RESEARCH IN MANAGEMENT OF TECHNOLOGY AND BUSINESS
e-ISSN: 2773-5044

RMTB

Vol. 6 No. 2 (2025) 571-582
https://publisher.uthm.edu.my/periodicals/index.php/rmtb

Malaysian Consumer Awareness on 3D Printed Food

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DOI: https://doi.org/10.30880/rmtb.2025.06.02.045

Article Info

Received: 30 September 2025
Accepted: 01 November 2025
Available online: 01 December 2025

Keywords

3D printing, 3D printed food, awareness, Malaysian consumer, diffusion of innovation, technology acceptance model

Abstract

3D printing is important for achieving the goals of Industry 4.0. Malaysia has not yet adopted 3D food printing technology due to concerns about security, safety, and halal issues. Additionally, there is a lack of research on the awareness of 3D-printed food among Malaysian consumers. The research aims to measure the awareness level of 3D-printed food among Malaysian consumers and explore the connection between perceived benefits, knowledge of 3D-printed food, willingness to consume, and attitude towards 3D-printed food awareness in Malaysia. The scope of this study involves the analysis of awareness-level data using the Technology Acceptance Model and Diffusion of Innovation as independent variables and through a questionnaire. In this study, a quantitative approach was used to collect data via surveys, with the subsequent data analysis carried out using IBM SPSS software, and a total of 85 respondents participated in this research. Results show an average level of awareness of 3D-printed food among Malaysian consumers, with a mean score of 3.22. Results of the hypothesis testing revealed that the higher the perceived benefits, the better the awareness of 3D food printing, and the higher the knowledge of 3D-printed food, the better the awareness of 3D food printing; these hypotheses were accepted. However, the hypotheses that the higher the willingness to consume, the better the awareness of 3D food printing, and the higher the attitude, the better the awareness of 3D food printing were rejected. This research helps to understand consumers and assists the food industry and government in understanding Malaysian consumer acceptance levels for further enhancement.

1. Introduction

Due to the increase in technology usage globally, many countries are entering Industry 4.0, which requires high-level skills and significant funding to achieve its goals and objectives (Bai *et al.*, 2020). 3D printing plays an important role in simplifying work and processes and is currently one of the emerging technologies in Industry 4.0. This technology transforms a design or idea, even with complex structures, into a physical 3D object, also known as a 3D-printed product (Amelia, 2021). 3D printing has a wide range of applications; it can be applied in the automotive and aerospace industries due to its capability to print tough and strong materials. It utilizes materials with high tensile and flexural strength, making it suitable for products requiring protective components with high endurance, such as antenna covers (Lee *et al.*, 2017). In the medical field, 3D printing is used to produce biomaterials, with reports showing that a tissue-organ printer has been developed that can create human-scale tissue with good mechanical stability (Kang *et al.*, 2016).

3D printing in food industry brings the benefits of making custom food properties and design, texture possible. 3D printed food makes unique personalized nutrients for every consumer on their own need and

demands. Culinary professional can create food designs and share among themselves, printing food according to own preference, consumer at home also be able to download and fabricate own food based on the design either sold on online by professionals or learning from getting from other sources (Nachal *et al.*, 2019).

In Malaysia, 3D food printing technology is still relatively new and yet to be fully. This is due to lack of exposure to knowledge about the initiative to use cutting-edge technology to transform the manufacturing sector, particularly production and operation, hinders Malaysia's progress towards 3D food printing (Lee & Zaidi, 2024). However, it is projected that this kind of technology will advance and rank among the nation's most significant inventions. The demand for food that is specific to meet specific dietary needs, such as patients, athletes, pregnant women, and children, who all require different amounts of nutrients is increasing at the moment. This can be achieved by using fewer, healthier ingredients in food while also enhancing its nutritious content (Manaf & Yusof, 2021).

3D printing technology on food industry in Malaysia are yet to be adapted. Malaysian are not aware of 3D printing technology in food industry as well as low experience to 3D printed food. Market in food industry have yet to offer 3D printed food product to every Malaysian end consumer, however its more favor in other industry such as medical and engineering. Consumers are willing to consume and try 3D printed food product, mainly because of consumers are able to create their own preference food properties designs. Consumers that are not willing to try 3D printed food product is because of neophobia towards product produced by the new food technology (Ng *et al.*, 2022).

Past research have been made on identifying the challenges of applying 3D printing technology into Malaysia manufacturing firm. Mainly due to the issue of time consumption activity, lack of expertise, extrusion mould control and materials, lack of standardization, high cost, large scale production, halal issue, and finally intellectual property (Lee & Zaidi, 2024). Another research survey has been made on focusing awareness and attitudes of Malaysian towards 3D printing technology limited in only Klang Valley, in this research has shown Malaysian have a low awareness level, lack of knowledge on technology and also less experience with 3D printing technology this is due to 3D printing is not as common as in medical or engineering field (Ng *et al.*, 2022). Few studies have been made based on the awareness of Malaysian consumers on 3D printed food with the latest on 2 years ago, due to the fast evolving of this technology researcher are having difficulty or unable to pinpoint the awareness level of Malaysia preventing further investment and development in 3D printing technology in food industry. In this research, awareness of Malaysian consumers on 3D printed food has been studied stated out the main advantage on what consumer accept on 3D printed food, government and industry especially from food sector are able to increase their awareness and focusing on improving and adopting to 3D food printing technology for further improvement. It can also increase Malaysian consumers on gaining the knowledge on 3D food printing of what it is capable of.

By researching past researcher as the behavior and intention of Malaysian consumer can be measured on whether it is more likely for 3D printed food awareness and the likeliness of Malaysian consumer on using the 3D food printing. In research by (Chatzoglou & Michailidou, 2019) have applied TAM method creating a set of constructs that include attitude, perceived risk, perceived usefulness and use of 3D printing. (Brunner *et al.*, 2018) showed positive feedback of having benefit perception on 3D food printing as it is convenient and fun to use for a quick meal preparation. Based on (Ng *et al.*, 2022), willingness to consume have become a key contributing on whether consumer accept 3D food printing in the research shown a highest positive review as it is excited for consumer to create their own preference food and having new food experience. In this study, perceived benefits, knowledge on 3D printed food, attitude, and willingness were selected as independent variables. Hence, this study aims to measure the level of Malaysian consumer awareness on 3D printed food and investigate the relationship of perceived benefit, knowledge on 3D printed food, attitude and willingness to consume toward Malaysian consumer awareness on 3D printed food.

2. Literature Review

2.1 3D Food Printing Technology

Using a 3D computer-aided design (CAD) system, a 3D model is created according to the fundamentals of 3D food printing. The created model file is then loaded into slicing software before printing. However, not every 3D printing method is appropriate for food fabrication. The wide variations in the physio-chemical properties of food make it challenging to incorporate into 3D printing technology (Godoi *et al.*, 2016). The four primary categories of 3D printing technologies applied in the food fabrication industry are liquid binding, extrusion method, hot air sintering, and selective laser sintering. Each of these methods, as discussed in the following sections, requires a specific type of material, such as a paste or powder (Mantihal *et al.*, 2020).

2.2 Awareness of 3D Food Printing

The foundation of both awareness models and assessment structures is the definition of acceptance. It is also essential to remain mindful that user needs must be prioritised over the level of innovation in order to increase usage and acceptance of new technologies and systems (Adell *et al.*, 2014). Although awareness is acknowledged to be important, neither its definition nor its measurement is entirely clear. Within this rapidly advancing field, little study has been conducted in relation to acceptance theory. Many studies claim they can assess acceptance, whereas only a few are clear about what it actually is (Regan *et al.*, 2002). Definitions are sometimes vaguely stated and, when compared, often contradict one another. The terms of acceptance sometimes overlap or even conflict (Busse & Siebert, 2018).

To summarize, in most previous studies, researchers applied the Technology Acceptance Model (TAM) to determine consumer acceptance levels using variables such as perceived risk and perceived usefulness. Other researchers have also chosen the diffusion of innovation (DOI) approach to gather variables related to respondents' adoption of a technology. The attitude variable has likewise been widely used by researchers as an independent variable to capture consumers' views on 3D food printing technology.

2.3 Technology Acceptance Model

After more than 25 years since its introduction by Fred Davis in 1986, the Technology Acceptance Model (TAM) has gained significant traction as the leading framework for analysing various factors influencing individual adoption of new technologies. Perceived usefulness and perceived ease of use are the two core variables introduced by TAM, which are assumed to play a mediating role in the complex relationship between potential system usage and external variables or system characteristics. Derived from psychology-based theories such as the Theory of Planned Behavior (TPB) and the Theory of Reasoned Action (TRA), TAM has become a key tool for understanding user behaviour when interacting with technology. A comprehensive and systematic study in this field cannot be achieved without a clear understanding of the model's origins, development, modifications, and limitations (Marangunić & Granić, 2015).

2.4 Diffusion of Innovation

The perceived qualities of technology and the creativity of the organisations implementing them have been the primary focus of the Diffusion of Innovation (DOI) theory. According to Rogers (2004), individuals' perceptions of these traits predict the rate of innovation adoption. He identifies five characteristics of an innovation that affect its adoption: its relative advantage compared with current technologies, its compatibility with the organisation's workflow and skills, the challenges associated with its application, the ability to trial the innovation, and the observability of its development both within the organisation and among competitors.

2.5 Perceived Benefits

The range to which an individual believes that utilising a specific system is able to upgrade their work performance" become the definition of perceived benefits used here. This is implied by the definition of useful, which is "being capable of being utilised advantageously." Through an organisational setting, extra pay, promoting, salary raise, and other rewards are usually given to employees as a recognition of individual own hard work. Conversely, a system that have a high perceived benefits is one in which an individual feels that there is a favourable use-performance relationship (Davis, 1986). When a system is perceived as useful, it should be implemented with excellence in order to accomplish the task. Even though a technology function is simple to use, a user may reject it if they believe it to be inefficient. Thus, in this context of study, the extent of perspective of the user believes that utilising 3D food printing will give the result that what benefits can be gained to explain perceived benefits.

2.6 Willingness to Consume

Among the most common concepts in ideas of human preference is that of risk (Bauer, 1960). Originally, perceived risk was described as having two dimensions: variability and bad results. What consumers think of the unpredictable factors and not favourable effects of making a purchase is known as perceived risk. Since consumers are aware of the risk, it is perceived rather than generally actual (Pathak & Pathak, 2017). According to (Lim, 2003) the greater the perceived risk, the lower the probability of their purchase. Due to the fact that "consumers tend to be more often driven to prevent errors instead of to get the most value in purchasing," perceived risk is a powerful tool for explaining consumer behaviour (Mitchell, 1999).

2.7 Knowledge on 3D Printed Food

Since the initial assumptions have been developed using only logical reasoning and a Cartesian understanding of human nature, knowledge definition is difficult (Bolisani & Bratianu, 2018). Consumers knew very little regarding 3D food printing. The survey participants' lack of knowledge about 3D printing technologies and 3D printed foods could be a reason that causes this (Manstan & McSweeney, 2020). Consumers tend to avoid food when they are unfamiliar with it (Tan *et al.*, 2015).

2.8 Attitude

Global and relentless predispositions, whether or not favourable or negative, regarding a stimulus as well as class of stimuli are referred to as "attitudes" (Wittenbrink & Schwarz, 2007). An individual's attitude is defined as their viewpoint, evaluation of an individual or thing, and ability to react either positively or negatively to a particular idea, object, person, or circumstance. It usually falls into three categories: cognitive (perceptions and beliefs), personality (actions along with mentioned intent towards something based on both "cognitive" alongside its "affective" responses). Another dimension is feelings, which include both likes and dislikes as well as feelings and evoked emotions (Vargas *et al.*, 2016).

2.9 Hypothesis Development and Research Framework

In a previous result from (Groot, 2018), the result indicated that a customer's opinion of a 3D food printer's utility is influenced by how natural they believe the food it produces to be. Put simply, when a printer can create natural food items, people view it as being more useful. The consumer's willingness to utilise the food printer is influenced by their perception of its benefits. Thus, the greater an individual's perception of a food printer's utility, the more probable it is that they will have a favourable opinion of it. As a result, there is a greater likelihood of buying a food printer.

H1: The higher the perceived benefits the higher the awareness of 3D food printing.

According to (Siddiqui *et al.*, 2022), consumer are more to be aware and take important of food that might cause risk to health problem especially new food. Furthermore, according to (Bearth & Siegrist, 2016), consumer will most likely reject food that are made from novel technologies 3D printed food, if not more benefits are seen or perceived compared to conventional food. Consumers will more likely to look for the benefits of the food that it can offer from the health and societal perspective before consumption (Seo & Shigi, 2024).

H2: The higher the willingness to consume the higher the awareness of 3D food printing

According to (Tan *et al.*, 2015) consumer tend to avoid food or product that are new to them, this is because of consumer usually stick to their original preference and reject to test on something new considering the risk and potential harm from new product because not knowing the content and harm of the product. According to (Manstan & McSweeney, 2020), it has stated that consumer that have minimum or no knowledge on 3D printed food will cause consumers to avoid in either trying or getting to know more about 3D printed food.

H3: The higher the knowledge on 3D printed food the higher the awareness of 3D food printing

In a previous study although attitudes on 3D-printed food were not initially shared by all respondents, they were generally quite unfavourable. The emphasis on the benefits of the end-user and demonstration of multiple applications of the technology that existed currently in the food processing industry during the survey had an obvious and positive impact relating to the opinions for the surveyed population, however their overall attitudes remained varied and unfavourable (Brunner *et al.*, 2018).

H4: The higher the attitude the higher the awareness of 3D food printing

2.10 Research Framework

Fig. 1 shows research framework as perceived usefulness, perceived risk and attitude as independent variable for measuring for dependent variable Malaysian consumer acceptance on 3D printed food.

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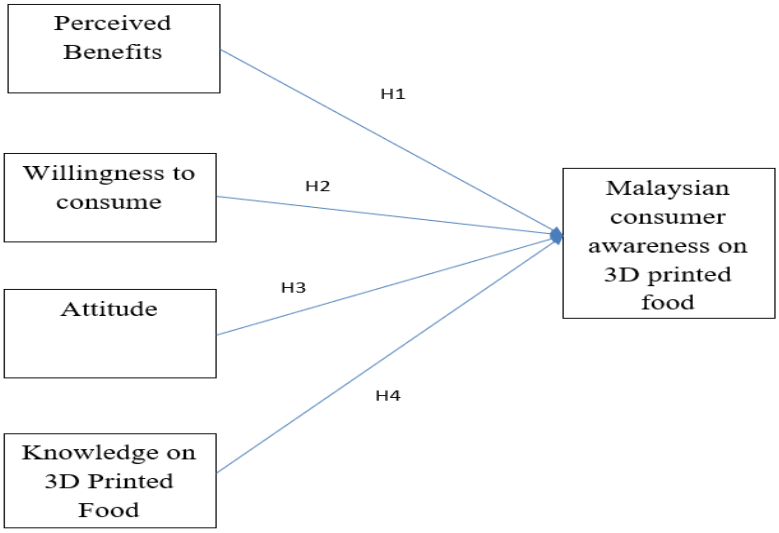

Fig. 1 *Research Framework*

3. Research Methodology

3.1 Research Design

Quantitative approach was selected in this study because of data result collected can be quantify, therefore easy to interpret and analysing. Quantitative data is more scientific, objective focus, and acceptable. Moreover, this research involves a large sample size and measuring acceptance on Malaysian consumer. Therefore, quantitative approach is more as it is more efficient and effective. This study employs a cross-sectional questioning method in which all participants receive a single question along with do not get the chance to provide additional information. an additional query or a second survey from the exact same participants. A cross-sectional study allows researchers to collect data from a large number of participants at the same time (Thomas, 2023).

3.2 Questionnaire Development

The questionnaire consists of six sections, in the first section A discuss on identifying respondent's demographic, included gender, race, age range, education level as well as awareness of 3D food printing. Section B focus on Perceived risk, gathering data on respondents according to 3D printing food technology whether it pose as a threat or risk to consumer health. In the second section, C section primarily obtains data of perceived benefits, either respondents think 3D food printing are benefits or otherwise. Next, for section D shows the knowledge on 3D printed food. Next section E identifying either attitude of Malaysian consumer will affect the acceptance on 3D food printing. Section F shows the willingness of consumer to try the 3D printed food either they are able to accept trying new product. Section G is dependent variable, consumer acceptance on 3D food printing by Malaysian consumer based on individual opinion.

Table 1 *Questionnaire of this study*

Section	Variables	Source
A - Demographic	Gender Race Age Education Level	
B - Perceived Benefits	- I think 3D printed food makes producing food easier and more convenient - In my opinion, 3D printed food meets the dietary needs of people with health issues - In my opinion, 3D printed food fulfilled personalised nutritional needs - In my opinion, 3D printed foods are environmentally	(Brunner *et al.*, 2018), (Manstan & McSweeney, 2020)
C - Knowledge on 3D printed food	- I believe that 3D-printed food is safe. - I think that 3D printers bring convenience to people's lives - I think 3D printers are a socially desirable technology.	(Chang *et al.*, 2024), (Seo & Shigi, 2024)

	- I think that 3D printed food products will contribute to the development of the food industry.	
D - Attitude	- Using 3D printers is a good idea - I am interested in cultured meat. - I am interested in 3D printed food - In my opinion it is better to be using 3D printers	(Chatzoglou & Michailidou, 2019),(Seo & Shigi, 2024)
E - Willingness to consumer	- I think it is safe to consume - I think it is beneficial to health - I think it is a fun experience - I think it is not disgusting	(Ng *et al.*, 2022)
F - Malaysian awareness towards 3D printed	- I have heard of 3D food printing - I understand how a 3D printer works - I have dealt with 3D food printing before	(Ng *et al.*, 2022)

3.3 Sources of Data

In this research, primary data and secondary data have been used by researcher in obtaining relevant data according from sources via questionnaire Google form for primary data. Secondly sources from journals, article, thesis, etc have been used for obtaining secondary data.

3.4 Data Collection Technique

The researcher has used a questionnaire question to distribute to the intended population of Malaysian consumers. Malaysian consumers' perceived risk, perceived usefulness, and attitudes are the targeted population of the survey connections on the degree of consumer acceptance of drone-delivered parcels in Malaysia. Google form have been selected by researcher for collecting data is because of time efficiency, improves accuracy, and cost efficiency as transportation, paper printing cost have been reduced by using Google form (Olio *et al.*, 2018). Google form have been selected by researcher for collecting data is because of time efficiency, improves accuracy, and cost efficiency as transportation, paper printing cost have been reduced by using Google form (Olio *et al.*, 2018).

3.5 Population and Sampling

Targeted population in this research is the Malaysia consumer that have awareness and knowledge on 3D printing technology. Krejcie & Morgan method have been used in determining total sample size to be taken for research. Researcher have calculated and taken a total of 384 sample size from the number population of 33.4 million Malaysian. In this research, researcher have selected simple random sampling technique as sampling technique as it is easy to implement, result yield from simple random sampling technique has the same probability rate to all respondents to be selected.

3.6 Pilot Test

Number of respondents for pilot test have various of type to calculate and according to (Nieswiadomy, 2002), a number of 10 respondents is sufficient for taking as pilot test, however other researcher (Lackey & Wingate, 1986) considers that 10% of total respondents to true questionnaire respondents' number is recommended. However, the final choice to be determined by the population's size as well as variation, and also by time and financial constraints. Therefore, researcher have selected 30 respondents as the sample size for completing pilot test.

Table 2 *Reliability statistics*

Variables	Cronbach's Alpha	N of items
Perceived Benefits	0.850	4
Knowledge on 3D printed food	0.780	4
Attitude	0.892	4
Willingness to consume	0.871	4
Awareness towards 3D printed food	0.870	3

As shown at Table 2 shows that Cronbach's alpha coefficient value that are more than 0.90 has an excellent reliability level, while 0.80-0.89 have a good reliability level, 0.70-0.79 is acceptable level, 0.60-0.69 is questionable level, 0.50-0.59 is poor level and finally value that are less than 0.59 is unacceptable. Overall Cronbach's alpha coefficient value of this pilot test is higher than 0.90, shows that the reliability level is

excellent, therefore no changes is needed. Perceived benefits that have 4 items have 0.850 value of Cronbach's alpha, knowledge on 3D printed food have 4 items and have 0.780 value of Cronbach's alpha, attitude have 0.892 Cronbach's alpha value of 0.892 and have 4 items. Finally, willingness to consume and an awareness towards 3D printed food have 3 items and Cronbach's alpha of 0.871 and 0.870 respectively.

3.7 Data Analysis Technique

In this research, IBM SPSS Statistic 27.0 software has been used to examine and analyse data collected from questionnaires survey form. Reliability analysis test is mainly to test and measure for the relevant and reliability of data collected, the characteristics of a specific individual as well as independent sample that are tested through descriptive statistics. Normality test have been utilised in checking either questionnaire have been equally distributed to respondents, enable identifying the relevant connection between independent variable with dependent variable.

4. Results and Discussion

4.1 Response Rate

Researcher has targeted a total of 384 respondents from the sample size of over 34.31million, however researcher have succeeded in getting only 85 response only with a total of 22.4% response rate from (85/384 x100% = 22.4%). 85 of respondents were used for calculation in SPSS software therefore, a completion rate of 100% have been taken.

4.2 Data Cleaning

The dataset may contain errors or undesirable data for some sort of reasons. Therefore, the first step in making sure the data is right and relevant are data cleaning. Eliminating anomalies, substituting missing data, deleting not needed data, and deleting or correcting inaccurate data are all options in this process. There are no missing number for this research.

4.3 Demographic Information

Table 3 shows a total of 85 respondents that have done the questionnaire through the online survey. 21 of respondents out of the total of 85 are female which is 24.71% of the total respondents, and 64 of the respondents are males which are 75.29%. There is a total of 73 Chinese from the total number of 85 respondents which is 85.9% the majority of race in this research, a total of 2 Indian which is 2.4% the lowest in this research, 4 Malay which is 4.7% and finally 6 Other which is 7.1%. There are 0 respondents, which are 45-54, 55-64 and 65 ages and above.

Table 3 *Demographic data table*

Category	Items	Frequency	Percent
Gender	Female	21	24.7
	Male	64	75.3
Race	Chinese	73	85.9
	Indian	2	2.4
	Malay	4	4.7
	Other	6	7.1
Age	18-24	76	89.4
	25-34	8	9.4
	35-44	1	1.2
Education level	Bachelor's	64	75.3
	Diploma	9	10.6
	Master's	2	2.4
	SPM/STPM	10	11.8
Have u heard of 3D printing food?	No	22	25.9
	Yes	63	74.1

There is a total of 76 respondents which is in the range of 18-24 age which is 89.4% and 8 respondents in between 25-34 range of age which is 9.4% and only 1 respondent is in 35-44 range of age which is 1.2%. In this research, majority of respondents are made up from the age group of 18-24 years old. A total of 64 respondents from the 85 are bachelor's level of study which is 75.3%, then 9 respondents are Diploma level which is 10.6%, 2 respondents are Master's education level which is 2.4% and finally 10 respondents are SPM and STPM level which is 11.8%. the item "I have awareness of 3D food printing" that have to be answered by respondents. Respondents are able to select "yes" or "no" as answer in order to further understanding whether respondents have experience with 3D printing food. Table 4.4 shows that a total of 22 respondents out of 85 have not heard of 3D printing food while 63 respondents have heard of 3D printing food before.

4.4 Awareness towards 3D Printed Food

As shown in Table 4 the average mean of these 3 items is from 3.16 to 3.31 which is considered as average mean. Among of the 3 items, "I understand how a 3D printer works has the highest mean number which is 3.31 while "I have dealt with 3D food printing before". Therefore, standard deviation for 3 items differs between 1.153 to 1.080, it means data collected is distributed around the mean. Average number of means shows that the awareness of Malaysian towards 3D printed food is only on average level. The overall mean for Malaysian level of awareness towards 3D printed food is 3.22 while the standard deviation is 0.89.

Table 4 *Statistics of Malaysian Awareness towards 3D Printed Food*

Variables	Mean	Standard Deviation
I have heard of 3D food printing	3.18	1.082
I understand how a 3D printed works	3.31	1.080
I have dealt with 3D food printing before	3.16	1.153
Overall	3.22	0.89

First objective of this research is to measure the level of Malaysian consumer awareness on 3D printed food. As shown on above, the level of item has shown an average outcome for all of the 3 items "I have heard of 3D printing food", "I understand how a 3D printer work", "I have dealt with 3D food printing before". This have shown that Malaysian consumer has only an average level of awareness to the existence or understanding what is 3D printed food. Kolmogorov-Smirnov test for all 3 items have shown the result of less than 0.05 which is P<.001 have shown that it is significant.

According to Ng *et al.* (2022) due to the lack of knowledge of Malaysian consumer about 3D food printing, the respondents initially had a neutral opinion of the technology. This results from inexperience and lack of familiarity with the technology. It takes a full understanding of potential customers to develop belief in new technologies like 3D food printing compared to this paper research, as most of the respondent is male and age between 18-24 and have education of Bachelor's level having higher education and more exposed to current technology, therefore majority of respondent have heard of 3D printing and aware of its existence. Even though more people have become aware of this technology, many respondents had never heard of or encountered 3D food printing. Respondents had a few worries about 3D food printing, especially related to the technology's potential health benefits, the high cost of 3D-printed food, or the possibility of decline in employment as a result of its adoption in the food industry. The majority of research participants thought printed meals were highly processed (Tesikova *et al.*, 2022)

4.5 Normality Test

Result have shown the normality test for this research, which have the result from both Kolmogorov-Smirnov and Shapiro-Wilk. However, for this research paper, Kolmogorov-Smirnov have been selected as it is more suitable for sample size that are more than 50 respondents, which in this research have a total of 85 valid respondents. Significant level of dependant variable is less than 0.001 which means the data is significant, thus data is not normally distributed. Acceptance normality test has shown significant value of (P= 0.001, P<.005). Therefore, the data is not normally distributed.

4.6 Correlation Analysis

As shown in Table 5 the correlation of perceived benefits towards Malaysian awareness towards 3D printed food. Correlation of perceived benefits towards Malaysian awareness towards 3D printed food of negligible correlation, which is 0.217 correlation coefficient. Significant shown the level of 0.046, which is less than 0.05 Thus, hypothesis of higher perceived benefits, higher Malaysian awareness towards 3D printed food is to be accepted. Research shows the correlation between willingness to consume towards Malaysian awareness towards 3D printed food. Correlation of knowledge on 3D printed food towards Malaysian awareness towards

3D printed food of negligible correlation, which is 0.113 correlation coefficient. Significant shown the level of 0.302, which is more than 0.05 Thus, hypothesis of higher willingness to consume, higher Malaysian awareness towards 3D printed food is rejected.

Table 5 Correlation analysis

Variables	Correlation Coefficient	Sig. (2-tailed)	N
Perceived benefits	.217*	.046	85
Willingness to consume	.113	.302	85
Knowledge on 3D printed food	.262*	.015	85
Attitude	.149	.175	85

Research shows the correlation between knowledge on 3D printed food towards Malaysian awareness towards 3D printed food. Correlation of knowledge on 3D printed food towards Malaysian awareness towards 3D printed food of negligible correlation, which is 0.262 correlation coefficient. Significant shown the level of 0.015, which is less than 0.05 Thus, hypothesis of higher knowledge on 3D printed food, higher Malaysian awareness towards 3D printed food is to be accepted. Research shows the correlation between Attitude towards Malaysian awareness towards 3D printed food. Correlation of knowledge on 3D printed food towards Malaysian awareness towards 3D printed food of negligible correlation, which is 0.149 correlation coefficient. Significant shown the level of 0.175, which is more than 0.05 Thus, hypothesis of higher attitude, higher Malaysian awareness towards 3D printed food is rejected.

Second objective is to investigate the relationship between independent variable and dependent variable. The independent variable of this thesis is perceived benefit, knowledge on 3D printed food, attitude and willingness to consume, while the dependent variable of this thesis is Malaysian consumer awareness on 3D printed food. From the result of the survey, researcher have the result of overall mean between the average level which is 3.32 using 5-Likert scale. Due to their lack of knowledge about 3D food printing, the respondents initially had a neutral opinion of the technology. This results from the absence of ignorance and lack of experience with technology.

From the first independent variable relationship to dependent variable which is perceived benefits (H1b; r = 0.217) which shown that have negligible correlation with the dependant variable, Malaysian consumer awareness on 3D printed food. While comparing to research by (Brunner *et al.*, 2018) shows that perceived benefits have relevant in the promotion of technology also known as the early adopters, this is because of the information included in the questionnaire had been successful in persuading participants who were convenience-and nutrition-conscious of the technology's benefits and in highlighting potential benefits that 3D printers could offer them. Thus, hypothesis is accepted and shows high relationship level.

As for second independent variable, knowledge on 3D printed food relationship with dependent variable has a negligible correlation with 0.113 correlation coefficient. Moreover, significance level has the result of 0.302 which is more than 0.05 compared to (Brunner *et al.*, 2018) paper have the result of 0.008 in term of significance level with -0.17 correlation coefficient therefore hypothesis of Brunner et al (2018) is accepted, this could be due to the difference of population taken as paper from Brunner et al (2018) is taken from German-speaking resident from Switzerland while result from this paper is aimed at Malaysian consumer. Therefore, hypothesis for this research is rejected showing that have low relationship level.

Third independent variable, attitude have also the negligible relationship on 0.262 value. While having 0.015 significance level which is less than 0.05. Hypothesis is then accepted showing high relationship level between independent variable and dependent variable as compared to previous study which have positive correlation with significant level of 0.001 with the correlation coefficient of 0.740 and hypothesis is also accepted for (Chang *et al.*, 2024a) research paper this is because of eco-friendly actions are accompanied by environmental concerns attitude of consumer are.

As for the fourth independent variable willingness to consume variable have the correlation coefficient level of 0.149, therefore negligible relationship result. Significance level of 0.175 which is more than 0.05, therefore showing low relationship level, thus hypothesis have been rejected comparing to research from (Brunner *et al.*, 2018) for having also negligible correlation with the value of 0.22 with significant level of 0.002 and the hypothesis of this item have been accepted as strong determinants for its section, therefore hypothesis is accepted in (Brunner *et al.*, 2018) research. However, this similarity of negligible relationship could be related to same education level in both of research as both majority respondents are obtained from above bachelor's level

5. Conclusion

This research has successfully achieved the 2 objectives and 4 of the hypotheses created. From the result of 2 objective which is to measure the level of Malaysian consumer awareness on 3D printed food and the second objective investigate the relationship between the independent variable and dependent variable. The

independent variable of this thesis is perceived benefit, knowledge on 3D printed food, attitude and willingness to consume, while the dependent variable of this thesis is Malaysian consumer awareness on 3D printed food have obtained the result of only 2 hypotheses which are the higher the perceived benefits, the better the awareness of 3D food printing and the higher the knowledge on 3D printed food, the better the awareness of 3D food printing are to be accepted and prove significant result. It should, overall, focus on improving the target market's view of the advantages of 3D food printing, raising their willingness to try food that is printed in 3D, and providing consumers with sufficient trust to set aside their feelings of fear and lack of experience with technology. As a result, the knowledge could convince customers to adopt 3D food printing.

The first limitation of this study was the sample size of the thesis by taking a sample size of 384 respondent as the target. However, this still does not prove the majority of Malaysian consumer answer and awareness towards the title awareness of Malaysian consumer on 3D printed food, thus the result obtained is not fully represented by the Malaysian consumer as whole. Moreover, respondent obtained is 85 respondent (22.4%) from the targeted 384 sample size. Moving on to the next limitation, survey is done through online questionnaire. This has formed the problem of not having the full attention of respondent in answering the survey form, therefore result obtained might not be necessarily the most accurate answer from respondent. Additionally, questionnaire sent to respondent or sample size might often be ignored or rejected to complete the questionnaire, forming problem of having longer or unnecessary time to complete the survey. Result taken from online questionnaire is not the most accurate and best method to calculate or interpret the result and form a conclusion from it. Finally, having not sufficient reference from the past research paper has led to the challenges in obtaining relevant or related information and details for researching and referencing purposes. Information from past researcher have the issue of either being out of date or details from research paper might not necessarily be what researcher desired.

Recommendation for further research is by using other independent variable for possible relevant variables that might affect the awareness of consumer on 3D printed food. Researching for possibility for consumer in order to try and accept 3D printed food especially in residential area that are having higher potential and possibility in accepting and adopting 3D printed food technology, minimizing possible drawbacks from this action. Additionally, another method could be adopted in order to obtain more precise and accurate answer from respondent. Plus, results from other method could result in getting higher quality answer and necessary data for research purpose. Furthermore, acceptance of Malaysian towards 3D printed food can be made in the future for confirming the possible potential of 3D printed food in Malaysia, providing data for either government or industrial in investing for 3D printed food, it also increases awareness and acceptance of Malaysian towards 3D printed food improving the technology and advancement of Malaysia.

Acknowledgement

Communication of this research is made possible through assistance by Faculty of Technology Management and Business, Universiti Tun Hussein Onn Malaysia,

Conflict of Interest

Authors declare that there is no conflict of interests regarding the publication of the paper.

Author Contribution

The authors confirm contribution to the paper as follows: ***study conception and design:*** *Lee Kah Weng, Lee Te Chuan;* ***data collection:*** *Lee Kah Weng;* ***analysis and interpretation of results: :*** *Lee Kah Weng, Lee Te Chuan* ***draft manuscript preparation:*** *Lee Kah Weng, Lee Te Chuan. All authors reviewed the results and approved the final version of the manuscript.*

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