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# Impact of Internal and External Factors on the Purchasing Behaviour of Customers in the Hotel Industry Context: Does 3D-Printed Food Matter?

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**Abstract**

The main goal of this study was to examine how the both internal and external factors (IEF) affect hotels adoption to 3D food printing technology. Furthermore, the study aimed to do an empirical investigation into the possible mediating role of hotels adoption to 3D-printed food (3DPF) between (IEF) and the purchasing behavior of customers (PBC) in Egyptian hotels. In order to find out what the chosen customers thought about the study's components (IEF, 3DPF, and PBC) a questionnaire was created and distributed to them. The questionnaire was designed with four main factors in mind: (1) study participant demographics; (2) internal and external factors; (3) 3D-printed food; and (4) Customer purchasing behavior. The study hypotheses were investigated using the bootstrap technique in structural equation modelling (SEM). The study's findings demonstrated that understanding the both of internal and external Factors for implementing 3D food printing technology significantly help the hotels to adopt 3DPF and improved the purchasing decisions and use of 3D-printed food among the research sample's customers. Furthermore, it has been discovered that 3D-printed food has a considerable and partial impact on the relationship between both internal and external factors and purchasing behavior. Based on these results, a set of recommendations were developed for applying 3D food printing technology in Egyptian hotels.

## 1. Introduction

Three-dimensional (3D) food printing is a rapid prototype method based on computer-aided additive manufacturing (Wang *et al.*, 2022). 3D food printing creates food layers by ayers to create personalized products with the right texture, flavor, shape, and size. Numerous customer categories, such as kids, the elderly, expectant mothers, sports, sick, and so forth, are catered to by this. Patients with dysphagia may find that 3D-printed food items match their original form and pique their appetite, allowing them to eat with honor (Pant *et al.*, 2021). Foods for people with dysphagia, a condition of swallowing brought on by pharyngeal or esophageal issues, must be risk-free and gentle enough to chew and swallow. Conventional diets that are mashed, pureed, or in a thick liquid are not visually appealing and do not stimulate the appetite well (Xing *et al.*, 2022). This emphasizes how urgently soft, form-fitting, and nourishing foods are needed for those with dysphagia. At the moment, beef sauce (Dick *et al.*, 2021), mashed veggies (Pant *et al.*, 2021), dark mould (Xing *et al.*, 2022), etc. are among the materials that can be 3D printed for dysphagia diets. Unfortunately, regarding the high quality and high shape fidelity of 3D printed surimi for dysphagia diets, no research has been conducted. This is likely because it is difficult to meet both the printing shape retention and the dysphagia property, which makes it suitable for patients with dysphagia who have trouble chewing, swallowing, and digesting food. The implementation of 3D printing technology has the potential to significantly benefit the food sector. It can be leveraged to produce personalised food designs, digitally personalise nutrition, optimise the supply chain, and expand the range of food ingredients available. With the help of this technology, common people can produce some amazing and intricate food designs that are impossible to accomplish with manual labour or traditional moulds. These designs are created using predetermined data files that contain the artistic and culinary expertise of chefs, nutritionists, and food designers, as well as culinary knowledge (Sun *et al.*, 2015c). It can also be used to produce custom candy forms and colorful images on the surface of solid edible substrates (Zoran and Coelho, 2011). Additionally, 3D food printing enables the digitally and individually customize an individual's nutritional needs based on their current state of nutrition and well-being (Wegrzyn et al, 2012; Sun et al., 2015c; Yang et al., 2015; Severini and Derossi, 2016). The conventional food supply chain may be made more efficient with the use of 3D food printing. When this method is widely used, manufacturing will gradually move to more customer-friendly locations and there will be less need for transportation, which will reduce the cost of overriding, packaging, and distribution (Sun et al, 2015b; Chen, 2016; Jia *et al.*, 2016). By employing non-traditional food components, including insects, high-fiber plant-based materials, and plant- and animal-based byproducts (Severini and Derossi, 2016).

The food industry is heavily investigating 3D printing. The attainment of accurate and exact printing has been the subject of few studies, despite the fact that it is essential to the effective and seamless printing of food products. The objectives of this study are to gather and examine data on how to accomplish precise and accurate food printing, to examine the use of 3D printing in various food-related fields, to make some recommendations, and to offer an insightful analysis of the issues and developments surrounding 3D food printing. In light of the aforementioned reasoning, we thus developed two research questions, which are detailed as follows:

- **RQ1:** What are the internal and external factors influences affect hotels adoption to 3D food printing technology?
- **RQ2:** Are hotels adoption to 3D food printing technology impacts on customers' purchasing behavior?
- **RQ3:** How does 3D-printed food operate as a mediator in the interaction between customers' purchasing behavior and internal and external Factors for adoption?

## 2. A Literature Review

### 2.1. 3D food printing technology and elements impacting the accuracy of printing

According to Liu *et al.,* (2017), 3D food printing is a flexible technique that allows for the creation of personalised meals with precise textures, forms, and sizes. It is based on computer-aided additive manufacturing. This strategy has a lot of uses when it comes to serving a variety of customer demographics, including kids, elderly people, pregnant women, athletes, and patients. For instance, food designed for people with dysphagia that is 3D printed closely resembles the original food, greatly enhancing the eating experience (Pant *et al.*, 2021). Hydrocolloids, mashed vegetables, beef sauce, black fungus, pork, and surimi are among the materials for 3D printing in dysphagia diets (Zhu *et al.,* 2023). The originality of this technique goes beyond its conventional printing module to include thermal- and nonthermally assisted processing modules, allowing for simultaneous printing and cooking to reduce the danger of microbial contamination (Guo *et al.,* 2023). The use of hot-extrusion 3D printing to produce whole-grain, highland barley-prepared biscuit is an illustration of this progress (Guo *et al.*, 2023).

There are now four main types of 3D printing methods used in the food industry: inkjet, binder jetting, Selective Sintering Printing (SLS), and extrusion-based printing. Hot-melt chocolate and soft materials like dough, mashed potatoes, and meat puree are frequently extruded using extrusion-based printing (Engmann and Mackley, 2006; Yang *et al.*, 2015). As mentioned before, the material properties, processing factors, and post-processing methods all have an impact on the precision and caliber of printed goods. There are benefits and drawbacks to each 3D food printing method. Table 1 compares various 3D printing methods and the variables that impact printing accuracy and precision.

**Table 1: Disparities in 3D food technology comparison.**

| | | Printing with extrusion | Particularized laser sintering | Binder jetting | Inkjet printing |
|---|---|---|---|---|---|
| | **Available material** | Chocolate, soft materials like pureed meat, cheese, and dough. | Powdered ingredients like chocolate, sugar, and fat. | Powdered ingredients such as, protein, sugar, and starch, as well as liquid binder. | Low-viscosity substance, like pizza sauce. |
| **Elements that impact printing accuracy** | **Material characteristics** | Mechanical strength and rheological characteristics. | Particle size, wettability, melting temperature, and flow ability | Particle size, wettability, flow ability, viscosity, and surface tension of the binder. | Surface characteristics, compatibility, and rheological qualities of ink. |
| | **Factors involved in processing** | Nozzle movement rate, printing height, printing rate, and nozzle diameter. | Laser spot diameter, laser thickness, scanning speed, laser power, and laser energy density. | Layer thickness, nozzle diameter, printing rate, and head kinds. | Printing height, nozzle diameter, printing rate, and temperature. |
| | **after processing** | Controlled addition and recipe | Elimination of superfluous components. | Baking, heating, coating the exterior, and trimming away extra material. | No |
| | **Benefits** | Simpler gadgets mean, more material possibilities. | Intricate 3D food creation with a range of textures. | Intricate 3D food construction, unlimited colour possibilities, and a range of tastes and textures. | More options for materials, higher-quality printing, and quicker production. |
| | **Restrictions** | Incapable of creating intricate culinary patterns and has trouble supporting three-dimensional structures during post-processing. | Fewer ingredients, lower-quality goods. | Products with less nutrition and little material. | Simple food design that is limited to picture adornment or surface filler. |
| | **Items*** |  |  |  |  |

The following website provided the product images: (a) To find out more about Natural Machines Co., go to https://www.naturalmachines.com. (b) TNO (c) Three Dimensions Systems Co., available at https://www.threedimensions.com/gallery/culinary (d) Systems for Food Jet Printing: To find out more, go to http://www.foodjet.com.

### 2.2. Utilizing 3D printing for food in some niche markets

- **Elderly food**

Ageing populations are an issue in several nations, including Sweden, Canada, and Japan. Gnawing and consuming difficulties impact 15%–25% of older persons over 50 and up to 60% of residents in nursing homes (Sun *et al.*, 2015a). Unappealing porridge-like food is frequently given to patients with this illness, which can result in nutritional deficits and appetite loss. The performance project, which seeks to create an automated production procedure and offer individualised and particularly food with texture using Technology for 3D printing, has received funding from the EU (European Union) in order to address this issue (Davide and Xavier, 2018). As part of the experiment, scientists have built simulation foods that mimic real foods' textures and tastes, like gnocchi and peas. The soft, pureed nature of these foods makes them easier for the elderly to swallow, in addition to making them a favourite meal. Additionally, based on each person's unique age, physical condition, and dietary and energy needs, customised nutritional meals can be prepared (Severini and Derossi, 2016; Davide and Xavier, 2018).

According to a performance survey on 3D printing food in assisted living facilities, 54% of respondents thought the food had a good texture, 79% believed it was comparable to food prepared using a traditional methods for cooking, and 43% stated they favoured food printing in cases of dysphagia. A few of nursing establishments in Germany printed soft meals for senior citizens who had difficulty chewing and swallowing (Wiggers, 2015). The more delicious Plates made with 3D printing consisting of peas, mashed potatoes, and broccoli have made a successful debut on the market, and 1000 organisations around the country regularly Prepare this kind of food item. (Wiggers, 2015).

### 2.3. Obstacles of 3D food printing technology

Researchers have been working very hard lately to bring 3D food printing to the food business. However, a number of obstacles still stand in the way of this technology's widespread application in the food industry. 1) Printing with accuracy and precision 2) Productivity of the process 3) the creation of vibrant, multifaceted, multiflavor products.

Printing accuracy and precision are critical for the food industry's use of 3D printing technology. One advantage of 3D printing is its capacity to produce eye-catching and captivating structures for consumable products, stimulating customer curiosity and appetite. Still, there aren't many published publications that concentrate on printing accuracy. To produce a precise and accurate print, consideration should be given to material characteristics (such as rheological characteristics, particle size, etc.), process parameters (such as nozzle diameter, printing speed, printing distance, etc.), and post-processing techniques (such as baking, frying, cooking, etc.).More work needs to be done to ensure accurate and exact printing. Lower production costs might result from increasing production efficiency. Using bigger nozzle or laser diameters and speeding up printing are two basic ways to boost process productivity. But this frequently results in a decrease in the accuracy and clarity of printed goods, which puts 3D printing of food in a difficult situation. We emphasise that in order to achieve sufficient printing precision, a big nozzle diameter and rapid printing speed should be used. Another way to boost printing productivity is to use multi-nozzle printers to create multiple objects at once. However, doing so will definitely increase the technological challenge and complicate the control system. For this reason, high process productivity and accurate printing require a great deal of study.

Since people's experiences with food are greatly influenced by its color, flavor, and texture, it is vital to create a 3D edible structure with these desired characteristics. While there have been multiple attempts (Hasseln, 2013; Hasseln *et al.*, 2014) to create food products with various flavours, textures, and colours using 3D printing technology, these endeavours have not been generally adopted. Therefore, creating food products with a range of flavours, hues, and textures merits more attention.

### 2.4. 3D Printing Technology SWOT Analysis

Every new technology carries with it both advantages and disadvantages. Notwithstanding the significant implications that 3D printing technology holds for the building, industrial, military, and medical sectors, numerous technological and legal obstacles still outweigh the advantages of this technology. Concerning topics that require attention include patenting and intellectual property law, environmentally friendly and sustainable development, and design certification and standardization. Certain guidelines and policies while implementing both technologies stay largely the same since the processes involved in both technologies are extremely comparable. Risks, such as those related to public safety, ethics, and intellectual property rights, must be appropriately managed in addition to the advantages (Al-Rodhan, 2014).

For every business, individual, or product, a SWOT analysis is conducted. This procedure entails defining the purpose of any project and determining which external and internal Factors are appropriate and inappropriate for achieving that goal. The SWOT analysis of 3D printing technology, as presented in Table 2, identifies both external and internal positive and negative variables (Gurung, 2017).

Table 2: 3D printing's SWOT analysis

| Strengths (positive, internal forces) | Weakness (negative internal Factors) |
| --- | --- |
| 1. The efficiency of the material and manufacturing process, as well as smart (programmable) materials.<br>2. A prognosis for positive market growth.<br>3. Colour print with multiple materials.<br>4. Time-effective. | 1. Advances in 3D printing technology.<br>2. Limited and pricey smart material.<br>3. Expensive printer hardware that might prevent the general population from using it.<br>4. Needs a controlled environment and specialised personnel |
| **Positivity in external Factors as opportunities** | **Threats (negative, external Factors)** |
| 1. Aids with logistics and transportation issues.<br>2. Aids in transportation and logistical issues.<br>3. Beneficial for medical implant applications.<br>4. The idea of a smart city, including its structures.<br>5. 4D printing. | 1. Compatibility of machines<br>2. Health issues, public safety, and environmental effects.<br>3. Rights to intellectual property: copyright, patents, and trademarks.<br>4. System susceptible to software piracy and hacking. |

**Source**: Gurung (2017).

While it is well recognized that foods created using 3D printing technology are enjoyable, inventive, healthful, and nourishing, a sizable percentage of study participants, according to Lupton and Turner (2016), believed that 3D printed meals included a lot of unknown components. They indicated that people frequently view the manufacture of foods with distrust, even when they seem to be quite comparable to foods that people are familiar with. Participants evaluated whether 3D foods were sufficiently "real" or "food-like" in later research. They revealed that the look and feel of the 3D-printed food were two important elements influencing their responses to the food products (Lupton and Turner, 2018). Brunner *et al.* (2018) shown in another study that after customers were informed about the four aspects of food items produced with 3D printing-fun, convenience, nutritional and health knowledge—their attitudes towards the meal were positively influenced. Thus, based on those previous studies, this study incorporated four characteristics (health, fun, creativity, and natural content) as selection attributes for 3D-printed food, assuming that these traits cause customers to perceive both utilitarian and hedonic value. Therefore, the following hypotheses were proposed:

**H.1.** Purchasing behavior of customers in hotels are significantly influenced favourably by both internal and external factors.

**H. 2.** 3D-printed food in hotels is significantly improved by both internal and external factors.

### 2.5. Purchase behavior intentions, values, and attitudes towards food produced via 3D printing

Values as perceived of customers express their opinions, level of satisfaction, and brand loyalty. Through the mediation of attitudes, customer perceived values influence how their behavior is formed (Homer and Kahle, 1988; Kalof *et al.,* 1999). (Scholderer et al., 2004; Lea and Worsley, 2005; Chen, 2007) conducted an initial study that produced a food-related lifestyle model, wherein food consumption behaviors are influenced by values and attitudes. Applying this food-related lifestyle model, additional researches have demonstrated strong relationships between attitudes towards food choices and perceived value.

Customer attitudes are defined as an individual's fondness or distaste for particular goods, services, or items. They represent the opinions, judgements, and convictions of a person towards a particular service or product (Fishbein and Ajzen, 1977). Attitudes towards purchasing a certain good or service are defined by (Shim *et al.,* 2001;Tarkiainen and Sundqvist, 2005) as assessing the probability of purchase based on the customer's favourable or unfavourable preference for, perception of, and interest in the purchase target. Therefore, attitudes can be described as customers' inclination to express favourable or negative emotions to the product (Chang and Liu, 2009).

According to Eroglu and Harrell (1986), intentions are the likelihood that a person's beliefs and attitudes will be carried out by their planned or anticipated future behavior. Purchase intentions are an intermediary variable that sits between attitudes and actual behavior, and attitudes are widely recognised as an important determinant of inclinations to purchase (Bianchi, 2017). Purchase intentions, which indicate customer propensity to buy particular products or services, are therefore frequently used to gauge actual purchase behavior (Tsiotsou, 2006). This conversation has led to the hypothesis that attitudes towards Foods manufactured in 3D are impacted by customer- values as perceived, such as hedonic and utilitarian values, and that these views in turn influence purchase intentions. As a result, the following theories were developed:

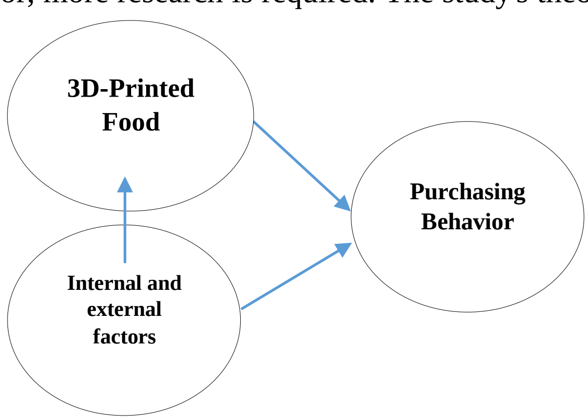
**H. 3.** The purchasing behavior of customers in hotels is significantly and favourably impacted by 3D-printed food.

Customers today are exposed to a variety of modern food technologies, such as food irradiation, nanotechnology, and genetic manipulation of food (Rollin *et al.,* 2011; Siegrist, 2008). Customers are hesitant to adopt these food innovations because they perceive hazards, even if the scientific community has demonstrated their safety (Cox *et al.*, 2007; Frewer *et al.*, 2011; Ronteltap *et al.,* 2007). Customers' negative attitudes towards innovative food technology and increased demand for natural foods are a result of these perceived hazards (Rozin, 2005). In light of this, Cox and Evans (2008) created the Food Technology Neophobia Scale (FTNS), a psychological diagnostic instrument for identifying neophobia related to food technology. The acceptability of novel food technology by an individual has now been widely assessed using FTNS (Evans *et al.*, 2010).

People's opinions on eating 3D-printed food may differ depending on how naive they are about food technology and food neophobia, as they are not yet familiar with the concept. As a result, even when they have comparable opinions on the qualities of 3D-printed food, people who have a strong tendency towards The types or degrees of perceived value that differ between food neophobia and food technology neophobia may arise from the purchase of 3D-printed food. This leads us to believe that 3D-printed food's effects features on customer perceived value would be greatly regulated by food neophobia and neophobia in food technology. In Figure. 1, these proposed correlations are shown. As a result, the following theories were developed:

**H.4.** In the context of the hotel business, 3D-printed food significantly mediates the relationship between internal and external factors and the purchasing behavior of customers.

Drawing from the extant literature on the relationship between internal and external Factors, Customer Purchasing Behavior, and 3D-Printed Food, our aim is to examine not only the direct influence of IED on PBC within the hotel sector, but also the indirect consequences of IED via the intermediary role of 3DFP. To fully comprehend the mechanisms underlying this link in the context of the hotel sector, more research is required. The study's theoretical framework is shown in Figure 1.




Fiqure1: The conceptual model for research

## 3. Materials and Methods

### 3.1.Metrics and instrument development

In order to conduct this study, information was gathered via a questionnaire that was mostly filled out by participants. We discovered dependable scales that have been applied frequently after examining the structures of current research. We developed a four-part standard questionnaire using these scales. The basic demographic data of the participants, including age, gender, and level of education, was covered in the first half of the questionnaire.

In the second section, participants rated how much they agreed or disagreed with statements on three dimensions using a five-point likert scale that ranged from strongly disagree at 1 to strongly agree at 5 points. the first dimension, "internal and external factors," included the following: 1) smart material and efficiency of material and manufacturing process, (2) positive market growth forecast and time more efficient, (3) multi-material and color print, (4) expensive smart material and limited, (5) expensive hardware (printer) that may restrict public from using it, (6) helps logistic problems, transportation, (7) concept of smart city, buildings and structures and5d printing, (8) machine compatibility,(9) public safety and health problems and impact on environment. This measure was adapted and used by Gurung (2017).

The items in the second sub-dimension of 3d-printed food are: (1) 3d-printed foods are a healthier option, then we can deal with the problem of elderly people having trouble swallowing (dysphagia). (2) food can be created to minimize chemicals and preservatives while meeting each person's specific nutritional needs; (3) the experience of consuming 3d printed foods is engaging and enjoyable; (4) customers find the concept of printed food intriguing and fun; (5) chefs and home cooks can experiment with intricate shapes and textures, enhancing culinary creativity and attractiveness. (6) By printing food, we may make vegetables in visually appealing sizes and forms to encourage kids to eat more veggies. this tool has been modified and utilised by Brunner *et al.* (2018), Mantihal (2019), Baiano (2022), Caulier *et al.* (2020, and Mavr *et al*. (2023). the third sub-dimension refer purchasing behavior, this dimension include; (1) regarding food that is 3d printed, I feel optimistic, (2) my attitude towards buying food that has been 3d printed is excellent, (3) my perspective on buying food that has been 3d printed is really positive, (4) I want to purchase food that is 3d printed, (5) I want to purchase food that is 3d printed, (6) there's a good probability I'll buy food that has been 3d printed. this measure was adapted and used by (Fishbein and Ajzen 1977; Chen, 2007; lee *et al.*, 2015).

Following their preparation in English, the survey's contents were translated into Arabic in order to get feedback from native Arabic speakers. A similar questionnaire was then translated into English from Arabic once more to make sure the meaning of any word is was modified. In addition, five academics with expertise in hospitality evaluated the questionnaire's content and provided feedback to confirm its validity. This helped to guarantee that the research tool accurately measured the constructs intended to measure the study's variables. In addition, to evaluate the questionnaire's viability and determine whether it was appropriate and cohesive, in addition to whether the questions were easily understood, consistently presented, and well-defined, a pilot research was conducted on 25 hotel guests who were not included in the study's main sample. Based on suggestions from the test participants, a few modifications were made to the questionnaire's wording. The placements of a few statements were also adjusted. The

Cronbach's alpha for the research dimension scale was 0.906, indicating a very high level of reliability and internal consistency.

### 3.2.Data gathering and sampling

This research study's main aim is to examine how customer purchasing behaviors at a range of four- and five-star hotels in Egypt are influenced by internal and external factors. The possible mediating role of 3D-printed food in this association is also examined in this study. In order to accomplish this, a questionnaire was created and distributed to the selected clients in order to find out how they felt about the three main areas of the study—internal and external factors, purchasing behavior, and 3D-printed food.

Hair *et al.* (2014) criteria were used to select a suitable sample size. They offered suggestions for calculating the ideal sample size by totaling the variables under examination. At the very least, a variable-to-sample ratio of 1:10 is adequate. This study required a minimum of 210 participants owing to the large number of variables (21 total). The 397 participants in our study provide an adequate sample size. According to the legitimate responses gathered from the research participants (397), 35% of the analysed persons were female (N = 139), and over three-quarters of the people who were evaluated (65%) were male (N = 258). Those from 20-30 made up the largest group (50.6%, N = 201) in terms of age. According to the research, 59.9% of the participants (N = 238) had a bachelor's degree.

The participants were made aware that taking part in the research was completely voluntary. A consent form was given to them to sign before they could take part in the study. Given that CMVs are conceivable, the participants were requested to complete the questionnaire on their own. The potential risk of CMV was reduced because the participants were given the assurance that their information would be kept confidential and utilised only for the study. As there was no "right" or "wrong" response, participants were requested to be totally honest. Furthermore, a common and simple statistical technique (Harman's single-factor test) was used to identify CMV. The information was collected over a duration of about two months, from February to March of 2024.

### 3.3.Data Analysis

The data was analysed using Amos version 24 and SPSS version 24. In order to verify the research components of the study and to depict the demographics of the respondents, descriptive statistics like percentage, mean, and frequency were used. Common Method Variance was detected by Harman's single-factor test (CMV). Cronbach's alpha and confirmatory factor analysis (CFA) were employed to confirm the reliability and validity of the measurement devices. By calculating the composite reliability (CR) and average variance extracted (AVE), convergent validity was verified. Investigations were conducted into the heterotrait-monotrait ratio (HTMT) and the Fornell-Larcker criteria for discriminant validity. After developing several hypotheses regarding the study's variables, we used structural equation modelling (SEM) with the assistance of the bootstrapping technique to determine the direction and interrelationships of the variables.

## 4. Research findings

### 4.1.Characteristic statistics

The following are the mean values for all research study variables: Participants showed agreement on the majority of the evaluated issues, with an with an average rating of (Strengths= 4.20-SD; 0.80; Weaknesses=4.05-SD;.96; Opportunities=3.82-SD; 1.12; Threats=3.82-SD; 1.07;

Health=4.41-SD;.71;Fun=4.42-SD;.64; Creativity=4.32-SD;.74; Attitude=4.30-SD;.76; Purchasing Intention=4.00-SD;.68).

**4.2.Model of Measurement**

As indicated before, a self-administered questionnaire was used to collect the data. Thus, a common the variance/bias (CMV) method was established by Harman's single factor test (Rodríguez-Ardura and Meseguer-Artola, 2020). The data demonstrated that every variable (more than 50%) of the variation was not an issue, suggesting that the CMV does not suggest an issue. The study's constructs were examined for accuracy and stability using a maximum probability CFA. Table 3 demonstrates that both the latent variable CR and Cronbach's alpha have values above the 0.80 acceptable internal consistency cutoff value. (Rodríguez-Ardura and Meseguer-Artola, 2020).

Convergent and discriminant validities were also used to investigate construct validity (Chin, Gopal, and Salisbury, 1997). A factor loading of at least 0.50 and an average variance extracted (AVE) of greater than 0.50 are necessary for convergent validity. (Duckworth and Kern, 2011). Convergent validity was achieved since all of the research objects had factor loadings greater than 0.50 and AVEs for each construct greater than 0.50. For a construct to have discriminant validity, the square root of the AVE of each construct must be greater than the correlation between that construct and another, as per the Fornell-Larcker criterion. Table 3 provides an illustration of how the square root of all the constructs in the AVE is more relevant than the correlations between the constructs.

**Table 3. Confirmatory factor analysis characteristics and reliability.**

| Variables | | Sup-Variables | Codes in Fig.3 | Code | Attributes | Factor Loading | Estimate^ | Theta | Sum (estimate) | Sum (estimate)2 | [1]CR | AVE[2] | MSV[3] | SQRT (AVE) | SQRT (MSV) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Independent variable | Internal and external determinant | Strengths | A11 | S1 | Smart material, efficiency of material, and manufacturing process. | 0.768 | 0.589 | 0.410 | 6.87 | 47.196 | 0.930 | 0.588 | 0.251 | 0.77٧ | 0.501 |
| | | | A12 | S2 | Positive market growth forecasts and time are more efficient. | 0.715 | 0.511 | 0.488 | | | | | | | |
| | | | A13 | S3 | Multi-material and colour print. | 0.618 | 0.381 | 0.618 | | | | | | | |
| | | Weaknesses | A21 | W1 | Expensive smart material and limited. | 0.879 | 0.772 | 0.227 | | | | | | | |
| | | | A22 | W2 | Expensive hardware (a printer) that may restrict the public from using it. | 0.724 | 0.524 | 0.475 | | | | | | | |
| | | Opportunities | A31 | O1 | Helps with logistic problems and transportation. | 0.749 | 0.561 | 0.438 | | | | | | | |
| | | | A32 | 02 | Concepts of smart cities, buildings and structures, and 5D printing | 0.8 | 0.64 | 0.36 | | | | | | | |
| | | Threats | A41 | T1 | Machine compatibility | 0.808 | 0.652 | 0.347 | | | | | | | |
| | | | A42 | T2 | Public safety and health problems and their impact on the environment. | 0.809 | 0.654 | 0.345 | | | | | | | |
| Mediating variable | 3Dfp | Health | B11 | H1 | 3D-printed foods are a healthier option, and we can address the issue of swallowing problems (dysphagia) among the elderly. | 0.772 | 0.595 | 0.404 | 4.072 | 16.581 | 0.841 | 0.483 | 0.544 | 0.702 | 0.741 |
| | | | B12 | H2 | Food can be created to minimize chemicals and preservatives while meeting each person's specific nutritional needs. | 0.801 | 0.641 | 0.358 | | | | | | | |
| | | Fun | B21 | F1 | The experience of consuming 3D printed foods engaging and enjoyable. | 0.857 | 0.734 | 0.265 | | | | | | | |
| | | | B22 | F2 | Customers find the concept of printed food intriguing and fun. | 0.606 | 0.367 | 0.632 | | | | | | | |
| | | Creativity | B31 | C1 | Chefs and home cooks can experiment with intricate shapes and textures, enhancing culinary creativity and attractiveness. | 0.526 | 0.276 | 0.723 | | | | | | | |
| | | | B32 | C2 | By printing food, we may make vegetables in visually appealing sizes and forms to encourage kids to eat more veggies. | 0.51 | 0.260 | 0.739 | | | | | | | |
| | | Attitude | C11 | N1 | Regarding food that is 3D printed, I feel optimistic. | 0.768 | 0.589 | 0.410 | | | | | | | |
| | | | C12 | N2 | My attitude towards buying food that has been 3D printed is excellent. | 0.866 | 0.749 | 0.250 | | | | | | | |

[1] **CR =** Composite Reliability
[2] **AVE** = Average Variance Extracted,
[3] **MSV7 =** maximum shared variance

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | C13 | N3 | My perspective on buying food that has been 3D printed is really positive. | 0.842 | 0.708 | 0.291 | | | | | | | |
| Dependent variable | Customer value- | Purchasing Intention | C21 | A1 | I want to purchase food that is 3D-printed. | 0.249 | 0.062 | 0.937 | 2.936 | 8.6200 | 0.690 | 0.367 | 0.010 | 0.602 | 0.103 |
| | | | C22 | A2 | I advise others to purchase food that is 3D printed. | 0.165 | 0.027 | 0.972 | | | | | | | |
| | | | C23 | A3 | There's a good probability I'll buy food that has been 3D printed. | 0.046 | 0.002 | 0.997 | | | | | | | |

Note: *** $p < 0.001$.

**Table 4. Correlation between constructs and discriminant validity according to the Fornell-Larcker standard.**

| the structure | IED | 3DPF | PBC |
|---|---|---|---|
| 1.Internal And External Factors | **0.777** | | |
| 2. 3D-Printed Food | 0.349 | **0.702** | |
| 3.Purchasing Behavior of Customers | 0.242 | 0.631 | **0.602** |

**Note:** The square root of the research constructs used by AVE is shown by bold diagonal numbers.

Furthermore, in accordance with Henseler, Ringle, and Sarstedt (2015), the model's discriminant validity was evaluated using the heterotrait-monotrait correlation ratio (HTMT). The authors found that when the HTMT value is more than 0.85, discriminant validity is weakened. All HTMT values were below 0.85, in accordance with Table 5's findings, indicating the existence of discriminant validity for every pair of latent components.

**Table 5. Validity of discrimination by HTMT.**

| the structure | IED | 3DPF | PBC |
|---|---|---|---|
| Internal and External Factors | | | |
| 3D-Printed Food | 0.221 | | |
| Purchasing Behavior of Customers | 0.198 | 0.194 | |

**Note:** Henseler et al. (2015) stated that the HTMT should be smaller than 0.85.

Table 3 presents statistical data indicating that the study's model fit was satisfactory. The model's fit is indicated by the following metrics: $x2/df = 2.480$, $p < 0.001$, incremental fit index (IFI) = 0.949, normed fit index (NFI) = 0.917, comparative fit index (CFI) = 0.948, Tucker-Lewis coefficient (TLI) = 0.938, root mean square residual (RMR) = 0.072, and root mean square error of approximation (RMSEA) = 0.061.

### 4.3.Modeling Structural Equations (SEM)

To follow the study's path and identify its causal relationships, SEM was utilised. Table 6 confirms Hair et al.'s (2014) findings that the study model fits the data well. The following were the goodness-of-fit indices: x2/df = 2.480, p < 0.001, RMR = 0. 072, RMSEA = 0. 061, TLI = 0. 938, NFI = 0. 917, IFI = 0. 949, and CFI = 0. 948. Table 4 details the direct effects of internal and external factors on customers' purchasing behavior with regard to 3D-printed food, whereas Figure 2 explains the indirect effects of these factors on customers' purchasing behavior. The study's findings support H1, indicating that IEF significantly improves PBC (β = 0.242, t-value = 5.084, p < 0.001). IEF significantly affects 3DPF to the same degree (β = 0.349, t-value = 6.113, p < 0.001). Thus, we agree with H2. Furthermore, there is support for the third hypothesis, which suggests that 3DPF has an impact on PBC (β = 0.631, t-value = 10.356, p < 0.001). It was looked into if 3DPF had an impact on how the IEF and PBC were interacting. This indirect association was confirmed through the use of a bootstrapping technique. Table 4 demonstrates that the indirect effect of IEF on the PBC through the 3DPF was favourable and statistically significant (β = 0.220, t-value = 4.064, p < 0.001). Consequently, we approve H4. A path analysis was carried out using partial and complete mediation techniques from Zhao et al. (2010) and Kelloway (1995) to look into the mediating role of 3DPF in the relationship between IEF and PBC. This shown that complete mediation can only be established when the indirect effects are large but the direct effects are not, and partial mediation can only be demonstrated when both channels are substantial. The SEM results indicate that the 3DPF serves as a partial mediator of the link between the IEF and the PBC.

**Table 6. Estimates of structural parameters.**

| Path Hypothesized | | Typical Path Coefficients | t-Value | Outcomes |
|---|---|---|---|---|
| Direct Path | | | | |
| $H_1$: IEF→PBC | | 0.242 | 5.084*** | Accepted |
| $H_2$: IEF →3DPF | | 0.349 | 6.113*** | Accepted |
| $H_3$: 3DPF → PBC | | 0.631 | 10.356*** | Accepted |
| Indirect path | | | | |
| $H_4$: IEF → 3DPF | PBC | 0.220 | 4.064*** | Accepted |

**Note:** A model fit is indicated by the following data: x2/df = 2.480 p < 0.001; CFI = 0.948; NFI = 0.917; IFI = 0.949; TLI = 0.938; RMR = 0.072; RMSEA = 0.061. *** P is less than 0.001. (PBC; customers' purchasing behavior; 3DPF; food printed using 3D technology); IEF; internal and external factors.

Standard Loading: CR is for composite reliability; AVE stands for average variance extracted standard loading; CFA stands for standardised factor loading; The data are fit by the composite reliability model: Root mean square residual (RMR) = 0.072; root mean square error of approximation (RMSEA) = 0.061; Tucker-Lewis coefficient (TLI) = 0.938; x2/df = 2.480; p < 0.001; comparative fit index (CFI) = 0.948; normed fit index (NFI) = 0.917; incremental fit index (IFI) = 0.949.

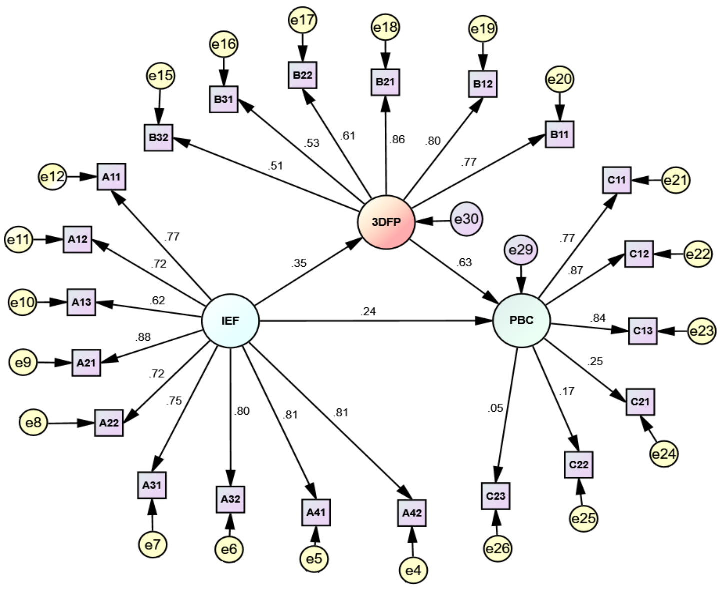



**Figure 2: Research conceptual model standardized estimates**

## 5. Discussion

In addition to examining the potential mediating role of 3D-printed food (3DPF) in this relationship, the primary goal of this research is to empirically examine the impact of internal and external factors (IEF) on the purchasing behavior of customers (PBC) in a selection of Egypt's four- and five-star hotels. This result agrees with what Lupton and Turner (2018) which showed that in a study, participants rated how "real" or "food-like" 3D foods were. They disclosed that two significant factors impacting their reactions to the food products were the appearance and texture of the 3D-printed food. These noteworthy deductions can be made in light of the findings of the research's tested hypotheses. First, the subsequent SEM results demonstrated that IED significantly and favourably influenced the purchasing decisions made by guests at the hotels under investigation. Second, the results of this study showed that IED greatly contributes to 3D-printed food in the context of the hotel sector when considering the interaction between IEF and 3DPF. Third, this study showed that 3DPF significantly improves customers' purchasing decisions. Last but not least, this study confirmed that 3DPF grows with internal and external factors, which in turn serves to improve customer purchasing behavior among hotel visitors. It also showed that 3DPF has a substantial, partial effect on the relationship between the two constructs. The mediating function of 3DPF on both internal and external factors as well as client purchasing behavior was also investigated in this study. This agreed with what was mentioned by Ronteltap, Van Trijp, Renes, and Frewer (2007), Cox, Evans, and Lease (2007), Siegrist (2008), Rollin, Kennedy, and Wills (2011), and Frewer et al. (2011). Which mentioned that modern food technologies that customers encounter include food irradiation, nanotechnology, and genetically modified food. Even though the scientific community has shown that many food innovations are safe, customers are reluctant to embrace them because they believe there are risks. These perceived risks have led to customer negative views towards cutting-edge food technology and an increase in demand for natural foods (Rozin, 2005).

## 6. Practical and Theoretical Repercussions

### 6.1.Theoretical Implications

This research has various theoretical ramifications. First, by offering a thorough grasp of the influence of IEF on 3DPF and customer purchasing behavior, the study's findings greatly add to the body of knowledge on IEF, PBC, and 3DPF in the context of the hotel industry. The study underscored the noteworthy direct influence of IEF on customer purchasing behavior. Second, the study's conclusions showed how important IEF is in encouraging 3DPF among hotel patrons. Third, the study demonstrated how important 3DPF is to improving customers' purchasing behaviors among hotel guests. The study found that customers who are more involved in making behavioral purchasing decisions related to 3D printed foods, such as purchasing foods printed in different shapes whose shapes can be controlled to suit different levels of health conditions and controlling the degree of softness of foods to suit other medical conditions, tend to obtain higher levels of 3D printed food, starting with 3D technology. This is likely due to the fact that accepting 3D-printed food increases the purchasing decisions of customers in the hotels in the research and study sample, this ultimately results in the development of more efficient methods regarding printed food technologies depending on the effectiveness of internal and external Factors. Fourth, the results of the study validated that 3DPF has a major mediating role in the link between IED and customer purchasing behavior. To the best of the writers' knowledge, this is the first empirical study that looks into 3DPF's intervening role in this relationship, especially in the context of the hospitality business in a developing nation (like Egypt). The development and validation of a new theoretical framework incorporating IEF, PBC, and 3DPF in the context of the hotel business is the fifth contribution. Given the importance of the results, this paradigm can serve as a guide for future studies exploring these links in various hospitality industry situations. Sixth, these results may provide a useful foundation for hospitality researchers to better comprehend the factors driving customer increased inclination to buy 3D food technologies inside the hotel industry.

### 6.2.Practical Implications

It is important to take into account additional practical implications for hotel operators, especially in destinations in Egypt. The study's conclusions validated that IEF significantly influences customers' purchasing behavior both directly and indirectly (via 3DPF). Furthermore, it demonstrated the important, partly mediating role of 3DPF in the link between IEF and PBC. Additionally, the study confirmed that 3DPF had a major positive impact on customers' purchasing behavior. Therefore, hotel management ought to promote a 3D-printed food culture at work in order to advance printed food technology and establish a setting where 3D printed meals can be served in a variety of client scenarios.

Hotel management needs to create and maintain focused policies and Programs that facilitate staff members' use of printed food technology. Some of these Programs include goal-setting that can be used to incentivize customers to use particular 3D food technologies and rewarding staff members financially whenever they successfully implement food technology. Additionally, by emphasizing dedication, behavioral modifications, and instruction in the use of contemporary technologies, executives should support hotel staff in implementing new food technology practices. They must also provide financial resources to purchase these technologies due to their high price. Furthermore, In order to encourage a sense of ownership and involvement, they ought to involve staff members in project planning initiatives. Additionally, offering chances for education and training can help staff members better grasp the contributions they can make to the effective application of 3D-printed food innovations. Asking staff members for suggestions and starting a conversation about procedures and guidelines that can lessen the detrimental effects that these technologies are having on customers is one efficient method to do this. The hotel can enhance the functionality of more recent printed food technologies without spending extra money on research and development by including staff members in this way. Therefore, by lowering the import duties, Egyptian politicians ought to encourage the use of this technology.

## 7. Limitations and Further Research

Many researchs constraints were discovered: Participants in this study were customers of four- and five-star hotels. It will be challenging to generalise these findings as a result. These findings, therefore, ought to be relevant to this particular segment of the hotel business. Future research could look at the attitudes of customers in other hotel industries and luxury hotels, as well as restaurants of all kinds and calibers and food service sections of hospitals with a diverse patient base, regarding the use of 3D-printed food technologies. Secondly, the study solely looked at one element—3D-printed food—as a mediating factor between the impact of external and internal variables on customer purchase decisions. Future studies could look into additional processes that could affect this link. Third, information was gathered through a self-administered questionnaire, allowing customers to provide truthful responses based on their personal experiences. Combining quantitative and qualitative methodologies may lead to potentially better insights in future research. Future studies should investigate various moderating effects and evaluate them using the VAB model. The first step in addressing customer perceptions and behavioral intentions of 3D printed food was taken by this study.

## 8. Conclusions

The first part of this study looked at the ways in which both internal and external factors affect customer purchase behavior. This research confirms the significant influence of internal and external factors in the hotels in the study sample on the purchasing behavior of customers. Likewise, we confirmed the indirect influence of internal and external factors of the organization on customers' purchasing behavior through the use of 3D-printed food. The relationship between internal and external factors and customers' purchasing behavior was only somewhat regulated by 3D-printed food, despite having a complete mediating effect, according to the data. This research found a clear relationship between internal and external factors and both customers' purchasing behavior and 3D-printed food. These results verify the main influence of internal and external factors in activating and encouraging the customer to make the purchasing decision for 3D-printed food. Managers encourage their employees to succeed in producing 3D-printed foods by providing them with passion, vision, and a clear desire from new customers to make the purchasing decision to buy those foods, and by adopting standards to achieve optimal success in using these 3D food technologies. Further proof that these initiatives have been successful in enhancing customers' purchasing behavior through the use of these technologies for 3D food in the hotel sector comes from the positive correlation that has been observed between 3D-printed food and customers' purchasing behavior.

## Statement of Data Availability

The original contributions made during the study are included in the article and supplementary material; for further details, get in touch with the corresponding author or authors.

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# تأثير العوامل الداخلية والخارجية على السلوك الشرائي للعملاء في سياق صناعة الفنادق: هل للأغذية المطبوعة ثلاثية الأبعاد أهمية؟

محمد أحمد السعيد
كلية السياحة والفنادق – جامعة المنصورة

هيثم الصوالحي
كلية السياحة والفنادق – جامعة مدينة السادات

**معلومات المقالة**

**الكلمات المفتاحية**
العوامل الداخلية والخارجية؛ سلوك الشراء؛ الأغذية المطبوعة ثلاثية الأبعاد؛ صناعة الفنادق.

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**المجلد ٢٧، العدد ١، (٢٠٢٤)، ص ٥٨-٧٨.**

**الملخص**

يعد الهدف الرئيسي من هذه الدراسة هو دراسة تأثير العوامل الداخلية والخارجية لتطبيق تقنية طباعة الطعام ثلاثية الأبعاد على تبني الفنادق لتلك التقنية. علاوة على ذلك، هدفت الدراسة إلى إجراء تحقيق تجريبي في الدور الوسيط المحتمل لتبني الفنادق المصرية الأغذية المطبوعة ثلاثية الأبعاد (DPF3) بين العوامل الداخلية والخارجية (IEF) المؤثرة في تطبيق تلك التقنية (كمتغير مستقل) وسلوك الشراء للعملاء (PBC) (كمتغير تابع). من أجل معرفة رأي العملاء حول متغيرات الدراسة – العوامل الداخلية والخارجية، وسلوك الشراء، والأغذية المطبوعة ثلاثية الأبعاد – تم تصميم استبيان وتوزيعه على العملاء عينة الدراسة. تم تصميم الاستبيان مع أخذ أربعة عوامل رئيسية في الاعتبار: (١) الخصائص الديموجرافية للمشاركين في الدراسة؛ (٢) العوامل الداخلية والخارجية؛ (٣) الأغذية المطبوعة ثلاثية الأبعاد؛ و (٤) سلوك الشراء. تم التحقق من فرضيات الدراسة باستخدام تقنية التمهيد في نمذجة المعادلات البنائية (SEM). أظهرت نتائج الدراسة أن فهم العوامل الداخلية والخارجية لتطبيق تقنية طباعة الأغذية ثلاثية الأبعاد يساعد بشكل كبير الفنادق على تبني تلك التقنية وتحسين قرارات الشراء واستخدام الأغذية المطبوعة ثلاثية الأبعاد بين عملاء عينة البحث. علاوة على ذلك، تم اكتشاف أن الأغذية المطبوعة ثلاثية الأبعاد لها تأثير كبير وجزئي على العلاقة بين العوامل الداخلية والخارجية وسلوك الشراء لدى العملاء. بناء على تلك النتائج، تم وضع مجموعة من التوصيات لتطبيق تقنية طباعة الطعام ثلاثية الأبعاد بالفنادق المصرية.