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Tomorrow Taste Comes Today: Exploring Customers' Intention to Buy 3D Printed Food in Egyptian Restaurants

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Abstract

Purpose – To explore the effect of 3D printed food characteristics on the Value-Attitude-Behavioral model in Egyptian restaurants.

Design/methodology/approach – Using a quantitative design, self-administrated questionnaire was conducted with customers who eat at restaurants.

Findings – Four characteristics of 3D printed food: health, fun, creativity and natural content were explored. The primary result identified was 3D printed characteristics have a positive and significant effect on hedonic value. Moreover, hedonic and utilitarian perceived values have an effect on customer attitude toward 3D printed food. Respondents indicated attitude toward 3D printed food led to the intention to buy it.

Originality/value – This research highlights the need for 3D food printing technology in the restaurants in Egypt. Moreover, this study adapted the Value-Attitude-Behavioral model in the context of 3D printed food.

Research limitations/implications – In the present study, 4 characteristics of 3D printed foods are being considered. In future, additional factors could be considered to deal with advancements in the food and beverage industry.

Practical implications – The study has been recommended the marketers and decision makers to show the advantages of 3D printed food in ads.

Social implications – This study will help the community by offering them a new type of technology that has positive effect on environment. Besides, it will help the people with allergies and elderly people to have the food that is suitable for them.

Keywords: Additive manufacturing, 3D printing, Food service, Food characteristics, VAB model.

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1. Introduction

The case of guest misbehaviour with 3D printing, also known as additive manufacturing (AD) and rapid prototyping (RP), has a debate between researchers, industry, and the public and has applications in medicine, engineering, art, gastronomy, and manufacturing (Murphy & Atala, 2014). 3D printing is computer-aided design (CAD) software that uses excessive material layers to produce 3D objects. It originated first in 1980 in the prototyping industry and was used in the food industry for a decade (3D-printing.com, 2021; Hoffman, 2020). It has the benefit of flexibility in design and removes human errors while decreasing food waste (Hossain et al., 2020). It has been extended in food manufacturing to customise food content and design and add nutritional content (Dankar et al., 2018). 3D printed food is classified into two types: fused deposition modelling (FDM), which replaces moulding operations, and "ink-jet," which generates 2D and 3D designs. Both methods are based on the usage of computer-generated designs (Zhang et al., 2016; Godoi et al., 2016). After the fourth industrial revolution and three-dimensional (3D) printers' appearance, the process of food manufacturing has changed. The usage of 3D printing in the culinary industry is now on the increase. A wide variety of foodstuffs, including pasta, pizza, and meat, as well as confectionery items such as chocolate, ornamental cake toppings, and many more, have been printed (Izdebska-Podsiadły & Żołek-Tryznowska, 2016). 3D printing is considered a type of digital gastronomy that redesigns the taste, color, and texture of food, and it is used in food retailers, the catering industry, and culinary services. It enables food items to be converted into funny shapes; a personalised food diet; helping elderly people who have problems with chewing and swallowing; and making healthy food by using healthy ingredients. It reduces food waste and aims to create a sustainable environment by using the ingredients more effectively and efficiently in the storage, transportation, and reusing of discarded food (Fourie, 2019; Dankar et al., 2018; Lupton & Turner, 2016).

One of the advantages of 3D printed food that academics and practitioners address is using a variety of ingredients to produce food that is futuristic, creative, healthy, and sustainable (Lipton et al., 2015). It minimises barriers to resources, supports innovation, and allows designers to create new designs, tastes, and nutritional value (Malone & Lipson, 2007). There are a lot of food alternatives made from 3D printers. Sustainable ingredients, nutritional food, and fewer likeability items (such as edible insects) are turned into powder and inserted into printer cartridges to make attractive and easily consumable food (Lupton & Turner, 2016). A research group called "Nova meat" has made steaks made of green beans by using 3D printers. Moreover, " Biozoon" is another team that uses 3D printers and makes chicken and meat dishes made from green beans (Lupton, 2017; Jung, 2019). 3D printers mix the food ingredients and the desired nutritional content to generate high-quality meals (Palaniappan et al., 2020).

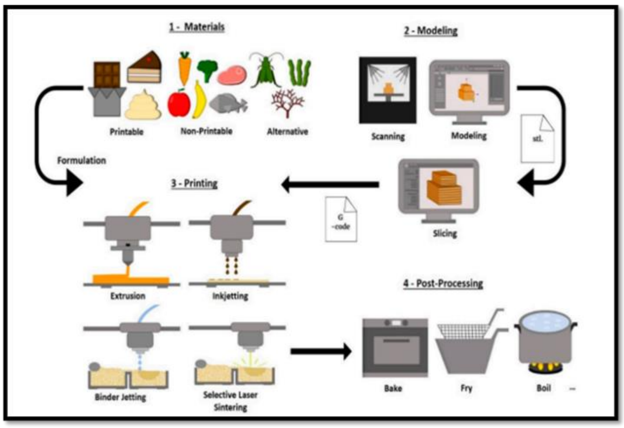

Figure 1 : Schematic of the 3D food printing process (Source: Pereira, Barroso, & Gil, 2021)

Various food producers

food items by using 3D printers. One of the largest chocolate manufacturers, The Hershey Company, has produced chocolate using 3D printers (Liu et al., 2017). Furthermore, "Food Ink" is the first 3D printing restaurant that produces nine courses by using 3D printers, and all chinaware and cutlery are made from 3D printers (RealFood, 2016; Buhr, 2015). “La Enoteca” restaurant in Barcelona is a two-Michelin-star restaurant that uses 3D printers to produce dishes by using coral-based ingredients (Lee et al., 2021). Another restaurant in the Netherlands named "Wolvega" serves many 3D printed foods by using five groups of nutrients made from honey and beans to make an item in the form of the Eiffel Tower (Manufacture3D, 2018). Some pop-up restaurants have employed 3D printers to provide a one-of-a-kind eating experience by printing food in complicated forms that are both personalised and aesthetically attractive (Hoff, 2018). Furthermore, it is used to produce meals with personalised texts or images, such as corporate logos or personalised birthday greetings. 3D printed food can be applied in domestic cooking to enhance the quality of food and improve the efficiency of food preparation by customization of colors, textures, shapes, flavors, and nutrition value (Sun et al., 2015).

Ayad and Shehata (2014) investigated the attitudes of tourism stakeholders (hotels and airlines) toward the potential value of applying 3D printing technologies in the tourism and hospitality industry in Egypt and found the result that tourism stakeholders have a positive attitude toward the importance of applying 3D printing technologies and the role of it in the tourism and hospitality industry in Egypt. In addition, Kesheck (2018) found that the Egyptian chefs have an interest in knowing about the new technology of 3D printers, especially the younger ones. The Egyptian chefs stated that this technology can be used to create new production methods. It can add value to the dishes by creating new aesthetics, tastes, and textures.

Academics expect that in the future, 3D printers will be available in kitchen appliances to be used in homes. Furthermore, because it is a new technology, there are some consumer concerns and mistrust about it. Innovation in food usually faces consumers' mistrust and fear, and this is a problem that faces marketers (Guiné et al., 2020). Therefore, the attitude and intention of customers toward the 3D-printed food have to be studied.

2. Statement of the Problem

Recently, the food and beverage sector has been subjected to various trends, and these trends have an influence on the success or failure of restaurant businesses. Food items which focus on personal care, healthy ideas, and functional claims are developing as a new trend as consumers' attention to personal health grows. This promotes a developing demand for customized healthy food, which tries to adapt and construct diets depending on an individual's health status (Sun et al., 2018).

Moreover, technology is gradually displacing human labour in the restaurant sector, from street kiosks to fine dining facilities (Ivkov et al., 2016). Moreover, technology is an essential component of how restaurants work, from the cash register to the kitchen (Keane, 2018). In addition, the restaurant industry is very competitive, and every company wants to be one step ahead of the competition. Therefore, restaurant owners adapt to new strategies and adopt technology solutions to expand their operations and remain ahead of the competition (Rahman et al., 2021).

Furthermore, older people are at risk of malnutrition and poor dietary intake. Physical changes associated with aging, including chewing and swallowing abnormalities, lead to nutrient deficits in older people (Zulkowski, 2006). Besides, there is a need for making healthy food choices by using menu labeling in restaurants (Shawky et al., 2019). In addition, reducing food waste and creating a sustainable environment by using the ingredients more effectively and efficiently in the storage, transportation, and reusing of discarded food has become important (Aldaco et al., 2020). Because it helps turn alternative resources like proteins from algae, beet leaves, or even insects into palatable items with familiar shapes, 3D technology may also be healthy and ecologically sustainable (McHugh & Cristina, 2017). Finally, there were five primary promising themes discovered, depicting 3D printed food innovations as futuristic, creative, nutritious, efficient, and sustainable (Lupton, 2017).

In addition, after COVID-19, the hospitality industry and restaurant industry face many challenges (Gursoy & Chi, 2020; Kaushal & Srivastava, 2021). The number of customers who visit it has decreased, and as a result, the revenue has decreased. Besides, restaurants have to decrease the number of employees to follow the social distance (Shahbaz et al., 2020). As a result, small restaurant entrepreneurs explored new technologies, innovations, and the digital interventions to meet the consumers' satisfaction with the contactless eating experience (Vig & Agarwal, 2021). Likewise, restaurant managers should consider waste management to cover the increased costs (Kaushal & Srivastava, 2021). In this regard, 3D food printing is considered one of the new strategies that restaurants can apply to face this problem.

In the food industry, 3D printing is being studied in a variety of areas, including customized food designs, personalized and digitalized nutrition, a simpler supply chain, and a broader source of accessible food material (Sun et al., 2015). One of the advantages of 3D printing technology is that it enables food specialists to preload recipes, which may subsequently be customized in shape, color, texture, flavor, or nutrition (Godoi et al., 2016). Accordingly, diagnosing the situation of implementing 3D printing food in the foodservice industry is a vital issue. It increases the restaurant's chance of survival and success in the dynamic environment.

Although there are many studies about the applications of 3D printing technologies in the areas of architecture, construction (Hanna, 2021), engineering (Abd Elfatah, 2019) medical industries (Hafez et al., 2015), packaging, advertising (Kamal El Din, 2018), automotive (El Mogy & Rabea, 2021), and many other fields, there are limited studies for 3D printing applications in the restaurant industry and other sectors related to hospitality in Egypt.

Previous studies explored the attitude toward the application of 3D printing technology in the tourism and hospitality industry in Egypt from the point of view of the industry and did not study it from the customers' view. As a result, the aim of this study is to fill a void by investigating consumer attitudes toward 3D printing technology and its applications in food production, as well as the implications for their purchasing intentions.

As a result, applying technology in restaurants (i.e., 3D food printing) is becoming more acceptable and is considered an essential component of how restaurants work after

COVID-19 to offer a safe environment and displace human labor in the restaurant sector to keep the social distance. Moreover, the youth segment who accepts technology has increased.

Consequently, the problem can be formulated as follow:

"Is there a relationship between 3D printed foot attributes (Health, Fun, Creativity, and Natural content) and customers' attitude and intention to purchase 3D printed food in Egyptian restaurants?"

3. Significance of the Study

This study would assist restaurant businesses towards a more definitive phase in incorporating 3D printers into their operations. It will help to fill the knowledge gap about the attitude and intention of customers to use 3D printing technology in restaurants in Egypt. Also, this study will adapt a Value-Attitude-Behavior (VAB) model to investigate the customers' intent to patronize restaurants that use 3D printers (Lee et al., 2021). This will contribute to the literature that studies the new trends in the restaurant industry. Furthermore, the findings of this study can be used to develop a framework for implementing 3D printing applications in the restaurant industry in Egypt.

4. Literature Review

4.1 What is 3D printed food?

Charles Hull created 3D printing technology in 1984 when he patented stereolithography, the first technique that allowed the production of 3D objects from digital data. Initially created for industrial prototyping, numerous university-led projects helped to make this technology available to the general public and democratized its home use in the 2000s (Savini & Savini, 2015). Nanotek Instruments Inc. received a patent in 2001 for a "rapid prototyping and production technique for 3D food items". (Brunner et al., 2018). This was the very first notion of a 3D food printer; unfortunately, subsequent attempts by appliance experts Electrolux and Philips suffered from many technological shortcomings, and they identified no industrial or home uses for 3D food printing (Sun et al., 2015).

In 2007, two Cornell University researchers demonstrated the Fab@Home Model 1, the first functional and reproducible 3D printing device compatible with food, inspired by the FabLab initiative at the Massachusetts Institute of Technology (Sun, *et al.*, 2015; Malone & Lipson, 2007; Godoi, et al., 2016). A meal produced using an automated additive technique is referred to as 3D printed food (Lipton et al., 2015). While this description may appear to be unclear, pizza vending machines that appeared in 2015 are considered a primary idea of this 3D printing. The dough is made, spread, covered with tomato sauce and cheese, and baked all in the same machine (Sun et al., 2015). 3D printed food fundamentally changes the way we think about food preparation and production since it can modify the whole process, from grocery shopping to preparing the ingredients and cooking. To clarify, as there is no food production and preparation, (1) there is less staff required, resulting in lower food costs, and (2) food becomes easier to transport (Tran, 2016).

It is a digitally controlled, robotic technique that may be used to layer complicated solid meals and mix them together via phase transitions or chemical reactions. The original food printer concept dates back to the 1960s, when the popular film Star Trek depicted a "replicating machine" capable of producing meals on demand. However, Nanotek Instruments Inc. patented a technology for 3D manufacturing of personalized birthday cakes in 2001 (Baiano, 2020). More comprehensively, 3D printed food applications in restaurants in Egypt will provide customers with more choices and accessibility to the foods of their choice (Alexander, 2020). In addition, 3D printed food can be attractive to new customers seeking different food experiences (Lansard, 2021). Guests' perception of safety, quality, and efficiency can be improved by using 3D food printers that increase the guest's intention to interact with technology in the future (Lupton & Turner, 2016; Otto & Kurreck, 2018; Baiano, 2020).

Finally, 3D food printing has many advantages as it can use a variety of ingredients such as proteins from algae, beet leaves, and edible insects and convert them into healthy and environmentally friendly food (Lupton & Turner, 2016). 3D printed food is a mixture between luxury cuisine and scientific precision. It allows chefs to create delectable and inventive dishes that humans are unable to create (Alexander, 2020). It helps the customers to have a new experience of seeing their dishes being produced in front of them (Otto & Kurreck, 2018). Consuming 3D printed food is safe as it is produced in clean and safe machines (3D-printing.com, 2021). Furthermore, 3D printed food provides control over nutrients, vitamins, and proteins to customers who seek restricted healthy diets (Baiano, 2020). It helps to present food in a more attractive way when processing nutritious plants and insects that are rich in proteins in a semi-liquid form, which helps to make it more consumable (Kim et al., 2019).

In addition, it allows making dishes with special designs that are difficult to make by hand. These benefits are very useful not only for customers' satisfaction and loyalty but also for the restaurant operations, which provide them with lower costs, faster production time, provision of consistent product quality, management of supply chain operations, etc (Manstan & McSweeney, 2020; Attaran & Attaran, 2020; Kewuyemi et al., 2021). Furthermore, the opportunities that 3D food printers as an economic system (Jayaprakash, et al., 2020) would create, like extending the shelf life of food materials (Attaran & Attaran, 2020) and improving health and quality of life (Dankar et al., 2018).

4.2 The properties of 3D printed food

Much research has been conducted to investigate the most important factors in meal choosing. The Food Choice Questionnaire (FCQ) was developed by Steptoe, Pollard, and Wardle (1995), and includes factors such as health, mood, convenience, sensory appeal, natural content, price, weight control, familiarity, and ethical concerns, all of which are considered to be important factors influencing individual food choices. Of these attributes, much of the FCQ literature shows that health, taste, environmental benefits, and natural ingredients are of paramount importance to consumers' food choices.

Five key factors were explored by Chen and Antonelli (2020) for food purchasing and consumption, which are internal factors (e.g., sensory properties and perceptual attributes), external factors (information, social and physical environment), psychological factors (e.g., mood), socio-demographic variables (e.g., culture, economic variables, political elements), and cognitive factors (e.g., preferences, knowledge, attitude, expected effect, and trust). Furthermore, Lupton and Turner (2018) found that the main attributes that influence participants' responses to 3D-printed food are food content, appearance, estimated sensory qualities of food, and how much was rated as "real" or "food-like."

In addition, Caulier et al. (2020) invited military members to consume and assess different 3D printed recovery snack bars, and following consumption, participants were asked about their attitudes towards 3D printing. The findings show that consumer empowerment, desired degree of personalization, level of development, and suitability of 3D food printing technology all play a part in 3D printed food acceptance. Moreover, according to Brunner et al. (2018), fun, convenience, health, and personalized nutrition are important factors in promoting 3D food printing technology to the customers. As a result, the most essential factors in a consumer's food selection process are health, fun, environmental benefits, and natural content.

4.3Value-attitude-behavior (VAB) model

A value-attitude-behavior (VAB) is a model to describe the consequences of cognitions of an individual, starting from principal cognitions (value) to mid-scale cognitions (attitudes), and finally to the behaviors (Homer & Kahle, 1988). The VAB model investigates the relationship between value and behavior through the mediating role of attitude. Values are the social cognition that adapts the person to the environment (Homer & Kahle, 1988). Attitude means the response to a particular behavior that may be favorable or unfavorable in question (Vaske & Donnelly, 1999). Behavior is the volitional control of an individual and the intention is considered a predictor of the behavior.

The VAB model was applied in a variety of studies in food consumption contexts. To explain, the VAB model was applied in food purchasing studies and revealed that the value has an effect on attitude and the attitude has an effect on behavior. Pérez-Villarreal et al. (2020) applied the VAB model to investigate (1) the effect of values on consumption benefits (hedonic, utilitarian), (2) the effect of the consumption benefits on the attitude toward eating hamburgers at fast food restaurants, and (3) the effect of attitude on purchasing behavior. The results show that value affects the benefits of consumption (both hedonic and utilitarian). However, these benefits do not affect the attitude.

Another study by Teng et al. (2014) investigated the consumer's intent to patronise green restaurants by using the VAB model. The study explained the interrelationship between personal values, general attitudes, and environmental concerns and their influence on behavior. A face-to-face survey method was used in this study. The results show that personal values and general attitude affect the intention to visit green restaurants. In addition, personal values and environmental concerns affect the attitude toward green restaurants.

Shin et al. (2017) used the VAB model to investigate the decision-making process of organic menu items and found that values perceived by restaurant customers affect their organic menu choices through pro-environmental attitudes. Moreover, Choe and Kim (2018) found that the values of tourists toward local food affect their attitude and intention to eat local food. Therefore, the VAB model can be used to investigate a consumer's intention to eat 3D printed food.

4.4 Values, attitudes, and purchase intentions toward 3D printed foods

Consumers' perceived values display their attitude, satisfaction, and loyalty. Furthermore, perceived value affects the behavior through the attitude (Homer & Kahle, 1988). The study by Grunert et al. (1993) demonstrated that the perceived value and attitude affect the behavior of food consumption. This model has been applied in various studies that show perceived values affect attitude which affect behavior toward food selection (Chen, 2007; Lea & Worsley, 2005; Scholderer, et al., 2004). Attitude reflects a person's positive or negative thoughts, assessments, and convections toward a product or service (Fishbein & Ajzen, 1975).

Consumer attitude toward purchasing a specific product or service can be determined based on the preference of a person toward purchasing this product or service, which may be positive or negative (Shim, Eastlick, Lotz, & Warrington, 2001). Therefore, the attitude is considered a consumer's response toward a specific product or service, which may be positive or negative (Chang & Liu, 2009). Intention is used to measure behavior when the behavior cannot be measured. Intention is the probability of attitudes and beliefs being converted into action through expected behavior in the future (Eroglu & Harrell, 1986). Attitude is a predictor of intention, which is considered an intermediate between attitude and behavior (Bianchi, 2017). Therefore, intention can be employed to measure actual behavior (Tsiotsou, 2006). As a result, this study looks into the impact of value, which can be utilitarian or hedonic, on customer attitude, as well as the impact of attitude on the intention to buy 3D printed food.

5. Hypotheses of the study

The study hypotheses are formulated as follows (figure 2):

H1: 3D printed food attributes have a positive and significant effect on consumer perceptions of the utilitarian value of 3D printed food.

H2: 3D printed food attributes have a positive and significant effect on consumer perceptions of the hedonic value of 3D printed food.

H3: Perceived utilitarian value regarding 3D printed foods has a positive and significant effect on consumer attitudes toward 3D printed foods.

H4: Perceived hedonic value regarding 3D printed foods has a positive and significant effect on consumer's attitude toward 3D printed foods.

H5: A Consumer's attitude toward 3D printed foods has a positive and significant effect on their intention to purchase

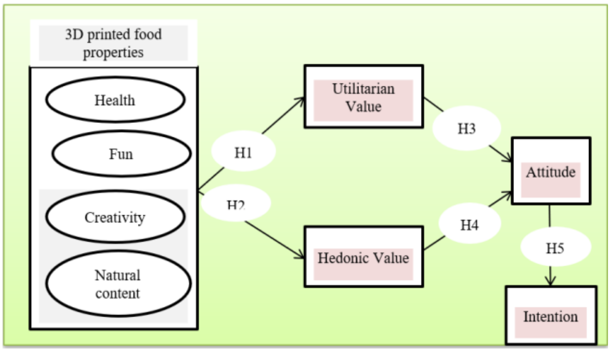

Figure 2: the Proposed Theoretical Model

6. Methodology of the Study

6.1 Research instrument and sampling

Using convenience sampling across several social networks, we conducted an online survey. The survey was created in Google Forms and the link was sent to participants via social media. All participants had at least a basic knowledge of 3D printed food technology since the survey started with a video and written explanation of 3D printed food and how it works. Following that, the questionnaire collected demographic data. Four categories were used for the age measurement (i.e., less than 20 years, 20–39, 40–59, and 60 or older). Participants may choose from four levels for education (college student, bachelor's degree, master's or Ph.D., and others). The third section of the questionnaire assessed respondents' agreement on the measurements using a five-point Likert scale (1 strongly disagree to 5 strongly agree).

The questionnaire was translated into Arabic and then back-translated into English to ensure content consistency. The questionnaire was then reviewed by two academic specialists who are fluent in Arabic in order to evaluate its content validity. After that, 10 students were given the revised version to test their comprehension of the survey's questions and clarity. A few changes were made as a result of input from both groups, including the rearrangement of several questions. From the 400 sent questionnaires, only 250 participants replied, with a response rate of 62.5%.

6.2 Measurements

Table 1 indicates the factors and the items and the sources of them.

Table 1: The study measurement

Factor	N. of items	Source
Health	5 items	(Steptoe et al., 1995) (Brunner et al., 2018)
Fun	3 items	(Brunner et al., 2018)
Creativity	5 items	(Brunner et al., 2018)
Natural content	4 items	(Steptoe et al., 1995) (Brunner et al., 2018)
Utilitarian value	4 items	(Babin et al., 1994) (Batra & Ahtola, 1991)
Hedonic value	4 items	(Babin et al., 1994) (Batra & Ahtola, 1991)
Attitude	4 items	(Fishbein & Ajzen, 1975) (Chen, 2007) (Lee et al., 2021)
Intention to purchase	4 items	(Chen, 2007) (Lee et al., 2021)

7. Results and Analysis

7.1 Demographic Data

The study data was analyzed using SmartPLS 3.0 and the Statistical Package for Social Sciences (SPSS, V.25).

Table 2: Respondents' Profile

Item	Frequency	Percentage
Gender		
Male	145	58
Female	105	42
Age		
Less than 20 y	18	7.2
20–39	214	85.6
40–59	13	5.2
60 and more	5	2
Marital status		
Single	215	86
Married	35	14
Educational level		
College student	132	52.8
Bachelor degree	70	28
Master or Ph. D degree	26	10.4
Other	22	8.8
Nationality		
Egyptian	28	11.2
Foreigner	222	88.8

The characteristics of the respondents are shown in Table 2. The study's sample included more males (58%) than females (42%), primarily aged 20–39 years old (85.6%) followed by less than 20 years old (7.2%). Moreover, most of respondents are single (86%). The respondents were found to be college students (52.8%) and have bachelor's degree (28%), being highly educated with having master or Ph.D. degree (10.4%) and/or others degree (8.8%).

7.2 Measurement Scale

To assess the research constructs, we used existing scales; Table 3 contains a summary of the study constructs and the measurement items. For convergent validity and reliability, we also examined the standard loadings, Cronbach's alpha, composite reliability (CR), and average variance extracted (AVE). We conducted a partial least squares regression analysis of the latent components using SmartPLS 3.2.7.

SmartPLS 3.2.7 was used for all statistical analyses because of its capability to handle sample sample numbers. In other words, by maximizing the explained variances of dependent variables, PLS aids prediction-oriented research. It can also evaluate complex forecasting models (Chin, Marcolin, & Newsted, 2003). Cohen (1992) recommended a minimum sample size of 188 at a 1% significance level and a minimum R2 value of 0.10; however, our sample size (n=250) was higher.

7.3 Measurement Model

Prior to running the regression, we examined the concept validity and reliability of the outer models. All of the constructs have strong internal consistency, and the values of Cronbach's alpha and CR are higher than 0.7 (DeVellis, 1991). According to (Hair, Black, Babin, Anderson, and Tatham (2006), factor loadings should be more than 0.4 to guarantee convergent validity; all of our items have loadings that are higher than this bare minimum, supporting the content validity and reliability of the constructs and items. We used Fornell and Larcker (1981) criteria to test for discriminant validity, or if the constructs share more variance with their own measures than with the other constructs (Chin, 1998). The correlation matrix in Table 2 demonstrates that the AVE of each construct is greater than its correlation with related constructs.

The degree to which a construct actually distinguishes itself from other constructs according to empirical criteria is referred to as discriminant validity (Hair, Hult, Ringle, & Sarstedt, 2014). The procedure agreed by researchers in (Fornell & Larcker, 1981) is used to assess the discriminant validity. Each construct's square-root of AVE and correlation coefficients with other constructs are compared. In order to compare the cross loadings of the indicators to the square-root of the AVE values, the construct's correlation is also studied. If a latent construct's square-root of AVE is higher than its greatest correlation with any other constructs, discriminant validity is supposed to be met. Table 4 and Table 5 reports the inter-construct correlation matrix and the square-root of AVE values, which demonstrate adequate discriminant validity for each construct.

Table 3: Results of Measurements Model- Convergent Validity

Construct	Item	Loading	Cronbach's Alpha	CR	AVE
Health	H1	0.898	0.929	0.946	0.779
	H2	0.889			
	H3	0.846			
	H4	0.911			
	H5	0.868			
Fun	F1	0.843	0.823	0.894	0.737
	F2	0.898			
	F3	0.832			
Creativity	C1	0.835	0.867	0.905	0.658
	C2	0.897			
	C3	0.872			
	C4	0.723			
	C5	0.71			
Natural content	NC1	0.809	0.855	0.902	0.697
	NC2	0.911			
	NC3	0.813			
	NC4	0.802			
Utilitarian value	UV1	0.916	0.895	0.925	0.754
	UV2	0.901			
	UV3	0.837			
	UV4	0.816			
Hedonic value	HV1	0.874	0.897	0.928	0.765
	HV2	0.839			
	HV3	0.919			
	HV4	0.863			
Attitudes	A1	0.907	0.944	0.96	0.856
	A2	0.941			
	A3	0.914			
	A4	0.938			
Purchase intentions	I1	0.911	0.892	0.925	0.758
	I2	0.940			
	I3	0.734			
	I4	0.882			

Table 4: Latent Variables Correlations

	Attitude	Creativity	Fun	Health	Hedonic value	Natural Content	Purchasing intention	Utilitarian value
Attitude	0.925							
Creativity	0.74	0.811						
Fun	0.712	0.857	0.859					
Health	0.805	0.655	0.694	0.883				
Hedonic value	0.876	0.821	0.774	0.728	0.874			
Natural Content	0.799	0.579	0.656	0.852	0.667	0.835		
Purchasing intention	0.833	0.738	0.766	0.76	0.835	0.776	0.87	
Utilitarian value	0.642	0.601	0.588	0.606	0.633	0.599	0.625	0.869

Table 5: Discriminant Validity

	Attitude	Creativity	Fun	Health	Hedonic value	Natural Content	Purchasing intention	Utilitarian value
A1	0.907	0.706	0.63	0.675	0.823	0.682	0.723	0.614
A2	0.941	0.644	0.631	0.747	0.803	0.75	0.803	0.565
A3	0.914	0.636	0.666	0.766	0.735	0.786	0.752	0.551
A4	0.938	0.748	0.705	0.789	0.875	0.743	0.803	0.641
C1	0.562	0.835	0.787	0.477	0.621	0.471	0.686	0.444
C2	0.662	0.897	0.816	0.553	0.695	0.495	0.686	0.575
C3	0.69	0.872	0.717	0.569	0.758	0.52	0.629	0.559
C4	0.504	0.723	0.615	0.521	0.581	0.388	0.543	0.44
C5	0.558	0.71	0.525	0.533	0.656	0.466	0.437	0.397
F1	0.597	0.732	0.843	0.696	0.611	0.553	0.648	0.45
F2	0.713	0.816	0.898	0.616	0.772	0.656	0.764	0.623
F3	0.493	0.639	0.832	0.468	0.584	0.453	0.53	0.406
H1	0.766	0.558	0.645	0.898	0.639	0.824	0.646	0.51
H2	0.738	0.598	0.593	0.889	0.678	0.73	0.688	0.606
H3	0.662	0.633	0.581	0.846	0.682	0.645	0.676	0.516
H4	0.775	0.59	0.684	0.911	0.677	0.827	0.688	0.534
H5	0.592	0.495	0.549	0.868	0.511	0.736	0.65	0.494
HV1	0.819	0.708	0.675	0.659	0.872	0.671	0.805	0.686
HV2	0.656	0.655	0.632	0.526	0.84	0.479	0.701	0.502
HV3	0.847	0.783	0.757	0.742	0.919	0.673	0.784	0.55
HV4	0.722	0.717	0.633	0.594	0.865	0.483	0.619	0.467
I1	0.761	0.671	0.683	0.617	0.795	0.603	0.911	0.579
I2	0.752	0.681	0.715	0.618	0.788	0.64	0.94	0.55
I3	0.494	0.603	0.623	0.681	0.486	0.667	0.734	0.495
I4	0.832	0.628	0.658	0.752	0.778	0.803	0.882	0.556
NC1	0.567	0.368	0.443	0.714	0.479	0.809	0.588	0.457
NC2	0.826	0.604	0.613	0.782	0.693	0.911	0.775	0.591
NC3	0.67	0.525	0.599	0.641	0.572	0.813	0.656	0.495
NC4	0.554	0.393	0.516	0.71	0.437	0.802	0.534	0.433
UV1	0.67	0.612	0.618	0.556	0.69	0.556	0.698	0.916
UV2	0.69	0.542	0.562	0.655	0.632	0.648	0.641	0.9
UV3	0.405	0.441	0.38	0.376	0.393	0.391	0.382	0.838
UV4	0.351	0.459	0.418	0.448	0.387	0.417	0.333	0.816

7.4 Structural model

The researchers evaluated the path coefficients and their significance (Hair, Ringle, & Sarstedt, 2011) using bootstrapping with 1,000 resamples, and the findings are shown in Table 6.

Table 6: Hypotheses Testing

	Original Sample (O)	Sample Mean (M)	Standard Deviation (STDEV)	T Statistics (|O/STDEV|)	P Values	Decision
H1: 3D printed food characteristics -> Utilitarian value	0.676	0.715	0.154	4.388	0.000	Supported
H2: 3D printed food characteristics -> Hedonic value	0.845	0.86	0.03	27.823	0.000	Supported
H3: Utilitarian value -> Attitude	0.144	0.188	0.143	1.004	0.316	Not Supported
H4: Hedonic value -> Attitude	0.786	0.746	0.131	5.978	0.000	Supported
H5: Attitude -> Purchasing intention	0.833	0.843	0.059	14.077	0.000	Supported

H1: 3D printed food attributes have a positive and significant effect on consumer perceptions of the utilitarian value of 3D printed food.

According to the Table 6, correlation coefficient found as 0.676 between 3D printed food attributes and Utilitarian value. It denotes that Hypothesis 1 is supported at 97.5% confidence level (see Table 7), and the relationship is significant (see Table 6). Therefore, it concludes 3D printed food attributes have a positive and significant effect on utilitarian value, which emphasized that Hypothesis 1 is proved.

H2: 3D printed food attributes have a positive and significant effect on consumer perceptions of the hedonic value of 3D printed food

The denoted positive correlation coefficient of 0.845 which is considered the highest correlation coefficient found amongst the five correlation coefficient values (see Table 6) and the higher T statistics value of 27.823 as well as P value of 0.000 indicates that 3D printed food attributes and Hedonic value have a significant relationship, where it supported at the 97.5% confidence level (see Table 7). Therefore, it emphasized that Hypothesis 2 is proved.

H3: Perceived utilitarian value regarding 3D printed foods has a positive and significant effect on consumer attitudes toward 3D printed foods.

The correlation coefficient found between perceived utilitarian value and attitude is 0.144 (see Table 6), while the P-value is 0.316 which means that it is higher than 0.05. Therefore, Hypothesis 3 is not accepted.

H4: Perceived hedonic value regarding 3D printed foods has a positive and significant effect on consumer's attitude toward 3D printed foods.

The correlation coefficient found between perceived hedonic value and attitude is 0.786 (see Table 6), and the relationship between the two variables are significant. In addition, Table 7 indicates that relationship between the two variables is acceptable at 97.5% confidence level. Therefore, Hypothesis 4 is acceptable.

H5: A Consumer's attitude toward 3D printed foods has a positive and significant effect on their intention to purchase

Attitude and the intention to purchase 3D printed food were shown to be significantly correlated, with a correlation coefficient of 0.833 (see Table 6). Additionally, Table 8 shows that at a 97.5% confidence level, the association between the two variables is satisfactory. As a result, Hypothesis 5 is accepted.

Table 7: Confidence Interval

	Original Sample (O)	Sample Mean (M)	2.50%	97.50%
3D printed food characteristics -> Utilitarian value	0.676	0.715	0.375	0.92
3D printed food characteristics -> Hedonic value	0.845	0.86	0.808	0.928
Utilitarian value -> Attitude	0.144	0.188	-0.017	0.465
Hedonic value -> Attitude	0.786	0.746	0.492	0.943
Attitude -> Purchasing intention	0.833	0.843	0.717	0.94

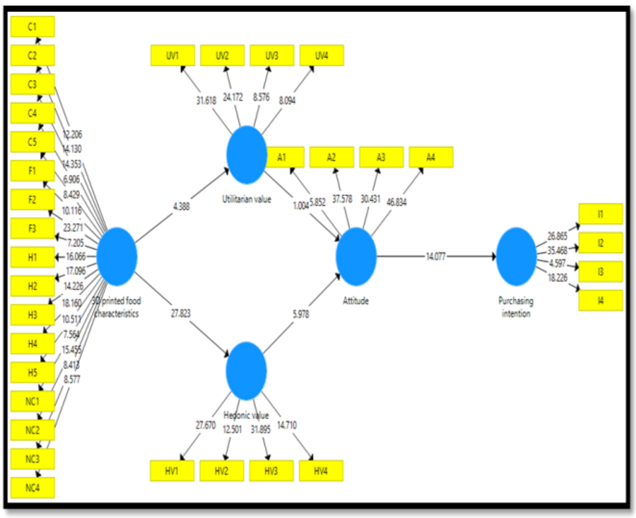

Figure 3: Path Analysis Model

Figure 4: Path Coefficients for the five variables

8. Discussion

8.1 Theoretical implications

This study is the first to shed light on the relationships between 3D printed food characteristics, the perception of value (utilitarian and hedonic), attitude, and 3D printed food purchasing intentions in Egyptian restaurants. First, 3D printed food attributes lead to the perception of hedonic and utilitarian values. Results revealed a positive link between 3D printed food characteristics and hedonic value. The characteristics of 3D-printed food may also stimulate consumers to buy it. Besides, this technology can be used to market food items in restaurants that provide funds in return for their dishes (Lupton & Turner, 2016). This may help consumers, especially the elderly, who need special qualities in food that they can eat (Zulkowski, 2006). This model may support the sustainability of food and decrease food waste (Baiano, 2020). Moreover, the results found that 3D printed food may not affect the consumers' utilitarian value. A possible explanation for this result is that the customers perceive this type of food as difficult to produce.

Given the great development potential of 3D food printing technology, it is crucial to understand how customers value 3D printed food. This research focused on determining what characteristics of 3D printed food do in order to better understand how customer perceived values affect attitudes and purchase intentions toward 3D printed food within the VAB model. These results have numerous significant theoretical implications, which are demonstrated below:

This study added 3D printed food attributes to the VAB model and found that they have a positive and significant effect on perceived utilitarian and hedonic values. This result is agreed with Yu et al. (2018), which found that the quality attributes of green restaurants lead to the intention of customers to visit them.

Consumers' favorable attitudes and purchase intentions regarding four particular characteristics of 3D-printed food were empirically confirmed as they are the key factors influencing customer perception of value. These characteristics include fun, creativity, natural content, and health advantages. Additionally, it is explored that the four characteristics of 3D-printed food considerably enhanced its hedonic value. The results of this study confirmed the study presented by Cronin et al. (2000) and emphasized the important role the product qualities play in determining customer perceptions of value. Such effects have received a lot of support in a number of fields and have been well shown in the context of 3D printed foods.

This study revealed that an important driver of customers' favorable attitudes toward 3D-printed food was consumer perceived hedonic values. Moreover, this study revealed that there was no relationship between utilitarian value and attitude, and this agreed with the study of Lea and Worsley (2005), who found that there was only a weak and unsupported correlation between consumer attitudes toward organic food and perceived value. Furthermore, Kwun (2011) found no correlation between perceived value and customer attitudes toward on-campus dining services.

Therefore, while customers have a perceived utilitarian value, this perception does not affect their attitudes. The study shows that even if customers have little experience with 3D printed food, once they begin to understand its benefits, their views become more relevant. In addition, this research analyzed consumers' perceived values concerning 3D food printed using a 2D method involving utilitarian and hedonic values and discovered that hedonic value had a stronger influence on the attitudes of customers toward 3D printed food. By comparing this unique finding with the latest relevant research, which revealed that utilitarian value had a more positive impact than hedonic value on consumers' attitudes towards functional food; it provides new insights into innovative creativity based on consumer value for food (Nystrand & Olsen, 2020).

By offering a new and more empirical understanding of how consumer attitudes and purchase intentions can be formed toward 3D printed food in association with its product attributes and consumer perceived value, these findings offer specific and distinctive contributions to the body of knowledge on technology-based food development.

8.2 Practical implications

This research offers new perspectives for marketers and decision-makers. For instance, showing a new type of food in the advertisement is one of the acceptable promotions and can encourage more customers to try it. According to the results, marketers should take into account the characteristics of 3D printed food, which are healthfulness, fun, creativity, and natural content, when marketing this new food. For example, if marketers or decision makers want to promote 3D printed food, advertisements that show customers eating the novel food with values that return to them may be effective.

Second, as most customers today prefer eating healthy food (Baiano, 2020), restaurant decision makers should clarify the healthfulness side of 3D printed food as it can contain more proteins and fibers. Moreover, markers should clarify that this new technology contains natural content and is free of additives. Furthermore, restaurants that have this type of technology will attract the segment of older people who need the special requirements that this type of food can offer.

Third, this type of technology can attract customers who look for creativity. It can help them mix the materials they want. Also, it can help those trying new tastes by mixing more than one taste. It also helps the customers try new methods of cooking and new recipes. Fourth, this technology is environmentally friendly as it decreases waste and leftovers. Therefore, policymakers in Egypt should support this technology by decreasing the taxes for importing it.

8.3 Limitations and future research

The study's measurements and data sampling are mostly responsible for its limitations and suggestions for further research. First, this study modified the previous characteristics of food from the literature; while people are adapting rapidly to new technology, 3D printed food may have other characteristics that should be investigated in the future. Therefore, it would be interesting to discover other characteristics that could be added to the four traits examined in the research. Second, because people in their 20s and 40s made up the bulk of the research sample, future studies must make use of more accurate data from other age groups as well. Third, more study is required to examine various moderating effects and evaluate them using the VAB model in order to provide a fuller understanding of customer perceived values, attitudes, and purchase intentions regarding 3D printed food.

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