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Disclosure of Nanomaterials under Nanotechnology Product Inventory, Voluntary Certification, and Voluntary Labelling

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ABSTRACT

Nanotechnology has revolutionised the food industry and flooded the consumers' market worldwide with engineered nanomaterials (ENMs), creating concerns on potential risks towards safety and health. This article analyses the institutional approach for disclosure of information on the presence of ENMs in food products and their limitations. It adopts a doctrinal approach and content analysis by examining relevant literature on disclosure of nanomaterials from journal articles and books from online databases and institutional websites. To overcome the limitations of the institutional approach of nanotechnology product inventories, voluntary certification programme, and voluntary labelling, this article proposes that the information disclosed must be in full and accurate. More importantly, the information on potential risks of exposure, use of nanotechnology, or presence of nanomaterials must be verified and constantly updated. This study hopes to significantly contribute to improving the transparency of nanofood information systems.

Keywords: Nanotechnology, nanotechnology product inventory, nanotechnology voluntary certification, nanotechnology voluntary labelling

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INTRODUCTION

Nanotechnology research and development at the atomic, molecular, or macromolecular levels, using a length scale of approximately one to one hundred nanometres in any dimension, offers new scientific, economic, and social benefits that have attracted

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large scale investments from government agencies and private sectors (Wang & Chien, 2013). The unique characters of nanomaterials display novel properties that behave differently from the same materials in bulk (Gallocchio et al., 2015). Owing to its uniqueness, nanotechnology has transacted across various fields such as food and agriculture (Thiruvengadam et al., 2018), pharmaceutical (Brown & Patel, 2015), and consumers' products (Potter et al., 2019).

In the food and agricultural industry, nanotechnology and nanomaterial are integrated throughout the food chain production as a tool and technique for cultivating, processing, or packaging food (He et al., 2019). Such integration has resulted in the production of nanofood (Sodano, 2017). It is estimated that in 2040, the consumer market will continue to see an influx of nanofood, with an estimation of more than 200 food companies worldwide investing in nanotechnology (Helmut Kaiser Consultancy, n.d.). Nonetheless, the benefits of engineered nanomaterials (ENMs) occasionally lead to adverse safety and health effects. This is because the unique features of nanomaterials, which differ from the bulk counterparts, can lead to toxicity. In fact, it is more alarming that the toxicity of nanomaterials cannot be identified from the existing toxicity of the bulk materials due to the different physicochemical properties between these materials (Kumar et al., 2019).

ENMs in food matrices have been shown to pose safety and health risks. The extremely small ENMs incorporated directly into food or food-related products, such as cookware and food packaging, are impossible to be detected by human eyes, or through taste or structure alone. While nanotechnology is popular among manufacturers, it is difficult to estimate the actual volume of nanofood in the marketplace as the manufacturers are not mandated to declare the presence of ENMs in their products. At the moment, some information regarding the presence of ENMs is available through the institutional approach of product inventory, voluntary certification system, or voluntary labelling, which is often without clarity or consistency.

This article elucidates the institutional approaches for disclosure of nanofood by analysing the sufficiency of these approaches to ensure full and accurate disclosure of information regarding the presence of ENMs in food products. This article is organised into four parts. The first part is the methodology of research. The second part offers an overview of the benefits and risks of nanotechnology in the agricultural and food industry. Meanwhile, the goal of this part is to allow readers to acquire sufficient knowledge of nanofood for a better understanding of the need for full and accurate disclosure. The following part analyses existing institutional approaches of nanomaterial disclosure, namely nanotechnology product inventories, nanotechnology voluntary certification system, and nanotechnology voluntary labelling. The last part summarises the finding and discussion, which addresses the limitations of these approaches. This paper ends with a conclusion.

METHOD

The work adopted the methodology of qualitative doctrinal research by analysing the relevant literature from research journals and books available in online databases and institutional websites. A comparative analysis was done for the nanotechnology product inventories in the European Union and the United States with the voluntary certification system and voluntary labelling. This was to uncover the strengths and limitations of the institutional approach and identify the most useful approach for the disclosure of nanomaterials. The finding from the semi-structured interview with NanoVerify was also included so as to provide a more comprehensive picture of the NanoVerify voluntary certification system.

BENEFITS AND RISKS OF NANOTECHNOLOGY IN THE AGRICULTURAL AND FOOD INDUSTRY

In the agricultural industry, the effective use of nanotechnology increases both the quantity and quality of agricultural produce (de Oliveira et al., 2018). Precision farming methods and smart delivery programme can increase crop productivity (Thiruvengadam et al., 2018) using nano-pesticides and nano-fertilisers in the management of phytopathogens, nutrient utilisation, controlled release of pesticides, or fertilizers (Kim et al., 2018). Meanwhile, in the livestock industry, nanomaterial is used as an antimicrobial agent for poultry products (King et al., 2018), animal breeding, and veterinary medicine (Hill & Li, 2017).

For the food industry, the application of nanotechnology is evident in food processing and food supplement. ENMs have been proven to enhance food quality, prolong shelf life, and reduce the problem of food spoilage (Cruz-Romero et al., 2019). ENMs also guarantee the safety of food (He & Hwang, 2016) and increase the physical properties of food by enhancing the appearance, texture, fragrance, and flavour, rendering the physiological appeal to food products (Pradhan et al., 2015). As for food supplements, ENMs can improve the delivery of nutrients through the nanoencapsulation process. The tiny particle of ENMs increases the solubility, bioavailability, and absorption of nutrients at the targeted area at a specific rate (Pathakoti et al., 2017). In the food packaging industry, nanomaterials produced food packaging is more environmentally friendly, flexible, stable, and with a stronger antibacterial agent compared to macro-sized materials (Hagen & Drew, 2016). Various functional benefits of nanotechnology have attracted giant food manufacturers such as Kraft, Ajinomoto, Heinz, Unilever, Mars (Qadri et al., 2018), as well as Nestle and Kelloggs (Sodano, 2017) to invest and manufacture commercial products using nanotechnology. These manufacturers produce many everyday food products, which means nanofood is an everyday food product that is probably being consumed on a daily basis.

The use of ENMs in the agricultural and food industry has increased the oral intake of nanoparticles in day-to-day consumption (Rompelberg et al., 2016).

A scientific study has demonstrated the potential migration of ENMs from food packaging to food matrices. For instance, silver nanoparticle from food packaging was shown to migrate to food matrices when exposed to high temperatures, with longer storage time, and with weaken polymer matrices (Morais et al., 2019). It increases the oral exposure of nanomaterials into the gastrointestinal tract (GIT), which raises safety and health concerns. The unique features of nanoparticles, such as fast motion and tiny, capable of penetrating deeper into the human body and reach the sensitive tissues, could also lead to various potential health complications (Sohal et al., 2018). It is important to highlight that the safety and health risks of ENMs are not based on a hypothetical assumption, but rather on grounded scientific studies.

Based on the theory of risk society of modernity by Ulrich Beck, the risk is seen as an inherent feature of modern society. Man-made risks from technological advancement include nanotechnology is invisible, uncertain, hard to control, and exposes the entire societies at risk (Beck, 1992). Accordingly, citizens and consumers should be allowed to make reasoned actions and choices to prevent and protect themselves from the risks which are made possible through disclosure of accurate information or proper labelling (Throne-Holst, 2012). This highlights the importance of revisiting the approaches of the information disclosure pathway on the risks and benefits of ENMs to ensure enough openness and transparency of information.

FOOD LABELLING IN MALAYSIA

The food labelling requirement in Malaysia is based on the Codex Alimentarius labelling standard issued by Codex Alimentarius Commission (CAC). The CAC is an international body for implementing the FAO/WHO Food Standards Programme. Codex standards have no binding effect on national food legislation (Li, 2014). However, as a member of CAC since 1971, Codex National Committee (CNC), i.e., the national contact point for Codex standards continuously reviews and harmonises the Codex standard with the domestic food regulatory framework (Food Safety and Quality Division, n.d.). Currently, there are ten food labelling standards and guidelines issued by the Codex Committee on Food Labelling (CCFL). Unfortunately, Codex has not issued any standard on nanofood labelling (Codex Alimentarius, n.d.). Arguably, from the perspective of Codex, nanofood and conventional food are subjected to the same labelling standard.

Meanwhile, the food labelling requirement in Malaysia is prescribed by the *Food Act 1983* (Act 281). The subsidiary legislation of the *Food Act 1983*, i.e., *Food Regulations 1985*, is the primary law on food labelling. Part V of the Food Regulations lists the mandatory requirements for food labelling such as labelling of ingredients, expiry date, weight, strength, and nutrient claim. Consistent with the Codex labelling standard, the act and the regulation do not have a specific provision mandating nanofood to be labelled or distinguished from conventional food.

However, some manufacturers voluntarily opt for additional labelling information to improve their products' commercial value and marketing tools (Golan et al., 2001). The additional information is provided by either voluntary certification or voluntary labelling by private institutions. Although the information provided is voluntary, the labelling is still subjected to the labelling laws. Most importantly, the information provided on the label must be accurate and not misleading.

Several labelling offences may be committed as a result of giving inaccurate and misleading information. Inaccurate information on a food label is a false label as regard to its nature, substance, composition under section 16 of the Food Act, and punishable by fine or imprisonment, or both. Under section 10 (1) (a) of the *Consumer Protection Act 1999* (Act 599), inaccurate information amounts to false or misleading representation as to the goods of a particular kind, standard, quality, composition, style, or model, which is punishable with fine under section 25 (1) (a) and (b) of the *Consumer Protection Act 1999*. The same may also amount to a false trade description under section 5 (1) (c) of the *Trade Descriptions Act 2011* (Act 730), which is punishable by fine or imprisonment, or both. Section 6 (1) describes trade description as to include nature, designation, quantity, method of the manufacturer, production, processing, or composition. Describing a food product manufactured with nanotechnology or containing nanomaterials is classified as part of the trade description. Therefore, the institutional and voluntary approach to food labelling is also subjected to regulatory requirements.

APPROACHES ON DISCLOSURE INFORMATION ON NANOFOOD

Currently, there are two approaches to disclosure information on the risks and benefits of nanofood in the consumer market, namely the institutional approach and the legislative approach. None of these two approaches requires mandatory labelling of nanofood. The institutional approach refers to the voluntary disclosure where manufacturers willingly inform that their food products are produced using nanotechnology or contain nanomaterials. Such disclosure, which is not subjected to any legislative mandate, can be in the form of nanotechnology product inventory, nanotechnology voluntary certification programme, or nanotechnology voluntary labelling. On the contrary, the legislative approach involves a legal mandate. The disclosure is compulsory, and the labelling requirement is prescribed in the legislation. Currently, labelling of nanofood is mandatory in the European Union under Regulation (EU) No 1169/2011 on the provision of food information to consumers. It is the only jurisdiction applying the legislative approach. This article only focuses on the institutional approach that is readily available and currently in use.

Nanotechnology Product Inventories

The continuous influx of nanotechnology products in the consumer market such as food and beverages, toothpaste, cookware, and food packaging has led to the introduction of nanotechnology product inventory that lists products that are produced using nanotechnology or contain nanomaterials. The aim of nanotechnology product inventories is threefold; to inform consumers that the products are produced using nanotechnology or contain nanomaterials, improve the transparency and sharing of information in the food supply, and fill the scientific gap about nanotechnology (Berube et al., 2010; Center for Food Safety, 2015). This approach is adopted by the United States and the European Union.

In the United States, there are two Consumer Product Inventory created by Woodrow Wilson International Center and by the Center for Food Safety. Consumer Product Inventory was established in 2005 under the Woodrow Wilson International Center for Scholars and the Project on Emerging Nanotechnology. It is a research institute dedicated to the responsible development of nanotechnology by minimising possible risks, as well as strengthening public and consumer engagement in the advancement of nanotechnology (The Project on Emerging Nanotechnologies, n.d.). On this premise, the Project on Emerging Nanotechnology thereafter created an inventory providing consumers, policymakers, and others with the outlook of nanotechnology products available in the market (Vance et al., 2015) and are available online. It is the first-of-its-kind inventory that has been frequently cited in scholarly articles as a baseline to prove the influx of nanotechnology products in the markets (Berube et al., 2010).

The Project on Emerging Nanotechnology began compiling nanotechnology products from around the globe at the beginning of 2005. The inventory is updated yearly (Hansen et al., 2016). The initial methodology used to gather information was done online through a systematic web-based search and limited to products with the information given in the English language (Maynard & Michelson, 2006). Information is provided by the manufacturers themselves. As registered users of the inventory, manufacturers can add their nanotechnology products into the inventory, but submitting relevant data such as nanoparticle function, properties, potential exposure pathways, toxicity, and lifecycle assessment is optional. Failure to provide any information does not inhibit the products from being included in the list (Wilson Center, 2006). Nonetheless, manufacturers are obliged to certify that their products are readily purchased by consumers, are identified as nano-based or other sources, and that nano claims for the product appear reasonable (Maynard & Michelson, 2006). As of January 2020, there are 119 products in the food and beverages category, including 16 cooking utensils, seven food products, 20 storage or packaging materials, and 70 food supplement products (The Project on Emerging Nanotechnologies, 2020).

Another consumer product inventory in the US was established in 2015 and maintained by the Center for Food Safety, a national non-profitable public interest, and environmental advocacy organisation that aims to protect human health and the environment by curbing the use of harmful technology in food production. Nanotechnology is among the food-producing technologies that have attracted the centre's attention. The centre has concerns over the integration of nanotechnology in the agriculture and food industry as it may lead to various safety and health issues. The product inventory for nanofood is accessible through its official website aimed at alerting consumers on the widespread of nanotechnology, filling the gap of information, and improving transparency in the food supply programme because the novel risks of nanotechnology remain largely unknown (Center for Food Safety, 2018). The inventory also complements the Food and Drug Administration (FDA) in reviewing products with unapproved nanomaterials that should not be on the market (Center for Food Safety, 2018).

The inventory listed nanotechnology products from the agriculture and food industry, namely food, beverages, food supplement, food packaging, cookware, nanofiltration, and fertiliser that are positively tested with nanomaterials, or claimed to contain nanomaterials. As of January 2020, there are 580 products listed and manufactured from all over the world available in the market throughout the United States (Center for Food Safety, n.d.). However, it is uncertain how frequent the inventory is updated.

In the European Union, the Danish Consumer Council and the Technical University of Denmark's Department of Environmental Engineering created The Nanodatabase in 2012. It was formed to address the issue of lack of information about nanotechnology products in the market and to help consumers identify such products in either physical stores or online markets (Hansen et al., 2016). The Nanodatabase is a publicly available database. In addition to containing a basic description of the listed product, it also includes information on product safety evaluation according to the NanoRiskCat (NRC). The NRC framework is a screening tool to identify, categorise, and rank the exposures and effects of nanomaterials used in consumer products developed by the Technical University of Denmark (Hansen et al., 2013). Indirectly, Nanodatabase also provides consumers with information on potential safety and health risks of nanotechnology products available in the European market. The database lists consumer products that are claimed to contain ENMs in the European market and is updated daily (Hansen et al., 2016). As of January 2020, there are 3120 products listed in the database and from this figure, 128 products are in the food and beverage category, and 165 products with oral exposure (The Nanodatabase, n.d.).

In addition to The Nanodatabse, two European consumer organisations, the European Consumers Organisation and the European Consumer Voice in Standardisation have documented an offline database in the form of a Microsoft Excel spreadsheet, with a list of products claimed to contain nanomaterials or associated with nanotechnology available in Europe (Vance et al., 2015). The spreadsheet was created in 2010 as a result of concerns over the safety and health risks of nanomaterials, as well as the increasing numbers of products with nanotechnology available in the European market, which have never been subjected to safety assessment. The products in the spreadsheet represent the most used by consumers, such as cosmetics, baby bottles, and vacuum cleaners (ANEC & BEUC, 2010). The list was last updated in 2013 (Hansen et al., 2016), and the volume of updated products listed is uncertain as the spreadsheet is not made available online.

All inventories described above are territorial. In 2010, the global Nanotechnology Product Database was created and run by StatNano, an open-access online platform established to release the latest information and statistic on the nanotechnology industry and monitor the global development and policies of nanotechnology (NBIC, 2016; StatNano, n.d.). Unlike the inventories in the United States and European Union, the global Nanotechnology Product Database provides reliable information as the accuracy of information supplied by manufacturers is verified according to the standard definition of nanotechnology provided by the International Standard Organisation (ISO), i.e., ISO/TS 80004-1:2015 Nanotechnologies Vocabulary Part 1: Core Terms, and ISO/TS 18110:2015 Nanotechnologies - Vocabularies for Science, Technology and Innovation Indicators. All products listed in the Nanotechnology Product Database must have received certification from relevant nanotechnology certification programmes. As of January 2020, there are 8964 products from 61 countries with the market all over the world, confirming that the inventory is indeed global in nature (Nanotechnology Products Database, n.d.).

In Malaysia, although there is no specific nanotechnology product inventory, Malaysia Halal Directory, which is a general halal certification is likely to be applicable to nanofood, particularly if it is related to food products consumed by Muslims. The directory is maintained by the Jabatan Kemajuan Islam Malaysia (JAKIM) with information on the names of companies, products, and slaughterhouses that have received *halal* certification from the Department. Nanofood is also subjected to *halal* monitoring and enforcement system, where the *halal* legal framework covers all consumer goods regardless of the materials used or size of the particle (Awang & Zakaria, 2019). *Halal* certification means that the sources, ingredients, and process must be *halal* (JAKIM, 2014). As of January 2020, there are 25 types of food and beverages with the word ‘nano’ listed under the directory (JAKIM, n.d.). However, it is uncertain whether the ‘nano’ products listed in the directory contain ENMs, or whether the term nano is used for promotional purposes such as that of ‘Cake Nano’ and ‘Nano Candy.’ In other words, there is one inherent limitation of the halal directory, i.e. it is a *halal* certification but not a nanotechnology certification. Besides, not all nanofood is *halal* certified.

Voluntary Certification System

In addition to nanotechnology product inventory, some countries have also adopted a nanotechnology voluntary certification system, i.e., Russia, United Kingdom, Iran, Thailand, Taiwan, and Malaysia (Lee, 2018). The aims of the voluntary certification system include promoting commercialisation of nanotechnology products and increasing consumer's confidence. Nonetheless, it does not concern about the safety and health risks of nanotechnology products. Table 1 provides a comparison of the voluntary certification systems in Taiwan, Iran, Russia, and Malaysia.

In Malaysia, NanoVerified was established in May 2015. It is run by NanoVerify Sdn. Bhd. (NanoVerify), a company limited by guarantee under NanoMalaysia Limited, an agency of the Ministry of Science, Technology, and Innovation (MOSTI). The Malaysian government empowers NanoVerify to monitor and facilitate nanotechnology development and commercialisation in the country. The focus of NanoVerify is to increase the commercial value of local nanotechnology products and create a greater market acceptance for both domestic and foreign markets (NanoVerify, n.d.). As of January 2020, 90 products have received certification from NanoVerify, which is inclusive of products with an expired certificate given that the certificate is valid for only two years. From a list of 21 products with an active certificate, only one product is registered under the food category, and two agricultural products are registered as nano fertiliser (NanoVerify, 2020). As a general certification authority, the certified products under NanoVerify also comprise of raw materials and final products.

NanoVerify certificate is granted to products that contain nanomaterials in a range of 1 nm to 100nm in size. Manufacturers intending to certify theirs as nanotechnology products may voluntarily submit the application form to NanoVerify Sdn. Bhd., either online or manually. The process is conducted based on standard operating procedures (SOP) to ensure the quality of the output and uniformity of testing procedures. The validation process involves two stages; product line inspection and laboratory testing. The product line inspection requires a visit to the production plant to identify the stage nanotechnology is applied to the product. Subsequently, the finished product must be submitted to NanoVerify lab partners, certified under ISO/IEC 17025 Testing and Calibration Laboratories, for detection analysis. Once it is verified and approved, the product can be labelled with the NanoVerified mark.

The strength of nanotechnology certification system rests on the validation and testing process. It certifies that a product is made using nanotechnology or contains ENMs, rather than the manufacturer's claim alone. NanoVerify website also provides full and accurate additional information relating to product description, advantage(s) of using nanomaterials, name of the manufacturer, validity period, and images of the products. This information can be used by the regulatory authority to identify the need

Table 1
An overview of the purpose, validity period and number of products certified as of January 2020 of the voluntary certification programmes in Taiwan, Iran, Russia and Malaysia

Countries	Est.	Certification agency	Purposes	Validity period	No. of product certified as of January 2020	Citation
Taiwan (NanoMark)	2003	Taiwan Nanotechnology Industry Development Association (TANIDA)	i) to protect consumer rights and interests, ii) to encourage sustainable development for outstanding companies, and iii) to enhance the international competitiveness of nanotechnology industry	3 years	34 products (no product from agriculture and food industry)	[1 2]
Iran (NanoScale)	2007	NanoProduct Certification Unit of Iran Nanotechnology Initiative Council	i) to enhance consumer trust and confidence, and ii) to create nanoproduct market transparency.	1 year	365 products (1 product from agriculture and 21 products from food industry)	[3]
Iran (NanoHealth)	2007	Food and Drug Administration of Iran	i) to support the commercialization of Nano-Health products	1 years	33 products (2 products from food industry)	[4 5]
Russia (Nanocertifica)	2011	Rusnano Group	i) to confirm the applicability of products and technologies to the nanotechnology domain ii) to assess products for compliance with specified characteristics and safety parameters iii) to guarantee the adequate quality of nanoproducts at each manufacturing and application stage, and iv) to confirm the compliance of nano industry enterprises and facilities with international requirements for the safe production and application of nano industry products.	Uncertain	132 products (1 product from agriculture and 4 products from food industry)	[6]
Malaysia (NanoVerified)	2015	NanoVerify Sdn. Bhd.	i) to control the false claim of nanotechnology products in the market ii) to gain public trust in nanotechnology and its benefits iii) to promote local high technology products in the market, and iv) to certifiy the presence and quality of nanomaterial-based products.	2 years	90 products (2 products from agriculture and 1 product from food industry)	[7]

Source: Author own interpretation

1 Taiwan Nanotechnology Industry Development Association (n.d.a)
2 Taiwan Nanotechnology Industry Development Association (n.d.b)
3 Iran Nanotechnology Innovation Council (n.d.)
4 Iran Nanohealth Committee Food and Drug Organanisation (n.d.)
5 Nanotechnology Product Database (n.d.a)
6 Nanotechnology Product Database (n.d.b)
7 NanoVerify (2020)

for regulatory intervention or sufficiency of the existing legislation to face nano risks. The practice of mutual mark recognition between NanoVerify and Taiwan NanoMark is laudable as it expands the reach of the national certification programme beyond territorial borders (NanoVerify, 2019).

Voluntary Labelling

Voluntary labelling of nanofood is another form of the institutional approach. In 2017, the ISO published a technical specification on "Nanotechnologies — Guidance on Voluntary Labelling for Consumer Products Containing Manufactured Nano-Objects ISO/TS 13830." The technical specification provides a framework for a harmonised approach for voluntary labelling provision for consumer products containing manufactured nano-objects or ENMs that may or may not exhibit or impart nanoscale phenomena. It does not prejudge the positive or negative effects of consumer products containing nanomaterials (ISO, 2017). Nonetheless, the technical standard has not attained the status of international standard, thus rendering manufacturers the liberty to decide on disclosing that their products contain ENMs or not.

FINDINGS AND DISCUSSIONS

The finding established that NanoVerify Sdn. Bhd. is the provider for voluntary certification in Malaysia, but with limitations that hinder full disclosure of information. Disclosure of information under the NanoVerify certification system is voluntary and is limited to locally manufactured nanofood currently available in the Malaysian market. For imported products, reference must be made to foreign nanotechnology product inventories and certification systems such as the global Nanotechnology Product Database.

According to Berube et al. (2010), inventory such as the Consumer Product Inventory does not have sufficient validity to justify the pervasiveness of nanotechnology in the consumer market because the products listed are not scientifically tested or verified as nanotechnology products. It is also based on the information that is readily available on the internet. However, reliance on internet-based information may also lead to an overestimation of nanofood in the market, particularly when manufacturers use the term 'nano' for promotional purposes, which in reality, the product is unrelated to nanotechnology. In addition, some inventories are not regularly updated, resulting in products listed to be out of the market such as that of the offline Microsoft Excel spreadsheets which contain information on the nanotechnology products in the European market between 2010-2012 (Vance et al., 2015). Ideally, any nanotechnology inventory programme must be regularly updated because the volume of products containing nanomaterials is robust, while some products are probably out of the market.

Another limitation is related to the territorial nature of the inventories such as those in the US and EU. These inventories are excluded products manufactured outside of the US and EU (Dekkers et al., 2007). It renders these inventories as insignificant to consumers in other parts of the world including Malaysia. Table 2 compares the strengths and limitations of five nanotechnology product inventories.

In addition, the voluntary nature of the institutional approaches may cause underestimation of the actual volume of nanofood in the market. Some industries may refuse to admit the use of nanotechnology in their products (Katharine, 2013), resulting in no disclosure. The myth that food products with nano label may lead to a negative perception among consumers, as a result of oral exposure and ingestion of nanomaterials in food matrices associated with safety and health risks, is still prevalent (Grieger et al., 2016). Manufacturers are cautious about attaching a label that can jeopardise the commercial status of their products. Furthermore, the certification programme centres on increasing the product's commercial value and consumer confidence toward the certified products, and there is less concern about risks.

Thus, the institutional approach for the disclosure of nanofood must be improved. This can be achieved by mandating all manufactures to make full disclosure of information on any potential risks associated with ENMs in food matrices. Scientific studies on the safety and health risks related to nanofood have been well documented. The approach taken by the Nanodatabase inventory in the European Union provides a nano risk category with a potential hazard evaluation for the listed products that can be used as a guideline by other inventories. Information provided by the NanoVerify certification system should ideally include risks of potential hazard evaluation like the Nanodatabase in the EU.

In addition, the procedure for detection and verification of ENMs must also be adopted by all institutional approaches. This will ensure the provision of full and accurate information. Reliance on manufacturers' claims or online information is definitely inadequate. Manufacturers must be required to submit documentation verifying that their products are derived from nanotechnology or contain ENMs. The approach adopted by the global Nanotechnology Product Database under StatNano, i.e., analysing and verifying the accuracy of information provided by manufacturers or available online prior to the listing, should be upheld. The detection and verification procedures are crucial to avoid the offence of mislabelling or false labelling or false description of the food product. Moreover, the functionality of all inventories depends largely on their ability to provide current and updated information. The Nanodatabase is a good example of such inventory as the products listed in Nanodatabase are updated daily. The official website of the certification institutions must reveal a report on the latest number of certified products and exclude the ones with an expired certificate.

Malaysia can learn from the EU and the US by introducing a nanotechnology product inventory to overcome the limitations of NanoVerify voluntary certification system that relies solely on the willingness of manufacturers to certify their products.

Table 2
An overview of the purpose, strengths, limitations and number of products listed as of January 2020 of different consumer product inventories

Inventory	Est.	Purposes	Strengths	Limitations	No. of products listed as of January 2020
Consumer Product Inventory (United States)	2005	i) to provide consumers, policymaker and others with the outlook of nanotechnology products available in the market	i) Publicly available online ii) Updated yearly iii) Reporting by manufacturers or users	i) Products listed not subjected to verification procedure (manufacturer's claim) ii) Exclude information on risks to safety and health iii) Only limited to product available in the United State market.	119 products (16 cooking utensils, 7 food products, 20 storage or packaging materials and 70 food supplement products)
Center for Food Safety (United States)	2015	i) to alert consumers on the widespread of nanotechnology, ii) to fill the gap of information, and iii) to improve transparency in food supply system	i) Publicly available online ii) Include information on risks to safety and health	i) Products listed not subjected to verification procedure (manufacturer's claim) ii) Only limited to product available in the United State market.	580 products
The Nanodatabase (European Union)	2012	i) to address the issue on lack of information about nanotechnology products on the market and ii) to help consumers to identify either in stores or via online market	i) Publicly available online ii) Include information on risks to safety and health iii) Updated daily	i) Products listed not subjected to verification procedure (manufacturer's claim) ii) Only limited to product available in the European market.	3120 products (128 products are food and beverage, and 165 products with oral exposure)
The European Consumers Organization and the European Consumer Voice in Standardization (European Union)	2010	i) To inform consumers on the increasing numbers of products with nanotechnology claim available in the European market due to safety and health concern	ii) Publicly available	i) Products listed not subjected to verification procedure (manufacturer's claim) ii) Offline iii) Only limited to product available in the European market.	Discontinued in 2013
Nanotechnology Product Database (StatNano)	2016	i) to provide the user with the inventory of consumer and commercial products that have improved features through nanotechnology or used nanomaterials	i) Publicly available online ii) Products from 61 countries available worldwide iii) Products listed subjected to verification procedure	i) Exclude information on risks to safety and health	8964 products

Source: Adapted from Hansen et al. (2016)

To do this, a new agency, which is either a consumer association or a research institute, may be tasked to set up an online platform for the product inventory. The online platform may also be accessed through mobile applications with information given in both the national and English languages so as to ensure that it is widely and easily accessible. The inventory must endeavour to make full disclosure of potential risks by adopting a verification and authentication procedure of ENMs of all nanofood currently available in the Malaysian market using the information.

CONCLUSION

Nanotechnology has significantly contributed to the agricultural and food industry which increases consumers' consumption of nanofood. Some might not even aware that they are consumers of nanofood. Consequently, it will expose consumers to potential safety and health risks. The information disclosure of nanofood is done through an institutional approach, i.e. using nanotechnology product inventory, voluntary certification programme, or voluntary labelling. Unfortunately, these approaches pose some limitations which prevent full and accurate disclosure of information, whereby such disclosure is vital for the product of emerging technologies with safety and health risks such as nanofood. When information is incomplete, it would be difficult for consumers or regulatory authorities to take a precautionary measure to prevent or minimise the risks. To ensure full and accurate disclosure of information, these institutional approaches must provide information on potential risk exposure, verification of the presence of nanomaterials, and information must be updated from time to time. Ensuring this provision can significantly contribute to improvement in the transparency of the nanofood information system.

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