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Consumers' Awareness and Knowledge of Nanofood in Malaysia

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ABSTRACT

The integration of engineered nanomaterials (ENMs) in the food and agriculture industry is now common and rampant among giant food manufacturers to enhance the quality, functionality, and physicality of food products. However, consumers have not been consulted and informed on the use of ENMs in food despite various potential safety and health risks associated with oral exposure of ENMs illustrated from scientific studies. In the European Union, the food law was amended to include provisions on nanotechnology after conducting a public consultation to explore public awareness and perception of nanotechnology. In the absence of a specific regulatory framework for nanofood in Malaysia, this study aims to analyse consumers' awareness and knowledge of nanofood. The result from the study serves as an invaluable input to the regulatory authority in framing any regulatory reform to regulate nanofood. A survey was conducted using a closed-ended questionnaire distributed online. The result indicates that the awareness and understanding of nanofood are still lacking and not satisfactory.

Keywords: nanofood and nanotechnology, nanofood labelling, public understanding and knowledge

INTRODUCTION

Nanotechnology is a molecular technology implemented at the nanoscale with a size range between 1 to 10 nanometres. A nanometre is one-billionth of a meter, and for comparison, the diameter of human hair is approximately between 80,000- 100,000 nanometres (National Nanotechnology Initiative, n.d). The existence of materials and particles in nanometre size is not new, as humans have been using nanoparticles dates back to the time of the ancient Greeks around the 5th century B.C. in the glass and poetry manufacturing industry (Bayda *et al.*, 2020). In the 21st century, nanotechnology is one of the most promising technologies. The size and shape of nanometre materials with smaller dimensions, higher surface areas, and high reactivities offer novel applications with solid commercial exploitations in various industries, which could not be performed by conventional bulk materials (McClements, 2020).

Currently, nanodevices and engineered nanomaterials (ENMs) have been exploited and applied in the food and agriculture industry. The benefits of ENMs to the food and agriculture industry have been widely acknowledged either by abundant scientific studies or through practical commercial applications by giant food manufacturers such as Kraft, Heinz, Nestle, McCormick, Unilever, Mars, Mars, and Ajinomoto (Kumari & Yadav, 2014). ENMs such as titanium dioxide nanoparticles, silver nanoparticles, zinc oxide, and silica amorphous nanoparticles have been successfully utilised as food additives, preservatives, emulsion, flavouring agents, nutrition enhancement, and food packaging substances (Shafiq *et al.*, 2020). The utilisation of ENMs has enhanced the physical appearance, taste, durability, function, and quality of food products (Sahoo *et al.*, 2021). However, the volume of nanofood in the domestic market is uncertain. There are two possible contributing factors namely, the domestic food industry treated ENMs equal as materials in the conventional bulk size, and food manufacturers are not under legal obligation to label the presence of ENMs in their products.

Despite the acclaimed benefits, there are emerging concerns arising from the application of ENMs. The oral exposure of ENMs in food products has been associated with various potential safety and health risks, as demonstrated by various scientific studies, either in vivo, in vitro, or in

silico. Scientific studies indicate that the oral exposure of ENMs from food products may, among others, lead to damage to intestinal glands, which reduce the absorptive capacity (Shahare *et al.*, 2013), liver inflammation, organ toxicity, and inflammatory responses (Gaillet & Rouanet, 2015), increase gene expression, changes in tissue and structure cell (Drew & Tagen, 2016), enhance tumour formation (Urrutia-Ortega *et al*., 2016) and possible genetic damage (Dussert *et al.*, 2020). No actual cases of injury or death caused by oral exposure to ENMs have ever been reported yet. There is a scientific uncertainty on the nature and extent of safety and health risks of ENMs to human's gastrointestinal tract. Due to the uncertainty, public perception becomes more critical to the regulatory authority because the law must be aligned with public perception, opinion and avoids criticism stemming from reactive legislation or loss of trust in the government (Capon *et al*., 2015).

In the European Union, the scientific uncertainty on the safety and health risks of nanofood is regulated using a specific regulatory framework. According to the European Commission (E.C.) (2008), products derived from nanotechnology or containing nanomaterials must comply with the European Union law on product labelling. The function of labelling is to ensure consumers have better access to information on nanotechnology products in the European market and enable them to make an informed choice. The European Union law on consumers' food information, i.e., Article 18 of the Regulation (E.U.) 1169/201 required food products contain ENMs must be labelled. The E.C. had conducted an online public consultation for its Strategic Nanotechnology Action Plan 2010-2015 from December 2009 to February 2010 to invite views on the needs in nanotechnology in the European Union. The result from the consultation shows that 90 per cent of the respondents strongly support the policies that establishing inventories on nanomaterials and demand for adequate information on consumers product such as claims verification, labelling of nano-content of consumer products (European Commission, 2010). The public consultation offered European consumers the opportunity to involve in the decision-making process on regulating the risks of nanotechnology and the regulatory authority with crucial information on the current state of public understanding of nanotechnology products.

On the contrary, the food regulatory framework in Malaysia, i.e., the Food Act 1983 (Act 281) and Food Regulations 1985 is silent on nanotechnology and ENMs. Nanofood and conventional food is regulated using the same regulatory framework. Besides that, public awareness and understanding regarding the presence of nanofood are also uncertain. It is essential to examine consumers' collective awareness and knowledge of nanofood in Malaysia. The findings from this study will give insight into the possible need for regulatory reform. The public may demand legal reform as a result of collective knowledge and awareness of new technology. This paper proceeds in four sections. Following the introduction, the first section draws upon the literature review on consumers' awareness and knowledge of nanofood. The second section presents the methodology adopted by this paper, then followed by the findings of the survey. The third part is the discussion and recommendation. This paper ends with a conclusion.

LITERATURE REVIEW

According to Burri and Bellucci (2008), two crucial points must be analysed when regulating technologies that imply scientific uncertainties on safety and health risks; first, the public must know the technology. If the public is not aware or has no knowledge of the technology and risks, the regulation cannot properly work and not significant to society (Mandel, 2018). Second, the public should be allowed to participate in the deliberative discussion on technology applications. It is known as upstream engagement, where the regulatory bodies initiate a discussion or consultation to identify their understanding and perception of the technology. It is the public that will experience the benefits or endure the negative consequences of the technology. Macnagthen *et al*. (2005) contended that the discussion with the public might change the course of national policy and regulation on nanotechnology because the contour of public concern on nanotechnology R&D involves safety and health risks. For instance, the regulatory history of contentious genetically modified organisms (GMOs). The controversies on the potential safety and health risks of GMO products have led to various debates and discussions, including on the role of government regulators and the need for a regulatory framework to manage the risks (Erdam, 2018).

There are two approaches available in regulating the technological risks, namely, technological approach and socio-cultural/political approach (Choi, 2013). The first approach requires mathematical calculation in accessing the probability and consequences of technological risks. For the second approach, technological risks are accessed based on public acceptability and the perception of a layman, which is connected to public knowledge on the regulated issue. There is also concern that public involvement in framing a regulatory framework for nanotechnology could be problematic. It occurs when the perception of the public does not correspond with the findings of scientific studies, the need of the industries, and politicians (Macnaghten *et al.*, 2005). On the contrary, according to Fuchs and Gazsó (2015), the regulatory authority must recognise the social acceptability and public understanding of risk and not solely rely on science or opinions of experts, which is insufficient. Public awareness and knowledge of the disputed issues play a critical task that could not be performed or accessed using the traditional risk analysis approach. It indicates the values, experiences, fears, and preferences of the public.

Other than previously discussed public consultation on nanotechnology conducted by the European Commission, Switzerland and Germany also had conducted a public discussion and survey on nanotechnology. In 2006, the Swiss focus group on nanotechnology had formed a publifocus to facilitate a discussion with the public on emerging technologies, including nanotechnology. The objective of the study is inter alia, to discover the public reactions to nanotechnology in Switzerland. According to the TA-SWISS Centre for Technology Assessment (2006) report, the publifocus has provided valuable input on the acceptance and rejection of nanotechnology, public demand for nanotechnology product declaration, need for further information, and clarification on nanotechnology, and request for regulation on nanotechnology products, including nanofood. The participants not only concern about the non-existence of domestic law but also the international regulatory aspect. In 2008, Federal Institute for Risk Assessment in Germany had surveyed the public understanding and perception of nanotechnology. The survey indicates that the acceptance of nanotechnology for food is the lowest compared to the acceptance of nanotechnology in other products such as food packaging and cosmetic products. Participants are concern about the safety and health status of oral exposure to nanomaterials. The findings from the public perception studies provide valuable insight into the framework to regulate the risks of nanotechnology.

In Malaysia, there are four studies conducted on to identify awareness, understanding, and perception of nanotechnology. The first study by Suhaimee *et al.* (2014), evaluate the level of awareness and knowledge (including risks and benefits) about nanotechnology in Malaysia. It is found that the level of awareness regarding nanotechnology is low in Malaysia relative to the developed countries. Most participants agreed that the perceived benefits exceed the risks, and they were willing to buy nanotechnology-based products. The second study by Rahim *et al.* (2015) aims to establish nanotechnology awareness and acceptance from society. The result shows the majority (74%) of the students know the term nanotechnology but unfamiliar with the risks and benefits. The majority of the students also feel that nanotechnology has issues on their risks, such as side effects and safety.

In 2019, there were two studies conducted. The first study is by Kamarulzaman *et al.* (2019), which is to determine the effects of moderators' influence on public perception of nanotechnology in Malaysia. The result indicates that Malaysians find that nanotechnology applications are beneficial, and the public's attitude towards nanotechnology is also positive. Consequently, the public has a low-risk perception of nanotechnology. The second study is by Karim *et al.* (2019) design to understand the perception of nanotechnology among students in private higher education institutes of Malaysia. The result showed that students have heard of nanotechnology, 80% have a good impression of the technology, and more than 72% are in favour of its application in a different sector.

It is important to note that the four previous studies are on nanotechnology in general and not specifically focus on nanofood. The systematic literature search on Scopus using the search string TITLE-ABS-KEY ((nanotechnology) AND (food) AND (consumers) AND (understanding) OR (knowledge) AND (Malaysia)) only yielded one article, which is by Suhaimee *et al.* (2014), discussed in the previous paragraph. There is an article by Hasim *et. al.* (2019) on nanofood in Malaysia. However, the focus of the study is to identify factors that influence the purchase intention towards nanofood, i.e., P3 Sweetener Liquid Drop. The study concludes that elevating consumers' acceptance of P3 Sweetener can be achieved by increasing consumers' knowledge, awareness, and product benefits. Therefore, there is no completed study on awareness and

understanding of nanofood in Malaysia from the literature reviewed. This paper believes that the findings from the previous studies are insufficient to represent the awareness and understanding of nanofood.

In other countries, research has been conducted to assess public awareness, knowledge, and perception of nanofood, as shared in Table 2. The result in all studies demonstrates that respondents viewed ENMs in a food product as unpleasant, associated with risks, and raised societal concern. Besides that, respondents would pay less for oil products manufactured using nanotechnology due to the negative influence on nanotechnology attributes such as risk perception. These studies also show that consumers' perception and acceptance of nanofood are directly connected with their awareness and knowledge about nanofood. Increased knowledge of potential safety and health risks will reduce consumers' acceptance of nanofood and vice versa. Therefore, a specific study focusing on nanofood is needed to identify the extent consumers' awareness and knowledge of the existence of nanofood and its benefits and risks.

METHODOLOGY

The study is designed as a descriptive study that employs a quantitative research method involving a survey. A self-developed survey questionnaire was used as an instrument for data collection. The survey questionnaire was designed to meet the objective of the paper. The questions were formulated by the researchers based on the information obtained from several sources, including the literature review and personal experiences. A small-scale pilot study involving 20 respondents was conducted to ensure the validity and reliability of the survey instruments. The data for the pilot study was collected face-to-face among law lecturers in Pusat Asasi, Universiti Teknologi MARA. The selection of 20 respondents for pilot study is based on 10% from the targeted sample size as suggested by Treece and Treece (1977). The survey questionnaire was distributed nationwide via Google form using non-probability sampling which is convenience sampling technique. The data is collected on November 2020 until March 2021 with a total of 231 responses.

RESULT

Respondents' Demography

Table 1: Respondents' Demography

Respondent demography	Total
Age:	
17-20	138
21-25	41
26-30	6
31-35	7
36-40	11
41-45	11
46-50	10
51 and above	6
Education Qualification	
SPM	117
Degree	47
STPM/Diploma	33
Master	24
PhD	8

Table 1 reports the respondents' demography. A total of 231 responses collected from the distributed questionnaire. The majority group of respondents came from the young generation with age group between 17-20 and 21-25 years old (179 respondents). These young generations possessed the minimum education qualification of Malaysian Certificate of Education as shown in Table 1 (117 respondents), 33 respondents hold either a Malaysian Higher School Certificate or a diploma and 47 respondents were degree holders. The rest of the respondents were Master and PhD holders.

Awareness and Knowledge of Nanofood

To investigate the awareness, and knowledge of nanofood, the respondents were asked nine questions with a 5-point Likert scale used to measure their awareness and knowledge. The five points consist of five answer options:

1- Strongly Disagree
2- Disagree
3- Neutral
4- Agree
5- Strongly Agree

Since it cannot be sure that the intervals between each of these five values are the same, the data collected below are ordinal data.

Question 1: I know that one nanometer is equal to billionth of a meter

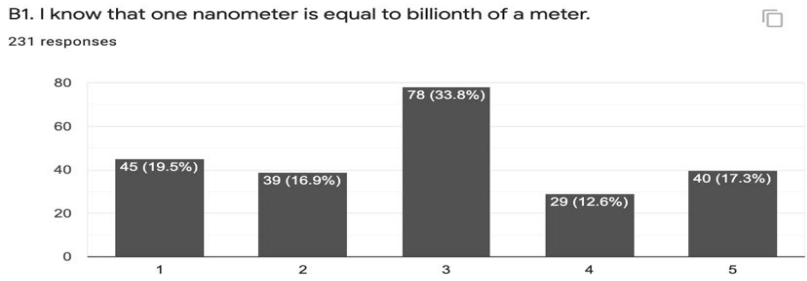

Figure 1: Size of Nanomaterials

Figure 1 depicts only 17.3% of the respondents (40) were confident that one nanometer is equal to a billionth of a meter, while 12.6% of the respondents (29) knew of this fact. The results also informed that from 231 respondents surveyed, 162 respondents (70.2%) were unknowledgeable, oblivious, and unable to decide whether they knew the said fact.

Question 2: I know nanotechnology has been integrated into the food processing industry

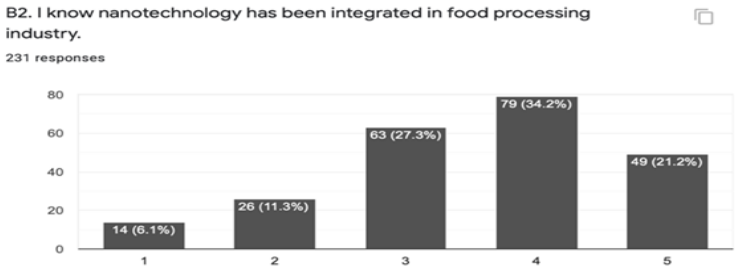

Figure 2: Nanotechnology in the Food Processing Industry

Figure 2 shows that 55.4% of the respondents knew and aware that nanotechnology has been integrated into the food processing industry, while only 17.4% of the respondents did not have such knowledge. However, 63 respondents (27.3%) showed neither positive nor negative knowledge on the said matter.

Question 3: I know nanotechnology in food involves particles that could not be identified by using naked eyes or through taste buds

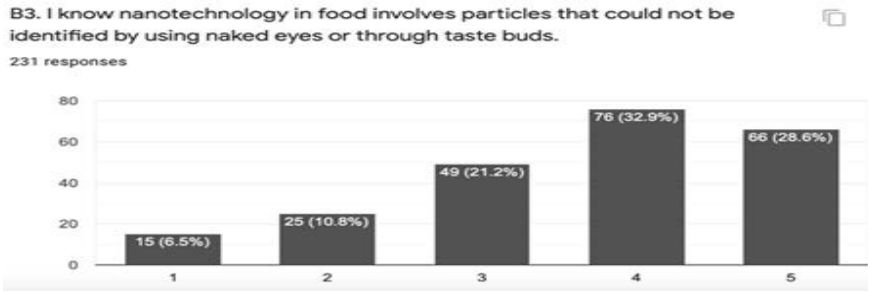

Figure 3: Identification of Nanoparticles

Question 4: I know about the existence of nanofood

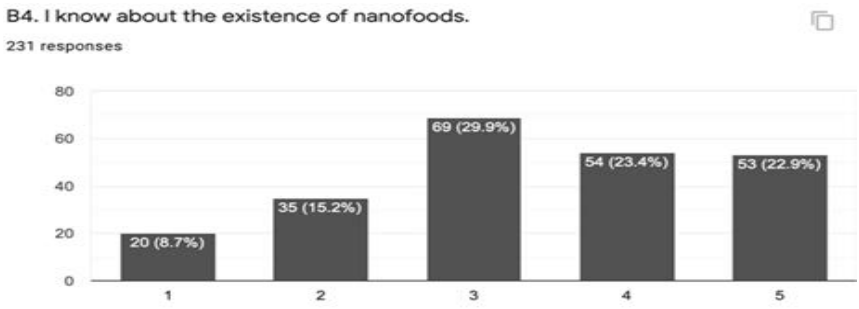

Figure 4: Existence of Nanofood

Figure 3 reports that more than half of the respondents (61.5%) with 76 respondents (32.9%) knew that nanotechnology in food involves particles that cannot be seen or identified by naked eyes or through taste buds and 66 respondents (28.6%) showed strong awareness for this fact. Only 17.3% (40) of the respondents indicated no or little knowledge, and 21.2% (49) of the respondents indicated indecisiveness.

However, though 61.5% admitted that they knew nanotechnology in food involves particles that are not visible either through eyes or taste, Figure 4 shows that only 46.3% (109) of the respondents stated they knew about the existence of nanofood. Majority of the respondents either unsure, lack or no awareness of the existence of nanofood.

Question 5: I know that nanofood is available in the Malaysia market

Figure 5: Nanofood in the Market

Figure 5 evident only 35.9% (83) of the respondents had good knowledge of the existence and availability of nanofood in the Malaysian market. While 12.1% (28) of the respondents admitted they did not seem aware at all, 16.9% (39) of the respondents might have poor awareness of the existence of nanofood in Malaysia, and 81 respondents (35.1%) were uncertain in their answers.

Question 6: I know the functions of nanomaterials in food products

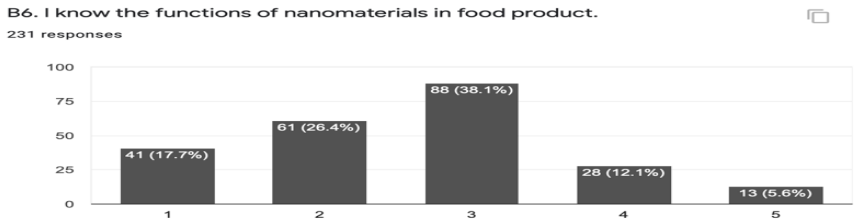

Figure 6: Functions of Nanomaterials in Food Products

In reply to the statement that they know the functions of nanomaterials in a food product, Figure 6 discloses only 13 respondents

showed strong agreement, and 28 respondents agreed. 102 of the respondents opposed the statement, which indicates that they did not have knowledge of the functions of nanomaterials in food. Meanwhile, 88 respondents showed indecisiveness or uncertain whether they knew or not.

Question 7: I know the benefits of nanofood

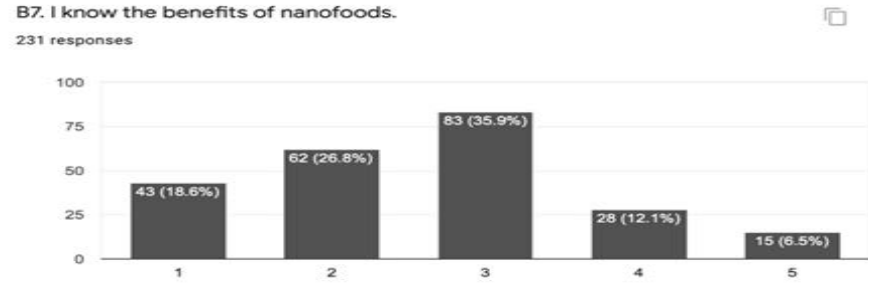

Figure 7: Benefits of Nanofood

Question 8: I know the safety and health risks associated with nanofood

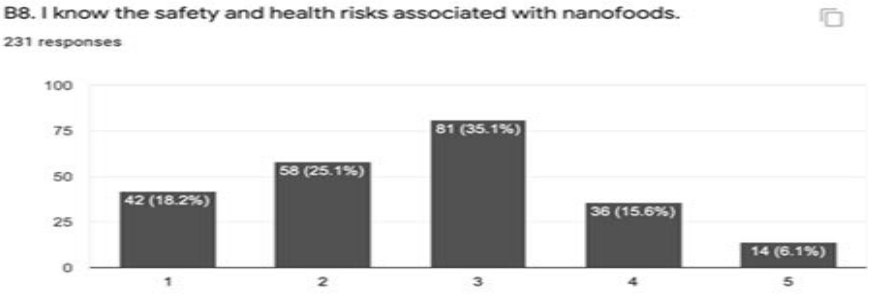

Figure 8: Safety and Health Risks of Nanofood

Figure 7 and 8 report consumers' knowledge of the benefit, safety, and health risks associated with nanofood. Both figures evident that only a quarter of the respondents were acquainted with knowledge on benefits and risks from the consumption of nanofood (43 and 50 respondents, respectively). This indicates that the majority of the respondents either were not aware, had no or little knowledge, or were unsure of the benefits and risks posed by nanofood consumption. While 188 respondents answered negatively on the benefits of nanofood (Figure 7), 181 respondents stated

that they did not know and also unsure of the safety and health risks from nanofood consumption (Figure 8).

Question 9: I know that I am a user of nanofood

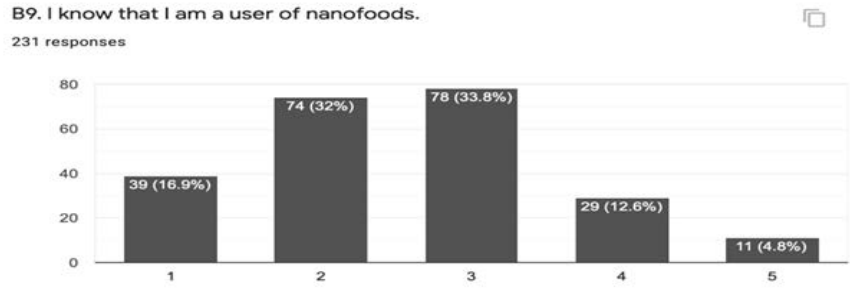

Figure 9: User of Nanofood

Lastly, on the question of whether the respondent knows that he is a nanofood user, Figure 9 reports only 11 respondents (4.8%) answered in affirmative and supported with another 29 respondents (12.6%) who also stated they aware that they consumed nanofood. In contrast, 113 respondents (48%) showed no or lack of knowledge on whether they were nanofood users, and 78 respondents (22.8%) were doubtful.

DISCUSSION AND RECOMMENDATION

With the growing applications of nanotechnology in the food industry and the rapid influx of nanofood in the marketplace, a survey was conducted nationwide and resulted in 231 respondents. The survey is aimed to analyse consumers' awareness and knowledge of nanofood. Knowledge of nanotechnology is the vital element directly connected to the awareness and understanding of the risks and benefits of nanotechnology (Siegrist *et al.*, 2007). The result has shown that 70.2% do not have knowledge of the basic characteristic of nanotechnology, i.e., the size of tiny nanoparticles. On the contrary, 61.5% knew that existence of ENMs in food products could not be seen using naked eyes.

Previous studies have shown a lack of comprehensive knowledge on the integration of nanotechnology in the food processing industry (Karim

et al., 2019; Hasim *et al*., 2019). Similarly, this study also demonstrates that knowledge about nanotechnology in the food processing industry is still lacking with 55.4%, although nanotechnology has been used in the food industry since the last decade (He *et al*., 2019). Besides that, 82.2% are not informed on the functions of nanomaterials in the food processing industry, and 81.3% have little knowledge or unsure about the benefits of ENMs for the food processing industry. Factors that contribute to the lack of knowledge is probably because of the limited research done by consumers on nanofood, difficulty to identify the availability of nanofood in the marketplace (Van Giesen *et al.*, 2018), and no actual injury or incident associated with nanotechnology that can trigger public concern or backlash (Siegrist, 2010). This article argues that another contributing factor is the absence of nano information affix to a food product. For some consumers, they read product labels because they are concern about the ingredients, and the presence of information on nanotechnology can enhance consumers' knowledge and understanding.

The consequence from the lack of knowledge is a lack of awareness (Hasim *et al*., 2019). It is not surprising that 53.8% are not aware of nanofood, and 64.1% are unaware of the presence of nanofood in Malaysia's market. The public should be familiar with the integration of nanotechnology in the food processing industry because the volume of nanofood is steadily growing across the globe due to the increased investment in nanotechnology research and development by giant food manufacturers (Handford *et al.,* 2015). Furthermore, awareness about nanofood should be higher because oral exposure of ENMs from food matrices and food packaging is associated with numerous potential safety and health risks, as illustrated by scientific studies (Hasmin *et al*., 2021). Unfortunately, only 21.6% are aware of the potential safety and health risks of ENMs. This study believes that consumers should be well-informed about the potential risks of ENMs so that they can take necessary precautions to avoid serious and irreversible injury from oral exposure to ENMs.

It is also important to note that 82.7% do not know that they are nanofood consumers. There is a possibility that consumers are being exposed orally exposed to ENMs without realising it. According to Marchant *et. al.* (2012), one of the problems with the integration of nanotechnology in consumer products is the difficulty identifying products containing

ENMs due to the tiny size of nanoparticles. The identification of nanofood can be made using food labelling. The fixation of nano labels will enable consumers to distinguish between nanofood and food free from ENMs. However, the current regulatory framework does not require the labelling of nanotechnology products, where the labelling requirement does not include the scale of materials (Karim, 2015). Based on a study by Burri and Belluci (2008) in Switzerland, the majority of the respondents demanded more information and more explicit information on the application of nanotechnology in consumer products.

The results demonstrate the lack of awareness and poor understanding of the integration of nanotechnology in the food processing industry, especially the safety and health risks of ENMs and lack of information on the availability of nanofood in the domestic marketplace. Therefore, the effort is needed to strengthen consumers' understanding of nanofood and increase the visibility of nanofood in the marketplace. This study recommends a nano labelling mechanism. Labelling may enhance consumers' awareness and knowledge about the product ingredients. In certain situations, the presence of a label is perceived as an indication of issues and leads consumers to figure out whether the label is the signal of warning or otherwise (Feindt & Poortvliet, 2020). Nano label allows consumers to become aware and informed about the availability of nanofood in the market. According to the International Organisation for Standardisation (2013), nano labels can improve communication and create understanding about nanotechnology products. For instance, the labelling requirement has been adopted for the controversial genetically modified (G.M.) food products. Food products derived or contained genetically modified organisms must be labelled as required under Regulation 7 of the Food Regulations 1985. The labelling requirement inter alia has been used as a tool to increase awareness about G.M. products and to regulate the potential safety and health risks.

CONCLUSION

As the volume of nanofood in the market is steadily growing, the present study provides valuable input on the consumers' awareness and knowledge about nanofood. This study found that consumers' awareness and knowledge of nanotechnology and ENMs in the food processing industry are still not

satisfactory, particularly on the existence of risks associated with nanofood is still low. They are also unaware that they have consumed ENMs, as they cannot identify the presence of ENMs in food products or distinguish between nanofood and conventional food. The awareness and understanding can be enhanced by providing consumers with information on the integration of nanotechnology in the food processing industry, i.e., nano labelling. This study believes that the lack of awareness and understanding of the risks of nanofood requires the reform of the food regulatory framework. The formulation of a regulatory framework to regulate the potential safety and health risks must include labelling requirements as the efforts and mechanism to enhance consumer awareness and understanding of nanofood.

Table 2: Study on Public Perception of Nanofood

Author	Country	No of respondent and methodology	Objective	Findings
Vandermoere *et al.* (2011)	France	752 respondents Questionnaire	To examine which factors, determine if people are pessimistic, ambiguous, or optimistic about nanofood and food packaging nanotechnology	44.1% of the respondents are ambiguous about nanofood packaging, and 42.8% on nanofood. Only a minor percentage of the respondents reported low scores on risks and benefits or high scores on risks and benefits. The data gives an indication that there will be strong opposition to nanofood by the French in the future.
Roosen *et al*. (2015).	Canada and Germany	Questionnaire 615 Canada 750 German	To analyse the role of trust in the evaluation of new food technology, namely nanotechnology.	The use of nanotechnology in the food and food packaging industry raises concerns in consumers' minds. However, it is uncertain whether these concerns are related to the lack of awareness of nanotechnology among the general public, or lack of awareness of nanotechnology uses in the food industry
Sodano *et al.*(2016).	Italy	300 respondents Questionnaire	To investigate attitudes of Italian consumers towards a set of applications of nanotechnology in the food domain.	Data shows that there is a reluctance among the respondents to buy foods produced using nanotechnology due to high-risk perception, low level of trust in nanotechnology, and food technophobia.

Steenis *et al.* (2016).	Netherland	141 respondents Questionnaire	To investigate to what extent consumers' attitudes towards existing food products are influenced by introducing a novel nanotechnology-based attribute to that product.	Nanotechnology applications more proximate to consumers (i.e., in the food itself) are deemed riskier yet not necessarily more beneficial compared to more psychologically distal nanotechnology applications. Adding nanotechnology attributes contributes to consumer attitudes towards food products but are not likely to lead to a categorical rejection of such products, although the likelihood of rejection seems to increase when technology applications become highly proximate to the consumer.
Zhou and Hu (2018).	United States	1131 respondents Questionnaire	To examines consumers' valuations for nano-attributes via a nationwide online survey in the United States.	The results suggest that consumers would pay less for canola oil if it were produced from nanoscale-modified seeds or is packed with nanotechnology-enhanced techniques. No significant difference is found for canola oil with health-enhancing nano-engineered oil drops.

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