was produced in a lab using an engineering technique, which may raise some concerns among consumers. This study investigated how Muslims consumers evaluated the risk on the idea of recombinant CLP as an alternative to mammal-based collagen, as well as to investigate their risk perception influenced their purchasing intention. In addition, the study attempts to investigate the moderating role of knowledge on the relationship between consumers' risk perception and purchase intention. The study collected data from 516 prospective Muslim consumers and analysed it using Partial Least Square Structural Equation Modelling (PLS-SEM). The findings indicate that health, quality, halal, and financial risks all have a significant impact on consumers' intentions to purchase the recombinant CLP. Consumer knowledge did not significantly moderate the relationship between customers' risk perceptions and purchasing intentions.

Keywords*:* Purchase Intention, Risk Perception, Recombinant Collagen

INTRODUCTION

Nowadays, research is generating new approaches to solving today's problems, and technology is advancing quickly. For example, attempts have been made in the field of food security to combat the depletion of supplies by manufacturing cultured meat in laboratories (Goodwin & Shoulders, 2013; Zhang et al., 2020). Similarly in collagen industries, with the limited sources and various challenges raised, the researchers had repeatedly come up with the notion to substitute the collagen extracted from mammals (Arshad, 2016; Chattopadhyay & Raines, 2014; Coppola et al., 2020; Dave et al., 2019; León-López et al., 2019; Olsen et al., 2003; Ramshaw et al., 2019; Subhan et al., 2015).

Collagen is vital in most consumable goods in the market such as food and beverages, cosmetics, nutraceuticals, pharmaceuticals, and medical (Borumand & Sibilla, 2014; Deal & Moskowitz, 1999; Omar et al., 2019; Oslan et al., 2022; Susanti et al., 2019). Furthermore, the collagen market in Asia Pacific is expected to grow from US$241.14 million in 2023 to US$386.68 million in 2030 driven by increased demand for nutricosmetics infused with collagen peptides. (Business Market Insights, 2023). As a result, it is clear that collagen is an essential raw ingredient in a variety of businesses.

However, Muslim consumers expressed discomfort because collagen was primarily produced from animal sources, particularly bovine and porcine (Markets and Markets, 2022). By 2022, bovine source will dominate output, followed by porcine and marine sources (Global Market Insight, 2022). Furthermore, the increased concern about mad cow disease had a severe impact on the collagen business, resulting in a shift to swine gelatine (Lestari et al., 2019). Moreover, producers collected collagen from swine because it is said to be the quickest and cheapest approach to produce collagen (Batu et al., 2015). Consequently, the diversion raised concerns among Muslim consumers, who are barred from consuming any swin-derived products.

In contrast, marine sources have been used as a substitute for non-halal collagen sources, but the results were insignificant (Gómez-Guillén et al., 2011; Lestari et al., 2019). Besides, producing collagen from marine source is more expensive than mammalian sources (Schmidt et al., 2016). Furthermore, the production procedure utilizing marine sources is highly complicated (Diogo et al., 2023), which led to the avoidance of producing marine-based collagen.

These concerns have prompted the creation of recombinant collagen-like protein (recombinant CLP), which has begun over the last three decades (Fertala, 2020). The recombinant CLP is collagen created in the lab using a recombinant engineering technique, and because natural collagen is derived from protein sources, recombinant collagen also contains protein-like nutrients. The International Institute for Halal and Research Training (INHATRT) at the International Islamic University Malaysia (IIUM) developed the recombinant CLP for this study, primarily to produce halal and vegetarian collagen (Awang et al., 2021; Awang et al., 2023; Salleh et al., 2021; Salleh et al., 2023).

Cell cultures generated in a lab were used to develop recombinant CLP, and these cells were fed vegetarian nutrition (Salleh et al., 2021; Salleh et al., 2023). Finally, collagen was recovered from these cells, and it was assured to be a halal collagen with a potential in halal pharmaceuticals (Salleh et al., 2023). Nonetheless, because the method involved cells that were generated in lab, recombinant CLP can be viewed as a novel technology by consumers (Guo et al., 2024), which may raise additional concerns. It is due to a remark from Slovic in his article, which indicates that the public frequently thought of themselves as an experiment to test a new technology, which has complicated the government (Slovic et al., 1982).

As a result, the purpose of this study is to evaluate if consumers' risk perceptions of INHART's recombinant CLP influence their propensity to purchase the recombinant CLP-based product. Furthermore, the objective of recombinant CLP development is primarily to provide halal certification, which may raise customer concerns, particularly among Muslim consumers. This study also looks into the moderating influence of knowledge in the relationship between customers' risk perception and intention to acquire a product based on recombinant CLP. Therefore, the objectives of the study are as follows:

1. To examine consumers' risk perceptions of the recombinant CLP.
2. To investigate the relationship between consumers' risk perception and their purchase intention.
3. To investigate the moderating role of knowledge on the relationship between consumers' risk perception and their purchase intention.

LITERATURE REVIEW

Collagen is a structural protein with 29 members that contribute to the mechanical characteristics, organization, and shape of tissues (Ricard-Blum, 2011; Yang et al., 2015). It is functional and widely used in a variety of industries, including food, cosmetics, pharmacology, and medicine (Silvipriya et al., 2015). Humans were born with enough collagen, and anyone born without it may suffer from a variety of illnesses (Sandhu et al., 2012), demonstrating that collagen is essential to humans. Meanwhile, collagen was isolated from mammals because it was largely present in connective tissues (Yang et al., 2015). Each member of the collagen family has unique characteristics and properties, and collagen Type I and II are commonly used in industry. (Silvipriya et al., 2015). Type I collagen is commonly found in the skin, bone, teeth, tendons, ligaments, vascular systems, and organs, whereas Type II collagen is found in the eyes and cartilage (Silvipriya et al., 2015).

Usually, collagen in industries is mostly extracted from mammals, especially porcine or bovine thus, this has caused a growing concern among Muslim consumers because they are strictly consuming goods from halal sources (Batu et al., 2015; Omar et al., 2019). Aside from that, the consumption of the collagen that was extracted from mammals could exposed the consumers to the risk of several illness such as allergy reaction (Davison-Kotler et al., 2019; Fertala, 2020). Moreover, the consumption of bovine sources of collagen could also induce an inflammatory response (MacEwan et al., 2018). In addition, researchers had discovered that animal-based collagen could cause greenhouse gas (GHG) emissions, which was also a reason for them to find another alternative to animal-based collagen (Bainbridge, 2022).

Therefore, researchers had experimented with the recombinant CLP to alternate the animal-based collagen (Davison-Kotler et al., 2019). It has been identified in numerous bacterial genome databases (An et al., 2014; Yu et al., 2014). This bacteria collagen can be developed to have similar physicochemical properties to animal collagen (Yu et al., 2014). The experiments on recombinant CLP have been continuously conducted for more than three decades since the outcome exhibited the potential for recombinant CLP to be applied in the medicine, drugs, food, and cosmetics industries (Fertala, 2020). The recombinant CLP in this study was developed using the selected bacteria, namely *Escherichia coli (E. coli)* by the group of researchers at INHART as halal collagen to alternate the animal-based collagen (Abd Samad et al., 2017; Awang et al., 2020; Awang et al., 2021; Awang et al., 2023; Salleh, 2023a; Salleh et al., 2021; Salleh et al., 2023).

E. coli was transformed from a protein sequence of *Methylobacterium* sp. 4-46 that contains a collagen domain and was put into *Luria Bertani* broth as a medium to grow the *e. coli.* The Luria Bertani broth has the ability to permit fast growth and yields for many species (Salleh, 2023b; Salleh et al., 2021; Sezonov et al., 2007). The final product for the recCLP could be contributed to the halal pharmaceutical industry (Salleh et al., 2023).

Referring to the development of the recombinant CLP by INHART, this study was conducted to further investigate consumers' acceptance of the products based of recombinant CLP taking into account their risk perception. Risk perception is quantifiable and predictable; it has different meanings depending on the person's point of view (Slovic, 1987; Slovic et al., 1982). Besides, it is a common thread that run through decision making process with several factors that has strong bearing on the problems of risk-taking including brand loyalty, added value, personal and group influence, and impulse buying (Bauer, 1967).

Risk can generally be defined as the chance of injury, damage, or loss (Weber et al., 1992). There is a long-standing interest in risk as a clear attribute of a decision alternative thus, it has been applied in a wide variety of studies (Hakim et al., 2020; Siegrist, 2000; Siegrist et al., 2021; Weber et al., 1992; Yang et al., 2021). Risk perception has been identified as an important factor in purchase behaviour (Dowling & Staelin, 1994; Pelaez et al., 2019; Weber et al., 2002), and the theory-based risk perception was commonly adapted into the study according to the context of the study. For example, the perceived risk theory that was adapted into the study on e-commerce (Ashoer & Said, 2016; Choi & Lee, 2019; Pelaez et al., 2019; Yang et al., 2015). Therefore, we adapted the risk perception framework to investigate the relationship between risk perception and consumers' purchase intention.

RISK PERCEPTION FRAMEWORK

The fame of expected utility has made the development of an explicit theory of risk impractical; however, because expected utility had difficulty explaining human preferences, researchers sought other variables, and one of the approaches was to expand the concept and role of risk to explain human preferences (Kahneman, 1979; Slovic & Lichtenstein, 1983; Weber et al., 1992).

Slovic (1982) stated after 30 years of risk perception study that perceived risk is quantifiable and predictable, with varying meanings depending on the person's point of view (Slovic et al., 1982). The public's negative opinions of technology caused uncertainty and irritation among authorities (Slovic et al., 1982). The study then recommends the inclusion of clusters of variables that correspond to the cognitive tradition, such as people's knowledge and understanding about risk; the emotional and experiential tradition, such as personal experience; the social-cultural paradigm, such as the social amplification of risk; cultural theory, trust, and values; and relevant individual differences; such as gender, education, and ideology (Dryhurst et al., 2020; Slovic, 1987; Slovic & Peters, 2006; Van der Linden, 2014, 2017). Eventually, the public's risk perceptions may impact their decision on whether or not to accept a certain technology to be applied to their lives (Van der Linden, 2014)

The theory-based approach to risk perception is usually altered into the study depending on the setting of the research; for example, the perceived risk theory is adapted into the study on e-commerce (Ashoer & Said, 2016; Choi & Lee, 2019; Pelaez et al., 2019; Yang et al., 2015). Meanwhile, the risk perception theory was applied in a wide variety of research, such as online review (Yang et al., 2016), behavioural intention on the environment (Saari et al., 2021), willingness to buy foods with nanotechnology (Kuang et al., 2020), consumers' willingness to buy expiration date-based priced perishable food products (Konuk,

2018), nuclear power plant (Xiao et al., 2017), intention on halal food (Al-Ansi et al., 2019), and tourism (Olya & Al-ansi, 2018) among others. Several of the studies described above used prospect theory to assess their risk perception framework (Al-Ansi et al., 2019; Leung & Cai, 2021; Olya & Al-ansi, 2018; Olya & Han, 2020; Yeni et al., 2021). The theory was established after researchers discovered challenges in applying the expected utility theory to describe human preference (Weber et al., 1992).

RISK PERCEPTION AND PURCHASE INTENTION

Most research have associated risk perceptions to the intention to buy (Al-Ansi et al., 2019; Choi & Lee, 2019; Choi et al., 2013; Connor & Siegrist, 2010; Hakim et al., 2020; Hu et al., 2020; Ross et al., 2014; Xiao et al., 2017). Risk, in particular, has a positive impact on consumers' trust and serves as a variable influencing consumer decision making (Al-Ansi et al., 2019; Olya & Al-ansi, 2018). Siegrist provided a simple model in food technology studies that implies that trust influences customer risk and benefit, and both variables influence consumers' perceptions and acceptance of new food-based technology in the food industry (Siegrist, 2021). According to the causative model, the three most important factors influencing public acceptance are perceived benefit, perceived risk, and trust (Siegrist, 1999; Siegrist, 2000).

Bauer proposed the idea of risk perception in 1960, hoping that it would appeal to both practititioners and researchers (Bauer, 1967; Mitchell, 1999). In the 1990s, both practitioners (Farquhar, 1994) and academicians (Grewal et al., 1994) were drawn to the concept, which was then applied in a variety of areas, including intercultural comparisons (Alden et al., 1994), food technology (Frewer et al., 1994), dental services (Coleman et al., 1994), banking (Ho & Ng, 1994), and apparel catalogue shopping (Jasper & Ouellette, 1994).

In a halal study, perceived risk can be comprised of several types of risk: health, psychological, environmental, social, quality, financial, and time loss risk (Al-Ansi et al., 2019; Olya & Al-ansi, 2018; Yeni et al., 2021), and these risks may result in poor consumers' decision making (Mai, 2001; Olya & Al-ansi, 2018). Consumers frequently perceive environmental danger, quality risk, and health risk in halal food because of the probable contamination in the products due to the direct contact and mixture of halal products with forbidden harmful elements (Al-Ansi et al., 2019; Olya & Al-ansi, 2018). Furthermore, Muslim consumers must consumer halal products and services (Azam & Abdullah, 2020). Moreover, Muslim consumers also perceived social risk due to the questionable contents of halal items (Olya & Al-ansi, 2018) as well as financial risk because they may need to devote more time and effort to funding, purchasing, and consuming halal items (Bonne et al., 2007; Bonne & Verbeke, 2006; Khan et al., 2019; Olya & Al-ansi, 2018). Therefore, the hypothesis for this study was:

H1: Consumers' risk perception of health influences their purchase intention of the product contains recombinant CLP.
H2: Consumers' risk perception of social influences their purchase intention of the product contains recombinant CLP.
H3: Consumers' risk perception of environmental influences their purchase intention of the product contains recombinant CLP.
H4: Consumers' risk perception of quality and halal influences their purchase intention of the product contain recombinant CLP.
H5: Consumers' risk perception of financial influences their purchase intention of the product contains recombinant CLP.

MODERATING ROLE OF KNOWLEDGE

Moderating variables can indicate the degree or the direction of a relationship between independent and dependent variables (Baron & Kenny, 1986). For example, in an online shopping experience research, product knowledge can be used to assess the strength of the association between quality recommendation and consumer happiness (Yoon et al., 2013). Hence, knowledge as a moderator can influence the intensity of the association between variables (Pacheco et al., 2018).

According to Park et al. (1994), subjective knowledge is a self-assessment of an individual's knowledge about a product category, while objective knowledge refers to accurate and actual information about the product category that can be measured with a tailored test (Piha et al., 2018). Consumers' understanding of products is a major aspect in influencing their decision-making process (Leung & Cai, 2021). Typically, laypeople react to risks based on their subjective perception rather than objective knowledge because they have less information on risks (Bettman & Park, 1980; Kim & Bonn, 2015; Rao & Monroe, 1988).

Consumers' knowledge is an important factor that influences to consumers' behaviour (Ghali, 2019; Megido et al., 2016; Siegrist & Hartmann, 2020a; Wang et al., 2019). Consumers' knowledge significantly determines their intention to buy (Ghali, 2019), as well as their acceptance (Megido et al., 2016; Siegrist & Hartmann, 2020a). Moreover, knowledge has a positive relationship with public acceptance of nuclear energy (Wang et al., 2019) and is appropriate to be included in investigating the consumers' behaviour toward a product that is yet fledgling in the market (Ghali, 2019; Kuang et al., 2020).

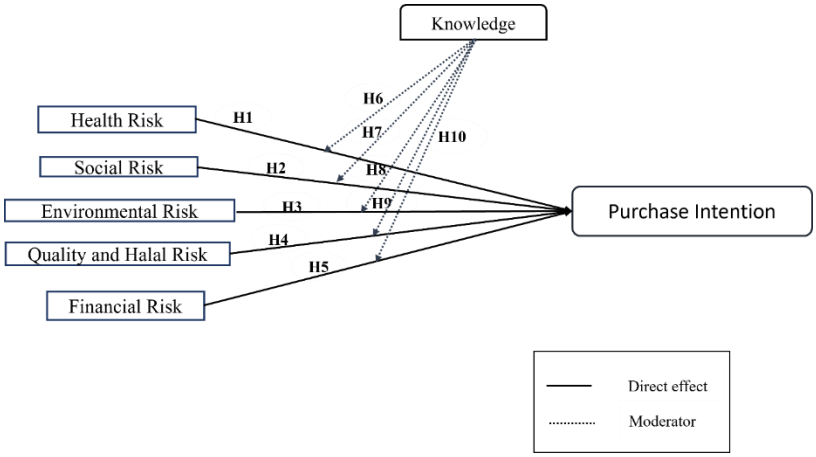
Furthermore, knowledge regarding risk perception for certain diseases is crucial, with knowledge of an infectious disease being negatively related to the public risk perceptions (Iorfa et al., 2020). Consequently, this adds to an increase in pre-cautionary behaviour (Iorfa et al., 2020; Zhong et al., 2021).

Several research have been conducted to investigate the relationship between product knowledge, brand knowledge, and knowledge in general (Kim & Bonn, 2015; Suki, 2016; Wang et al., 2019). According to the study's context, it has a moderating effect on the relationship between the predictors and the intention variables (Kim & Bonn, 2015; Suki, 2016; Wang et al., 2019). According to a study, the knowledge component moderated the relationship between consumers' views and purchase intention (Kim & Bonn, 2015). Several other studies had investigated the moderating role of knowledge in purchase behaviour, some of which accepted the hypothesis (Kim & Bonn, 2015; Wang et al., 2019), while others rejected the hypothesis (Suki, 2016).
Therefore, the hypothesis will be:

H6: Consumers' knowledge moderates the relationship between consumers' risk perception of health and their intention to purchase products containing recombinant CLP.
H7: Consumers' knowledge moderates the relationship between consumers' risk perception of social and their intention to purchase products containing recombinant CLP.

H8: Consumers' knowledge moderates the relationship between consumers' risk perception of environmental and their intention to purchase products containing recombinant CLP.
H9: Consumers' knowledge moderates the relationship between consumers' risk perception of quality and halal and their intention to purchase products containing recombinant CLP.
H10: Consumers' knowledge moderates the relationship between consumers' risk perception of financial and their intention to purchase products containing recombinant CLP.

Figure 1 Proposed framework (Author's illustration)



DATA COLLECTION AND METHODOLOGY

The study was meant to employ a quantitative (survey) approach to efficiently observe approval of recombinant CLP as halal collagen. A cross-sectional study was carried out utilizing the selected population sampling to determine the prevalence of the outcome of interest for a specific group (Levin, 2006).

The convenience sampling technique was used in the search for samples since it is less expensive and more convenient (Taherdoost, 2016). The target sample for this study was prospective Muslim consumers, regardless of ethnicity. This is due to their basic understanding of the norms requiring them to rigorously consume halal goods and services (Ngah et al., 2020). Furthermore, these target samples include basic information regarding collagen in general (Zolkepli et al., 2023).

After distributing 550 self-administered questionnaires to collect data, 516 samples responded to the questionnaires. Prior to completing the questionnaire, the respondents were given a brief overview of the recombinant CLP. The questionnaires were constructed by referring to previous studies and utilizing a 7-point Likert scale; from 1 = strongly disagree to 7 = strongly agree (Al-Ansi et al., 2019; Briliana & Mursito, 2017; Connor & Siegrist, 2010; Druică et al., 2021; Garg & Joshi, 2018; Ghali, 2019; Hakim et al., 2020; Hussain et al., 2016; Kuang et al., 2020; Liobikienė & Juknys, 2016; Ngah et al., 2020; Olya & Al-ansi, 2018; Onel & Mukherjee, 2016; Rahman et al., 2021; Ruan et al., 2016; Siegrist, 2021; Siegrist & Hartmann, 2020b; Suki, 2016; Y. Yang et al., 2015; Yeni et al., 2021).

DATA ANALYSIS TECHNIQUE

The convenience sampling technique was used to explore the purchase intentions of Muslim consumers in Malaysia. A variety of procedures were used to analyse the acquired data. First, after the collecting the data, it was edited, coded, and classified using Microsoft Excel according to the researcher's preferences. The data was then exported into IBM SPSS version 27 for screening, removing outliers, and testing normality. After that, the data was exported into SmartPLS to test the hypotheses using Partial Least Square – Structural Equation Modelling (PLS-SEM), which is a quantitative approach that can analyse a complex model (Sarstedt et al., 2017).

PLS-SEM was chosen since this study involves more than two constructs and indicators, and it can analyze non-normal data in addition to other qualities that PLS-SEM holds (Hair & Alamer, 2022; Hair et al., 2011).

FINDINGS

The descriptive analysis was performed using SPSS software to acquire the respondents' demographic profile, which included their gender, age, education, employment, and race. Table 1 summarised the analysis, revealing that 7.6% of the respondents were female. Most prior studies on behaviour included predominantly female participants (Mancuso et al., 2016; Rosa et al., 2018; Tan et al., 2016). Aside from that, female respondents also dominated the studies on halal products' research (Ag Majid et al., 2021; Ali et al., 2019; Mahbubi et al., 2019).

Among the respondents, 59.5% were aged between 30 and 39 years old, with the majority followed by those aged 40 to 49 years old (19.6%). For the education level, the majority of the respondents acquired bachelor's degrees (53.9%) as their highest level of education. Apparently, most of the respondents were between the age of 30 and 39 years old, and they were fairly educated,

which is quite similar to the respondents of other consumers' behaviour studies (Ali et al., 2019; Bukhari et al., 2020; Shan et al., 2017).

Table 1 Demographic Profile of the Respondents

Profile	Description	Frequency	Percent (%)
Gender	Male	131	25.4
	Female	385	74.6
Age	Below 20 years old	25	4.8
	20 – 29 years old	36	7.0
	30 – 39 years old	307	59.5
	40 – 49 years old	101	19.6
	50 – 59 years old	47	9.1
Education	Primary school	2	4
	Secondary school	42	8.1
	Diploma / Pre-University	87	16.9
	Degree	278	53.9
	Postgraduate	107	20.7
Employment	Private	184	35.7
	Government services	140	27.1
	Self-employed	79	15.3
	Pensioners	8	1.6
	Students	44	8.5
	Housewife	61	11.8
Races	Malay	506	98.1
	Chinese	3	0.6
	Indian	3	0.6
	Others	4	0.8

MEASUREMENT MODEL

PLS-SEM was adopted to test the study's hypotheses. There were two types of models for the model in PLS-SEM: the measurement model and the structural model. The measurement model consists of the indicators or items for each construct (variables). Since the model is reflective internal consistency reliability was tested by referring to composite reliability (Nunnally & Bernstein, 1994) and Cronbach alpha.

The outer loadings for each indicator were used to test the convergent validity. The cut off point for the outer loadings was higher than 0.7, which implies that the indicator is acceptable. The indicator with lower outer loadings should be considered omitted because it could increase the value of Average Variance Extracted (AVE). The AVE value should be higher than 0.5, indicating that the construct explains more than half of the indicators, thus demonstrating sufficient convergent validity (Afthanorhan, 2014; Chin, 1998; Fornell & Larcker, 1981).

Table 2 tabulates a complete result for all the items. Following the cut-off guidelines, items with values less than 0.5 were considered to have low outer loading and thus dropped from the model. HR1 was deleted due to lower outer loading, and the AVE values increased after deletion. The AVE values acquired were higher than 0.5, thus implying sufficient convergent validity as listed in Table 2. Meanwhile, all the values for composite reliability (CR) and Cronbach alpha (α) exceeded the minimum threshold of 0.7. Therefore, the results indicated the presence of internal consistency among multiple measurement items in all latent constructs.

Table 2 Reliability and Convergent Validity

Constructs	Items	Loadings	CR	AVE	α
PI Purchase Intention	PI1	0.862	0.856	0.666	0.745
	PI2	0.867			
	PI3	0.709			
HR Perceived Health Risk	HR2	0.659	0.853	0.594	0.778
	HR3	0.812			
	HR4	0.852			
	HR5	0.745			
SR Perceived Social Risk	SR1	0.599	0.834	0.570	0.732
	SR2	0.537			
	SR3	0.902			
	SR4	0.905			

ER Perceived Environmental Risk	ER1	0.718	0.847	0.582	0.762
	ER2	0.707			
	ER3	0.798			
	ER4	0.821			
FR Perceived Financial Risk	FR1	0.687	0.881	0.650	0.819
	FR2	0.849			
	FR3	0.863			
	FR4	0.814			
QHR Perceived Quality and Halal Risk	QHR1	0.818	0.879	0.593	0.828
	QHR2	0.850			
	QHR3	0.664			
	QHR4	0.716			
	QHR5	0.788			
KN Knowledge	KN1	0.510	0.849	0.534	0.777
	KN2	0.778			
	KN3	0.823			
	KN4	0.747			
	KN5	0.755			

Meanwhile, the discriminant validity concerns the degree to which the different constructs differ from one another (Afthanorhan, 2014; Hair Jr et al., 2021). Table 3 summarizes the discriminant validity assessment for the data. The method used to check for discriminant validity of the data from this study was the heterotrait-monotrait ratio (HTMT) of correlation. It is the mean of the average correlations for the items measuring the same construct (Hair et al., 2019; Henseler et al., 2015). The proposed threshold value was 0.90, where the model is considered to have sufficient discriminant validity if the value is lower than 0.90 (Henseler et al., 2015). Moreover, it is more conservative if the value is lower than 0.85 (Franke & Sarstedt, 2019; Hair et al., 2019). As tabulated in Table 3, all constructs yielded the value of lower than 0.85 hence, the discriminant validity was established for all constructs.

Table 3 Discriminant Validity

	DV_PI	IV1_HR	IV2_SR	IV3_ER	IV4_QHR	IV5_FR	MV_KN
PI							
HR	0.614						
SR	0.631	0.852					
ER	0.686	0.659	0.785				
QHR	0.754	0.554	0.688	0.773			
FR	0.775	0.641	0.638	0.687	0.719		
KN	0.662	0.448	0.405	0.475	0.481	0.592	

STRUCTURAL MODEL

Bootstrapping procedures were performed in the SmartPLS to assess the path coefficient. Three out of four risk dimensions present a t-value ≥ 1.645, implying a significant relationship. Table 4 presents the outcome, which showed that health risk perception ($\beta = 0.096$, $p < 0.05$), quality and halal risk perception ($\beta = 0.257$, $p < 0.001$), and financial risk perception ($\beta = 0.241$, $p < 0.001$) positively influence the intention to purchase the product containing the recombinant CLP.

As suggested, the R^2 value was assessed to measure the model's explanatory power and can be referred to as in-sample predictive power (Hair et al., 2019). The value of R^2 ranges from 0 to 1, with higher values indicating greater explanatory power, and as a guideline, R^2 values of 0.75, 0.50, and 0.25 can be considered substantial, moderate, and weak, respectively (J. F. Hair et al., 2011; Henseler et al., 2009). As tabulated in Table 4, the R^2 for the study was 0.519, implying that the model for this study has a moderate explanatory power. The R^2 suggested that 50 percent of the variance in intention to purchase the product containing the recombinant CLP can be explained by quality, halal risk perception, and financial risk perception.

Table 4 Result of Hypotheses Testing (Direct Relationship)

Hypotheses	Relationship	Std. Beta	Std. Dev	t-value	p-value	Decisions	R2
H1	HR -> PI	0.096	0.043	2.261*	0.012	Supported	0.519
H2	SR -> PI	0.041	0.048	0.837	0.201	Not supported	
H3	ER -> PI	0.076	0.051	1.474	0.070	Not supported	
H4	QHR -> PI	0.257	0.050	5.146*	0.000	Supported	
H5	FR -> PI	0.241	0.051	4.686*	0.000	Supported	

Note: significant at $p < 0.05$

MODERATING ROLE OF KNOWLEDGE

The moderation assessment follows the orthogonalizing approach (Henseler & Chin, 2010), which builds on the indicators approach and requires creating interaction terms for all product indicators (Ramayah et al., 2018). First, the interaction effect is created between two indicators of each relationship. The R^2 for the main model before interaction is 0.519, which means that 51.9% of the change in purchase intention is accounted for consumers' perception of health, social, environmental, quality and halal, and financial risk. With the inclusion of the interaction term, the R^2 increased to 0.533, or 53.3%. Hence, an increase of 1.4% in variance explained the purchase intention. Table 5 shows the moderation analysis to examine whether consumers' knowledge strengthens the relationship between risk perceptions and their intention to purchase the product containing recombinant CLP. However, the result indicates that all hypotheses on the moderating effect of knowledge are rejected because of the insignificant results.

Table 5 Moderation Analysis

Moderator	Std. Beta	Std. Deviation	t-statistics	P values	f2
KN x FR -> PI	-0.057	0.051	1.114	0.133	0.006
KN x QHR -> PI	-0.034	0.053	0.646	0.259	0.002
KN x ER -> PI	0.064	0.054	1.182	0.119	0.004
KN x SR -> PI	-0.022	0.052	0.425	0.335	0.001
KN x HR -> PI	-0.029	0.050	0.584	0.280	0.001

Note: $R^2 = 0.533$

DISCUSSION

Risk was one of the most common worries raised by consumers concerning new technology, particularly when it came to their safety and health. Consumers frequently believe that they are the experiments of the new technology, as opposed to the authority's decision making, which is for the benefit of society (Slovic, 1987). Similarly, in this study, the respondents perceived risk upon hearing the development of recombinant CLP from bacteria. It was apparent from the questionnaires regarding risk perceptions that they were valid and reliable; thus, they captured what the study intended to measure, which was risk perception.

Table 4 further illustrates the significant relationship between respondents' risk perceptions and their intention to purchase the recombinant CLP. The data supports the premise that health risk perceptions influence consumers' purchasing intentions (see Table 4). The findings correspond with the previous studies, which revealed that health risk influences tourists' behavioural intentions (Al-Ansi et al., 2019; Choi & Lee, 2019; Choi et al., 2013; Connor & Siegrist, 2010; Hakim et al., 2020; Hu et al., 2020; Ross et al., 2014; Xiao et al., 2017). Moreover, Slovic (1987) claims that some people believe they are experiments on the creations of manufacturers and authorities, despite the fact that they are for their benefit (Slovic, 1987). Likewise, recombinant CLP was examined as a substitute for animal-based collagen, which has various difficulties.

The findings of this study demonstrate that quality and halal risk influence consumers' intentions to purchase recombinant CLP. Similarly, earlier research has demonstrated that quality risk perception has a significant impact on consumers' willingness to buy halal foods (Al-Ansi et al., 2019; Olya & Al-ansi, 2018). Besides, choosing halal goods and services also means picking a high-quality product (Azam & Abdullah, 2020).

Meanwhile, consumers' perceptions of financial risk have a major impact on their intention to purchase the recombinant CLP. According to prior halal research, Muslim consumers are prepared to pay a premium for halal logistics because they are obligated to consume halal goods and services (Bonne et al., 2007; Bonne & Verbeke, 2008; Khan et al., 2019; Olya & Al-ansi, 2018). Furthermore, the price demonstrates that the products have high quality; hence, it plays a vital part in influencing consumers' willingness to buy a product (Di Vita et al., 2019).

The outcome of the respondents' risk perception and their intention to purchase a product based on recombinant CLP were in alignment with the theory of risk perception proposed by Slovic et al. (Slovic, 1987; Slovic et al., 1982; Slovic & Lichtenstein, 1983; Slovic & Peters, 2006). Apparently, respondents perceived risk in the development of recombinant CLP, which would influence their intention to purchase the final products made of recombinant CLP.

Moreover, according to Dryhurst et al. and Van der Linder, the inclusion of people's knowledge on particular products could affect their judgment and decision (Dryhurst et al., 2020; Van der Linden, 2014, 2017). Therefore, this study attempts to investigate the moderating role of knowledge with reference to several other literatures as well (Kim & Bonn, 2015; Suki, 2016; Wang et al., 2019)

This study also hypothesised that there are association between the consumers' risk perceptions and their intention to buy the products containing recombinant CLP would be moderated by their level of understanding about collagen. This is because information is seen as one of the key elements that influences how customers behave (Ghali, 2019; Megido et al., 2016; Siegrist & Hartmann, 2020a).

Consumers typically respond to risk based on their present understanding, which is subjective and may or may not be true (Leung & Cai, 2021). Kim and Bonn (2015) found that knowledge modifies environmental factors and purchase intention; the items in their environmental factor were somewhat similar to the items in the risk perception construct in this study's investigation (Kim & Bonn, 2015).

The role of knowledge as a moderator was assessed in this study, where it was hypothesized that consumers' knowledge strengthens the relationship between risk perception and consumers' purchase intention owing to the fact that knowledge is deemed an important factor that contributes to the consumers' behaviour (Ghali, 2019; Megido et al., 2016; Siegrist & Hartmann, 2020b). However, the hypotheses regarding the moderating role of knowledge in this study were not supported by the empirical result of this study. Even though the hypotheses were not supported by the final moderating analysis result on the one hand, the existence of knowledge as a moderating role does increase the R^2. It was probably due to the inaccuracies of the items constructed in the questionnaire because, previously, research had reported that knowledge has a moderating role in the relationship between predictors and consumers' behaviour (Kim & Bonn, 2015).

Further studies can be conducted with the adjustment in the items for knowledge variable. This is because other studies that discovered the individuals' perception of risk was significantly influence by their knowledge and understanding about viruses, leading them to take more precautions (Iorfa et al., 2020; Zhong et al., 2021). Consumers who are better informed about collagen in general perceive more risks, thus more likely to purchase products containing recombinant CLP (Zhang et al., 2017).

CONCLUSION

This study focuses on the development of recombinant CLP and examines consumers' risk perception toward recombinant CLP and their intention to buy products containing recombinant CLP. It can be concluded that this study has the potential to have an impact on theoretical, practical, and policy implications.

To begin, this study used the risk perception framework to investigate customers' risk perceptions regarding the development of a new form of bacterial collagen. Previous literature presents several approaches to the risk perception framework, and the majority of them looked into the relationship between risk perception and trust (Al-Ansi et al., 2019; Hakim et al., 2020; Hu et al., 2020; Siegrist, 2000). Furthermore, this study supports Slovic (1987) key work on the analysis of risk perception by the public and authorities on the introduction of a new potential hazard, such as food preservatives, microwave ovens, and several others (Slovic, 1987). Aside from that, the study's findings would add to the consumer behavior literature and may persuade other researchers to continue experimenting with recombinant CLP for other applications, such as cosmetics.

Meanwhile, the findings of this study will persuade industrial players of the future potential of products incorporating recombinant CLP. Besides, the cost of recombinant CLP is less than animal-based collagen. (Awang et al., 2021; Salleh et al., 2021), which may encourage businesses to replace animal-based collagen with recombinant CLP. Furthermore, the consumer responses indicated that they consented to replace animal-based collagen with recombinant CLP for halal uses.

Furthermore, Muslim consumers have traditionally been concerned about halal status, particularly with collagen and gelatine (Batu et al., 2015). As a result, the halal research institute has been formed in public universities such as INHART under IIUM, as well as other institutions such as Universiti Putra Malaysia and Universiti Malaya. Nonetheless, this study may add to the nation's economy, especially as Malaysia has grown exponentially known for its halal economy (MIDA, 2022; MIHAS, 2024; Mustaffa, 2019).

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