

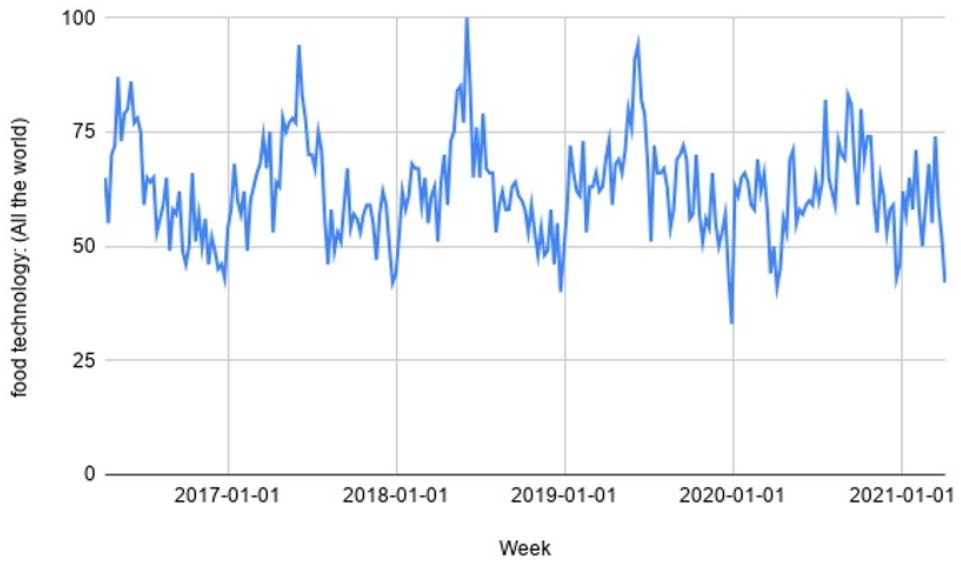


**Forecasting the next revolution:  
Food technology impact on consumers' acceptance and  
satisfaction**

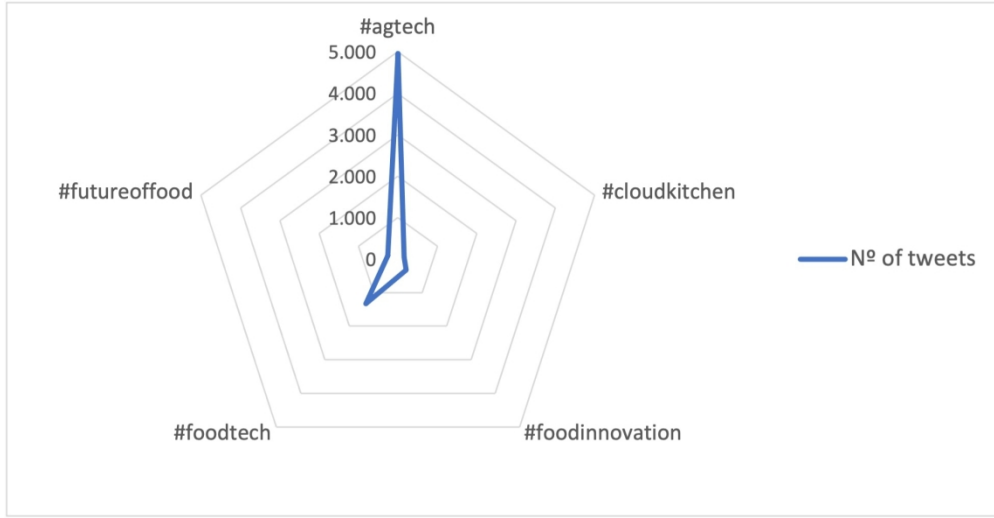
Journal:	<i>British Food Journal</i>
Manuscript ID	BFJ-07-2021-0803.R1
Manuscript Type:	Research Paper
Keywords:	sentiment analysis, text data mining, Twitter, Food technology, Innovation, consumers' acceptance

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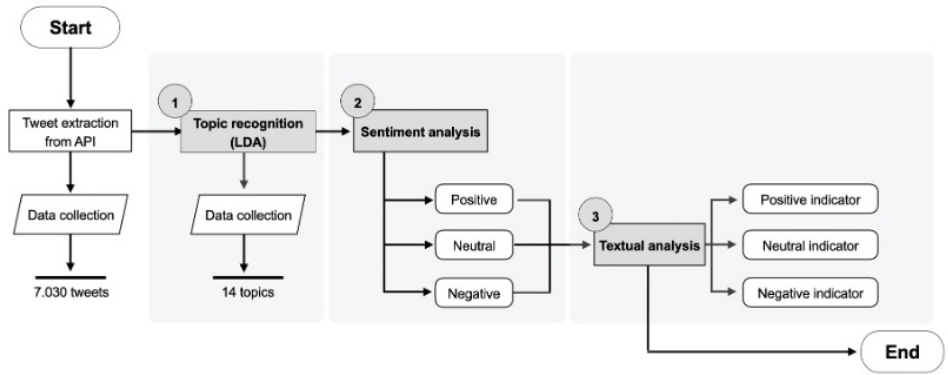
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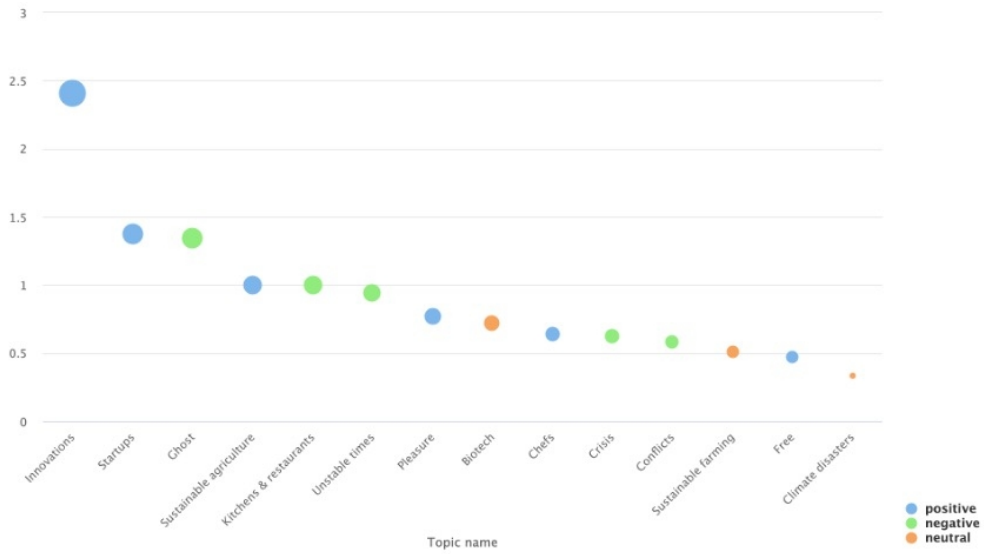
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**Table I.** Main studies on UGC and food.

Authors	Description
Vidal et al., 2015	In this study, the authors retrieve thousands of tweets and classify them to understand what the most spoken food-related topics are. With it, they want to learn about consumers' preferences, purchasing habits, timing, making plans, etc.
Park et al., 2016	Twitter comments were used in this research to examine customers opinions in different types of restaurants by classifying the different attributes that affect the meal experience.
Singh et al., 2018	This research analyses customers' opinions on the quality of food products using Twitter content to identify issues affecting consumers' satisfaction and its relation with the supply chain process.
Yu & Zhan, 2020	The investigation studied the online comments of three top restaurants to analyse the dinner experience of those customers as well as to understand which factors affect their feelings after the experience.
Goldberg et al., 2020	These researchers use data mining and sentiment analysis to learn and classify safety hazards that come from food consumption. They used review from two website and organise the information in different categories.
Mathayomchan & Taecharungroj, 2020	In this study, they use the comments on Google Maps of several restaurants of different cities to understand consumers' opinions as well learn the attributes that create a positive and/or negative experience at a food-related service.
Teichert et al., 2020	This research focuses on food delivery service. The authors classified thousands of comments from different websites into several categories to understand the different aspects that affect the overall consumer's experience.

**Table II.** Tweet collection concerning the hashtags employed.

Tag	Nº of tweets
#agtech	4.956
#cloudkitchen	158
#foodinnovation	326
#foodtech	1.327
#futureoffood	263

British Food Journal

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**Table III.** Identified topics related to food technology in UGC.

Topic name	Topic description	WP	Sentiment
Innovations	Observations concerning innovative solutions of products, energy, and related advancements.	2.41	positive
Start-ups	Comments on the actual progress of start-ups related to food technology.	1.37	positive
Ghost	Mentions regarding the lack of physical presence, the virtual dimension of all these implementations (such as bots, amazon, etc.).	1.34	negative
Sustainable agriculture	References to the need of guaranteeing sustainable and the benefits obtained from plant-based techniques.	1.00	positive
Kitchens & restaurants	Mentions concerning the impacts of kitchens, restaurants such as the food waste.	1.00	negative
Unstable times	Annotations regarding the actual uncertainty, insecurity, and the need of clearness.	0.94	negative
Pleasure	Remarks relative to the improvement food technology is going to imply in terms of enjoyment.	0.77	positive
Biotech	Recognition of the changes concerning biotechnology, genetic, engineering, and pest.	0.72	neutral
Chefs	References to the importance of gourmet chef.	0.64	positive
Crisis	Discussion of the current crisis.	0.62	negative
Conflicts	Recognition of the conflicts and the hunger consequences.	0.58	negative
Sustainable farming	Comments and opinions of upcoming sustainable farming initiatives.	0.51	neutral
Free	Mentions to free resources.	0.47	positive
Climate disasters	Mentions to climate change implications and disasters, such as floods and droughts.	0.33	neutral

**Table IV.** Sentiment Analysis conclusions' reliability (Krippendorff's alpha).

Conclusions' reliability	Krippendorff's alpha value	Sentiment	Average KAV
High	$\alpha \geq 0.800$	Positive	0.867
Tentative	$\alpha \geq 0.667$	Negative	0.747
Low	$\alpha < 0.667$	Neutral	0.685

British Food Journal

# Forecasting the next revolution: Food technology impact on consumers' acceptance and satisfaction

## ABSTRACT

*Design/methodology/approach:* Based on text data mining, 7030 tweets were collected and organized into 14 different food-related topics. Six of these categories were positive, five were negative and three were neutral.

*Purpose:* In a sector that needs to satisfy a fast-increasing population, advancements like cultivated meat and bio-circular economy are basic to sustain the industry and the society. As innovations are key for economic and social progress it is crucial to understand consumers' position on this matter.

*Findings:* Six categories related to food technologies were positively perceived by Twitter users, such as innovative solutions and sustainable agriculture, while five like the virtual dimensions of the industry or crisis-related scenarios, were negatively perceived. It is remarkable that three categories had a neutral sentiment, which gives ground to improvement before consumers have a negative opinion and consequently will be more complicated to change their minds.

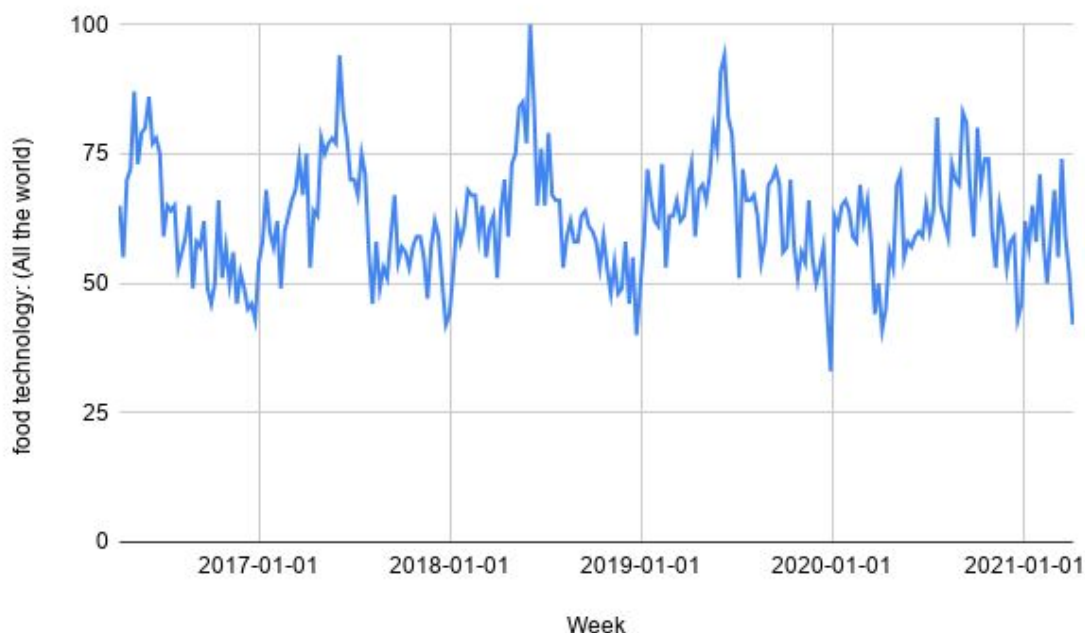
*Originality/value:* Technological innovations are becoming predominant in the food industry. The SARS-CoV-2 pandemic has made the sector improve even faster. Traditional methods needed to be substituted and technologies such as robots, Artificial Intelligence, blockchain and genetics are here to stay.

**Keywords:** sentiment analysis; text data mining; Twitter; food technology; innovation; consumers' acceptance

## Introduction

The Covid-19 pandemic has brought many changes to the food industry. Food safety and sustainability have become challenge during this health crisis. Innovations,

such as Industry 4.0 applications related to speed-up local food delivery and reduce food safety risks have aroused. The food sector is being revolutionised by the use of data analytics and Artificial Intelligence (AI, in advance). Real time monitoring has become essential for supply chain management, food security and smart agriculture (Galanakis et al., 2021). The SARS-CoV-2 emergency has also transformed the way we interact, which has introduced advances such as drone (Kim et al., 2021) and contactless delivery (Zhan & Chen, 2021). The coronavirus has also given impulse to other innovations in the food industry, such as robot systems, automation, web-based distribution systems and more dynamic e-commerce (Aday & Aday, 2020), in addition to nutritional and immune-boosting products (Galanakis et al., 2021).



**Figure 1.** Search trends on “food technology” in Google Trends report (2017–2021).

Figure 1 presents the relevance of food technology, as it reveals the number of searches that were conducted in Google from January 2017 to January 2021 in relation to this matter. The average of the search is 62.32, being 100 the value that defines the highest popularity of the term. This number, supported by a clear increasing and regular tendency, exposes the importance of the topic in the industry. Food technology, and all that it implies, have arrived to stay and it is provoking great and significant transformations in a business that wants to evolve (Jacobsen et al., 2021).

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3 51 The study of User-Generated Content (UGC, in advance) is decisive to forecast  
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5 52 the development of new technologies. Despite the fact that advancements are vital for  
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7 53 economic growth, some food technologies are not very well perceived by the public  
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9 54 (Siegrist & Hartmann, 2020). It is essential that consumers accept new high-tech  
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11 55 implementations in the industry for these to be developed (Siegrist et al., 2016).  
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13 56 However, individuals tend to the so-called neophobia, precisely the fear to new food  
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15 57 technologies (Cifci et al., 2020). This happens because people incline to feel risk in the  
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17 58 unknown which makes them not appreciate all the benefits and positive consequences  
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19 59 of these innovations on their health (Boccia & Punzo, 2021). Thus, it is very important  
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21 60 to understand consumers' attitude toward food technology innovations and examine if  
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23 61 a new technology is whether going to be accepted or rejected before it is implemented  
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25 62 and commercialised (Cifci et al., 2020).

26 63 Due to the Covid-19 crisis, this study aims to answer to the call for  
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28 64 acknowledging users' acceptance to new technologies in the food industry. This  
29  
30 65 research will offer insights regarding the sentiment-analysis, which will propose useful  
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32 66 information that will support collaborative learning to enhance the success of the  
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34 67 application and commercialisation of these high-tech advancements.

## 35 68 **2. Literature framework**

### 36 69 ***2.1 The role of Social Networking Services in the food industry***

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39 70 Today, we all live in a digital era in which social media has become the main  
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41 71 communication channel for human interaction (Jacobsen et al., 2021). Social networks  
42  
43 72 are used by over half of the whole world population, with still great potential to grow,  
44  
45 73 making them essential tools for present and future strategies (Elghannam et al., 2020).  
46  
47 74 Nowadays, more than 90% of young adults (under 30) use social media in their daily  
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49 75 lives (Fleming-Milici & Harris, 2020) and the total amount of users reached 3.48 billion  
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51 76 in 2019 (Ventura et al., 2021). Social networks are also a widespread tool for food  
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53 77 purposes. Food is a popular subject on social media, being easy to find culinary content  
54  
55 78 on different networks, including recipes, videos and photos (Nour et al., 2018).  
56  
57 79 Besides, social networking services can also help the food industry in many other ways,  
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59 80 achieving positive outcomes for both consumers and producers. Regarding the latter,  
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81 one of the best advantages of social media is the opportunity to avoid intermediaries

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3 82 in the supply chain, as it offers the possibility to have a direct contact with the  
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5 83 consumer. Consumers also gain insight into what they purchase, such as origin, safety  
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7 84 and wholesomeness (Elghannam et al., 2020). Social networks are also a fantastic  
8  
9 85 technology to create memorable experiences for consumers, improving companies'  
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11 86 relations with them at the same time as they offer entertainment, personalisation and  
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13 87 value creation (Jacobsen et al., 2021).

14  
15 88 Social media is also a great tool to spread information and develop trust  
16  
17 89 (Buskens, 2020). Producers can use this technology to improve the relationship with  
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19 90 the consumers, sharing information and emotions. Online networks also improve the  
20  
21 91 customer service attention. Networking systems are as well a fantastic opportunity to  
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23 92 approach targeted consumers and create a brand that aligns with the needs of new  
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25 93 generations (Fleming-Milici & Harris, 2020), adapting the marketing strategies to  
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27 94 connect with the selected audience and gain more engaged customers (Elghannam et  
28  
29 95 al., 2020).

30  
31 96 Food companies can also use social media to understand how consumers  
32  
33 97 perceive and use their products, and adapt them to their needs, offering information  
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35 98 of how they accomplish the co-creation process that results in a product that better  
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37 99 adapts to their desires (Jacobsen et al., 2021). These strategies require a clear  
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39 100 understanding of the messages in order to appropriately manage the information that  
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41 101 is given to the audience (Rutsaerta et al., 2013). Twitter is an essential network to  
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43 102 achieve that approach as it is considered the digital form of the long-standing word-of-  
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45 103 mouth (Samoggia et al., 2020).

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47 104 Twitter is one of the most used social networks and the most popular micro-  
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49 105 blogging site, holding around 500 million tweets per day, which makes it an excellent  
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51 106 platform for public communication (Araújo Britto Sass et al., 2020). Therefore, food-  
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53 107 related topics addressed in Twitter reflect consumers' interests. As a great data source  
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55 108 of consumers' conduct, this social network is fundamental to develop the appropriate  
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57 109 products and marketing strategies for the target market (Borrero & Zabalo, 2021).  
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59 110 Thus, Twitter's effective communication system allows food companies to listen to  
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111 consumers, handle customer service and create a viral branding environment for their  
112 products (Liu et al., 2017).

## 113 ***2.2 The influence of technology in the food industry***

114 The food industry is constantly developing new technologies to cope with new  
115 consumers' needs and tastes. Innovative technologies also help to improve production  
116 efficiency and processing times, guarantee safety and quality, reduce energy costs and  
117 are undertaking more environmentally friendly practices (Gallo et al., 2018). As  
118 consumers are increasingly becoming more exigent, they are looking for safe and  
119 natural products that are produced in a sustainable and ecological way (Putnik et al.,  
120 2020). Technology is also a necessary tool to deal with the increase in global food  
121 demand as well as to cope with food security and sanitary requirements (Jeyakumar  
122 Nathan et al., 2021). As food demand is expected to augment at impressive rates in the  
123 following decades, the industry has to face how to provide access to enough quantity  
124 of quality food and beverages. In this matter, technological innovations are essential as  
125 they can improve productivity in the sector (Duong et al., 2020).

126 Among the most innovative developments in the food industry, internet-driven  
127 agriculture; new production methods such as urban farming, which includes vertical  
128 farming, aquaponics and the Internet of Things; zero waste food processing via  
129 processing technology; natural preservatives and smart packaging stand out. Taking  
130 into account the aforementioned increase in the population and in demand, new  
131 forms of food, such as insect farming, microalgae and cultivated meat, are becoming  
132 significant (Mok et al., 2020). Furthermore, food personalisation is appearing to be a  
133 solution that can help improve life quality and consumers' health (Ueland et al., 2020).

134 As new technologies arise in the food industry, it is important to highlight some  
135 of the most developed innovations. Major technologies are being applied in the  
136 production stages to improve the manufacture processes and the final product.  
137 Robotics and autonomous systems (RAS, in advance) are an effective tool to improve  
138 productivity and reduce costs and risky situations during the different stages of the  
139 production. Many examples of high-tech implementations are appearing such as those  
140 related to harvesting, fruit picking, animal milking, food delivery to livestock, waste  
141 removal and aquaculture (Duong et al., 2020).

142 Ultrasound is another major technology that can considerably improve the  
143 production processes of the food industry. These mechanical waves, originated in

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3 144 molecular moves, can incite physical and chemical reactions applicable to food  
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5 145 processing stages. Ultrasound causes mechanical, chemical and biochemical changes in  
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7 146 liquids and gases that can improve the functional and high-quality of aliments. Hence,  
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9 147 it increases the control of the production processes and the evaluation of food state  
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11 148 while it reduces the usage of energy, becoming a green option for the procedure. It  
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13 149 can also be used to cut foods and bond the packaging in a safer, more economical,  
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15 150 hygienic and environmentally friendly way than before (Gallo et al., 2018).

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17 151 Another ecological innovation that can be used in the food production process  
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19 152 is hurdle technology. This advancement inactivates microorganisms so as to stimulate  
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21 153 food preservation. It avoids high temperatures, which helps to preserve the nutritional  
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23 154 value of the product, and thus improves the quality of the food product. Therefore,  
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25 155 hurdle technology is a process that allows to get a safe final product (Putnik et al.,  
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27 156 2020). One more technology to take into account and implement in the food industry  
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29 157 is cultured meat. The growth of animal meat in a laboratory gives the opportunity to  
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31 158 get a supply of protein of great quality at a very low environmental impact (Bekker et  
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33 159 al., 2017).

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35 160 Technological innovations are not only available to be applied in the production  
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37 161 process but they are convenient to improve consumers' experience. Specific mobile  
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39 162 applications for the gastronomic industry are increasing every day. It is possible to find  
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41 163 food-related apps for many matters, such as meal planning and preparation. However,  
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43 164 as Jacobsen et al. (2021) explain, the current top innovations are virtual reality and  
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45 165 augmented reality, which allows businesses to improve the customer experience  
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47 166 during the use of the product. While virtual reality is not very accessible, augmented  
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49 167 reality can be easily implemented through a mobile application in, for example, smart  
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51 168 packaging with including a , for instance, using a QR code. The product experience is  
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53 169 enhanced while consumers get food information in a very enjoyable way, which, at the  
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55 170 same time, helps to increase purchase intention.

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57 171 Another related technology that increases consumers' welfare is active  
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59 172 packaging. This innovative implementation avoids the usage of plastic packages to  
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173 preserve food as it creates sustainable, biodegradable, non-toxic and antimicrobial  
174 packaging by means of nanotechnology and nanocarbon materials, which prolongs the

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3 175 life of the aliment and maintains its sensory properties (Azevedo de Carvalho & Conte  
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5 176 Junior, 2020).

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7 177 Further important technologies are being developed to personalise food and  
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9 178 satisfy consumers' needs. We highlight 3D food printing and molecular and note-by-  
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11 179 note cuisines. On the one hand, 3D food printing permits the creation and  
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13 180 personalisation of on-demand consumable products while it reduces food waste and  
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15 181 contributes to sustainability (Jayaprakash et al., 2020). Molecular gastronomy, on the  
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17 182 other hand, allows the development of high-quality food through science techniques  
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19 183 such as dehydration, liquid nitrogen and enzymes, among others. Finally, note-by-note  
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21 184 cuisine performs new foods and flavours by using disaggregated parts of existing  
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23 185 foods. This allows to eliminate the components that provoke allergies or food sickness  
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25 186 to certain people (Cifci et al., 2020). It is also important to mention gene technology  
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27 187 applied to the food industry. Genetic applications can module the taste, safety and  
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29 188 nutritional value of the product to satisfy consumers' needs which at the end, can  
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31 189 solve worldwide hunger problems in a sustainable way (Boccia & Punzo, 2021).

### 32 190 ***2.3 User-generated content and sentiment analysis concerning food technology***

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34 191 Once a new product is created, consumers' opinions are very important to  
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36 192 analyse their acceptance. The Internet is a universal tool that allows users to share  
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38 193 their thoughts and reviews on the products they use. This kind of electronic word-of-  
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40 194 mouth is crucial for new marketing strategies. It has been stated that online comments  
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42 195 shape potential clients' predisposition to purchase products (Elghannam et al., 2020).  
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44 196 In this context, obtaining online information from other consumers as it is accessible  
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46 197 and credible has become compulsory. All the content found on social media, posted by  
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48 198 users, affects other potential consumers' willingness to purchase the product  
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50 199 (Jacobsen et al., 2021). All this information related to product critics can be shared by  
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52 200 others and it can reach an important number of potential customers (Fleming-Milici &  
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54 201 Harris, 2020). Through these ratings and reviews, consumers participate in the creation  
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56 202 of data, increasing, at the same time, their satisfaction towards the product or brand.  
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58 203 Through these media, individuals feel that they can participate and interact with the  
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60 204 company in a relaxed and informal way (Lin et al., 2020). Basically, social networks are  
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a free way for consumers to express their unbiased feelings towards a product

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3 206 (Mostafa, 2020). Also, social media is today one of the main sources of information  
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5 207 (Faour-Klingbeil et al., 2021).  
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7 208 UGC provides countless business advantages to companies. All the online  
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9 209 produced data can be an asset for brand communication as it has a relevant effect on  
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11 210 the image of the product and, therefore, on its final sales. UGC helps the brand to  
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13 211 understand how consumers feel about their products, in terms of features, innovation,  
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15 212 quality, etc., and also what customers think about the competitors of that company  
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17 213 (Liu et al., 2017). Sentiment analysis is a strategic tool to extract all the relevant  
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19 214 information from the vast amount of data that can be found online, by transforming  
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21 215 this input into structured facts (Chakraborty et al., 2020). Data is currently considered  
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23 216 as one of the most valuable resources, and Twitter, is the perfect place to access to  
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25 217 this specific topic-related information and analyse it (Borrero & Zabalo, 2021). Twitter  
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27 218 is an unlimited outlet from which to take all the data needed to understand  
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29 219 consumers' opinions as it covers many different topics (Araújo Britto Sass et al., 2020).

30 220 The food industry should take advantage of all these sources of information  
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32 221 and analyses to gain insight on consumers' thoughts and consequently, develop the  
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34 222 technologies that will be widely accepted. This way, consumers will be involved in the  
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36 223 innovation process and their needs will be assessed (Jacobsen et al., 2021). For  
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38 224 instance, some technologies, such as genetically modified foods or food irradiation, are  
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40 225 prone to get negative reviews just because people don't not understand them properly  
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42 226 or even fear them. It is important that experts provide adequate information about  
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44 227 these innovations to exceed negative comments on the Internet (Rutsaerta et al.,  
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46 228 2013).

47 229 Table 1 pinpoints revealing studies about sentiment analysis in the food  
48  
49 230 technology sector, which emphasize the importance of UGC in the industry. UGC  
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51 231 started to be mined around 2015 but it was not until recently that we find an  
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53 232 increasing number of studies using sentiment analysis in different areas of the food  
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55 233 industry (consumers' experience, supply chain, delivery services, safety, etc.).  
56  
57 234 However, research based on sentiment analysis regarding food related topics is still in  
58  
59 235 it is infancy as only few studies have been reported.

60 236 **Table 1.** Main studies on UGC and food.

Authors	Description
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Teichert et al., 2020	This research focused on food delivery service. The authors classified thousands of comments from different websites into several categories to later understand the different aspects that affect the overall consumer's experience.

### 237 3. Research questions approach

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3 238 The research approach adopted is based on Research Questions (RQs), which is  
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5 239 specifically thought-provoking in learning processes (Schumaker et al., 2016) as it  
6  
7 240 encourages the origination of new ideas.

8  
9 241 Table 1 points out studies that have revealed that, by examining UGC on social  
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11 242 media channels, popular topics can be identified. Therefore, the following RQ is  
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13 243 suggested:

14  
15 244 **RQ1:** *Is it possible to identify popular food technology topics examining UGC on*  
16  
17 245 *Twitter?*

18  
19 246 Sentiment analysis has been extensively employed to classify the feelings  
20  
21 247 expressed, which are basically categorised into positive, neutral and negative  
22  
23 248 sentiments (Saura et al., 2020). There are several previous studies that have mined  
24  
25 249 online, food-related UGC and made a classification depending on the aroused feeling  
26  
27 250 (i.e. positive, neutral or negative) (Dondokova et al., 2019; Mostafa, 2020; Chen et al.,  
28  
29 251 2020). Thus, the next RQ is proposed:

30  
31 252 **RQ2:** *Is it possible that the identified food technology topics in UGC on Twitter be*  
32  
33 253 *associated to different feelings?*

34  
35 254 It has been confirmed that the UGC from Twitter improves collective learning  
36  
37 255 (Stephansen & Couldry, 2014; Tang & Hew, 2017). Thus, this research can propose  
38  
39 256 relevant information concerning consumers' acceptance and satisfaction of the  
40  
41 257 technology used in the food industry and, even, address future insights. According to  
42  
43 258 the three established categories (positive, negative and neutral), customer satisfaction  
44  
45 259 can be understood. While positive implies that the customer is happy regarding the  
46  
47 260 food technology, negative implies to not focus on those aspects or topics that are  
48  
49 261 commented. Finally, the categories that turn to be neutral need a further  
50  
51 262 consideration for the product management (Chakraborty et al., 2020).

52  
53 263 **RQ3:** *Is it possible to foster collective learning of how to improve consumers accepting*  
54  
55 264 *and satisfaction of the technology used in the food industry by grouping the identified*  
56  
57 265 *food technology topics in relation to positive, neutral and negative feelings?*

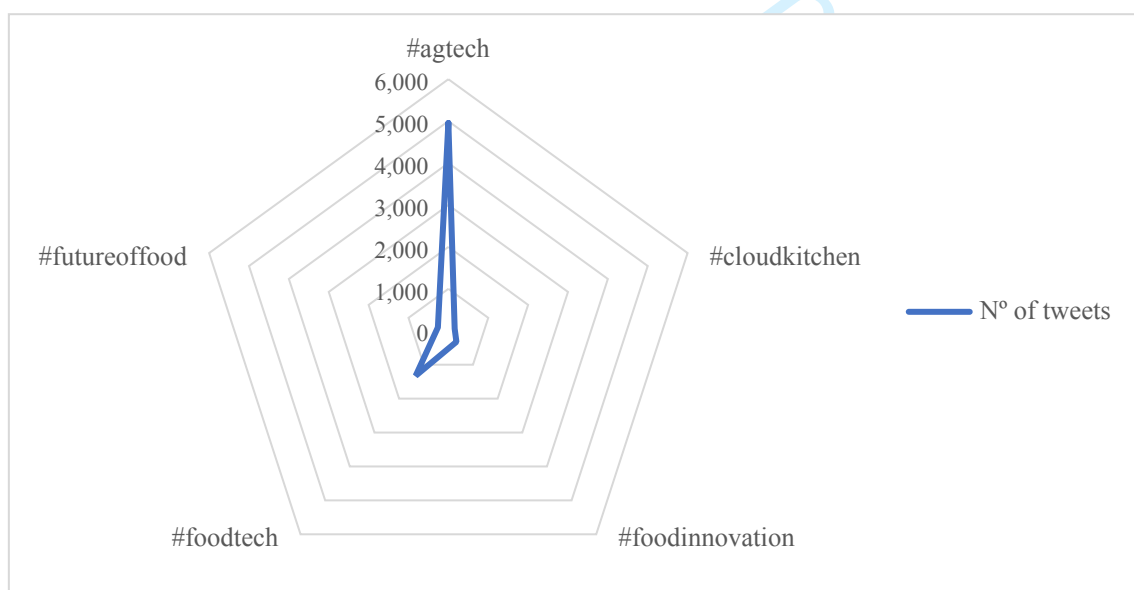
58 266 **4. Research methodology**  
59  
60

1  
2  
3 267 This research adopts Saura and Bennett's (2019) three-stage methodology for  
4 data text mining. In the first phase, the Latent Dirichlet Allocation (LDA) was  
5 268 implemented. Python was employed to assess the large dataset and identify datasets  
6 269 that were related. Before, 7030 tweets were extracted and cleaned within the  
7 270 hashtags #agtech, #cloudkitchen, #foodinnovation, #foodtech and #futureoffood. LDA  
8 271 was used to classify these tweets. Hence, it was used to categorise the food  
9 272 technology topics most discussed on Twitter based on the aforementioned dataset  
10 273 extracted of tweets (i.e. 7030).  
11 274

12 275 In the second period, the Support Vector Machine (SVM) type algorithm was  
13 276 executed to determine sentiment analysis. This stage allowed the recognition of the  
14 277 feelings for each topic by tagging these sentiments as positive, negative and neutral.  
15 278 Lastly, Atlas.ti was employed for text data mining within the results to arrange them  
16 279 regarding the weight of repetition of words. The system of measurement accepted is  
17 280 weighted percentage (WP), which distinguishes the words that are repeated the most.  
18 281

#### 282 **4.1 Data collection**

283 The data extraction was achieved by means of Python software 3.9.2 for Mac  
284 OS X connected to the public Twitter Application Programming Interface (API). The  
285 collected UGC was in English and Spanish and contained as keyword any of the  
286 following hashtags: #agtech, #cloudkitchen, #foodinnovation, #foodtech and  
287 #futureoffood. (Figure 2 and Table 2).  
288



288 **Figure 2.** Tweets collected concerning the most popular hashtags used in Twitter for  
 289 food technology

290 **Table 2.** Tweet collection concerning the hashtags employed.

Tag	Nº of tweets
#agtech	4.956
#cloudkitchen	158
#foodinnovation	326
#foodtech	1.327
#futureoffood	263

291

292 The dataset was cleaned by removing retweets, repeated tweets and not  
 293 readable tweets, which left a final sample of n= 7030 tweets. The data collection was  
 294 performed from the 8<sup>th</sup> of December 2020 to the 27<sup>th</sup> of January 2021; it comprised  
 295 the Christmas holidays, and the pre- and post-holiday stages. The food technology tags  
 296 #agtech, #cloudkitchen, #foodinnovation, #foodtech and #futureoffood in Twitter  
 297 were selected as these are the most used hashtags for food technology associated  
 298 tweets.

#### 299 **4.2 Topic detection**

300 The LDA model used is based on Jia's (2018), which follows a two-step  
 301 mathematical and probabilistic method. The first stage orders the keywords within a  
 302 database, where each word is encrypted in an independent file. Throughout the  
 303 second phase, the topics are randomly identified (Equation 1).

304 Equation 1

$$305 \quad p(\beta_{1:k}, \theta_{1:D}, Z_{1:D}, \omega_{1:D}) = \prod_{i=1}^K (\beta_i) (\beta_1) \times \prod_{d=1}^D \rho(\theta_d) \times \sum_{n=1}^N \rho(Z_{d,n} | \theta_d) p($$

$$306 \quad W_{d,n} | \beta_{1:K}, Z_{d,n})$$

307  $\beta_i$  distribution of word in topic i, altogether K topics

308  $\theta_d$  proportions of topics in document d, in all D documents

309  $Z_d$  topic designation in document d

310  $Z_{d,n}$  topic designation for the nth word in document d, in all N words

311  $W_d$  spotted words for document d

312  $W_{d,n}$  the  $n^{\text{th}}$  word for document d

313 The recognition of the topics and words is arranged ensuing Equation 2, by  
314 means of Gibbs sampling (Jia, 2018).

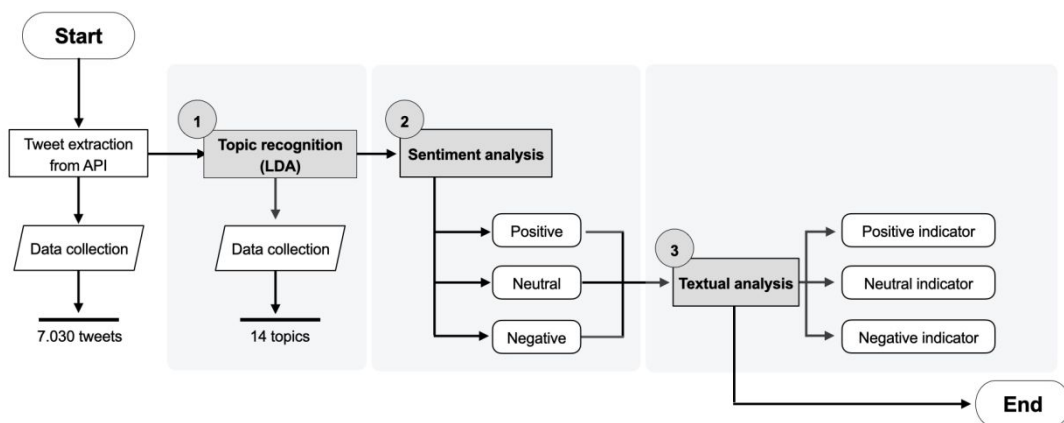
$$315 \rho(\beta_{1:k}, \theta_{1:D}, Z_{1:D} | \omega_{1:D}) = \frac{\rho(\beta_{1:k}, \theta_{1:D}, Z_{1:D}, \omega_{1:D})}{\rho(\omega_{1:D})}$$

### 316 **4.3 Sentiment analysis**

317 Once the most popular food technology topics in Twitter were recognised, a  
318 Python algorithm based on machine learning was executed. This phase comprised  
319 employing the algorithm for text data mining to categorise the feelings into positive,  
320 neutral and negative. Lastly, Krippendorff's Alpha Value (KAV) was employed to  
321 establish the precision of sentiment analysis. The reliability of the results was  
322 determined in the three sentiments. Thus, it was confirmed as when  $\alpha \geq 0.800$  the  
323 reliability of the results is high, when  $\alpha < 0.667$  the results are low and the threshold  
324 for tentative results is  $\alpha \geq 0.667$  (Krippendorff, 2004).

### 325 **4.4 Textual data analysis**

326 This phase was implemented by means of Atlas.ti software. Text data mining  
327 was fulfilled and labelled into the three sentiments (i.e., positive, neutral, negative).  
328 The dataset was organized ensuing three procedures: (1) identifying the frequency of  
329 repetition of the words; (2) determining the keywords' total weight measured as a  
330 weighted percentage (WP); and (3) filtering the words that are not applicable for the  
331 research purposes (Newton-John, 2018). WP labels the weight of the indicators  
332 grouped into nodes which is consistent with the number of times they are repeated  
333 (Newton-John, 2018). Figure 3 explains the three phases accomplished in this research.



334  
335 **Figure 3.** Phases of the research methodology.

336 **5. Results analysis**

337 The results of LDA estimation revealed 14 food technology-related topics,  
338 which are presented in Table 3. We retrieved the tweets written in English and Spanish  
339 as LDA revealed that content in those two languages. During this procedure, LDA  
340 classifies the words into topics, which were judiciously controlled and named in a  
341 unique language after studying the group of words (Büschken & Allenby, 2016; Jia,  
342 2018; Miller et al., 2017; Saura & Bennett 2019). The topic was named contemplating  
343 the 10 to 20 most repeated words, and the descriptions of the topics were made  
344 considering the content of the topics. Thus, this process entailed researcher'  
345 assistance for labelling the topics in one same language (i.e. English).

346 **Table 3.** Identified topics related to food technology in UGC.

Topic name	Topic description	WP	Sentiment
Innovations	Observations concerning innovative solutions of products, energy and related advancements.	2.41	positive
Start-ups	Comments on the actual progress of start-ups related to food technology.	1.37	positive

Ghost	Mentions regarding the lack of physical presence, the virtual dimension of all these implementations (such as bots, amazon, etc.).	1.34	negative
Sustainable agriculture	References to the need of guaranteeing sustainable and the benefits obtained from plant-based techniques.	1.00	positive
Kitchens & restaurants	Mentions concerning the impacts of kitchens, restaurants, such as the food waste.	1.00	negative
Unstable times	Annotations regarding the actual uncertainty, insecurity and the need of clearness.	0.94	negative
Pleasure	Remarks relative to the improvement food technology is going to imply in terms of enjoyment.	0.77	positive
Biotech	Recognition of the changes concerning biotechnology, genetic, engineering and pest.	0.72	neutral
Chefs	References to the importance of gourmet chef.	0.64	positive
Crisis	Discussion of the current crisis.	0.62	negative
Conflicts	Recognition of the conflicts and the hunger consequences.	0.58	negative
Sustainable farming	Comments and opinions of upcoming sustainable farming initiatives.	0.51	neutral
Free	Mentions to free resources.	0.47	positive
Climate disasters	Mentions to climate change implications and disasters, such as floods and droughts.	0.33	neutral

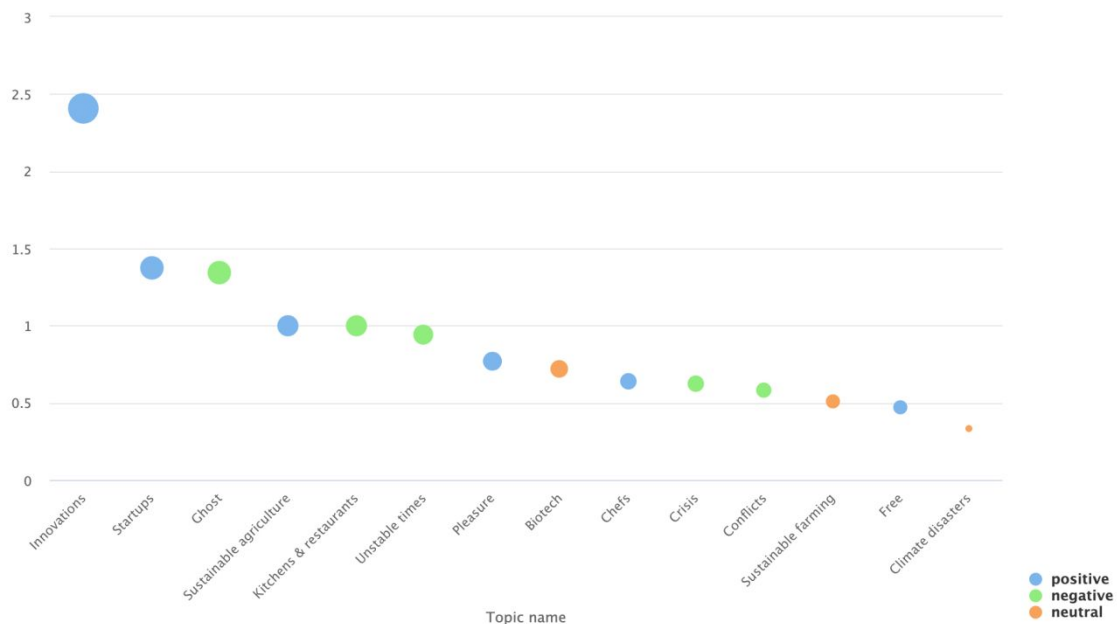
347 Sentiment analysis was accomplished ensuing Saura et al.'s (2020)  
 348 recommendations. The sentiment analysis algorithm was trained to accomplish the  
 349 recommended probability of success (Saura et al., 2020). Therefore, a sample of 750  
 350 posts was succeeded with data mining techniques to train the algorithm., following  
 351 Saura et al.'s recommendations.

352 Finally, Krippendorff's alpha values were assessed and the results were above  
 353 the thresholds (KAV) taking into account the complete database (i.e. 7030 tweets).  
 354 Table 4 specifies the sentiment analysis reliability.

355 **Table 4.** Sentiment Analysis conclusions' reliability (Krippendorff's alpha).

Conclusions' reliability	Krippendorff's alpha value	Sentiment	Average KAV
High	$\alpha \geq 0.800$	Positive	0.867
Tentative	$\alpha \geq 0.667$	Negative	0.747
Low	$\alpha < 0.667$	Neutral	0.685

356 The results of the textual analysis are shown in Figure 4, where the WP of each  
357 topic is identified concerning the feeling expressed (Krippendorff, 2004).



358  
359 **Figure 4.** Identified food technology topics in relation to the sentiment expressed and  
360 WP.

## 361 6. Discussion

362 The first objective of this study, related to first research question, was to  
363 identify popular food technology topics by examining UGC on Twitter. The analysis of  
364 the most repeated words of the selected tweets allowed us to establish the categories  
365 related to food technology users are talking about. Borrero & Zabalo (2021) also used  
366 this social media to obtain consumers' opinions and they confirmed that it is a valid  
367 tool to identify the topics of interest. As Samoggia et al. (2020) explained, social media  
368 has become essential to understand what consumers think, what are their perceptions  
369 on food products and what are their needs.

370 The use of Twitter to learn about the online conversation regarding food  
371 innovation is crucial to understand users' acceptance or rejection to specific matters of

1  
2  
3 372 the sector. Thus, we proposed the second research question to associate the identified  
4  
5 373 food technology topics to three different feelings (positive, neutral and negative).  
6

7 374 Finally, the last research question was endorsed to identify the innovations in  
8  
9 375 the food industry that can have the best acceptance. As social media are platforms  
10  
11 376 where individuals express their feelings and reveal their emotions (Elghannam et al.,  
12  
13 377 2020), they are extremely helpful as sources of information to learn about consumers'  
14  
15 378 perceived value and trust on these new technologies (Lin et al., 2020). Hence, this  
16  
17 379 sentiment analysis through a social network such as Twitter is very interesting as  
18  
19 380 opinions are not biased; consumers shared what they truly think, which is very  
20  
21 381 valuable (Mostafa, 2020).  
22

23 382 UGC has become an essential tool to learn about consumers' innovation  
24  
25 383 acceptance, which is very significant for the food sector (Samoggia et al., 2020). This  
26  
27 384 study reveals which new developments and products are more susceptible to  
28  
29 385 rejection, so strategies can be proposed to deal with consumers' apprehensions.  
30

### 30 386 **Conclusions**

31  
32 387 This research brought to knowledge important information regarding  
33  
34 388 technology in the food industry. Through data mining 7030 tweets were collected and  
35  
36 389 sorted into 14 different food-related topics, of which six categories were positive, five  
37  
38 390 were negative and three were neutral.  
39

40 391 It is interesting that the most commented topic –innovation– is considered  
41  
42 392 positive by Twitter users. Although some specific topics related to innovations are  
43  
44 393 commented separately and they do not arise a positive feeling, such as biotechnology  
45  
46 394 and genetics, it can be confirmed that innovative solutions and advancements in  
47  
48 395 general are accepted and supported.  
49

50 396 The second most mentioned category, food technology start-ups, is also well  
51  
52 397 perceived among Twitter users. This means there is strong support for those new  
53  
54 398 companies developing technologies for the industry. Sustainable agriculture, including  
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56 399 plant-based techniques, technologies applied to obtain bigger pleasure with food,  
57  
58 400 gourmet chefs and free resources are the other categories considered positive, and so  
59  
60 401 accepted by users.

1  
2  
3 402 However, some food-related topics are rejected by the Twitter community. The  
4  
5 403 virtual dimension of food-related technologies, such as bots or distributors, named as  
6  
7 404 ghost, is the third most commented subject but it is refused by users. Other negative  
8  
9 405 impacts on the food industry, as this study found out, are all the food waste taking  
10  
11 406 place in restaurants and kitchens, the insecurity and uncertainty of the current  
12  
13 407 unstable times, the crisis itself and the hunger as a consequence of these critical years.

14  
15 408 Finally, it is worth noticing three important topics that arise no specific  
16  
17 409 sentiment and remain neutral. Biotechnology and food genetics are considered neutral  
18  
19 410 by Twitter users. It is important that individuals understand the unlimited effective  
20  
21 411 solutions these technologies can provide to all society problems arising from world and  
22  
23 412 local crises, hunger, lack of resources and even pollution. Sustainable farming solutions  
24  
25 413 are also seen as neutral by users, along with climate change disasters. Users'  
26  
27 414 indifference in these crucial topics need to evolve to a positive feeling which entail  
28  
29 415 developing the required strategies that makes consumers accept the innovations.

### 30 416 **6.1 Theoretical implications**

31  
32 417 This research is another step in the advancement of knowledge regarding food-  
33  
34 418 technology topics in UGC. Before 2020, only three relevant studies about UGC in the  
35  
36 419 food industry were published. These three studies (Vidal et al., 2015; Park et al.,  
37  
38 420 2016; Singh et al., 2018) focused on Twitter comments to understand users' opinions  
39  
40 421 in food-related topics, such as habits, restaurants and food quality. However, none of  
41  
42 422 these focus on food technology. Interestingly, during 2020, three food data mining  
43  
44 423 studies (Yu & Zhan, 2020; Mathayomchan & Taecharungroj, 2020; Teichert et al.,  
45  
46 424 2020) were published regarding consumers' experience. For instance, Goldberg et al.  
47  
48 425 (2020) analysed and classified safety hazards coming from food consumption.

49 426 Up-to-date this is the first research that categorises Twitter users' opinions by  
50  
51 427 using food-technology-related hashtags and reveals users' sentiment analysis. It is  
52  
53 428 important to continue analysing online comments in different social networks in order  
54  
55 429 to understand what consumers think about all the new technologies that are been  
56  
57 430 developed in the food industry (Elghannam et al., 2020; Lin et al., 2020).  
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3 431 Additionally, it has been proven that this methodology is also more efficient  
4  
5 432 than traditional consumer analyses, such as questionnaires or focus groups, as it allows  
6  
7 433 researchers to get more and diverse information from larger data sets (Mostafa, 2020).  
8  
9 434 Big data analysis is cost-effective and allows the management of public information  
10  
11 435 from all the consumers using social media around the globe.

12  
13 436 This research, then, starts a new tendency on studies focused on data mining to  
14  
15 437 understand consumers perceptions. It opens the door to deeper research within the  
16  
17 438 use of social media channels. As technology becomes more present and essential in  
18  
19 439 society, it is crucial to keep researching into consumers' acceptance.

20  
21 440 This investigation also encounters some limitations associated with its  
22  
23 441 approach. The time and hashtags used over the data collection is limited and so  
24  
25 442 further research is encouraged to get larger samples of data over longer periods of  
26  
27 443 time to better understand consumers and get more information to develop the best  
28  
29 444 possible strategies for the industry.

## 30 445 **6.2 Managerial contributions**

31  
32 446 This research provides useful information that can help firms create consistent  
33  
34 447 managerial strategies to succeed in the food technology industry. As Goldberg et al.  
35  
36 448 (2020) explain, text mining and sentiment analysis help companies to monitor  
37  
38 449 consumers' opinions and understand online data to make the right decisions. Data  
39  
40 450 analysis allows companies to make informed decisions on management and customer  
41  
42 451 services (Tao et al., 2020). It is advisable for food technology companies to follow this  
43  
44 452 research's findings in order to make good business decisions and make their  
45  
46 453 innovations more successful in the market.

47  
48 454 The findings on this study will assist businesses in two main ways. On the one  
49  
50 455 hand, we found out that innovative solutions of products, energy and related  
51  
52 456 advancements, the progress of start-ups related to food technology, sustainability and  
53  
54 457 benefits obtained from plant-based techniques as well as the gourmet and pleasant  
55  
56 458 experiences are positively accepted by consumers. So, the industry is encouraged to  
57  
58 459 develop these innovations and technologies. As Gan et al. (2016) explained, only by  
59  
60 460 learning from individual sentiments, it is possible to create those products and

1  
2  
3 461 experiences that will make people feel right. This study reveals the technologies and  
4 462 food services, that are best perceived.

5  
6  
7 463 On the other hand, some agriculture and food tendencies are not positively  
8  
9 464 perceived by consumers. The lack of physical presence in food businesses, the virtual  
10 465 dimension of food implementations, biotechnology, genetics and food engineering are  
11  
12 466 negatively and neutrally perceived. For this matter, companies must improve their  
13  
14 467 communication and marketing strategies. Businesses must show consumers all the  
15  
16 468 benefits that those technologies can bring to society. As this research also found out,  
17  
18 469 consumers consider unstable times, conflicts, crises, hunger consequences and climate  
19  
20 470 change implications as something negative for the food industry, so food technology  
21  
22 471 companies are encouraged to promote how their technology helps to improve those  
23  
24 472 critical situations.

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# Forecasting the next revolution: Food technology impact on consumers' acceptance and satisfaction

## ABSTRACT

*Design/methodology/approach:* Based on text data mining, 7030 tweets were collected and ~~sorted~~ ~~organized~~ into 14 different food-related topics. ~~of which six categories~~ Six of these categories were positive, five were negative and three were neutral.

*Purpose:* In a sector that needs to satisfy a fast-increasing population, advancements like cultivated meat and bio-circular economy are ~~key basic~~ to sustain the industry and the society. ~~As innovations are key for economic and social progress the present and the future, but~~ it is crucial to understand consumers' position on this matter.

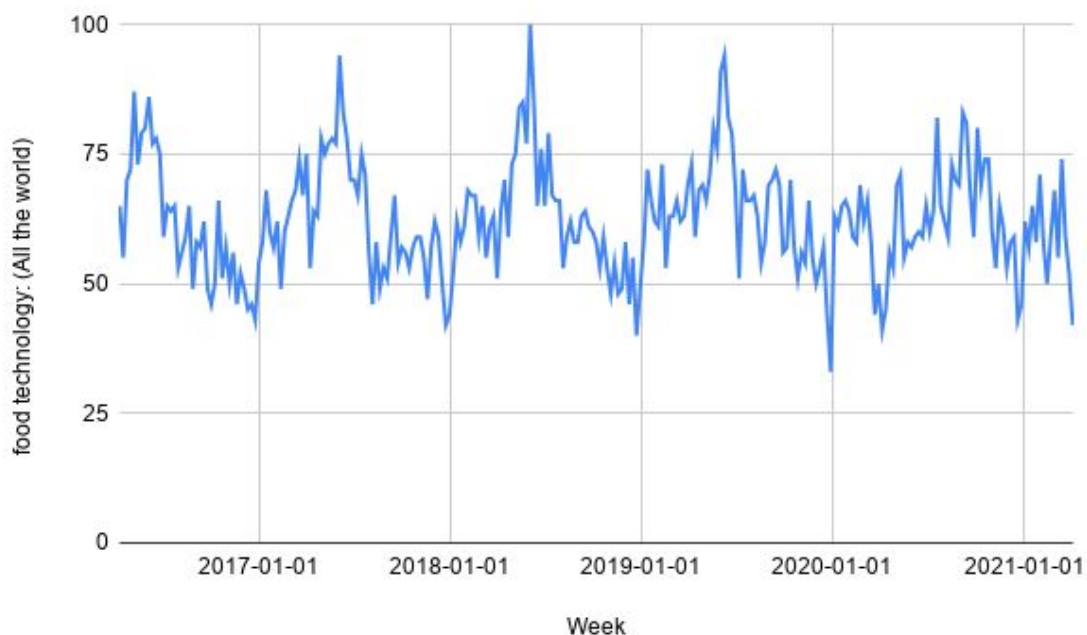
*Findings:* ~~Most~~ Six categories related to food technologies were ~~seen~~ positively perceived by Twitter users, such as innovative solutions and sustainable agriculture, while ~~five others~~, like ~~the~~ virtual dimensions of the industry or crisis-related scenarios, ~~have-were a~~ negatively perceived interpretation by consumers. It is remarkable ~~how~~ that three categories ~~topics have~~ had a neutral sentiment, which gives ground to improvement ~~in a privileged position, just~~ before consumers have a negative opinion and ~~it is~~ consequently will be more complicated to change their minds.

*Originality/value:* Technological innovations are becoming predominant in the food industry. ~~and T~~ he SARS-CoV-2 pandemic has made the sector improve even faster. Traditional methods needed to be substituted and technologies such as robots, Artificial Intelligence, blockchain and genetics ~~have arisen~~ are here to stay.

**Keywords:** sentiment analysis; text data mining; Twitter; food technology; innovation; consumers' acceptance

## Introduction

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3 32 The Covid-19 pandemic has brought many changes ~~in the way we interact with~~  
4 ~~the different actors of~~ to the food industry. Food safety and sustainability ~~has~~ ~~have~~  
5 33 ~~become~~ ~~key-a challenge~~ during this health crisis. ~~and~~ Innovations, such as Industry 4.0  
6 34 applications ~~related to speed-up local food delivery~~ and ~~reduce food safety risks~~  
7 35 ~~consumption~~, have ~~arouse~~ ~~aroused from-it~~. The food ~~sector~~ ~~industry~~ is being  
8 36 revolutionised by the use of data analytics and Artificial Intelligence (~~AI, in advance~~).  
9 37 Real time monitoring ~~and-management has ve~~ become essential ~~in~~ ~~for~~ supply chain  
10 38 ~~management~~, food security and smart agriculture (Galanakis et al., 2021). The SARS-  
11 39 CoV-2 emergency has also ~~changed~~ ~~transformed~~ the way we interact ~~in-society~~, which  
12 40 has ~~allowed innovations~~ ~~introduced advances~~ such as drone ~~delivery~~ (Kim et al., 2021)  
13 41 and contactless delivery (Zhan & Chen, 2021) ~~to-further-develop~~. The coronavirus has  
14 42 also given impulse to other ~~developments~~ ~~innovations~~ in the food industry, such as  
15 43 robot systems, automation, web-based distribution systems and ~~more dynamic~~ e-  
16 44 commerce (Aday & Aday, 2020), ~~as well-as in addition to~~ nutritional and immune-  
17 45 boosting products (Galanakis et al., 2021).  
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48 **Figure 1.** Search trends on “food technology” in Google Trends report (2017–2021).

49 Figure 1 ~~shows~~ ~~presents~~ the relevance of food technology, as it ~~reveals the~~  
50 ~~number of~~ searches that were conducted in Google from January 2017 to January 2021  
51 ~~in relation to this matter~~. The average of the search is 62.32, being 100 the value that

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3 52 ~~describes~~ ~~defines~~ the highest popularity of the term. This number, supported by ~~along~~  
4 ~~with the a~~ clear increasing and regular tendency, ~~shows~~ ~~exposes~~ the importance of the  
5 ~~subject-topic~~ in the industry. Food technology, and all that it implies, have arrived to  
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9 55 stay and ~~it's-it is~~ provoking great and ~~important~~ ~~significant~~ ~~changes~~ ~~transformations~~ in  
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11 56 ~~an industry business~~ that wants to evolve (Jacobsen et al., 2021).

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13 57 The study of User-Generated Content (UGC, ~~in advance~~) is ~~erueial~~ ~~decisive~~ ~~to~~  
14 ~~forecast for~~ the development of new technologies ~~in-the-food-industry~~. ~~Despite the~~  
15 ~~fact that advancements~~ ~~innovation~~ are ~~key~~ vital for economic growth, ~~but~~-some food  
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17 59 technologies are not very well ~~seen~~ ~~perceived~~ by the public (Siegrist & Hartmann,  
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19 60 2020). It is essential that consumers accept new ~~technologies~~ ~~high tech~~  
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21 62 ~~implementations~~ in the industry for these ~~advancements~~ to be developed (Siegrist et  
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23 63 al., 2016). However, ~~society~~ ~~individuals~~ tends to the so-called neophobia, ~~more~~  
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25 64 ~~specifically~~ ~~precisely~~ the fear to new food technologies (Cifci et al., 2020). This happens  
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27 65 because people ~~incline~~ to ~~see~~ ~~feel~~ risk in the unknown ~~and-so,~~ ~~which makes them~~ ~~they~~  
28  
29 66 ~~do~~ not appreciate all the benefits and ~~effects~~ ~~positive~~ ~~consequences~~ of these  
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31 67 innovations on their health (Boccia & Punzo, 2021). ~~Thus~~ ~~So~~, it is very important to  
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33 68 understand ~~consumers' attitude toward the reasons that make consumers be critical~~  
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35 69 ~~with~~ food technology ~~and~~ innovations and ~~study~~ ~~examine~~ if a new technology is  
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37 70 whether going to be accepted or rejected before it ~~is~~ ~~can-be~~ implemented and  
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39 71 commercialised (Cifci et al., 2020).

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41 72 Due to the Covid-19 crisis, this study aims to answer to the ~~recent~~ call for  
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43 73 acknowledging users' acceptance to new technologies in the food industry. This  
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45 74 research will offer insights regarding the ~~sentimental~~ analysis, which will propose  
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47 75 useful information that will support collaborative learning ~~so-as~~ to enhance the success  
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49 76 of the application and commercialisation of these high-tech advancements.

## 77 2. Literature framework

### 78 2.1 The role of Social Networking Services in the food industry

79 ~~Nowadays~~ ~~Today~~, we all live in a digital era in which social media has become  
80 ~~key~~ ~~the~~ ~~main~~ ~~communication~~ ~~channel~~ for ~~human~~ interaction ~~and-online~~  
81 ~~communication-is-an-increasing-tendency-trend~~ (Jacobsen et al., 2021). ~~This technology~~  
82 ~~Social networks are~~ used by over half of the whole world population, with still great

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3 83 potential to ~~keep growing grow~~, making ~~it~~ them ~~an~~ essential tools ~~in the present and~~  
4 ~~the future~~ for present and future strategies (Elghannam et al., 2020). ~~Actually,~~  
5 84 ~~Nowadays,~~ more than 90% of young adults (under 30) use social media in their daily  
6 85 lives (Fleming-Milici & Harris, 2020), ~~while and~~ the total amount of users reached 3.48  
7 86 billion in 2019 (Ventura et al., 2021). Social networks are also a widespread tool for  
8 87 food purposes. Food is ~~an on-topie popular~~ subject on social media, being easy to find  
9 88 ~~food culinary~~ content on different networks, including recipes, videos ~~and~~ photos ~~and~~  
10 89 ~~all-kind-of posts~~ (Nour et al., 2018). ~~But Besides, it social networking services~~ can also  
11 90 help the food industry in many other ways, achieving positive outcomes for both  
12 91 consumers and producers. ~~Regarding the latter,~~ one of the best advantages of social  
13 92 media ~~for producers~~ is the opportunity to avoid intermediaries in the supply chain, ~~as~~  
14 93 ~~it offers the possibility to have a and have a more~~ direct contact with the consumer,  
15 94 ~~This helps improving the in terms of traceability and price of the product.~~ ~~and~~  
16 95 Consumers also gain insights ~~into what the product~~ they purchase, such as origin,  
17 96 safety and wholesomeness (Elghannam et al., 2020). Social networks are ~~also~~ a  
18 97 fantastic technology ~~as well~~ to create ~~a memorable~~ experiences for ~~the consumers,~~  
19 98 improving companies' relations with ~~them their customers~~ at the same time as they  
20 99 offer entertainment, personalisation and value creation (Jacobsen et al., 2021).  
21 100

22 101 Social media is also a great tool to spread information and develop trust  
23 102 (Buskens, 2020). ~~This way,~~ Producers can use this technology to ~~create a link improve~~  
24 103 ~~the relationship~~ with the consumers, ~~both sharing~~ informational ~~but also~~ and emotions  
25 104 ~~al. improving at the same time~~ Online networks also improve their ~~customer service~~  
26 105 ~~attention.~~ Networking systems are ~~as well~~ a fantastic opportunity to approach  
27 106 targeted consumers and create a brand that aligns with the ~~needs of~~ new generations  
28 107 (Fleming-Milici & Harris, 2020), adapting the marketing strategies to connect with ~~their~~  
29 108 ~~the selected audience public~~ and ~~even~~ gain more ~~engaged consumers~~ customers  
30 109 (Elghannam et al., 2020).  
31 109

32 110 Food companies can also use social media to understand how consumers  
33 111 ~~perceive see~~ and use their products, and adapt them to their needs, ~~offering~~  
34 112 ~~information of how they accomplish the~~ co-creation process that results in ~~a better~~  
35 113 product that better ~~adapts to their desires~~ (Jacobsen et al., 2021). These strategies  
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3 114 ~~need~~ require a clear understanding of ~~effective communication~~ the messages in order  
4  
5 115 to appropriately manage the information that is given to the audience (Rutsaerta et  
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7 116 al., 2013). Twitter is an essential network ~~for all this to achieve that approach~~ as it is  
8  
9 117 considered ~~as~~ the digital form of the long-standing word-of-mouth (Samoggia et al.,  
10  
11 118 2020).

12  
13 119 Twitter is one of the most used social networks and the most popular micro-  
14  
15 120 blogging site, holding around 500 million tweets per day, ~~being which makes it~~ an  
16  
17 121 excellent platform for public communication (Araújo Britto Sass et al., 2020). ~~This way~~  
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19 122 ~~Therefore,~~ food-related topics ~~spoken~~ addressed in Twitter reflect consumers'  
20  
21 123 interests. ~~As a great data source of consumers' conduct, this social network and are~~ is  
22  
23 124 ~~key fundamental~~ to develop the ~~appropriate~~ products and ~~the~~ marketing strategies ~~for~~  
24  
25 125 ~~the target market of the sector, as it is a great data source of consumers' conduct~~  
26  
27 126 (Borrero & Zabalo, 2021). ~~Thus,~~ Twitter's effective communication system allows food  
28  
29 127 companies to listen to consumers, handle customer service and create a viral branding  
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31 128 environment for their products (Liu et al., 2017).

## 32 129 **2.2 The influence of technology in the food industry**

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34 130 The food industry is ~~continually~~ constantly developing new technologies ~~in~~  
35  
36 131 ~~order~~ to cope with new consumers' needs and tastes. Innovative technologies also  
37  
38 132 help to improve production efficiency and processing times, guarantee safety and  
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40 133 quality, reduce energy costs and ~~are~~ ~~undertaking~~ more environmentally friendly  
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42 134 ~~practices~~ (Gallo et al., 2018). As consumers ~~are~~ increasingly becoming more exigent  
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44 135 ~~demanding~~, they are ~~more than ever~~ looking for safe and natural products that are  
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46 136 produced in a sustainable and ecological way (Putnik et al., 2020). Technology is also a  
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48 137 ~~great necessary~~ tool to deal with the ~~rise-increase~~ in global food demand as well as to  
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50 138 cope with food security ~~and sanitary requirements~~ (Jeyakumar Nathan et al., 2021). As  
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52 139 food demand is expected to ~~augment~~ ~~increase~~ at impressive rates in the following  
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54 140 decades, the industry has ~~the challenge to face how~~ to provide access to enough  
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56 141 quantity of quality food and beverages. ~~In this matter, technological innovations are~~  
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58 142 ~~essential as they can~~ ~~which can be done by implementing technology to~~ improve  
59  
60 143 productivity ~~in the sector~~ (Duong et al., 2020).

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3 144 Among the most innovative developments in the food industry, ~~we can find~~  
4 internet-driven agriculture; new production methods such as urban farming, which  
5 145 includes vertical farming, aquaponics and the Internet of Things; zero waste food  
6 146 includes vertical farming, aquaponics and the Internet of Things; zero waste food  
7 147 processing via processing technology; natural preservatives and smart packaging ~~stand~~  
8 148 ~~out. New forms of food are also increasing, for example, insect farming, microalgae~~  
9 149 ~~and cultivated meat (Mok et al., 2020). With an~~ Taking into account the  
10 150 ~~mentioned~~ increase in the population and ~~so~~ in demand, new forms of food, such  
11 151 as insect farming, microalgae and cultivated meat, are becoming significant (Mok et  
12 152 al., 2020). Furthermore, ~~new needs appear emerge and~~ food personalisation ~~is~~  
13 153 ~~appearing to be~~ a solution that can help improve ~~people's~~ life quality and ~~promote~~  
14 154 consumers' health (Ueland et al., 2020).

15 155 ~~Considering the great number of As~~ new technologies ~~that are being created~~  
16 156 ~~arise~~ in the food industry, it is important to highlight some of the most developed ~~ones~~  
17 157 ~~innovations~~. Major technologies are being applied in the production stages ~~both~~ to  
18 158 improve the manufacture ~~itself processes~~ and the ~~obtained final~~ products. Robotics  
19 159 and autonomous systems (RAS, ~~in advance~~) are an ~~effective great~~ tool to improve  
20 160 productivity and reduce costs ~~in the food processing of supply chains. This technology~~  
21 161 ~~can be used as well to help human workers and reduce or eliminate~~ and risky  
22 162 situations. ~~RAS are applied in during~~ the different stages of the production. ~~stage in~~  
23 163 ~~several matters, such as~~ Many examples of high tech implementations are appearing  
24 164 ~~such as those related to~~ harvesting, fruit picking, animal milking, food delivery to  
25 165 livestock, waste removal and aquaculture (Duong et al., 2020).

26 166 Ultrasound is another major technology that can ~~greatly considerably help~~  
27 167 ~~improve the production processes of~~ the food industry. These mechanical waves,  
28 168 originated in molecular moves, can incite ~~provoke~~ physical and chemical reactions  
29 169 applicable ~~in to~~ food processing stages. Ultrasound causes mechanical, chemical and  
30 170 biochemical changes in liquids and gases ~~that can improve the~~ ~~with the intention of~~  
31 171 ~~getting more~~ functional and high-quality ~~of aliments foods. This technology helps to~~  
32 172 ~~Hence, it increases the~~ control of the production processes and ~~the evaluation of~~ food  
33 173 state while it reduces the ~~usage of~~ energy ~~use~~, becoming a green option for the  
34 174 ~~procedure process~~. It can also be used to cut foods and bond the packaging in a safer,

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3 175 more economical, hygienic and environmentally friendly way ~~than before~~ (Gallo et al.,  
4 176 2018).

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7 177 Another ~~green ecological~~ innovation that can be used in the food production  
8 178 process is hurdle technology. This ~~advacenment technology~~ inactivates  
9 179 microorganisms ~~so as to stimulate food presevation preserve food at the same time~~  
10 180 ~~that it is possible to, and thus while getting the desired quality and stability in the~~  
11 181 ~~product~~. It avoids high temperatures, which helps to preserve the nutritional value of  
12 182 the product, ~~and thus improves the quality of the food product. Therefore, hurdle~~  
13 183 ~~technology is a process that allows to get a safe final product. and it is safer~~ (Putnik et  
14 184 al., 2020). ~~A further One more technology to take into account and to~~ implement in  
15 185 the food industry is cultured meat. The growth of animal meat in a laboratory gives the  
16 186 opportunity to get an ~~infinite extense~~ supply of protein of great quality at a very low  
17 187 environmental impact (Bekker et al., 2017).

18  
19  
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21  
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24  
25  
26  
27  
28 188 ~~In addition, new technologies developed in the food industry can be applied~~  
29 189 ~~Technological innovations are not only available to be applied in the production~~  
30 190 ~~process but they are convenient to improve consumers' experience. For example, apps~~  
31 191 ~~high tech implementations are a tool that is included in the life of a huge part of the~~  
32 192 ~~population and food apps~~sSpecific mobile applications for the gastronomic industry  
33 193 are increasing every day. It is possible to find food-related apps for many matters,  
34 194 ~~including such as meal planning and preparation, help to achieving sustainability in~~  
35 195 ~~food consumption and getting information and customisation of content. But~~  
36 196 ~~However~~, as Jacobsen et al. (2021) explain, the ~~new step has arrived in the form of~~  
37 197 ~~current top innovations are~~ virtual reality and augmented reality, ~~in order to which~~  
38 198 ~~allows businesses to~~ improve the customer experience during the use of the product.  
39 199 While virtual reality is not very accessible, augmented reality can be easily  
40 200 implemented through a mobile application ~~in, for example, smart packaging with~~  
41 201 ~~including a , for instance, using a QR~~ code. The product experience is enhanced while  
42 202 consumers get ~~food information and understanding of the food~~ in a very enjoyable  
43 203 way, which, ~~also at the same time,~~ helps to increase purchase intentions.

44  
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57  
58 204 Another related technology that ~~helps increases~~ consumers' welfare is active  
59 205 packaging. This innovative ~~implementation technology permits to~~ avoids the usage of

1  
2  
3 206 plastic packages to ~~keep~~ preserve food ~~and use~~ as it creates sustainable,  
4  
5 207 biodegradable, ~~notn-toxic~~ and antimicrobial packaging by means of nanotechnology  
6  
7 208 and nanocarbon materials, which ~~to create-s while it~~ prolongs the life of the ~~product~~  
8  
9 209 ~~aliment~~ and maintains its sensory properties (Azevedo de Carvalho & Conte Junior,  
10  
11 210 2020).

12  
13 211 ~~Other~~ Further important technologies are being developed ~~in-order~~ to  
14  
15 212 personalise food and satisfy consumers' needs. We highlight 3D food printing and  
16  
17 213 molecular and note-by-note cuisines. ~~On the one hand~~, 3D food printing permits the  
18  
19 214 creation and personalisation of on-demand consumable products while it reduces food  
20  
21 215 waste and contributes to sustainability (Jayaprakash et al., 2020). Molecular  
22  
23 216 gastronomy, on the other hand, ~~permits allows~~ the development of high-quality food  
24  
25 217 through science techniques such as dehydration, liquid nitrogen and enzymes, among  
26  
27 218 others. Finally, note-by-note cuisine ~~creates-performs~~ new foods and flavours by using  
28  
29 219 disaggregated parts of existing foods. This allows to eliminate the components that  
30  
31 220 provoke allergies or food sickness to certain people (Cifci et al., 2020). It is also  
32  
33 221 important to mention gene technology applied to the food industry. ~~Gene technology~~  
34  
35 222 ~~applied to food~~ Genetic applications can ~~influence module-on~~ the taste, safety and  
36  
37 223 nutritional value ~~as of the product~~ to satisfy consumers' needs ~~while which at the end,~~  
38  
39 224 ~~it~~ can solve worldwide hunger problems in a sustainable way (Boccia & Punzo, 2021).

### 225 **2.3 User-generated content and sentiment~~al~~ analysis concerning food technology**

40  
41 226 Once a new product is created, ~~people's~~ consumers' opinions are very  
42  
43 227 important to analyse their acceptance ~~of this new creation in the market that novelty.~~  
44  
45 228 The Internet is a ~~worldwide universal~~ tool that allows users to share their thoughts and  
46  
47 229 reviews on the products they use. This kind of electronic word-of-mouth is crucial ~~in~~  
48  
49 230 ~~for~~ new marketing strategies. ~~and~~ It has been stated that ~~it~~ online comments shapes  
50  
51 231 ~~helps~~ potential clients' ~~predisposition~~ to ~~decide-on~~ the purchase products (Elghannam  
52  
53 232 et al., 2020). ~~In this context, obtaining~~ online information from other consumers as it  
54  
55 233 is accessible and credible has become compulsory. All the ~~comments-and-photos~~  
56  
57 234 ~~content~~ found on social media, posted by users, ~~helps-other-people-to~~ affects other  
58  
59 235 potential consumers' willingness to purchase the product ~~get-an-idea-of-the-product~~  
60  
236 ~~they-are-researching~~ (Jacobsen et al., 2021). All this ~~content~~ information shared by

1  
2  
3 237 related to product critics can be shared by others and it can reach an important  
4  
5 238 number of ~~people potential customers~~ (Fleming-Milici & Harris, 2020). Through these  
6  
7 239 ratings and reviews, consumers participate in the creation of ~~information data, which~~  
8  
9 240 increasing, ~~at the same time,~~ their satisfaction towards the product or brand. ~~as~~  
10  
11 241 ~~Through these media, they individuals~~ feel that they can participate and ~~can~~ interact  
12  
13 242 with the company in a relaxed and informal way (Lin et al., 2020). Basically, social  
14  
15 243 ~~media is networks are~~ a free way for consumers to express their ~~real unbiased~~ feelings  
16  
17 244 towards a product (Mostafa, 2020). Also, social media is ~~nowadays today~~ one of the  
18  
19 245 main sources of information (Faour-Klingbeil et al., 2021).

20  
21 246 UGC provides ~~great countless~~ business advantages to companies. All the online  
22  
23 247 produced data can be an asset for brand communication as it has ~~a~~ relevant effect on  
24  
25 248 the image of the product and, ~~therefore, on~~ its final sales. UGC helps the brand to  
26  
27 249 understand how consumers feel about their products, in terms of features, innovation,  
28  
29 250 quality, etc., and ~~also what customers think about the competitors of that company~~  
30  
31 251 (Liu et al., 2017). Sentiment analysis is a ~~key strategic~~ tool to extract all the relevant  
32  
33 252 information from the ~~huge vast amount of data produced that can be found~~ online, by  
34  
35 253 transforming this ~~big data input~~ into structured facts (Chakraborty et al., 2020). Data is  
36  
37 254 ~~currently~~ considered as one of the most valuable resources, ~~nowadays~~ and Twitter, ~~for~~  
38  
39 255 ~~example,~~ is the perfect place to ~~extract access to this specific topic-related~~ information  
40  
41 256 and analyse it, ~~mostly for its public character~~ (Borrero & Zabalo, 2021). Twitter is an  
42  
43 257 ~~great unlimited~~ outlet from which to take all the ~~data needed to understand~~  
44  
45 258 consumers' opinions as it covers many different topics ~~and as people share opinions~~  
46  
47 259 ~~there every day~~ (Araújo Britto Sass et al., 2020).

48  
49 260 The food industry should take advantage of all ~~these sources of information~~  
50  
51 261 ~~resources~~ and analyses ~~in order~~ to gain insight on consumers' thoughts ~~and so and~~  
52  
53 262 ~~consequently,~~ develop the technologies that will be widely accepted ~~by the general~~  
54  
55 263 ~~public.~~ This way, consumers will be involved in the innovation process and their needs  
56  
57 264 ~~can be included will be assessed~~ (Jacobsen et al., 2021). ~~People tend to trust~~  
58  
59 265 ~~consumers' opinions related to the food industry and food advancements, This which~~  
60  
266 ~~helps companies to know their needs and level of trust. but it~~ However, this can also  
267 ~~provoke a general negative feeling about a specific product.~~ For instance, some

268 technologies, such as genetically modified foods or food irradiation, are prone to get  
 269 negative reviews ~~as just because~~ people don't not understand them properly or even  
 270 fear them. It is important that experts provide adequate information about these  
 271 innovations ~~and help real and accurate information fight to exceed~~ negative comments  
 272 on the Internet (Rutsaerta et al., 2013). ~~It is important, then, to understand the online~~  
 273 ~~conversation about food technologies that companies want to succeed in order to for~~  
 274 ~~companies to use this information in their advantage and also prevent misleading~~  
 275 ~~information from affecting their advancements research. In the table down below,~~  
 276 ~~Table 1 pinpoints some important revealing~~ studies about sentiment analysis in the  
 277 food technology sector ~~that help understand~~ , ~~which emphasize~~ the importance of  
 278 UGC ~~about innovations~~ in the industry. UGC started to be mined around 2015 but it  
 279 wasn't not until recently that we find an increasing number of studies using sentiment  
 280 analysis in different areas of the food industry (consumers' experience, supply chain,  
 281 delivery services, safety, etc.). ~~Still, However, research based on sentiment analysis~~  
 282 ~~regarding food related topics is still in it is infancy as only few studies have been~~  
 283 ~~reported, , there is not yet a lot of research on this area, which makes it very~~  
 284 ~~interesting to pursue.~~

285 **Table 1.** Main studies on UGC and food.

Authors	Description
Vidal et al., 2015	In this study, the authors retrieved thousands of tweets and classified them <del>in order</del> to understand what the most spoken food-related topics are. With it, they wanted to learn about consumers' preferences, purchasing habits, timing, making plans, etc.
Park et al., 2016	Twitter comments were used in this research to examine customers opinions in different types of restaurants by classifying the different attributes that affect the meal experience.
Singh et al., 2018	This research analysed customers' opinions on the quality of food products using Twitter content to identify issues affecting consumers' satisfaction and its relation with the

supply chain process.

Yu & Zhan, 2020 The investigation studied the online comments of three top restaurants in order to analyse the dinner experience of those customers as well as to understand which factors affect their feelings after the experience.

Goldberg et al., 2020 These researchers used data mining and sentiment analysis to learn and classify safety hazards that come from food consumption. They used reviews from two websites and organised the information in different categories.

Mathayomchan & In this study, they used the comments, on Google Maps, of Taecharungroj, 2020 several restaurants of different cities to understand consumers' opinions as well as to learn the attributes that create a positive and/or negative experience at a food-related service.

Teichert et al., 2020 This research focused on food delivery service. The authors classified thousands of comments from different websites into several categories to later understand the different aspects that affect the overall consumer's experience.

### 286 3. Research questions approach

287 The research approach adopted is based on Research Questions (RQs), which is  
288 specifically thought-provoking in learning processes (Schumaker et al., 2016) as it  
289 encourages the origination of new ideas.

290 Table 1 points out studies that have established revealed that, by examining  
291 UGC on social media channels, popular topics can be identified. Therefore, the  
292 following RQ is suggested:

293 **RQ1:** *Is it possible to identify popular food technology topics examining UGC on*  
294 *Twitter?*

295 Sentiment analysis has been extensively employed to classify the feelings  
296 expressed, which are basically categorised into positive, neutral and negative  
297 sentiments (Saura et al., 2020). There are several previous studies that have mined  
298 online, food-related UGC and made a classification depending on the aroused feeling

1  
2  
3 299 (i.e. positive, neutral or negative) (Dondokova et al., 2019; Mostafa, 2020; Chen et al.,  
4  
5 300 2020). Thus, the next RQ is proposed:

6  
7 301 **RQ2:** *Is it possible that the identified food technology topics in UGC on Twitter be*  
8  
9 302 *associated to different feelings?*

10  
11 303 It has been confirmed that the UGC from Twitter improves collective learning  
12  
13 304 (Stephansen & Couldry, 2014; Tang & Hew, 2017). Thus, this research can propose  
14  
15 305 relevant information concerning consumers' acceptance and satisfaction of the  
16  
17 306 technology used in the food industry and, even, address future insights. **According to**  
18  
19 307 **the three established categories (positive, negative and neutral), customer satisfaction**  
20  
21 308 **can be understood. While positive implies that the customer is happy regarding the**  
22  
23 309 **food technology, negative implies to not focus on those aspects or topics that are**  
24  
25 310 **commented. Finally, the categories that turn to be neutral need a further**  
26  
27 311 **consideration for the product management (Chakraborty et al., 2020).**

28  
29 312 **RQ3:** *Is it possible to foster collective learning of how to improve consumers accepting*  
30  
31 313 *and satisfaction of the technology used in the food industry by grouping the identified*  
32  
33 314 *food technology topics in relation to positive, neutral and negative feelings?*

#### 34 315 **4. Research methodology**

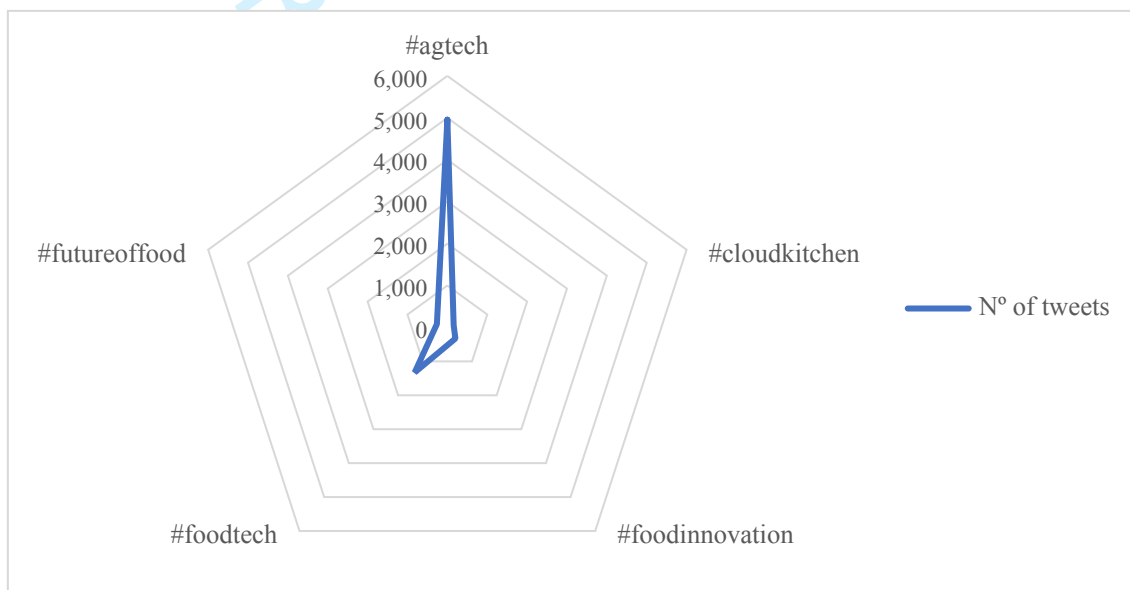
35  
36  
37 316 This research adopts Saura and Bennett's (2019) three-stage methodology for  
38  
39 317 data text mining. In the first phase, the Latent Dirichlet Allocation (LDA) was  
40  
41 318 implemented. Python was employed to assess the large dataset and identify datasets  
42  
43 319 that were related. Before, 7030 tweets were extracted and cleaned within the  
44  
45 320 hashtags #agtech, #cloudkitchen, #foodinnovation, #foodtech and #futureoffood. LDA  
46  
47 321 was used to classify these tweets. Hence, it was used to categorise the food  
48  
49 322 technology topics most discussed on Twitter based on the aforementioned dataset  
50  
51 323 extracted of tweets (i.e. 7030).

52  
53 324 In the second period, the Support Vector Machine (SVM) type algorithm was  
54  
55 325 executed to determine sentiment analysis. This stage allowed the recognition of the  
56  
57 326 feelings for each topic by tagging these sentiments as positive, negative and neutral.  
58  
59 327 Lastly, Atlas.ti was employed for text data mining within the results to arrange them  
60

328 regarding the weight of repetition of words. The system of measurement accepted is  
 329 weighted percentage (WP), which distinguishes the words that are repeated the most.

#### 330 **4.1 Data collection**

331 The data extraction was achieved by means of Python software 3.9.2 for Mac  
 332 OS X connected to the public Twitter Application Programming Interface (API). The  
 333 collected UGC was in English and Spanish and contained as keyword any of the  
 334 following hashtags: #agtech, #cloudkitchen, #foodinnovation, #foodtech and  
 335 #futureoffood. (Figure 2 and Table 2).



336  
 337 **Figure 2.** Tweets collected concerning the most popular hashtags used in Twitter for  
 338 food technology

339 **Table 2.** Tweet collection concerning the hashtags employed.

Tag	Nº of tweets
#agtech	4.956
#cloudkitchen	158
#foodinnovation	326
#foodtech	1.327
#futureoffood	263

340

341 The dataset was cleaned by removing retweets, repeated tweets and not  
 342 readable tweets, which left a final sample of n= 7030 tweets. The data collection was

performed from the 8<sup>th</sup> of December 2020 to the 27<sup>th</sup> of January 2021; it comprised the Christmas holidays, and the pre- and post-holiday stages. The food technology tags #agtech, #cloudkitchen, #foodinnovation, #foodtech and #futureoffood in Twitter were selected as these are the most used hashtags for food technology associated tweets.

#### 4.2 Topic detection

The LDA model used is based on Jia's (2018), which follows a two-step mathematical and probabilistic method. The first stage orders the keywords within a database, where each word is encrypted in an independent file. Throughout the second phase, the topics are randomly identified (Equation 1).

Equation 1

$$p(\beta_{1:k}, \theta_{1:D}, Z_{1:D}, \omega_{1:D}) = \prod_{i=1}^K (\beta_i) (\beta_1) \times \prod_{d=1}^D \rho(\theta_d) \times \sum_{n=1}^N \rho(Z_{d,n} | \theta_d) p(W_{d,n} | \beta_{1:K}, Z_{d,n})$$

$\beta_i$  distribution of word in topic i, altogether K topics

$\theta_d$  proportions of topics in document d, in all D documents

$Z_d$  topic designation in document d

$Z_{d,n}$  topic designation for the nth word in document d, in all N words

$W_d$  spotted words for document d

$W_{d,n}$  the n<sup>th</sup> word for document d

**Thenceforth,** The recognition of the topics and words is arranged ensuing Equation 2, by means of Gibbs sampling (Jia, 2018).

$$\rho(\beta_{1:k}, \theta_{1:D}, Z_{1:D} | \omega_{1:D}) = \frac{\rho(\beta_{1:k}, \theta_{1:D}, Z_{1:D}, \omega_{1:D})}{\rho(\omega_{1:D})}$$

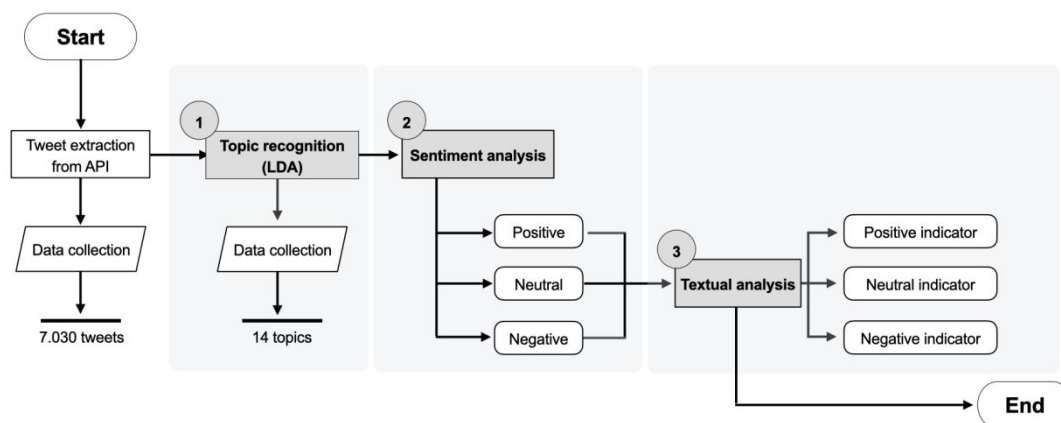
#### 4.3 Sentiment analysis

Once the most popular food technology topics in Twitter were recognised, a Python algorithm based on machine learning was executed. This phase comprised employing the algorithm for text data mining to categorise the feelings into positive, neutral and negative. Lastly, Krippendorff's Alpha Value (KAV) was employed to

370 establish the precision of sentiment analysis. The reliability of the results was  
 371 determined in the three sentiments. Thus, it was confirmed as when  $\alpha \geq 0.800$  the  
 372 reliability of the results is high, when  $\alpha < 0.667$  the results are low and the threshold  
 373 for tentative results is  $\alpha \geq 0.667$  (Krippendorff, 2004).

#### 374 4.4 Textual data analysis

375 This phase was implemented by means of Atlas.ti software. Text data mining  
 376 was fulfilled and labelled into the three sentiments (i.e., positive, neutral, negative).  
 377 The dataset was organized ensuing three procedures: (1) identifying the frequency of  
 378 repetition of the words; (2) determining the keywords' total weight measured as a  
 379 weighted percentage (WP); and (3) filtering the words that are not applicable for the  
 380 research purposes (Newton-John, 2018). WP labels the weight of the indicators  
 381 grouped into nodes which is consistent with the number of times they are repeated  
 382 (Newton-John, 2018). Figure 3 explains the three phases accomplished in this research.



383

384 **Figure 3.** Phases of the research methodology.

#### 385 5. Results analysis

386 The results of LDA estimation revealed 14 food technology-related topics,  
 387 which are presented in Table 3. We retrieved the tweets written in English and Spanish  
 388 as LDA revealed that content in those two languages. During this procedure, LDA  
 389 classifies the words into topics, which were judiciously controlled and named in a

390 **unique language** after studying the group of words (Büschken & Allenby, 2016; Jia,  
 391 2018; Miller et al., 2017; Saura & Bennett 2019). The topic was named contemplating  
 392 the 10 to 20 most repeated words, and the descriptions of the topics were made  
 393 considering the content of the topics. **Thus, this process entailed researcher'**  
 394 **assistance for labelling the topics in one same language (i.e. English).**

395 **Table 3.** Identified topics related to food technology in UGC.

Topic name	Topic description	WP	Sentiment
Innovations	Observations concerning innovative solutions of products, energy and related advancements.	2.41	positive
Start-ups	Comments on the actual progress of start-ups related to food technology.	1.37	positive
Ghost	Mentions regarding the lack of physical presence, the virtual dimension of all these implementations (such as bots, amazon, etc.).	1.34	negative
Sustainable agriculture	References to the need of guaranteeing sustainable and the benefits obtained from plant-based techniques.	1.00	positive
Kitchens & restaurants	Mentions concerning the impacts of kitchens, restaurants, such as the food waste.	1.00	negative
Unstable times	Annotations regarding the actual uncertainty, insecurity and the need of clearness.	0.94	negative
Pleasure	Remarks relative to the improvement food technology is going to imply in terms of enjoyment.	0.77	positive
Biotech	Recognition of the changes concerning biotechnology, genetic, engineering and pest.	0.72	neutral
Chefs	References to the importance of gourmet chef.	0.64	positive
Crisis	Discussion of the current crisis.	0.62	negative
Conflicts	Recognition of the conflicts and the hunger consequences.	0.58	negative
Sustainable farming	Comments and opinions of upcoming sustainable farming initiatives.	0.51	neutral

Free	Mentions to free resources.	0.47	positive
Climate disasters	Mentions to climate change implications and disasters, such as floods and droughts.	0.33	neutral

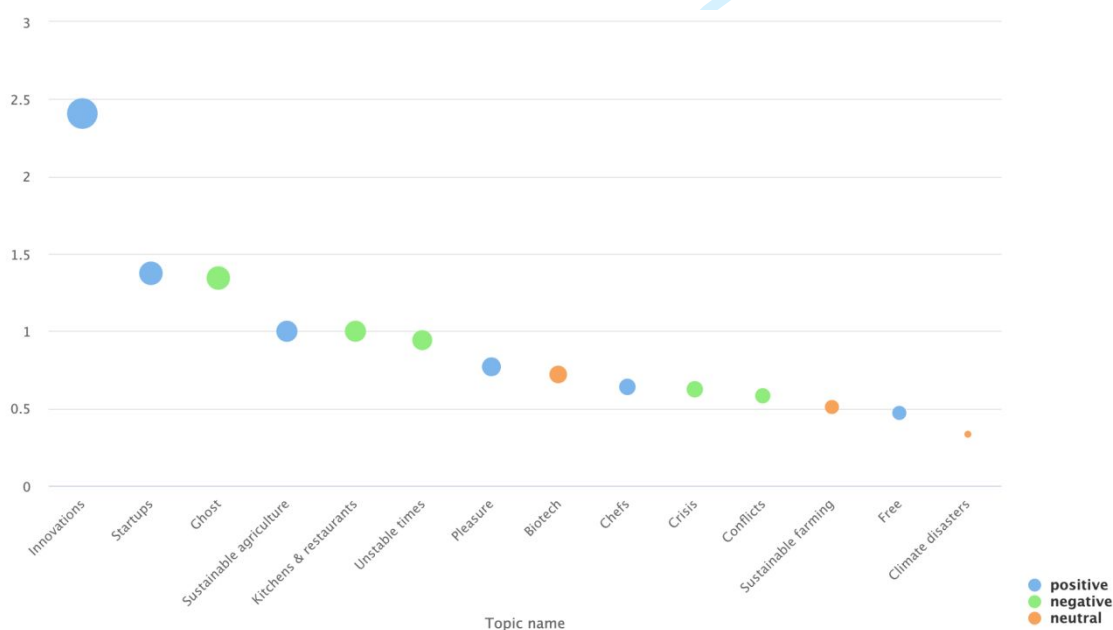
396 Sentiment analysis was accomplished ensuing Saura et al.'s (2020)  
 397 recommendations. The sentiment analysis algorithm was trained to accomplish the  
 398 recommended probability of success (Saura et al., 2020). Therefore, a sample of 750  
 399 posts was succeeded with data mining techniques to train the algorithm, following  
 400 Saura et al.'s recommendations.

401 Finally, Krippendorff's alpha values were assessed and the results were above  
 402 the thresholds (KAV) taking into account the complete database (i.e. 7030 tweets).  
 403 Table 4 specifies the sentiment analysis reliability.

404 **Table 4.** Sentiment Analysis conclusions' reliability (Krippendorff's alpha).

Conclusions' reliability	Krippendorff's alpha value	Sentiment	Average KAV
High	$\alpha \geq 0.800$	Positive	0.867
Tentative	$\alpha \geq 0.667$	Negative	0.747
Low	$\alpha < 0.667$	Neutral	0.685

405 The results of the textual analysis are shown in Figure 4, where the WP of each  
 406 topic is identified concerning the feeling expressed (Krippendorff, 2004).



407

1  
2  
3 408 **Figure 4.** Identified food technology topics in relation to the sentiment expressed and  
4  
5 409 WP.

## 6 410 **6. Discussion**

7  
8  
9 411 ~~The first objective of this —is research’s main first objective, related to first~~  
10 412 ~~research question,~~ was to identify popular food technology topics by examining UGC  
11  
12 413 on Twitter. The analysis of the most repeated words of the selected tweets allowed us  
13  
14 414 to establish the categories related to food technology users are talking about. Borrero  
15  
16 415 & Zabalo (2021) also used this social media to obtain consumers’ opinions and they  
17  
18 416 confirmed that it is a ~~valid great~~ tool to identify the topics of interest ~~of the public.~~ As  
19  
20 417 Samoggia et al. (2020) explained, social media has become ~~key essential~~ to understand  
21  
22 418 what consumers think, what are their perceptions on food products and what are their  
23  
24 419 needs.

25  
26  
27 420 The use of Twitter to learn about the online conversation regarding food  
28  
29 421 innovation is crucial to understand users’ acceptance or rejection to specific  
30  
31 422 ~~subdivisions-matters~~ of the sector. ~~Thus, we proposed the second research question to~~  
32 423 ~~associate the identified food technology topics to three different feelings~~ ~~The food~~  
33 424 ~~technology topics we obtained were associated to three main different feelings (i.e.~~  
34  
35 425 positive, neutral and negative).

36  
37  
38 426 ~~So through this sentiment analysis, it was we~~ Finally, the last research question  
39  
40 427 ~~was endorsed~~ to identify the innovations in the food industry that can have ~~a better~~  
41  
42 428 ~~the best~~ acceptance. As social media are platforms where ~~people individuals~~ express  
43  
44 429 their feelings and reveal their emotions (Elghannam et al., 2020), they are extremely  
45  
46 430 helpful as sources of information to learn about consumers’ perceived value and trust  
47  
48 431 on these new technologies (Lin et al., 2020). ~~Furthermore—Hence,~~ this sentiment  
49  
50 432 analysis through a social network such as Twitter is very interesting as opinions are not  
51  
52 433 biased; consumers shared what they truly think ~~and feel and the information we get~~  
53 434 ~~from this platform is, thus,~~ which is very valuable (Mostafa, 2020).

54  
55 435 UGC ~~is nowadays~~ has become an essential tool to learn about consumers’  
56  
57 436 innovation acceptance, ~~and precisely in which~~ is very significant for the food sector  
58  
59 437 (Samoggia et al., 2020). ~~This is imperative because, as Siegrist et al. (2016) explained,~~  
60

1  
2  
3 438 ~~there is a general food neophobia in society.~~ This study reveals which new  
4  
5 439 developments and products are more susceptible to rejection, so strategies ~~can be~~  
6  
7 440 ~~proposed~~ to deal with consumers' apprehensions ~~can be developed to make new~~  
8  
9 441 ~~technologies marketing a success.~~

## 10 11 442 **Conclusions**

12  
13 443 This research brought to knowledge important information ~~with regarding to~~  
14  
15 444 technology in the food industry. Through data mining ~~we~~ 7030 tweets ~~were~~ collected  
16  
17 445 ~~that we and~~ sorted into 14 different food-related topics, of which six categories were  
18  
19 446 positive, five were negative and three were neutral.

20  
21 447 It is ~~remarkable~~ interesting that the most commented topic –innovation– is  
22  
23 448 considered positive by Twitter users. ~~Although some specific topics related to~~  
24  
25 449 ~~innovations are commented separately and they do not arise a positive feeling, such as~~  
26  
27 450 ~~biotechnology and genetics, it can be confirmed that~~ innovative solutions and  
28  
29 451 advancements ~~in general~~ are accepted and supported.

30  
31 452 The second most mentioned category, food technology start-ups, is also  
32  
33 453 ~~welcomed~~ well perceived among ~~in the~~ Twitter users. ~~society, which~~ This means there  
34  
35 454 is strong support for those new companies developing technologies for the industry.  
36  
37 455 Sustainable agriculture, including plant-based techniques, technologies applied to  
38  
39 456 obtain bigger pleasure with food, gourmet chefs and free resources are the other  
40  
41 457 categories considered positive, and so accepted by users.

42  
43 458 However, some food-related topics are rejected by the Twitter community. The  
44  
45 459 virtual dimension of food-related technologies, such as bots or distributors, ~~what we~~  
46  
47 460 ~~called named as~~ ghost, is the third most commented subject but it is ~~renounced~~  
48  
49 461 ~~refused~~ by users. ~~It is worth considering as it is being more implemented while as~~  
50  
51 462 ~~society advanced and different crises arise.~~ Other negative impacts on the food  
52  
53 463 industry, as this study found out, are all the food waste taking place in restaurants and  
54  
55 464 kitchens, the insecurity and uncertainty of the current unstable times, the crisis itself  
56  
57 465 and the hunger as a consequence of these critical years.

58  
59 466 Finally, it is worth noticing three important topics that arise no specific  
60  
467 sentiment ~~but and~~ remain neutral. Biotechnology and food genetics are considered

1  
2  
3 468 neutral by Twitter users. It is **key important** that **people individuals** understand the  
4  
5 469 **many-great unlimited effective** solutions these technologies can provide to all society  
6  
7 470 problems arising from world and local crises, hunger, lack of resources and even  
8  
9 471 pollution. Sustainable farming solutions are also seen as neutral by users, along with  
10  
11 472 climate change disasters. **People Users'** indifference in these crucial topics need to  
12  
13 473 evolve to a positive feeling **which entail developing** ~~needed~~ **the required** strategies  
14  
15 474 that ~~will-be-accepted-by~~ **makes consumers accept the innovations at the same time**  
16  
17 475 **that they help the world's society and the environment.**

### 18 476 **6.1 Theoretical implications**

19  
20  
21 477 This research is another step in the **advancement of knowledge not-so-studied**  
22  
23 478 **regarding** food-technology-related topics in UGC ~~in social media~~. Before 2020, only  
24  
25 479 three relevant studies about UGC in the food industry were published. These three  
26  
27 480 studies (Vidal et al., 2015; Park et al., 2016; Singh et al., 2018) focused on Twitter  
28  
29 481 comments to understand users' opinions in food-related topics, such as habits,  
30  
31 482 restaurants and food quality. However, ~~they-do not~~ **none of these** focus on food  
32  
33 483 technology. Interestingly, during 2020, three food data mining studies (Yu & Zhan,  
34  
35 484 2020; Mathayomchan & Taecharungroj, 2020; Teichert et al., 2020) ~~kept focusing were~~  
36  
37 485 **published regarding** consumers' experience. For instance, Goldberg et al. (2020) ~~gave a~~  
38  
39 486 **step forward by analysed and classified** safety hazards coming from food consumption.

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41 487 **Up-to-date this** is the first **study research** that categorises Twitter users'  
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43 488 opinions by using food-technology-related hashtags and ~~gets-reveals~~ users' sentiment  
44  
45 489 analysis **on key innovations of the industry**. It is important to continue analysing online  
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47 490 comments in different social networks in order to understand what consumers think  
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49 491 about all the new technologies that are **been** developed in the food industry  
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51 492 (Elghannam et al., 2020; Lin et al., 2020).

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53 493 Additionally, it has been proven that this methodology is also more efficient  
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55 494 than traditional consumers analyses, such as questionnaires or focus groups, **as it**  
56  
57 495 **allows** researchers to get **more** and diverse information, ~~more-varied-and~~ from larger  
58  
59 496 data sets (Mostafa, 2020). Big data analysis is cost-effective and allows the  
60  
61 497 management of public information from all the consumers using social media around  
62  
63 498 the globe.

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3 499 This research, then, starts a new tendency on studies focused on data mining to  
4 understand consumers perceptions. It opens the door to deeper research within the  
5 500 use of social media channels. As technology becomes more present and essential in  
6 use of social media channels. As technology becomes more present and essential in  
7 501 society, it is crucial to keep researching into consumers' acceptance.  
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11 503 This investigation also encounters some limitations associated with its  
12 approach. The time and hashtags used over the data collection is limited and so  
13 504 further research is encouraged to get larger samples of data over longer periods of  
14 505 time to better understand consumers and get more information to develop the best  
15 possible strategies for the industry.  
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## 18 508 **6.2 Managerial contributions**

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23 509 ~~In practice, this research~~ This research provides useful information that can  
24 helps firms to create consistent managerial strategies to succeed in the food  
25 510 technology industry. As Goldberg et al. (2020) explain, text mining and sentiment  
26 analysis help companies to monitor consumers' opinions and understand online data  
27 511 to make the right decisions. Data analysis allows companies to make informed  
28 512 decisions on management and customer services (Tao et al., 2020). It is advisable for  
29 food technology companies to follow this research's findings in order to make good  
30 513 business decisions and make their innovations more successful in the market.  
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38 517 ~~The present study showed how Twitter users developed the conversation~~  
39 around the hashtag #agtech, followed by the hashtag #foodtech. This means that  
40 518 technology in the food industry and, more specifically in the agriculture sector, is a key  
41 519 subject to develop practical strategies. On the other hand, #cloudkitchen hashtag is  
42 barely used. Therefore, managers are encouraged to create strategies that allow cloud  
43 520 kitchen innovations to become more important for consumers and make it attractive  
44 521 to them.  
45 522  
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49  
50 524 The findings on this study will assist businesses in two main ways. On the one  
51 525 hand, we found out that innovative solutions of products, energy and related  
52 526 advancements, the progress of start-ups related to food technology, sustainability and  
53 527 benefits obtained from plant-based techniques as well as the gourmet and pleasant  
54 528 experiences are positively accepted by consumers. So, the industry is encouraged to  
55 529 develop these innovations and technologies. As Gan et al. (2016) explained, only by  
56 530 learning from individual people's sentiments, it is possible to create those products

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3 531 and experiences that will make people feel right. This study ~~let us know which~~ reveals  
4 532 the technologies and food services ~~are welcomed by the public~~, that are best  
5 533 perceived ~~so we can exploit and recreate the positive feelings into new innovations~~.

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7  
8 534 On the other hand, some agriculture and food tendencies are not positively  
9 535 perceived by consumers. The lack of physical presence in food businesses, the virtual  
10 536 dimension of food implementations, biotechnology, genetics and food engineering are  
11 537 negatively and neutrally perceived. For this matter, companies must improve their  
12 538 communication and marketing strategies. Businesses must show consumers all the  
13 539 benefits that those technologies can bring to society. As this research also found out,  
14 540 consumers consider unstable times, conflicts, crises, hunger consequences and climate  
15 541 change implications as something negative for the food industry, so food technology  
16 542 companies are encouraged to promote how their technology helps to improve those  
17 543 critical situations.

18 544 ~~Specifically, it is crucial to transform biotechnology, genetics, food engineering~~  
19 545 ~~and sustainable farming opinions image from something neutral to something positive.~~  
20 546 ~~A worldwide communication strategy should be developed in order to make~~  
21 547 ~~consumers see the bright side of those innovations and all the benefits they can bring~~  
22 548 ~~to society. There is a bigger effort to make, mostly in marketing and communication,~~  
23 549 ~~to transform the negative opinion users have on the lack of physical presence in some~~  
24 550 ~~food businesses into a positive one, in order to develop greater innovations that help~~  
25 551 ~~societies in times of crises and conflict.~~

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Manuscript ID: BFJ-07-2021-0803  
British Food Journal

## RESPONSE TO REVIEWERS

### REVIEWER 1

Thank you for your submission to the British Food Journal. Please find my feedback on your manuscript. It is meant to be constructive so that it can help you to publish your work.

Thank you very much for all your interesting suggestions. We have endorsed all your requests, which have meaningfully improved the quality of the manuscript. Thus, we are sending you a revised version of the article in 2 formats: one in red font so you can easily review all the changes accomplished, and other version without the use of red font or strike-out text to facilitate the revision.

1. First, I would recommend having this manuscript checked by a professional English editor for grammatical issues. Also, and separate to this, is the use of awkward and unprofessional words and terms that I have not come across in the extant marketing, branding or food literatures before. Even in your Abstract on the first page! Please fix this. For example, here are just 4 of many problematic terms I found in your manuscript...

*“up to our knowledge” – replace with “to the best of our knowledge”*

*“Not-so-studied” – replace with – “the lack of examination in the literature”*

*“nowadays” – replace with – “Today”*

*“Thenceforth” – just delete this – who says this?!*

Thank you very much for these notes. We have checked the whole text again to change all the terms you highlighted as well as all the grammar mistakes and weird sentences we found. We have now a clearer and better-written manuscript. This has significantly improved the quality of the article, as now the research can be better understood.

2. I quite like the front end of your paper. The topic is interesting and your literature review is thorough. The problems arise when you introduce your 3 research questions... Where is your discussion of the results of your 3 research questions in the results and discussion sections? You need to address this issue as it is a major weakness of your paper that will stop it from being published. You need to discuss each of the answers to your research questions in detail in the back end of your manuscript! For example, in your Discussion Section on page 15, you say your main objective was to identify popular food technology topics. How does this relate to your 3 research questions? Please guide the reader through this...

Thank you very much for this helpful remark. It was not clear in the discussion what we found out in every step of the research. We have announced the three research questions again and specified the answers that we got in our research. Now, the discussion section has gained clarity and the reader can better follow what we did. Besides, we have been

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3 more concise and we have improved the conclusion by offering further information  
4 about the results that we got.  
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7 3. Page 16 line 354 – why is it remarkable? Consumers' self reporting their own  
8 knowledge doesn't mean their knowledge is correct or accurate. After all, genetically  
9 modified food is a technological food innovation, but your consumers have separated  
10 these. I would discuss this if I were you as many readers will pick up on this.  
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12 Thank you very much for this specific comment. Remarkable was probably not the best  
13 word for what we tried to explain. We changed it into "interesting" and explained why it  
14 was so. That note has become clearer for the reader and better put, explaining the  
15 difference between the positive topic "innovation" and the neutral one about  
16 "biotechnology", explaining that innovations in general seem to be helpful are seen as  
17 something positive, while maybe some specific advancements are not the best solutions  
18 for Twitter users.  
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22 4. Your research method appears sound.

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24 Page 18. Since your theoretical contribution section is so small (there is no theoretical  
25 contribution, just contextual), your managerial contributions section needs to be much  
26 stronger. With the exception of paragraph 2, there is a "so what" factor as it currently  
27 reads. Be more specific, be relevant, make more recommendations for people in the  
28 food industry. Show them how important the findings of your paper are to them. Areas  
29 for future research would also be beneficial for this paper.  
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32 Thank you very much for all these remarks. We have improved both parts of the paper  
33 by including future research and limitations the theoretical implications section and we  
34 have also made a better analysis of the managerial recommendations, pointing out the  
35 different strategies food technology companies should develop according on the  
36 findings of our research. We know think that last part of the paper gives a better close to  
37 the investigation.  
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40 Finally, the major issue I have with this paper relates to your 3 RQs and the fact that  
41 you forget about them and don't even mention them in the back end of your paper.  
42 Please address this and the other issues I have brought up and I'm sure you will get this  
43 manuscript published.  
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46 Best wishes.  
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49 Dear reviewer,  
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51 We are very thankful for such a detailed review. We have proceeded to change and  
52 improve all the suggestions that you mentioned and we believe this have made our  
53 manuscript better, clearer and more interesting. Thank you very much. The quality has  
54 significantly improved. We have tried our best to enhance your recommendations as  
55 well as the comments of the other reviewer.  
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Additional Questions:

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1. Originality: Does the paper contain new and significant information adequate to justify publication?: There is no theoretical contribution, but there is a contextual contribution. It is an interesting and appropriate topic for the BFJ.

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We have proceeded to make all the recommended changes and now the paper provides a better understanding of the findings of the investigation as well as a better writing and clearer information. We have very much improved our theoretical and managerial contributions and we better show the importance of our research for future researched and practical industry developments. The paper is appropriate for the British Food Journal as it covers an interesting and modern topic related to the food industry, appornting knowledge in technology and innovation as well as in consumer experience.

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2. Relationship to Literature: Does the paper demonstrate an adequate understanding of the relevant literature in the field and cite an appropriate range of literature sources? Is any significant work ignored?: The paper does a great job on the literature however it does a very poor job in it research questions which are not answered or addressed.

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We are happy that our literature review was thorough, interesting and relevant, but we also saw our problem with our research questions. We have better addressed them in the final discussion and we now think that paper has a better closing regarding the main points of the empirical research.

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3. Methodology: Is the paper's argument built on an appropriate base of theory, concepts, or other ideas? Has the research or equivalent intellectual work on which the paper is based been well designed? Are the methods employed appropriate?: The paper has an appropriate methods section.

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Thank you very much for this remark. We have used a quite new research method that allows us to get a lot of unbiased information from consumers, which gives us much interesting information to work with for the business and for future research.

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4. Results: Are results presented clearly and analysed appropriately? Do the conclusions adequately tie together the other elements of the paper?: No - there is no link between the 3 RQs in the front end and what is presented in the back end. The 3 RQs aren't even discussed in the results or discussion sections.

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The paper now analyses the three research questions in the back end of the paper, giving a better understanding of the researched topic and a better understanding of the obtained results. The discussion section now includes a RQ by RQ analysis that helps the reader understand the findings of the investigation.

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5. Implications for research, practice and/or society: Does the paper identify clearly any implications for research, practice and/or society? Does the paper bridge the gap between theory and practice? How can the research be used in practice (economic and commercial impact), in teaching, to influence public policy, in research (contributing to the body of knowledge)? What is the impact upon society (influencing public attitudes, affecting quality of life)? Are these implications consistent with the findings and conclusions of the paper?: This could be much stronger.

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We have now included a better compound of implications our research has for both theory and management. We have clearly stated all the strategies that can be now followed in research and in business to make our paper useful for scientific contribution, but also very interesting for the food industry and their business assets. It is better shown now how our findings can help the industry to develop and succeed.

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6. Quality of Communication: Does the paper clearly express its case, measured against the technical language of the field and the expected knowledge of the journal's readership? Has attention been paid to the clarity of expression and readability, such as sentence structure, jargon use, acronyms, etc.: This section needs work. Awkward wording that does not usually appear in the marketing/food/branding literature abounds. For example, 'no-so-studied', "thenceforth" etc. Plus many grammatical errors abound.

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The paper is now written in a better English, using simpler language and more professional expressions. We have corrected the grammatical errors and proceeded to change all the weird formulations. Now the paper reads better and clearer.

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We hope that the above points effectively respond to your concerns and make the manuscript appropriate for publication. We have addressed all the suggestions, changing weird expressions and correcting grammatical errors and improving the back end of the paper, attending the three research questions at the end of our paper, to better show the findings and interest of our research, and by enriching our discussion, conclusion and contribution sections. Additional modifications have been made to the manuscript following suggestions made by another reviewer. We have tried hard to improve the manuscript. Thank you very much for your time and all your suggestions.

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## REVIEWER 2

Thanks the authors for their scholarly effort in writing this interesting paper. The authors need to address some issues to improve the quality and clarity of the manuscript.

Thank you very much for all your remarkable recommendations. We have accomplished all your requests, which have profoundly improved the quality of the manuscript. We are sending you a revised version of the article in two files: one includes all the changes in red font so you can easily review them and the other is a revised version without the use of red font or strike-out text to facilitate the revision.

### Additional Questions:

1. Originality: Does the paper contain new and significant information adequate to justify publication?: See the attachment

We have made all the recommended changes and include more explanations in order to present and better and proved paper. There are now many changes that help the reader better understand the research objective and the findings as well as all the implications this investigation may have for future research and for practical developments.

2. Relationship to Literature: Does the paper demonstrate an adequate understanding of the relevant literature in the field and cite an appropriate range of literature sources? Is any significant work ignored?: See the attachment

The paper makes a great effort in giving the reader a clear view of the food technology industry, current developments as well as of the methodology applied in the research. It has an extensive literature review that covers all the reader may need to understand the empirical investigation and it also helps them to have a wide context related to the industry.

3. Methodology: Is the paper's argument built on an appropriate base of theory, concepts, or other ideas? Has the research or equivalent intellectual work on which the paper is based been well designed? Are the methods employed appropriate?: See the attachment

This section has been reviewed and enriched and now it offers a more exhaustive comprehension of the steps accomplished to ensure the quality of the research.

4. Results: Are results presented clearly and analysed appropriately? Do the conclusions adequately tie together the other elements of the paper?: See the attachment

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All the sections including the results and conclusions of the paper have been reviewed and improved to provide the reader with a better understanding of the outcomes of our research.

5. Implications for research, practice and/or society: Does the paper identify clearly any implications for research, practice and/or society? Does the paper bridge the gap between theory and practice? How can the research be used in practice (economic and commercial impact), in teaching, to influence public policy, in research (contributing to the body of knowledge)? What is the impact upon society (influencing public attitudes, affecting quality of life)? Are these implications consistent with the findings and conclusions of the paper?: See the attachment

These last parts of the research have also been addressed. They have been restructured and improved so we now better show all the implications our paper has for society and for the scientific community.

6. Quality of Communication: Does the paper clearly express its case, measured against the technical language of the field and the expected knowledge of the journal's readership? Has attention been paid to the clarity of expression and readability, such as sentence structure, jargon use, acronyms, etc.: See the attachment.

We have thoroughly reviewed the whole text to correct many grammatical errors and we have also changed several expressions into a more professional language. The paper is now written in a simple and clearer way.

#### ATTACHMENT FILE

First of all I would like to thank the authors for their scholarly effort in writing this manuscript. The topic is interesting and timely in nature. I have a few observations regarding this paper as follows:

1. I am a bit confused with the title and the content of the manuscript. The authors' mentioned in the title that they have focused on the food technology impact on consumers' acceptance and satisfaction. Though the authors extracted the outcome of customers' feelings in three formats (positive, neutral, and negative), there is no clear explanation regarding the satisfaction level of consumers. For the greater readership, it is expected that the authors should be specific in explaining the outcomes related to consumers' satisfaction and also aligned with the title of the manuscript offered.

Thank you very much for your appreciation. We have realized that it was rather confusing and thus, we have clarified all the explanation in relation to the title of the

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manuscript in the arguments of the users' feelings. All these modifications have been accomplished in Section 3, third part. This suggestion has significantly improved the quality of the manuscript as now the title is aligned to the arguments offered.

2. The authors used research question approach to address the intended task to be carried out. I do suggest the authors to strengthen this part with more logical sequence and literature supports.

Thank you very much for this suggestion. We have proceeded to improve the way we use our three research questions throughout the paper. Now there is a better link between the RQs, our research objective and the obtained results.

3. Since the collected UGC was in English and Spanish, how they were unified. My concern is that how the authors ensured the content consistency in two different languages. More explanation is expected.

We totally agree. We have now improved the methodology section explaining in the first paragraph of section 5. (Results analysis) that LDA estimation revealed the food technology topics in two languages, which we controlled and named in a unique language after studying the groups of words. Thus, this process entailed research assistance. This has now clarified the methodological procedure we endorsed.

4. In the sentiment analysis part, the authors should give more explanation for taking 750 posts only (instead of 7030) to confirm the reliability aspect.

We completely agree. This part lacked of details. We have now clarified the processes and how reliability was estimated, and hence, we have specified that for reliability calculation all the database was taken into account (i.e., 7030 tweets).

5. The authors did not mention any sort of limitation of this scientific research. Any study in the domain of social research is not surely free from errors and limitations.

Thank you very much for this note. We have now included some limitations we have surely encountered in our research and encouraged future research in order to get better results and solve those limitations.

Dear reviewer,

We are very thankful for your comments as these have significantly improved the quality of the manuscript. We hope that all our comments and changes respond to your requests, making this revised version of the manuscript suitable for publication. We have certainly used our best efforts. Moreover, additional changes have been made to this revised version following the advice of another reviewer. Thank you very much for your time and all your comments.