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Social Media Analytics in Food Innovation and Production: a Review

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Abstract

Until recently social media and social media analytics (SMA) were basically used only for communication and marketing purposes. However, thanks to advances in digital technologies and big data analytics, potential applications of SMA extend now to production processes and overall business management. As a result, SMA has become an important tool for gaining and sustaining competitive advantage across various sectors, industries and end-markets. Yet, the food industry still lags behind when it comes to the use of digital technologies and advanced data analytics. A part of the explanation lies in the limited knowledge of potential applications of SMA in food innovation and production. The aim of this paper is to provide a review of literature on possible uses of SMA in the food industry sector and to discuss both the benefits, risks, and limitations of SMA in food innovation and production. Based on the literature review, it is concluded that mining social media data for insights can create significant business value for the food industry enterprises and food service sector organizations. On the other hand, many proposals for using SMA in the food domain still await direct experimental tests. More research and insights concerning risks and limitations of SMA in the food sector would be also needed. The issue of responsible data analytics as part of Corporate Digital Responsibility and Corporate Social Responsibility of enterprises using social media data for food innovation and production also requires a greater attention.

Keywords: food industry; food innovation; competitive advantage; social media analytics; responsible data analytics

1. Introduction

Data analytics becomes one of the major drivers behind innovation and growth in various economic sectors and industries. With digital technologies, cloud computing and machine learning algorithms growing volumes of digital data, both structured and unstructured, can be analyzed in real or near-real time to extract knowledge and insights leading to better business decisions and increased consumer and shareholder satisfaction. One of the most important sources of data for business analytics are social media platforms. Social media are rich in image and text data providing competitive information about opinions, needs, experiences and preferences of consumers from different regions and locations or age category groups (Gonçalves, 2017). Many businesses already intensively use social media platforms in their marketing strategies and day-to-day communication with consumers and clients. Social media data and social media platforms are also increasingly

used for co-innovation, product development and product design (Fan and Gordon, 2014; Alarcón et al., 2018). With the enormous penetration of social network platforms worldwide, one might expect that the importance of social media data for business intelligence and the overall business management will further increase. In 2017 there were 2.46 billion active social network users around the globe. It is estimated that this number will increase to 2.77 billion by 2019 and to 3.02 billion by 2021 (Statista, 2019).

The food sector, both food processing companies and food service sector organizations, might hugely benefit from analyzing the ever-increasing flows of social media data. Food and food products, as essential to human existence and well-being, generate strong user engagement. Users of social networking sites eagerly share their opinions and reviews about food brands, food products and food tastes. As Amato et. al (2017) note: "food photos are the second most popular subject in Instagram after selfies". Social, communal and visual characteristics of food have given rise to the emergence of the concept of "Instagrammable" food meaning "visually appealing food that people will want to share with family and friends" (Green, 2018). Food image sharing, food conversations and food-related posts are popular and widespread also on Twitter, Pinterest, Facebook, Tumblr and other social networking platforms. Internet and mobile technology users are also increasingly interacting with food culinary blogs and consumer online review sites. As a result, social media platforms not only tremendously increase the quantity and variety of information concerning consumers and their preferences – previously basically available only through costly surveys and public opinion polling, but they also change the way food is perceived and consumed around the world. Different food products, food traditions and novel proposals for foods and drinks become visually accessible to consumers located in various parts of the globe with just one click. As food images and discussions spread easily through multiple platforms and sites, they create food trends impacting consumer expectations, preferences and demands. Online reviews, hashtags, mentions and word of mouth also influence consumers' decisions on where and what to eat (cf. Rousseau, 2012). In addition, thanks to social media world consumers and other stakeholders more easily share information about problems and risks arising in the agri-food chain. It can be therefore argued that in many ways social media becomes a game-changer for the whole food sector.

Still, most food companies use only a fraction of social media resources and capabilities. According to OECD, agriculture and food industry, alongside mining and real estate, are among the least advanced in terms of digitalization (Calvino et al., 2018). On the other hand, innovative start-ups and businesses not traditionally associated with the food sector enter the agri-food chain in search of new profit and revenue opportunities. Disruptive digital and information and communication technologies make the competition in the food industry more intense and more dynamic. The ability to innovate and to exploit new technologies and new sources of information becomes therefore decisive for gaining and sustaining competitive advantage. However, knowledge concerning the uses of new technologies and services – including the uses of social media analytics – is still limited. The potential of social media is quite often approached and seen only through the prism of marketing and communication activities. The present paper aims to challenge this limited approach by providing a systematic literature review on different applications of social media analytics in the food industry sector and in the food domain. Themes and applications examined will include food production and food innovation. For the purposes of this paper food innovation is defined as including new or significantly improved food products or services and/or as involving changes in the organization and operation of the agri-food chain such as new or

significantly improved processes, logistics or distribution methods. At the same time, the paper will discuss risks and limitations of social media analytics in the food domain. Increasing awareness of both benefits, risks and limitations of SMA is crucial not only for successful management and use of social media data, but also for furthering responsible innovation.

The paper is structured as follows. Firstly, the methodology used to identify relevant studies, research articles and case reviews is outlined. Secondly, key themes and applications of SMA in the food sector are discussed. Specifically, major domains in which SMA is or can be used, sources of data, types of analysis, techniques employed, analytical tasks and functions of SMA in internal and external operations of food industry enterprises and organizations are presented. On the basis of the results of the review, the paper proposes a taxonomy of social media analytics capabilities in the food industry sector. Benefits, risks and limitations of SMA in the food domain are discussed and summarized in the following section. The paper ends with concluding remarks.

2. Methodology

An assessment of the role and potential utility of SMA for the food industry sector and food innovation has been based on systematic literature review. Since social media platforms gained global popularity relatively recently (following the launch of Facebook in 2004 and Twitter in 2006), the search for relevant research articles and case reviews was limited to items published in the last several years (between 2012 and 2018). The searching process for both peer-reviewed articles and grey literature was initiated by mid-December 2018 and ended by the beginning of January 2019. Three databases – Scopus, ScienceDirect and Google Scholar – were systematically searched for articles and papers with the following combination of keywords and entry terms: 'social media' and 'food', 'social media analysis/analytics' and 'food innovation', 'data mining/text mining' and 'food/food products', 'social media platforms/social networking sites' and 'food enterprises/companies', 'natural language processing' and 'food production/food sector/food industry', 'social media applications' and 'food/business opportunities', 'social media' and 'risks/limitations'.

In the following step, papers were screened for inclusion by taking into account academic disciplines represented. Papers not related to business economics, food technology and engineering, management sciences, data sciences, information and communication technologies and digital technologies were excluded from further processing and analysis (i.a. papers in medical and computer sciences incidentally referring to food issues with no research objectives related to food or food-related problems). Also, papers offering systematic literature reviews were excluded from the review. As a result 167 papers were identified for further evaluation. The last step in the selection process consisted of abstract examination. It was assumed that papers not mentioning the analysis component of social media data will not be relevant for the planned review. Following the removal of duplicates, 50 papers were selected for the final analysis. To extract relevant information and insights the fundamental part the analysis was based on in-depth qualitative review. Also, cross-referencing was used to deepen and extend the understanding of SMA capabilities and limitations in the food industry sector.

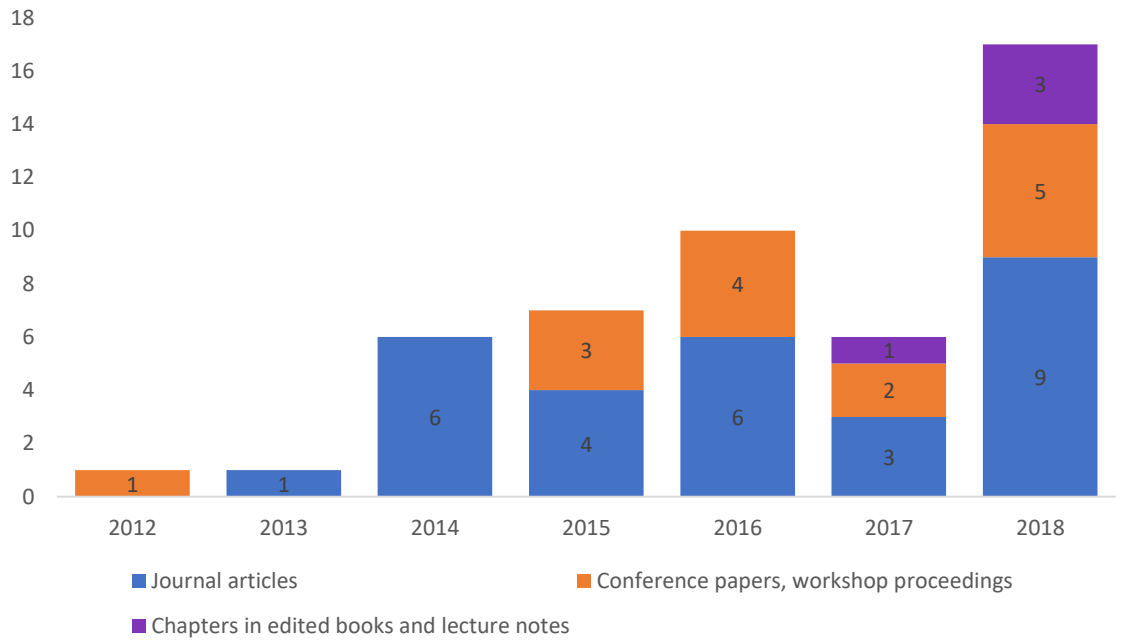
3. Results and Discussion

The number of papers exploring potential applications of social media data and social media analytics in the food industry sector and generally in the food domain shows that the topic becomes increasingly popular among researchers. This seems to be linked to a broader interest in opportunities for businesses to leverage digital technologies and the increasing flows of digital data to optimize business performance and outcomes. The following sections present, synthesize and discuss the results of the conducted review.

3.1. Overview of papers selected for the study

The vast majority of papers (36) were published in the last three years (between 2016 and 2018). A general increasing trend in the number of publications dealing with SMA and food can be observed. Following the selection process, 1 paper from 2012, 1 paper from 2013, 6 from 2014, 7 from 2015, 10 from 2016, 6 from 2017 and 17 from 2018 were included for the review. Also, two articles from the year 2019 were taken into account because of their high relevance. More than 60% of selected papers come from journals. The remaining are conference papers, workshop papers and book chapters in edited volumes.

Fig. 1. Distribution of papers taking into account the year of publication and the type of publication (2012-2018)



Only about 17% (9 papers) were published in journals devoted specifically to food issues and food problems (among these *Food Quality and Preference* takes the leading role with 4 papers published on the subject). Most papers were published in journals and conference proceedings with scopes directly focused on ICT technologies, electronic business, Internet and information systems, information retrieval, data systems, computing systems and artificial intelligence. Three main categories of recipients of the results of social media analytics emerge from the reviewed papers: 1) food processing enterprises, 2) retail and food service sector organizations, especially food delivery and catering industry, and 3) food inspection and monitoring authorities.

Concerning specific research areas and topics, the focus of the majority of the papers was on consumer sentiments towards food companies, food brands and food products (14)

and on food-related consumer behavior (8). Food risks and food-related crisis situations made up the second major research stream (12). There were also papers highlighting the great potential of SMA in the area of sustainable food production and consumption, i.a. through using social media data to minimize food waste, to improve food safety and quality, and to increase the responsiveness to public health needs (7). Relatively new proposals and themes concerned such issues as tracking food preferences and ideas for product development and customization (6). In these studies SMA was used i.a. for flavor pairing, food sensory analysis, evaluation of food tastes, smell and characteristics. Single articles were dealing with SMA in the context of food supply, commodity markets and food prices. The individual papers as divided into specific research areas and topics are presented in the Table 1.

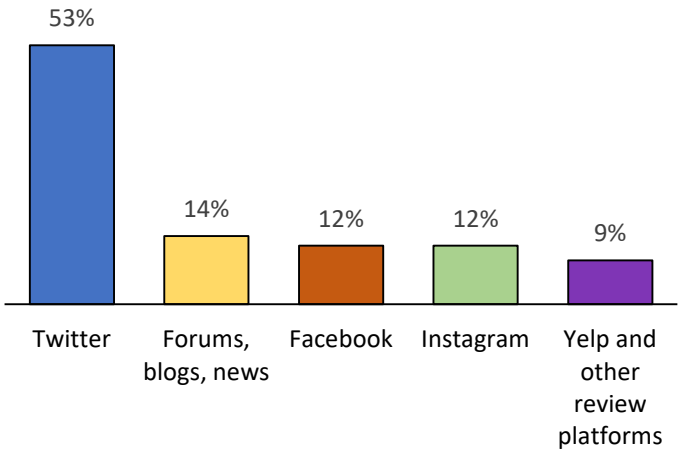
Table 1. Distribution of papers by research area and topic

Research areas and topics		References	#	%
Marketing and consumer research	sentiments towards food companies, food brands and food products	Dixon et al. 2012; Dixon 2013; Salampasis, Paltoglou, Giachanou 2014; Kim and Jeong 2015; Zhai et al. 2015; Vidal et al. 2015; Vidal, Ares and Jaeger 2016; Park, Jang and Ok 2016; Amato et al. 2017; Halibas, Shaffi and Mohamed 2018; Mostafa 2018; Mihuandayani et al. 2018, Yüksel and Tan 2018; Bilgihan, Seo and Choi 2018.	14	44
	food-related consumer behavior	Abbar, Mejova and Weber 2015; Coary and Poor 2016; Coelho, De Oliveira, De Almeida 2016; Mejova, Abbar and Haddadi 2016; Holmberg et al. 2016; Moreno-Sandoval et al. 2018; Rahimi, Mottahedi and Liu 2018; Khan et al. 2018.	8	
Supply chain management	food monitoring, food events, risks/crisis situations	Gaspar et al. 2014; Rutsaert et al. 2014; Kuttschreuter et al. 2014; Kate, Negi and Kalagnanam 2014; Li, Lv, Zhu and Lin 2015; Ciceri et al. 2015; Tse et al. 2016; Jang et al. 2016; Ihm et al. 2017; Wang, Balasubramani and Cruz 2017; Stevens et al. 2018; Zavala and Ramirez-Marquez 2019.	12	24
Sustainable food systems	food waste minimization, food quality, public health	Mishra and Singh 2018; Singh, Shukla and Mishra 2018; Rich, Haddadi, and Hospedales 2016; Razali et al. 2017, Nguyen et al. 2017; Huangfu and Zeng 2018; Liu and Sinnott 2018.	7	14
Food production	product development and customization	Fehér et al. 2014; Carr et al. 2015; Kusmierczyk, T., Trattner and Nørvåg 2016; Kim at al. 2018; Wang Y. et al. 2018; Arellano-Covarrubias et al. 2019.	6	12
Food markets	food supply and demand, food prices	Kim, Cha and Lee 2017; Lukyamuzi, Ngubiri and Okori 2018, Kahn 2018.	3	6

The above distribution is limited to the list of major research topics and objectives as they have been specified in the selected papers. Hence, it does not necessarily reflect all relevant contributions made by the Authors of the reviewed papers. It should be noted that some papers have covered more than one research area and topic. At the same time, some papers could not be assigned to any specific category.

Most of the reviewed papers are research papers based on social media data analysis. Only three papers refer to and present social media metrics in the context of additional surveys and data collection to examine specified research questions. By and large, Twitter has been the most important source for social media data extraction and analysis. Both text messages and images posted on Twitter have been used in the examined studies. Other sources of social media data included news, online posts, texts and photos published on multiple forums, blogs, social networking sites, multimedia sharing sites, Facebook, Instagram, Yelp and various platforms with consumers' opinions, ratings and reviews. The distribution of social media data sources as used in the reviewed papers is presented in the Figure 1.

Fig. 2. Distribution of social media data sources used in the reviewed papers



As for the types of analysis, descriptive, diagnostic, predictive and prescriptive approaches have been used in the reviewed papers. Sentiment analysis and text mining have been the most popular techniques, particularly in the descriptive and diagnostic types of studies. Other papers have made use of social network type analysis to analyze i.a. ways of spreading information in online food communities or ways of presenting food in social media among users of certain age groups. Image recognition was used for food trend analysis and for potential dietary assessment and healthcare applications. Papers with predictive approaches have been based on multiple data sources and used various techniques, including text mining, natural language processing and simulation, i.a. to predict overweight on the basis of social media data or to forecast food price fluctuations. Prescriptive approaches have been found in papers dealing with ideas and proposals for using social media channels to change food habits or to influence consumer food choices.

3.2. Taxonomy of SMA capabilities in the food industry sector

Having reviewed the selected papers, it is evident that SMA may be used for various purposes and in various ways to change and improve operations and processes in a widely understood food industry. The results of the overview described the previous sections largely correspond with and fit into the framework developed by Ghani et al. (Ghani et al.

2018). This framework has been an inspiration to present a taxonomy of SMA capabilities in the food industry sector. The presented taxonomy (Fig. 2) takes into account proposals, ideas and results included in and extracted from the reviewed papers.

The basic finding of the review is that SMA may stimulate changes, improvements and innovation in different areas and domains of the food industry business. The reviewed papers show that social media data may be used in food production, food marketing, food supply chain management and food safety and quality management. Other – but less apparent – applications of SMA extend to such domains as food integrity and food security. While the first four domains of SMA applications directly relate to and benefit food processing companies and other businesses engaged in the food supply chain, the latter two concern mainly public authorities and institutions responsible for food monitoring and food inspections. Applications in the food integrity domain might however also include competitive analytics, i.e. analytics which uses social media data to monitor and track activities and integrity of other actors in the food supply chain, both competitors, clients or partners of a given company.

In the domain of food production, specific data sources, types and analytical techniques seem more relevant than others. These include microblogging, multimedia sharing files, food blogs and text mining to recognize consumers sentiments, ideas and expectations about specific categories of foods, flavors and recipes. As the reviewed papers show, social media data are useful not only for analyzing emerging food trends, but also for identifying differing food tastes and food habits in different parts of the world. Knowledge and insights about varied food product preferences might therefore improve both production planning and product development (Carr et al. 2015). Specifically, accurate information acquired through SMA enables strategies directed towards food customization. Such strategies might involve tailoring food products to differing consumers preferences concerning a variety of food characteristics and qualities, related i.a. to food ingredients, tastes, texture, smell, nutritional or functional properties (i.a. Arellano-Covarrubias et al. 2019). Also, social media platforms allow for extracting valuable information about general consumers' opinions and concerns impacting their food choices (i.a. concerns over the environment and animal welfare which often translate into preferences for buying sustainable, ethically sourced food products). Overall, since social media platforms become increasingly important for discussing and sharing information on food-related issues, SMA might foster data-driven innovation and customization in the food production domain.

Marketing based on social media channels and social media data becomes a standard in many industries. Also food companies have been increasingly using social media technologies to improve their marketing strategies. Marketing makes up therefore the second important domain of SMA capabilities in the food industry sector. The reviewed papers assigned to marketing category focus primarily on analyzing consumer sentiments towards food companies, brands and products (i.a. Dixon et al. 2012, Vidal et al. 2015; Vidal, Ares and Jaeger 2016). Such analyses provide important guidance and support for managing brand experience and consumer loyalty and may also inform targeted marketing strategies. Other important SMA capabilities not directly covered in the examined papers refer to influencer marketing. Recent experiences show that a single tweet or a share from an influencer (a person or organization regularly followed by many other users of social media platforms) might result in a significantly increased interest in a given content. Potentially, it may also result in increased sales if the content shared or promoted by an influencer concerns specific products or services. At the same time, it should be noted that social

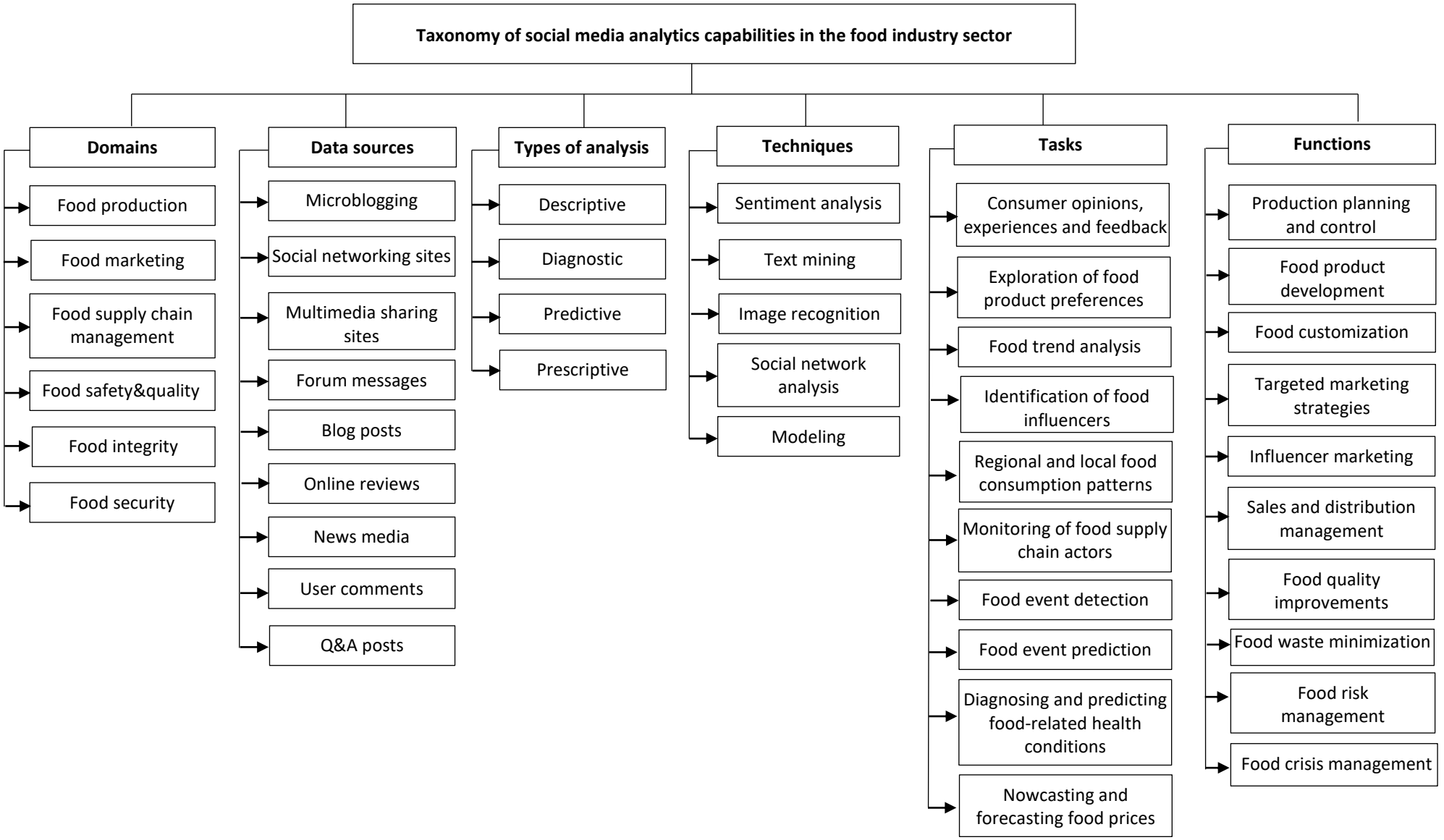
media platforms are open to different types of communications and may also promote unhealthy foods. One of the findings of the reviewed papers is that colorful photos depicting desserts, sweets and high-calorie foods attract greater interaction and activity across social networking sites (particularly among the youth), than healthy foods rich in nutrients (cf. Holmberg et al. 2016).

Capabilities of SMA also extend to food supply chain management issues. Papers using social media data to analyze food consumption patterns in specific countries and regions or in larger and smaller local communities show that this kind of analysis may provide important hints and insights as far as sales and distribution policy is concerned. SMA might help in taking decisions about entering a new market or about choosing a new location for a restaurant (cf. Rahimi, Mottahedi and Liu 2018). Since SMA allows for predicting fluctuations in demand for specific categories of food or for the catering services, it may also help in coordinating and planning food deliveries. Some authors also point to SMA capabilities to promote sustainability in the food supply chain, i.a. through food waste minimization (Mishra and Singh 2018). These results may be achieved by using social media data to align food product qualities to consumers' preferences (e.g. with regard to fat content in meat products) so as to reduce discarded parts of food.

Food safety and quality and food integrity are another two areas where SMA can generate meaningful insights. These days consumers rarely make complaints about inadequate quality of food directly to food producers or to a grocery store. A more convenient and more rapid way to express one's dissatisfaction with purchased or consumed food is through social media platforms (Alarcón et al. 2018; Mishra and Singh 2018). As some authors of the reviewed papers point out, social media sites prove powerful tools for spreading information about food scandals, food safety issues or unethical practices of food businesses (cf. Stevens et al. 2018). Data mining techniques may therefore help in food event detection, risk assessment or in early warning systems (Li, Lv, Zhu and Lin 2015). Overall, continuous monitoring and analysis of social media data has been seen as crucial for effective food crisis management and food crisis communication. Other promising directions of SMA in this area include diagnosing and predicting food-related health conditions (cf. Huangfu and Zeng 2018). Although these analyses are mainly done for the purposes of public health policy, one might expect that food companies seeking new sources of competitive advantage will be increasingly interested in pursuing sustainability strategies based on public health data.

Social media platforms have been also used as a new data source for assessing food security and food insecurity landscapes (e.g. by identifying food shortages in specific regions or municipalities). The reviewed papers demonstrate such applications are particularly relevant for developing countries (Kahn 2018; Lukyamuzi, Ngubiri and Okori 2018). Solutions offered in this domain include i.a. a nowcast model that identifies tweets mentioning food prices and forecasts daily price fluctuations of major food commodities (Kim, Cha and Lee 2017). Since such models provide more timely market statistics, they may improve public authorities interventions in the sphere of food security policy. Nowcasting models might be also helpful for various firms engaged in the agri-food trade.

Fig. 3.



Source: own elaboration based on classification in Ghani et al. 2018 and literature on SMA and food issues.

3.3. Benefits and risks of SMA in food innovation and production

Knowledge and insights extracted from social media data are considered crucial for many businesses. As the reviewed papers demonstrate, benefits of SMA are also substantial for the food industry enterprises – food processing companies and food service sector organizations. Proposals and ideas discussed in the selected papers show that SMA has a great potential in furthering innovation both in production and in management processes. Social media are continuously delivering new sets of data about consumers' opinions, needs and preferences. Consequently, with the use of SMA businesses become more-consumer oriented and more responsive to changing market trends. Advanced data analytics based on social media also leads to more informed decision-making in different business areas. Yet, not only insights based on advanced data analytics, but also simple use and monitoring of social media channels might bring tangible benefits to food innovators. This is because social media channels themselves are important co-innovation tools and enablers. Recent example relates to the discovery of aquafaba. This new food product was brought to light in 2014 by Joël Roessel, the French tenor who experimented with liquids from canning to find an alternative to eggs. This discovery was subsequently discussed on multiple blogs and forums and Facebook users with Goose Wohlt, American software engineer, invented the name "aquafaba" to describe this invention (Valle 2015).

By and large, the examined literature has highlighted positive effects of social media analytics. This comes as no surprise, since the overwhelming majority of papers intended to confirm the usefulness of social media data in a wide variety of analytical tasks. Major benefits of SMA in the food industry sector may be synthesized into four major categories. These include:

- benefits related to improved consumer experiences with food products, food services and food brands such as increased consumer loyalty and increased sales;
- new knowledge and insights potentially translating into reduced operating costs, new food products or improvements in products and processes in food industries;
- more efficient and more sustainable food supply chain i.a due to accurate insights into food demands and food consumption patterns and through food waste minimization;
- more effective monitoring of food safety and quality through early warning system based on food event and food hazard detection.

The presented review might offer a guidance for developing strategic uses of SMA in the food industry sector. Many of these proposals and promises still await direct experimental tests. Such tests may be particularly relevant for enterprises and organizations seeking new sources of competitive advantage. Nonetheless, one should also note that SMA does not come without risks and limitations. The reviewed literature, however, pays little attention to these problems. Papers and reports devoted to digital technologies and social media in general yield more meaningful insights in this respect. The fundamental risks associated with the use of SMA in the food domain are related to rapidly changing food trends (cf. Bomkamp 2017). These changes are stimulated by network effects which are typical for digital communication. Since social media metrics make it sometimes difficult to draw a clear delineating line between food trends and food fads, following SMA hints might be risky. Some authors also question the reliability of user-generated data. Social media users tend to post, share and like content that reflects their better "self" (cf. Gil-Or et al. 2015). Such data depict well the reality of social media world, yet they might have little value and impact as

far as real-life decisions, including food consumption choices, are concerned. Recent reports also point to the problem of bots imitating human behavior in the Internet (Read 2018). With fake clicks and fake social media accounts, many social media metrics used in marketing strategies might be – if not counterproductive – at least useless. Other concerns relate to SMA insights favoring unhealthy foods, particularly if such insights and subsequently marketing strategies promise increased sales among specific groups of consumers. Therefore, one of the most important research tasks for the future will be to develop guidelines for responsible SMA in the food industry sector. Such guidelines could be part of broader strategies for corporate digital responsibility and corporate social responsibility of food companies.

4. Conclusion

The primary contribution of this paper is a systematic literature review of 54 papers that deal with social media analytics and social media applications in the food industry sector. Based on the conducted review, the paper shows that information, knowledge and insights generated by analyzing social media data are strategically important and valuable for food industry enterprises and food service sector organizations. At the same time, it should be noted that many proposals included in the reviewed papers have not been yet tested in real world conditions. Therefore, more empirical evidence about the value of SMA in the food sector would be needed. There is also a need to establish guidelines for responsible use of social media data and social media analytics in food innovation and production.

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