ESTEEM Journal of Social Sciences and Humanities
Vol. 7, Special Issue, October 2023
https://ejssh.uitm.edu.my

Key Drivers of Consumer Acceptance of Technology Use in Food Production: Synergy between Health Benefits and Psychological Factors

Ahmed Thaufiq Lee[1], Hashim Fadzil Ariffin[2] Irina Mohd Akhir[3] and Mazarina Devi[4]

[1,2,3]Faculty of Hotel and Tourism Management, Universiti Teknologi MARA Cawangan Pulau Pinang, Malaysia
[4]Faculty of Engineering, Universitas Negeri Malang, Indonesia
**corresponding author: [2]hashim@uitm.edu.my*

ABSTRACT

ARTICLE HISTORY

Received:
30 May 2023
Accepted:
20 October 2023
Published:
20 November 2023

KEYWORDS

Technology
Food Production
Consumer Acceptance
Health Benefits
Psychological Factors

Growing numbers of people were forced to dedicate a substantial amount of time every day to gathering and hunting in order to meet their own families' food needs due to limitations in food processing and storage methods. This research investigated the influence of perceived health benefits and psychological factors on consumers' acceptance of technology applied in food production. The health benefits include direct health benefits, reduction of disease risk, and better life conditions. The psychological factors attribute consists of information obtained, evaluation of new technology, and understanding of hazards. The closed-ended questionnaires were applied to collect data from an estimated sample size of 128 respondents in Penang State, Malaysia. The results indicated that most of the respondents were male, between the ages of 18 and 30. The research discovered that the influence of perceived health benefits and psychological factors had a significant influence on consumers' acceptance of technology applied in food production. The research results also revealed that most respondents agreed that lack of knowledge is a major factor in why people refuse to accept the technological influence on food production. This study concludes that manufacturers, government agencies, and advocacy groups must collaborate and cooperate to increase public awareness about genetically modified foods.

e-ISSN 2600-7274

1. INTRODUCTION

Food is an essential component of human life and survival. Since the dawn of time, mankind has needed food to survive. Historically, when the human population was substantially smaller, resources were sufficiently available, and food preparation and storage were not as necessary. As populations expanded, constraints in food processing and storage techniques compelled an increasing number of people to invest significant time each day so that they could provide food for their own families through harvesting and hunting.

The advent of new food technology has facilitated significant advancements within the food industry. According to Kampers (2016), advancements in nanotechnology have made it feasible to investigate the phenomena occurring at the nanoscale. This newfound understanding can potentially be leveraged to develop novel nanostructures that have the potential to improve the overall quality of food. However, not all technologies are welcomed equally by consumers. For example, According to Butz et al. (2003), there are a few issues with the high-pressure processing of food. Additionally, Europe does not permit some food technologies, like gene technology (Gaskell et al., 2013). Furthermore, public acceptance is uncertain regarding other food innovations. Nanotechnology, for instance, has the potential to develop completely novel food items (Jandt & Watts, 2020) and is widely used in the food manufacturing and packaging industries (Augustin & Sanguansri, 2009). According to He and Hwang (2016), the implementation of nanotechnology has been found to have a positive impact on various aspects of the food industry. These include improvements in food safety and processing, enhancement of flavor and nutritional content, advancements in delivery techniques, more effective disease detection methods, optimization of food functionality, environmental protection measures, increased cost-effectiveness of storage and distribution, as well as enhanced plant nutrient absorption. Currently, there is a lack of understanding regarding the potential public reception of nanotechnology-based food products. The level of consumer acceptance of various types of nanotechnologies in food products remains uncertain. Steenis and Fischer (2016) conducted a study examining consumer attitudes towards diverse applications of food nanotechnologies, but the extent of acceptance by consumers remains ambiguous.

The development of food items is contingent upon consumer approval (MacFie, 2007). In general, there has been an increase in public interest regarding food production technologies (Grunert et al., 2002). According to Wilkinson et al. (2004), there may be variations in the way consumers and professionals perceive risks. The decision-making process of consumers regarding food selection is often discussed in the context of two key factors: the establishment of quality expectations prior to the purchase and the subsequent evaluation of quality experience post-purchase. One of the challenges identified in the establishment of quality expectations is the limited capacity of consumers to develop anticipatory expectations that accurately reflect their subsequent experiences. Therefore, it is imperative to take into account the perspectives of consumers when it comes to emerging food technologies during the initial phases of product development.

According to Siegrist and Hartmann (2020), customers may exhibit confidence in the food industry's ability to ensure the safety of food products, particularly through the utilization of food technology. However, they may also experience a deficiency in social trust towards the industry as a whole, primarily stemming from the belief that it prioritizes financial gain over

the welfare of consumers. In order to achieve commercial success, it is crucial to consider the perspectives of both laypersons and experts simultaneously. The level of acceptance of emerging food technology may exhibit variability among individual consumers. Meijer et al. (2021) argue that increasing transparency about food formulation and processing is critical for restoring consumer trust. This approach enables food manufacturers to communicate how their products are processed within their facilities and allows consumers to fully comprehend the benefits offered by various processing methods. Manufacturers can increase consumer awareness and trust by emphasizing the advantages of factory processing over home food preparation.

We can now examine the various strategies designed to increase societal acceptance of emerging food technologies. As a result, the primary goal of this research is to determine the relationship between perceived health benefits of innovative food products, consumer psychological factors, and consumer acceptance of food production technology. In this technological influence on food production study, it is hypothesized that there is a relationship between perceived health benefits of innovative food products, consumer psychological factors, and consumer acceptance of technology use.

2. LITERATURE REVIEW

2.1 Consumer Acceptance

According to Gaskell et al. (2013), the medical field recognizes the extensive applications of gene technology. However, European consumers still demonstrate apprehension towards the consumption of genetically modified (GM) crops. This study provides clear evidence that the attributes of a product significantly impact its adoption as an emerging technology, and this impact can be either favorable or unfavorable. The cost of the items being acquired is an additional factor that must be taken into account. Spence and Townsend (2006) reported that a significant portion of individuals residing in the United Kingdom have expressed their willingness to purchase GM foods, contingent upon their accessibility at a reasonable cost. The level of consumer acceptance remains uncertain, thus necessitating further investigation. The expectation of benefits is crucial to the consumption of new food items (Frewer et al., 2003). According to a study conducted in Switzerland, the general public places a higher value on the perceived benefits of GM products than on their concerns about these products (Siegrist & Hartmann, 2020). According to Spence and Townsend (2006), the popularity of GM food is influenced more by its benefits than by its preparation method. According to a literature review conducted by Ronteltap et al. (2007), consumer acceptance of new food technology is heavily influenced by their perception of the costs and benefits associated with it.

2.1.1 Consumer Attitude

According to Siegrist and Hartmann (2020), the acceptability of gene technology is influenced by perceived advantages and hazards. The researcher further emphasized that several studies have used this model to assess its validity. Furthermore, an experimental investigation found that people who read about a genetically altered soybean that had a clear consumer advantage were substantially more comfortable consuming it than those who read about a soybean that had no clear consumer benefit (Brown & Ping, 2003). This association between behavioral beliefs and attitude is not substantiated by a prospective investigation, according to the original concept (Singh & Verma, 2017). There is a conceptual gap between the advantages that people believe the development of a particular technology will bring and the behavioral beliefs that relate a particular activity to a certain outcome. If these arguments are true, we should predict

that the influence of perceived advantages on the intention to consume GM food is independent and equivalent to the effect of attitudes on the intention to consume GM food.

2.1.2 Food Production

A food innovation's impact on consumer attitudes is not limited to the invention itself but also to the social, economic, and political context in which it is implemented (Singh & Verma, 2017). Public anxiety over dangers that professionals consider low-risk can be exacerbated through social amplification mechanisms (Pidgeon et al., 2003). In the case of GM foods, such social amplifying mechanisms may be witnessed in several European nations (Gaskell et al., 2013). At this time, there are no signs that a similar amplification process is likely to occur in foods made using nanotechnology. According to MacFie's (2007) research, consumer acceptance is a critical determinant of successful product development. Food technology used in the manufacture of a product can have an impact on consumer purchasing decisions. Nonetheless, consumers prioritize a product's advantages over its technical specifications. If consumers believe that a novel food technology has no discernible value for them or society but instead benefits producers and the food industry, it may create challenges and jeopardize the food sector. Because industry innovations are critical for economic and social progress, it is critical to understand consumers' perspectives on issues such as production, technology, and acceptance (Recuero-Virto & Valilla-Arrospide, 2022).

2.2 Health Benefits of Innovative Food Products

A growing number of consumers are becoming aware of functional foods in hopes of reaping additional health benefits that may reduce certain disease risks or promote optimal wellness. Several health benefits are related to functional food. According to the study of Van Kleef et al. (2005) and the classification of functional foods proposed by Makinen-Aakula (2006), the health benefits of innovative food products may be grouped into three main classes: direct health benefits, reduction of disease risk, and better living conditions. Examples of health benefits are those reports referring to the main types of functional foods available on the market. Health claims traditionally consist of front-of-package information, which links the product with specific health-related functions (Lähteenmäki, 2013).

2.2.1 Direct Health Benefits

Because environmental and health regulations are laxer in developing nations, most pesticide control is conducted manually, and farmers are less educated and less informed about the pesticide’s adverse side effects. The health risks for farmers applying pesticides in developing nations are frequently greater than in developed nations. Thus, reduced exposure to insecticides during spraying operations has direct health benefits for farmers. Reduced exposure to insecticides during spraying operations has direct health benefits for farmers. Additionally, GM crops, particularly genes from the soil bacterium Bacillus thuringiensis (Bt) crops, are related to health advantages. GM crops, particularly those using genes from the soil bacterium Bacillus thuringiensis (Bt) crops, are related to health advantages (cite relevant sources). Contaminants in food and drinking water caused by pesticides can be reduced using Bt crops, which are GM to resist pests. Further, there was also evidence that Bt maize contained considerably lower amounts of some mycotoxins than non-Bt maize, whereby mycotoxins have been implicated in the development of cancer and other disorders in humans (Wu et al., 2014). A considerable portion of mycotoxin contamination is caused by insect damage, particularly in maize. Maize

is thoroughly examined for mycotoxin contamination in the United States and other affluent nations. Many underdeveloped nations, however, do not conduct regular mycotoxin inspections of the highest standard. This is indicated by Milićević et al. (2010), where they stressed that poor methods of food handling and storage are already exposed to higher levels of mycotoxins. Reduced mycotoxin levels in Bt maize may lower the testing and grading expenses in these countries. Therefore, Bt crop technology may be able to help reduce the overall health and economic burden in these instances (Wu, 2006; Qaim et al., 2008).

2.2.2 Reduction of Disease Risk

The genetic alteration of dietary fat composition was another driving factor for consumer acceptance. Scientists have altered the natural makeup of oil plants in response to the growing need for saturated fatty acids and the concurrent decline in demand for mono- and polyunsaturated fatty acids, as reported by Pandey et al. (2010). For example, soybean cultivars with a few-fold greater level of oleinic (oleic) acid (a monounsaturated fatty acid) and rape varieties rich in stearic acid (a long-chain saturated fatty acid) with no ill health consequences have been developed through laboratory research (Singh & Verma, 2017). Further, plant cells were able to produce omega-3 acids (polyunsaturated fatty acids) through the introduction of genes that synthesize unsaturated fatty acids. Omega-3 acids are highly prized for their beneficial health effects, such as lowering serum levels of low-density lipoprotein (LDL) cholesterol and triglycerides and also lowering the risk of cardiovascular disease. Kramkowska et al. (2013) argue that genetic modifications of plants and animals are justified due to their potential to address global food scarcity, enhance crop yields, improve the nutritional content of food, and facilitate the development of pharmaceutical products. Nevertheless, it is plausible that the consumption of transgenic food could potentially have adverse implications for the well-being of individuals. Hence, the debate revolved around the ethical validity of genetic modifications, with a multitude of instances demonstrating the potential hazards associated with their implementation.

2.2.3 Better Life Conditions

The use of formulation and blending in the production of novel functional foods has a long history in the effective treatment of vitamin A and D deficits, many B vitamins, iodine, and iron deficiency. It is a simple, inexpensive, and adaptable technique (Betoret et al., 2022). As the importance of dietary components and their health benefits has grown in recent years, this food product category has gained more attention from the scientific community, consumers, and food producers (Kim et al., 2010). The term "edible films and coatings" refers to any sort of material used to encase various foods to prolong the shelf-life of the product. These components could be used to limit pathogen growth on the food surface and give nutrients to the consumer (Betoret et al., 2022). Although there are still many unsolved issues regarding this new technology, it has the potential to usher in a new era of functional foods (Ismail et al., 2009). A limited number of clinical trials have utilized this technology to influence food creation or nutritional recommendations; however, a multitude of challenges must be resolved before genomics may become an acknowledged technique for doing so (Betoret et al., 2022).

2.3 Psychological Factors

Grunert et al. (2002) stated that a broader framework of attitudes and values can influence how people perceive new food technologies. It has been proposed that perceptions of genetically modified organisms (GMOs) in the context of food production are influenced by both general attitudes towards GM technology and attitudes towards nature. A recent study found that when

assessing new hazards, people tend to rely on their prior knowledge of known hazards (Visschers et al., 2012). Individuals use semantically related information to make these assessments. The evaluation of a novel technology is dependent on the underlying concepts and visual representations of this emerging food technology. Siddiqui's (2022) review investigated the impact of social and psychological factors on public attitudes towards genetically modified (GM) foods, as well as consumers' perceptions of the use of such foods. According to the analysis presented in this review, genetically modified (GM) foods are characterized as unnatural and artificial, which influences the general reception and adoption of these products.

2.3.1 Food Information

As a result of advancements in technology and increased knowledge, certain consumers are well-informed about the presence of genetically modified (GM) foods. These individuals actively strive to raise awareness among others regarding similar concerns. This underscores the importance of understanding the perceptions of Malaysian consumers regarding genetically modified (GM) foods, as both local and global apprehensions about food safety continue to escalate (Sendhil et al., 2013). The acceptance, awareness, and perception towards the genetic GMF are still insufficient to fulfill the Malaysian market and expectantly play a major role in a long period of time (Azlin et al., 2020). The awareness and debate surrounding genetically modified (GM) foods have intensified with the progression of technology and the dissemination of knowledge among consumers. Some argue that the heightened awareness among certain consumers, who actively seek to inform others, indicates a growing concern about the potential risks associated with GM foods. These individuals believe that a comprehensive understanding of Malaysian consumer perceptions is crucial, given the increasing worries about the safety of genetically modified foods on both a local and global scale. On the other hand, skeptics contend that the concerns raised about GM foods might be exaggerated or based on insufficient scientific evidence. They argue that technological advancements in agriculture, including genetic modification, have the potential to address pressing issues such as food security and crop resilience. Some emphasize the need for a balanced perspective that considers both the potential benefits and risks associated with genetically modified foods.

Various strategies, such as labeling mechanisms, media platforms, and government-provided information, can be used to raise consumer awareness about GM foods. Malaysians have a relatively limited understanding of GM foods. Despite the availability of numerous GM food products on the market, consumers are unable to detect the presence of GM foods due to a lack of proper labeling on packaging. The interaction between consumer knowledge and information availability influences the adoption of GM foods. In line with this idea, Hakim et al. (2020) conducted a study to assess consumers' knowledge of the mandatory labeling of foods containing genetically modified ingredients as well as to investigate the underlying motivations behind consumers' willingness to purchase these foods in Brazil. The Sendhil (2021) study looks at emerging trends in research outputs related to consumer perception and preference for GM foods. Furthermore, the study makes policy recommendations to encourage the consumption of such foods. There is a scarcity of comprehensive research in developing countries on the development of genetically modified food products with enhanced characteristics and substantial equivalence while minimizing any significant adverse effects.

2.3.2 Evaluation of New Technology

Existing empirical data suggests that the majority of people have limited knowledge of nanotechnology, according to a study conducted by Vandermoere et al. (2011). Previous research in the United States and Canada found that consumers have a favorable attitude

towards nanotechnology (Priest, 2008). Furthermore, Cormick (2009) cites that Curall et al. (2006) stressed consumers' perceptions of nanotechnology as having lower risks and benefits when compared to genetic modification technology. It is worth noting, however, that when it comes to food-related applications, consumers tend to view them less favorably or at least differently than other domains of application (Siegrist & Hartmann, 2020). This may vary from one person to another (Khan et al., 2017). Compared to American consumers, Europeans appear to be less positive about nanotechnology (Gaskell et al., 2013). The commercialization trajectory and public acceptability of new nanotechnology applications have frequently been speculated to replace GM (Kearnes et al., 2006).

The commercialization of nanotechnology-based foods and food packaging has already occurred, although with a limited number of items. Soon, nanotechnology may play a greater role in the food business (Goebelbecker & Albrecht, 2016), with government agencies and the private sector devoting substantial resources to its development and implementation (Brown et al., 2015). However, toxicity studies reveal that certain nanomaterials may have unanticipated impacts on human health and the environment (Frewer et al., 2011). Corley et al. (2009) cited Renn and Roco's (2006) argument that assessment frameworks for new risks are necessary for the development and implementation of effective risk legislation. Utilizing nanotechnology, new meals and food packaging with various advantages are being researched and developed. In the food industry research area, nanotechnology may be employed to generate healthier meals or to improve organoleptic qualities. While in the area of functional foods, investigation of delivery methods to transport food components to their action site may be necessary (Weiss et al., 2006). Several Chinese staple foods have been negatively affected by biotic and abiotic risks that threaten to disrupt domestic food supply networks in high-profile incidents. According to Wilkinson et al. (2013), rice and pork, two of China's most significant agricultural commodities and most extensively eaten food products, have been affected particularly severely, with rice production suffering from widespread soil contamination and pork production suffering from widespread outbreaks. Both dangers raise questions about food safety, but because of the larger implications for food supply chains they raise, policymakers and the scientific community should pay close attention to them.

There are new developments in food biotechnology that may help to solve some of these problems with the food supply. GMOs and genome-editing technologies, such as CRISPR-Cas9, have emerged as two of the most significant food biotechnologies that potentially improve food security and food safety (Gaskell et al., 2013). A GMO involves the insertion of genetic material from a foreign species into the DNA of a host organism, which is seen by some consumers with great mistrust. Many people, however, believe that genome editing has the potential to bring about a significant transformation in the field of food biotechnology in a morally acceptable way. This is primarily because genome editing techniques do not necessitate the incorporation of genetic material from another species. These techniques, on the other hand, involve the rearrangement or removal of specific sequences within the same organism (Butz et al., 2003). To rationalize the allocation of resources, both in terms of time and financial investment, a thorough understanding of the extent to which consumers embrace products generated through technological procedures is required.

3. METHODOLOGY

3.1 Research Design

This study applied the quantitative research method, which generates numerical data through its findings.

3.2 Population and Sample

Penang's population was approximately 1.61 million in 2021, with 738,500 on the island and 872,600 on Seberang Perai's mainland (Bagheri et al., 2022). The state in question has a notably high population density and is considered one of Malaysia's most urbanized regions. Seberang Perai is Malaysia's second-most populous city, according to the Department of Statistics Malaysia (Izhar et al., 2021). The region's population is highly diverse in terms of racial, cultural, linguistic, and religious backgrounds. To achieve a broad understanding of the subject matter, the study used a nonprobability convenience sampling method, which is commonly used in qualitative research. The participants were Penang residents who were familiar with the technology used in food production. The final sample size was decided using the G-Power software application by considering the power, effect size, and significance level. The projected number of participants for the study was determined at 128.

3.3 Development of the Survey Instrument

The closed-ended questionnaires were applied to collect data from the estimated sample size that was segregated into 4 sections measuring quantitative data to test three groups of items, totaling up to 4 sections, A-D. The incorporation of survey questions into research as a means of collecting pertinent information in a dependable and valid fashion is an essential component of research methodology. This can be achieved by ensuring that all the survey items are included in the compilation.

3.4 Data Collection

To understand consumer acceptance of technological influence in food production, a survey in Penang was conducted. Penang is arguably one of the most populated and well-developed states in Malaysia (Hutchinson & Saravanamuttu, 2012). It is relevant to conduct a survey related to technology in a high-growth modern city (Kanu et al., 2023). The questionnaire, which is self-administered, was developed using Google Form. The questionnaire employed provides locations for respondents to simply check the circles on the Likert scale that correspond to their responses. This eliminates the need for them to enter numbers or a circle, both of which can ease the respondents' decision-making process. To avoid any possible ambiguity, the questions were worded in a clear and straight-forward manner.

4. DATA ANALYIS AND RESULTS

Employing frequency and multiple regression is pivotal in scrutinizing consumer acceptance of GMF concerning health benefits and psychological factors. Frequency analysis reveals prevalent responses, while multiple regression dissects the complex interplay among variables, quantifying the impact of factors like perceived health benefits and health benefits on consumer acceptance.

4.1 Respondent Socio-Demographic Profiles

Table 1 depicts the socio-demographic profiles of the 128 respondents. It reveals that the proportion of male respondents, 54.7% (n = 70), is somewhat greater than the proportion of female respondents, which is 45.3% (n = 58) in this study. The largest age group of respondents is 18–30 years old, with a total of 67 out of 128 (52.3%), followed by the 31–40-year-old age group with 22.7% (n = 29), while the age group above 60 years old had the smallest proportion (n = 5, percentage = 3.9%). Consequently, in terms of race, the Malay led with 69.5% (n = 89)

of the survey, followed by the other 14.1% (n = 18), which consists of the minority races and other Bumiputera. The Chinese settled in third place with 10.9% (n = 14), while the Indians are the smallest group that participated in this study with 5.5% (n = 7). Lastly, from Table 1, there are 7.8% (n = 10) respondents with an SPM education level, 11.7% (n = 15) respondents with a certificate's education level, and 25.8% (n = 33) respondents with a diploma education level. Degree holders appeared to be the majority in the survey with 46.1% (n = 59), while master holders contributed with 8.6% (n = 11) in the study.

Table 1: Respondent Socio-Demographic Profiles

Socio Demographic Item	Option	Frequency	Percentage
Gender	Male	70	54.7
	Female	58	45.3
Age	18-30	67	52.3
	31-40	29	22.7
	41-50	21	16.4
	51-60	6	4.7
	>60	5	3.9
	18-30	67	52.3
Race	Malay	89	69.5
	Chinese	14	10.9
	Indian	7	5.5
	Other	18	14.1
Education	SPM	10	7.8
	Certificate	15	11.7
	Diploma	33	25.8
	Degree	59	46.1
	Master	11	8.6

4.2 Reliability Test

This evaluation is critical for establishing the degree of congruence between respondent ratings and the obtained data. The internal consistency of the instrument was then examined using Cronbach's alpha. Consumers' awareness and acceptance of technology applied in food productions scored 0.812, consumers' perceived health benefits scored 0.934, and consumers' psychological factors attributes scored 0.803.

4.3 Predictors of Consumer Acceptance of Technology Use in Food

Multiple regression analysis was used to investigate the independent effects of two variables on a dependent variable. The perceived health benefits of innovative food products and consumer psychological factors are the independent variables being investigated in this study. Consumer acceptance is the dependent variable of interest. Potential confounding variables will also be considered during the analysis. It is worth noting that demographic profiles can influence both predictor factors and consumer acceptance of technology in food production. As a result, demographic profiles must be considered as potential confounding variables in the multiple regression analysis.

The multiple regression analysis indicated that health benefits was a significant predictor of consumer acceptance, ß = -0.541, t(127) = -7.220, p < 0.001. This means that the Health Benefits had significant negative regression weights, indicating consumers with higher perceived Health Benefit scores were expected to have lower acceptance scores, after controlling the confounding variables in the model. Next, the multiple regression analysis indicated for Psychological Factors analysis was a significant predictor of consumer acceptance, ß = -0.462, t(127) = -5.853, p < 0.001. This means that the Psychological Factors had significant negative regression weights, indicating consumers with higher Psychological Factors scores were expected to have lower acceptance scores, after controlling the confounding variables in the model. The finding also portrays a similar result to the previous study by Siegrist and Hartmann (2020) proved that consumer acceptance is related to and influenced by psychological factors. The multiple regression model with all two predictors indicated that the combination scores of perceived health benefits and consumer psychological factors accounted for 30.3% of the variability in the overall scores of the respondents' acceptance of technology use in food production, R2 = .303, p < 0.001.

Table 2: Multiple Regression Analysis

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	18.430	1.525		12.088	.000
	Health Benefit	-.500	.069	-.541	-7.220	.000
	Psychological Factors	-.467	.080	-.462	-5.853	.000
a. Dependent Variable: Consumer Acceptance						

5. DISCUSSION

Based on the statistical analysis, all hypotheses proposed in the study were accepted. Specifically, the study found that there is a relationship between perceived health benefits and consumer acceptance of technological influence on food production. Also, there is a relationship between consumer psychological factors and consumer acceptance of technological influence on food production. Several studies have analyzed consumer responses to health claims (Annunziata & Vecchio, 2013), all of which are designed to assess perceived healthfulness or advantages, persuasiveness or believability of the claim, and consumer comprehension of the claim itself.

Hence, the finding also portrays a similar result to the previous study by Bui (2015), which proved that consumer acceptance is related to and influenced by the health benefit factor. This might be influenced by their priority over the importance of health. The negative correlation might portray that consumers may be more accustomed to and prefer foods that are rich in flavor, which often involve ingredients or cooking methods that may not align with optimal health benefits. Healthier food options may sometimes be perceived as bland or unfamiliar, leading to a lower level of consumer acceptance. Generally, it is understandable that most people will prioritize their health factors first, and for that, it might be relevant enough to conclude that this study also obtained a similar result to the previous study despite having been conducted in a different region, time, and geographic location.

Next, the second hypothesis demonstrates that there is a connection between psychological factors and consumer acceptance of technological influence on food production. This study has

found that while most of the respondents agreed that lack of knowledge has become a major factor in why people refuse to accept the technological influence on food production, most of them support the idea that food biotechnology can revolutionize the food supply chain in the future and ask the manufacturer to provide more information about GMF on the label of food packaging. A potential reason for a negative but significant correlation between psychological factors and consumer acceptance of GMFs could be the impact of perceived risks and uncertainties associated with genetic modification. Consumers' psychological factors, such as risk perception, trust in the technology, and general attitudes toward biotechnology, can significantly influence their acceptance of GMFs. If individuals perceive GMFs as risky, unnatural, or unpredictable, it can create a negative psychological bias that affects their acceptance. So, it is safe to conclude that despite the lack of awareness in this area, most of the respondents support the movement to utilize technologies in food production to the fullest.

As the research demonstrates that there is a significant relationship between psychological factors and consumer acceptance of technological influence on food production, the hypothesis is accepted. However, previous research related to this study had a slightly different result. According to Siegrist and Hartmann, in 2020, even though the hypothesis and objective are accepted, he claimed that there is not a strong relationship between psychological factors and consumer acceptance of technological influence on food production. Siegrist and Hartmann's (2020) study focused on general psychological dimensions and did not identify any significant connections between these components and the adoption of novel food technology. The relationship between environmental views and the perception of new food technology is poor. The personal relevance of naturalness appears to be the most relevant variable. Consumers with a strong desire for organic foods and an emphasis on natural food production assess modern food technology unfavorably.

For the negative correlation between food health benefits and consumer acceptance, limitations include potential cultural bias due to an insufficiently diverse sample, a focus on short-term preferences without accounting for long-term shifts, and reliance on self-reported data without behavioral validation. Additionally, external factors like marketing strategies and societal trends might not have been adequately considered, impacting the study's applicability to real-world scenarios. Regarding the negative correlation between psychological factors and consumer acceptance of GMFs, limitations involve the study's potential lack of generalizability to diverse populations, susceptibility to social desirability bias in respondent answers, and the static nature of attitudes over time. The study may not have thoroughly explored the influence of media narratives, ethical considerations, and personal values, limiting the comprehensive understanding of psychological factors affecting consumer acceptance of genetically modified foods.

6. CONCLUSION

The escalation of lifestyle-related ailments and the progressive increase in healthcare expenditures are the primary contributors to this trend. The phenomenon of demographic changes, as exemplified by the aging population in many developed countries, the rise in life expectancy, and the pursuit of a higher quality of life, has fueled scientific research aimed at discovering or developing nutritional food products. Thus, it is critical to recognize and address the persistent lack of knowledge about GMFs. The prevalence of GMFs has outpaced public awareness. To address this issue, manufacturers, government agencies, and advocacy groups must collaborate and cooperate. Implementing government-led educational initiatives, disseminating lectures, and establishing official websites have the potential to significantly improve public understanding of biotechnology and GMFs. The implementation of a mandatory

labeling system for imported products containing GM ingredients increases transparency and empowers consumers to make more informed decisions. This method improves transparency and credibility by reducing ambiguity and doubt. Finally, these measures are critical to closing the knowledge gap and promoting informed consumer choices about genetically modified foods.

ACKNOWLEDGEMENT

The authors would like to acknowledge Universiti Teknologi MARA Cawangan Pulau Pinang for the assistance in completing this research.

AUTHORS' CONTRIBUTION

ATL carried out the introduction and literature review sections. ATL collected and refined the data and performed the data analysis using SPSS. HFA contributed to the refinement of the data methodology section. IMA refines the discussion and implication sections. All authors contributed by reading and approving the final manuscript.

CONFLICT OF INTEREST

None declared.

REFERENCES

Annunziata, A., & Vecchio, R. (2013). *Consumer perception of functional foods: A conjoint analysis with probiotics.* Food Quality and Preference, 28(1), 348-355.

Augustin, M. A., & Sanguansri, P. (2009). *Nanostructured materials in the food industry.* Advances in Food and Nutrition Research, 58, 183-213.

Azlin, A. M. Z., Baki, R., Enio, M. S. K., & J Ho Abdullah, S. (2020). *Awareness and acceptance of genetic modified food (GMF) among the Malaysian consumers.* JBMP (Jurnal Bisnis, Manajemen dan Perbankan), 6(1), 56-62.

Bagheri, M., Tuan Lonik, K. A., Jaafar, M., Adam, R., Asma Wan Talaat, W. I., & Wolf, I. D. (2022). *Integrating Social, Economic, and Environmental Factors to Evaluate How Competitive Urban Landscapes Are for the Development of Sustainable Cities: Penang Island in Malaysia as a Case Study*. Land, 12(1), 104.

Betoret, E., Barrera, C., Seguí, L., & Betoret, N. (2022). *Sustainable strategies in the development of functional foods. In Innovation Strategies in the Food Industry* (pp. 145-156). Academic Press.

Brown, J., Fatehi, L., & Kuzma, J. (2015). *Altruism and skepticism in public attitudes toward food nanotechnologies.* Journal of Nanoparticle Research, 17, 1-31.

Brown, J. L., & Ping, Y. (2003). *Consumer perception of risk associated with eating genetically engineered soybeans is less in the presence of a perceived consumer benefit.* Journal of the American Dietetic Association, 103(2), 208-214.

Bui, D.T. (2015). *Consumer acceptance of functional foods in Ho Chi Minh City. Eurasian Journal of Business and Economics*, 8(16), 19-34.

Butz, P., García, A. F., Lindauer, R., Dieterich, S., Bognar, A., & Tauscher, B. (2003). *Influence of ultra high pressure processing on fruit and vegetable products.* Journal of Food Engineering, 56(2-3), 233-236.

Corley, E. A., Scheufele, D. A., & Hu, Q. (2009). Of risks and regulations: how leading US nanoscientists form policy stances about nanotechnology. Journal of Nanoparticle Research, 11, 1573-1585.

Cormick, C. (2009). *Why do we need to know what the public thinks about nanotechnology?. Nanoethics*, 3(2), 167-173.

Frewer, L., Scholderer, J., & Lambert, N. (2003). *Consumer acceptance of functional foods: issues for the future.* British Food Journal, 105(10), 714-731.

Frewer, L. J., Bergmann, K., Brennan, M., Lion, R., Meertens, R., Rowe, G., Siegrist., M., & Vereijken, C. M. J. L. (2011). *Consumer response to novel agri-food technologies: Implications for predicting consumer acceptance of emerging food technologies.* Trends in Food Science & Technology, 22(8), 442-456.

Gaskell, G., Stares, S., & Fischler, C. (2013). *Have GM crops and food a future in Europe. Successful Agricultural Innovation in Emerging Economies: New Genetic Technologies for Global Food Production.* Cambridge University Press, Cambridge (UK), 331-347.

Goebelbecker, J., & Albrecht, E. (2016). *Soft Regulation Follows Hard Risk Management—European Food Sector on Nanotechnologies*. European Food and Feed Law Review, 107-118.

Grunert, K. G. (2002*). Current issues in the understanding of consumer food choice. Trends in Food Science & Technology*, 13(8), 275-285.

Hakim, M. P., Zanetta, L. D. A., de Oliveira, J. M., & da Cunha, D. T. (2020). *The mandatory labeling of genetically modified foods in Brazil: Consumer's knowledge, trust, and risk perception. Food Research International*, 132, 109053.

He, X., & Hwang, H. M. (2016). *Nanotechnology in food science: Functionality, applicability, and safety assessment.* Journal Of Food And Drug Analysis, 24(4), 671-681.

Hutchinson, F. E., & Saravanamuttu, J. (Eds.). (2012). *Catching the wind: Penang in a rising Asia.* Penang Institute.

Ismail, M., Allaudin, Z., Pérusse, L., Al-Naqeep, G., Kesäniemi, Y. A., Jokela, M., Corey, P. N. (2009). 3rd *Congress of the International Society of Nutrigenetics/Nutrigenomics* (ISNN). Lifestyle Genomics, 2(4-5), 189-224.

Izhar, A. I., Choong, W. W., & Wee, S. C. (2023). *Key determinants enhancing local community acceptance of migrant labour settlements in Seberang Perai, Penang, Malaysia.* City, Culture and Society, 34, 100533.

Jandt, K. D., & Watts, D. C. (2020). *Nanotechnology in dentistry: Present and future perspectives on dental nanomaterials.* Dental Materials, 36(11), 1365-1378.

Kampers, F. W. (2016). *Nanotechnologies in Agrofood and Water. In Nanotechnology and Human Health* (pp. 100-121). CRC Press.

Kanu, H. B. S., Songyan, Z., & Liu-he-Lu, H. (2023). *An Investigation on the Prevailing HRM Factors Influencing the Normal Existence of SMEs in the Economic Development Atmosphere of Sierra Leone.*

Kearnes, M., Grove-White, R., Macnaghten, P., Wilsdon, J., & Wynne, B. (2006). *From bio to nano: Learning lessons from the UK agricultural biotechnology controversy.* Science as Culture, 15(4), 291-307.

Khan, I., Tango, C. N., Miskeen, S., Lee, B. H., & Oh, D. H. (2017). *Hurdle technology: A novel approach for enhanced food quality and safety–A review.* Food Control, 73, 1426-1444.

Kim, Y. H., Goh, B. K., & Yuan, J. (2010). *Development of a multi-dimensional scale for measuring food tourist motivations.* Journal of Quality Assurance in Hospitality & Tourism, 11(1), 56-71.

Kramkowska, M., Grzelak, T., & Czyzewska, K. (2013). *Benefits and risks associated with genetically modified food products.* Annals of Agricultural and Environmental Medicine, 20(3).

Lähteenmäki, L. (2013). *Claiming health in food products. Food Quality and Preference,* 27(2), 196-201.

MacFie, H. (2007). *Consumer-led food product developmen.* (Ed.). Elsevier.

Makinen-Aakula, M. (2006, September). *Trends in functional foods dairy market.* In Proceedings of the third functional food net meeting.

Meijer, G. W., Lähteenmäki, L., Stadler, R. H., & Weiss, J. (2021). *Issues surrounding consumer trust and acceptance of existing and emerging food processing technologies.* Critical Reviews in Food Science and Nutrition, 61(1), 97-115.

Milićević, D. R., Škrinjar, M., & Baltić, T. (2010). *Real and perceived risks for mycotoxin contamination in foods and feeds: challenges for food safety control.* Toxins, 2(4), 572-592.

Pandey, A., Kamle, M., Yadava, L. P., Muthukumar, M., Kumar, P., Gupta, V., Ashfaque, M. & Pandey, B. K. (2010). *Genetically modified food: its uses, future prospects and safety assessments.* Biotechnology, 9(4), 444-458.

Pidgeon, N., Kasperson, R. E., & Slovic, P. (2003*). The social amplification of risk* (Eds.).

Priest, S. H. (2008*). North American audiences for news of emerging technologies: Canadian and US responses to bio-and nanotechnologies. Journal of Risk Research*, 11(7), 877-889. Proceedings of the National Academy of Sciences, 112(48), 14743-14744.

Qaim, M., Pray, C. E., & Zilberman, D. (2008). *Economic and social considerations in the adoption of Bt crops. In Integration of insect-resistant genetically modified crops within IPM programs* (pp. 329-356). Dordrecht: Springer Netherlands.Cambridge University Press.

Recuero-Virto, N., & Valilla-Arrospide, C. (2022). *Forecasting the next revolution: Food technology's impact on consumers' acceptance and satisfaction.* British Food Journal, 124(12), 4339-4353.

Ronteltap, A., Van Trijp, J. C. M., Renes, R. J., & Frewer, L. J. (2007). *Consumer acceptance of technology-based food innovations: Lessons for the future of nutrigenomics.* Appetite, 49(1), 1-17.

Sendhil, R., Nyika, J., Yadav, S., Mackolil, J., Rama Prashat, P. G., Workie, E., Ragupathy, R. & Ramasundaram, P. (2021). *Consumer perception and preference towards genetically modified (GM) foods: bibliometric evidence and policy imperatives.* agriRxiv, (2021), 20210260196.

Siddiqui, S. A., Asif, Z., Murid, M., Fernando, I., Adli, D. N., Blinov, A. V., Golik, A. B, Nugraha, W. S., Ibrahim, S. A. & Jafari, S. M. (2022). *Consumer Social and Psychological Factors Influencing the Use of Genetically Modified Foods—A Review.* Sustainability, 14(23), 15884.

Siegrist, M., & Hartmann, C. (2020). *Consumer acceptance of novel food technologies. Nature Food*, 1(6), 343-350.

Singh, A., & Verma, P. (2017). *Factors influencing Indian consumers' actual buying behaviour towards organic food products. Journal of Cleaner Production,* 167, 473-483.

Spence, A., & Townsend, E. (2006). *Examining consumer behavior toward genetically modified (GM) food in Britain. Risk Analysis*, 26(3), 657-670.

Steenis, N. D., & Fischer, A. R. (2016). *Consumer attitudes towards nanotechnology in food products: an attribute-based analysis.* British Food Journal, 118(5).

Van Kleef, E., Van Trijp, H. C., & Luning, P. (2005). *Consumer research in the early stages of new product development: a critical review of methods and techniques.* Food Quality and Preference, 16(3), 181-201.

Vandermoere, F., Blanchemanche, S., Bieberstein, A., Marette, S., & Roosen, J. (2011). *The public understanding of nanotechnology in the food domain: the hidden role of*

*views on science, technology, and natur*e. Public Understanding of Science, 20(2), 195-206.
Visschers, V. H., Wiedemann, P. M., Gutscher, H., Kurzenhäuser, S., Seidl, R., Jardine, C. G., & Timmermans, D. R. (2012). *Affect-inducing risk communication: current knowledge and future directions.* Journal of Risk Research, 15(3), 257-271.
Weiss, J., Takhistov, P., & McClements, D. J. (2006). *Functional materials in food nanotechnology*. Journal of Food Science, 71(9), R107-R116.
Wilkinson, S. B., Rowe, G., & Lambert, N. (2004). *The risks of eating and drinking: Consumer perceptions and 'reality'*. EMBO reports, 5(S1), S27-S31.
Wu, F. (2006). *Mycotoxin reduction in Bt corn: potential economic, health, and regulatory impacts.* Transgenic Research, 15, 277-289.
Wu, F., Groopman, J. D., & Pestka, J. J. (2014). *Public health impacts of foodborne mycotoxins.* Annual Review of Food Science and Technology, 5, 351-372.

AUTHOR BIOGRAPHIES

Ahmed Thaufiq Lee is a graduate of Bachelor of Science (Hons.) Culinary Art Management, Faculty of Hotel and Tourism Management, Universiti Teknologi MARA, Pulau Pinang, Malaysia.

Hashim Fadzil Ariffin is a Professor and has been a member of the Faculty of Hotel and Tourism Management, Universiti Teknologi MARA since 1995. Currently he is the Head of Study Centre at the faculty.

Irina Mohd Akhir possesses a Master's degree in Hospitality Management (Hotel Management) from Universiti Teknologi MARA (UiTM), Malaysia. She currently holds the position of senior lecturer in the Faculty of Hotel and Tourism Management at UiTM Pulau Pinang, Malaysia. She holds one UiTM Patent, the Housekeeping Trolley and has experiences in supervising final year graduates.

Mazarina Devi is a lecturer in the Department of Food and Fashion Education, Faculty of Engineering, Universitas Negeri Malang, Indonesia. Her research interests are food innovation, functional food and nutrition.