

METaverse IN FOOD PRODUCTION

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Abstract: The metaverse is an opportunity for processes to be improved and optimized and also a way for the user to integrate with the processes and be able to know, in fact, the product they are consuming. This article highlights the interaction of the metaverse with food production, whether from agriculture or the food industry itself. The effects that this new business model brings, are reflected in the costs and efficiency of industrial processes, leading to faster problem solving. The multiverse will also be able to provide the user with different experiences, whether gastronomic or tourism. Finally, the integration between consumer and industry is important, mainly, to ensure business transparency.

Keywords: Augmented reality; NFTs; User experience; Virtual; Manufacturing.

INTRODUCTION

In 1992, Neal Stephenson, an American writer, published his science fiction book titled "Snow Crash," in which he first introduced the concept of the metaverse (Silva et al., 2022). Since then, the development of technology has accelerated and stimulated society to adjust to new techniques and practices, such as the metaverse (Pereira, 2022).

The metaverse is an intelligent network focused on innovation and problem solving. It brings together people from all over the world to collaborate on projects, exchange ideas and solve problems. The metaverse is a virtual environment that mimics the real world, allowing people to connect and interact as if they were physically present. This makes the experience more engaging and intuitive, as well as allowing people to learn from each other.

Technological development has been widely debated in the industrial sector, as a way to offer the market more product options, but also to improve communication with stakeholders. This adaptation has been a great challenge for the food industry, which needs to improve and keep up with the evolution of technological innovations (Campos et al., 2022).

The relationship between the metaverse and the food industry is of great importance in the coming years, even though feeding involves several sensory experiences. The 3D world of the metaverse enables numerous new processes applicable in this area, such

as being able to improve real-life gastronomic skills in the virtual environment, make a better connection between consumer and product, create intelligences focused on innovation and problem solving in the industry, more efficiency in the delivery market, as well as creating new branding capabilities, among others. In order to examine the theme of the metaverse applied to food production, this study undertook a bibliometric analysis and a literature review on the subject, examining the main issues discussed, challenges and opportunities for application.

MATERIAL AND METHODS

To perform the survey of articles, we used the search of specific keywords in the database Scopus and Web of Science. The term ('METaverse' AND 'FOOD') was inserted to aggregate titles, abstracts and pertinent keywords, reaching a number of 15 articles.

Subsequently, the results were for more detailed analysis through the tool 'Bibliometrix' (RStudio software, version 1.4.1106). This approach allowed to synthesize the current state of research on the subject and generate relevant discussions and correlations. Following the reading of the articles, here the main challenges and opportunities will be addressed, using 10 articles from the 15 initially listed.

RESULTS AND DISCUSSION

Bibliometric analysis

Bibliometric analysis indicates that the "metaverse in food production" appears in scientific databases as of 2015. The number of publications on the topic has increased since then, with the largest increase recorded in 2022. Figure 1 shows a cloud of words containing the twenty most mentioned expressions in the articles studied. It is noticeable that hypersensitivity, virtual reality, allergy (food and contact), agriculture (technology and food production) and traceability are among the most mentioned. Therefore, it is important for companies and scientists to explore these topics to communicate more effectively with their target audiences.



Figure 1. Wordcloud obtained from the bibliometric analysis relating the terms "metaverse" and "food".

Table 1 presents the main opportunities and challenges of the use of metaverse in food production.

Table 1. Opportunities and challenges of the metaverse in food production

Title	Opportunities	Challenges	Author
Travelling the metaverse: potential benefits and main challenges for tourism sectors and research applications.	It allows you to visit production sites, breweries or farms in different states or nations and interact with influencers and chefs.	It is not necessary to have social acceptance, accessibility and environmental sustainability of these technologies; Ensure effective management of sensitive data	Monaco; Sacchi (2023)
Metaverse: Perspectives from graphics, interactions and visualization.	It develops the sensory experience, as the "Virtual Cocoon" can spray flavors directly into the user's mouth, and the "Food Simulator" uses chemical and mechanical bonds to simulate food chewing sensations.	-	Zhao et al. (2022)
Virtual reality consumer experience escapes: preparing for the metaverse.	-	It identifies escapism as a challenge to be overcome, as it induces behaviors such as binge eating and different eating patterns, where the person is dependent on unhealthy eating habits.	Han et al. (2022)
Food and beverage consumption habits through the perception of health belief model (grab food or go food) in Surabaya and Pasuruan.	People's preference to buy food online and withdraw for consumption is on the rise.	The foods sold are energy-dense and poor in nutrition. With this, people are at risk of degenerative diseases such as hypertension, diabetes mellitus, stroke, among others.	Mahmudiono et al. (2022)
Multi-scale governance and data for sustainable development.	Networked intelligence and incubators are a new paradigm for solving complex problems by combining humans and machines.	-	Pastor-Escuredo et al. (2022)

Can metaverse provide any new developments in the field of allergy and immunology?	It contributes to the control of allergic people, because if the allergist has registered in the system the current allergy of the patient, a notification may appear when the patient intends to buy a product that contains that allergen.	Web-based metaverse applications 3.0 can introduce the practice of contact allergies, since the longer the contact time, the greater the likelihood of allergy.	Çerçi; Kendirlinan (2022)
Ukemochi: a video see-through food overlay system for eating experience in the metaverse.	Assists in food acceptability by overlaying an image of food segmentation inferred by deep neural networks in a virtual social environment	-	Nakano et al. (2022)
Construction and design of food traceability based on blockchain technology applying in the metaverse.	Improvement of food traceability through application and the meaning of the concept derived from digital virtual food and traceability technology of agricultural food in the metaverse	-	Bian et al. (2022)
Drift characteristic analysis of additive manufactured Ag NPs-PEDOT: PSS flexible temperature sensor.	1. In agriculture, the agricultural metaverse aims to optimize the production chain, saving costs, increasing efficiency in order to achieve sustainable agriculture. 2. Allows management and control, as well as learning and training. Temperature sensors with potential applications in various applications	-	Wang et al. (2022)

Possibilities of interaction between consumers and producers or entrepreneurs

The metaverse presents a revolution in the way people consume products, because it allows the consumer to visit and know production sites, as well as interact directly with the product even though they are in different countries. In this way, the consumer can obtain more detailed information about the product in choice, seeking to meet all their needs. A proposal of interaction that allows the creation of a totally immersive and interactive reality, with unlimited possibilities between entrepreneurs, producers and consumers, is the creation of virtual stores in the metaverse. Virtual stores invite the consumer to walk through the space, observe the products closely and even try them out, characterizing a great innovation for online retail (Shafiee et al., 2021). As an example, the wine sector, which can use the metaverse to personalize wine tasting experiences through augmented reality, enabling sensory experiences similar to what they would have outside the virtual environment. According to Monaco and Sacchi, (2023), some wineries have already presented projects in which the user is taken by a virtual tour of the grape vineyards. That way, you can be physically in any

country, but enjoy the wineries of Italy from your couch.

On the other hand, in addition to stores, it is also possible to hold more interactive and creative virtual events with the metaverse, such as product launches, conferences and lectures, allowing access to the public from anywhere in the world without the need to physically move and, consequently, this makes it possible to expand networking strategies and access to exclusive content of the industries (Gibson et al., 2014).

Another way to improve the user experience is through NFTs (non-fungible tokens), which are unique virtual articles in which only one user has the original file. Cha (2022) compares NFTs as the Mona Lisa painting, where there are numerous re-readings of the work, but there is only one original Mona Lisa. Have you ever thought about acquiring an NFT of some typical food in which only you will have the possibility to try? Therefore, NFTs are a new type of business within the metaverse itself, which is even capable of giving the user the ability to create, sell and distribute their content over the internet. This is very interesting for brands, because the user himself ends up doing "free" marketing to companies, while managing to profit from it (Hollensen et al., 2022).

Trends in the use of metaverse in agriculture

The use of metaverse in agriculture is a growing trend. There is even a specific name for this interaction: Agriverse (Kang et al., 2022). And this technology can contribute to the agricultural sector by lowering production costs, increasing productivity, managing farm information and improving product quality. In addition, the metaverse also allows farmers to make smart decisions based on academic research. Often, technology held in academia can be slow to arrive in the field, due to the difficulties researchers encounter in advancing to pilot scale. To make this integration faster, the virtual farm emerges as a tool capable of performing simulations, in the virtual environment, through the results of scientific research, to predict situations that could bring some impact to the productivity of crops, such as the attack of pests or the growth of crops under the climate and soil conditions of that place. In livestock, the metaverse can help control and predict herd reproduction and monitor animal behavior to predict disease (Feng et al., 2022). Legund and Burch (2021) bring in their study an analysis on the use of robots that are able to carry out the harvest of fruits, for example, through a mapping program of the area in which it recognizes what is the product to be harvested and under what conditions. This can be useful in plantations that have difficult topographic conditions or even when there is a lot of variation in the ripeness of the fruits.

Despite being an interesting alternative to be implemented on farms, the metaverse requires adequate internet signal like 5G/6G. In many rural locations the 3G signal is still scarce and with oscillating signal, which hinders the installation of the technology. To grant access from the small to the large farmer or rancher, it is necessary that the internet signal in agricultural areas is improved, especially in developing countries.

Networked intelligence focused on innovation and problem solving

In the industry, the metaverse is considered a promising alternative in process optimization due to several factors. One of these factors is to avoid the activation of technical assistance when problems occur in machinery and even in operational control. Generally, the encounter between assistance and company is slow due to factors such as distance, displacement, communication between the means and even the cost for the operation (Wang, 2022). Through this technology, it is possible for technicians and suppliers to make a virtual visit to industrial plants, identifying online problems that are impacting on the productivity of the processes and thus being more efficient in correcting the problem.

Within the food industry, the supply chain is the one that most demands the exchange of information between stakeholders, for price evaluation and quality of inputs and raw materials. In the quest for greater transparency and improvement of the supply chain, so that industries do not become depleted by some consumables, the use of Blockchain is also an alternative (Tijan et al., 2019). This technology can be understood as a form of data exchange, where each time an action is performed, it is captured by blocks and the data related to this action is distributed through nodes (which are the computers connected to that network). Each block is able to demonstrate previous and future movements, making a more transparent and secure system between industry and stakeholders (Berke, 2018). An example of the use of Blockchain in the industry is in the area of logistics, through the traceability of cargoes, with the aim of improving supply chain management with lower costs. Therefore, as soon as the cargo movement begins, it is possible to demonstrate in real time, variables such as truck opening, total load weight, temperature, among others (Shi et al., 2023).

The sum of Blockchain and Internet of Things (IoT) technology can also contribute to cost reduction and improvements within the industrial process itself through the deployment of Industry 4.0 or 5.0.

Improved food traceability

The metaverse can be thought of as a food traceability tool that offers farmers, manufacturers and consumers a means to monitor the life cycle of their products. This means that from the moment food is planted to the moment it hits store shelves, users can keep track of their entire production, logistics and sales process.

The automation of industrial processes through technologies such as Blockchain and the Internet of Things (IoT), which are fundamental constituents for the functioning of the metaverse, creates a very precise traceability network. During the production of a certain item, for example, a traceability code can be created for each batch of the product, which is available within a Blockchain. In this code, the amount of ingredients and inputs handled is available, as well as their respective suppliers, from the preparation of dough to the final packaging. This information can be known to the user through a QR code on the product packaging, or by entering a numeric code on a platform created by the company. This same system that indicates all the variables of the process to minimize the risk of non-compliant products, can also be used by regulatory bodies as a form of real-time inspection, to avoid fraud during food production, and even for the industry itself to

attest its quality control in the face of false information that, sometimes it is found on social networks (Hawashin et al., 2023).

In addition, the metaverse also offers a tool to share information about food with other users, allowing for greater collaboration and exchange of experiences. This can be beneficial for research centers in the food industries, which today fund market satisfaction surveys, and which usually capture little information due to consumers' fear of talking about unpleasant situations or giving suggestions for improvements. In this way, the industry achieves a much greater number of responses and even market needs suggested by the users themselves (Hollensen et al., 2022).

Delivery market

The metaverse can be a possibility of innovation also for delivery markets. That's because people are looking for increasingly practical and convenient ways to buy products and services. With delivery, they can receive everything they need without having to leave home, which is ideal for those who lead a hectic pace of life. In addition, delivery allows companies to be more flexible regarding opening hours and payment methods, which makes the customer experience even better. The metaverse interacting with food delivery, for example, can lead the consumer to produce their own food within a virtual environment and receive it in their home after a certain time (Mocado and Sacco, 2023). Thus, the user can have the feeling of playing a game, but with the condition of having physically what he manipulated in the virtual environment. It is possible that the number of NFTs for the acquisition of specific dishes or items will also grow, leading to a much higher consumption power, where the user may be the only one to try a certain food (Hawashin et al., 2023).

Sensors in food

Although not within a virtual environment, the application of artificial intelligence (AI) and the internet of things (IoT) in the food industry can assist in the rapid analysis of products to check their physicochemical properties and to ensure the absence of contaminants. Rady et al., (2020) developed a sensor based on near-infrared (NIR) technology to evaluate allergenic substances in powdered foods. The authors built a tool that allows them to analyze in real time if there is the presence of these substances in the product. The significance of the development of this type of technology allows that things other than allergens can be read by these sensors, which would facilitate during the receipt of inputs in the industry the rapid identification of quality deviations and consequent impediment of the

use of this input. Currently, to ensure that the input is within specifications, the use of laboratory tests is required, which require a lot of time and work (Ren et al., 2022).

The industry, through the metaverse, could have access to the temperature variations that the product or even raw materials may suffer during the transport of cargo, through sensors included in the packaging. This would facilitate the maintenance of food quality parameters and assist in identifying refrigeration problems in the transport vehicle itself. Still, this information could help in the improvement of food products, avoiding that when suffering a temperature variation caused by an external agent, the product remains stable inside its packaging (Ben-Daya et al., 2020).

Sociological, economic and environmental reflections

The metaverse is a virtual world where people can experience different realities. However, it is important to take into account some sociological, economic and environmental aspects. First, the metaverse is altering the way people interact. With the popularization of this technology, social relations may become more distant. In the study by Dwivedi et al., (2022), the authors report the concern regarding the psychosociological picture of users, since there are already reports of offenses and undesirable behaviors within the platform.

In relation to the economy, the metaverse tends to reduce the costs and time with financial transactions between industry and stakeholders (Hassoun et al., 2023), even leading to greater transparency within the negotiations.

The environmental impact of the metaverse still needs further assessment, given the divergence of opportunities and challenges described for this technology. Some authors such as Akten (2022), point out that an NFT transaction can produce 48 kg of CO₂, due to the consumption of large amounts of electricity due to the need for large data centers for data storage. Cao et al. (2023), demonstrate that the metaverse is a tool to assist in carbon neutralization and promote sustainable development, through the reduction of resource consumption and the digital transformation of processes within companies/industries.

Therefore, it is interesting that when developing the metaverse, environmental policies are developed together to ensure the sustainability of the business.

Managing sensitive data

The arrival of the metaverse presented challenges for managing sensitive data. Given that technology and

digital environments are increasingly present in industrial activities, it is of paramount importance that companies ensure the security of all data exchanged in these spaces, additionally, as virtual environments become increasingly complex, on the other hand, it is also increasingly difficult to maintain the confidentiality of data. On the other hand, there are tools and techniques that can be used to minimize this risk (Rocha et al., 2020). In Brazil, one of the main laws that aim to protect the privacy of this information exchanged between the industry and the consumer is the LGPD (General Data Protection Law), which describes how companies should collect, store and use the personal data of their respective customers, as well as impose penalties for companies that do not comply with these standards (Brasil, 2018). In addition to the LGPD, there are other important regulations for this industrial sector, including the FSMA (Food Safety Modernization Act) and the GFSI (Global Food Safety Standard) that determine a standardization in food safety processes and in data collection and storage within the food industry (Yiannas, 2023).

Companies must comply with applicable laws and regulations and implement appropriate security measures to protect confidential information, as well as maintain the quality of brands in the marketplace. In addition to the legislation, data present in the metaverse can be organized and ensured with the use of virtual incubators, which serve to write the user's own decision-making regarding the policies offered by the digital medium (Pastor-Escuredo et al., 2022).

CONCLUSION

The metaverse is the future. This technology will revolutionize the way data will be interpreted and applied in the real world. The user will be most responsible for the continuity of the development of the technology, since it is he, who will be having the experience of selling, buying or sharing content, and in this way, will need the experience to be continuously improved. Industries will benefit by anticipating problems in process lines and reducing losses through automation systems. The consumer is also benefited, since he can observe in real time the entire production process, in addition to the possibility of knowing places and tasting flavors from anywhere in the world.

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