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Mass customization in food production: a perception about the theme and future directions

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Abstract: Mass Customization (MC) has become a significant market trend, mainly with the dissemination of new technologies, such as the Internet of Things (IoT). This article aims to identify possibilities of MC adoption for produced food and to identify barriers and enablers related to MC success. For to develop the MC theme in food production, as the first step, a systematic literature review was carried out. The systematic search of several databases (Emerald Insight, Science Direct, Web of Science, Proquest and Scopus) was conducted, and 52 studies met the inclusion criteria and were included in this review. Results show food perishability, difficulty in processing, nutritional values quantification of the customized food products and perceived complexity of the customization benefit by the customers as barriers to MC implementation in the food sector. Each of these barriers is discussed together with the recommended enablers to overcome them. The results presented contribute to the identification of opportunities for new products, processing, and services associated with custom food products and the improvements implementation of foods already customized by companies. This paper gathers considerations to direct the MC success of food engineering and food sector companies. To accompany the industry 4.0 scenario, it becomes essential to develop mass customization strategies. The challenge of Food Engineering is precise to create methods that align with such a situation. In this way, the present article presents itself as an initial step towards a new way of thinking about food engineering processes.

Keywords: food technologies, innovation, barriers, enablers, personalization.

1. Introduction

The term Mass customization (MC) (DAVIS, 1987) aims to meet specific consumer demands (PINE II, 1993) through technologies application and production systems capable of delivering goods and services with similar efficiency to those produced massively (TSENG; JIAO; MERCHANT, 1996). MC successful application can be verified in companies of the most varied areas (FOGLIATTO et al., 2012), as services sector (YAO; DENG, 2015; LUNA et al., 2017), automobile (KHAN; HAASIS, 2016; FETTERMANN et al., 2017), construction (FETTERMANN et al., 2019) and modulated furniture (FETTERMANN; ECHEVESTE, 2011). In the food sector, applications in the personalized nutrition area (BOLAND, 2008; CALEGARI et al., 2018) and food production (MCINTOSH et al., 2010; MATTHEWS; MCINTOSH; MULLINEUX, 2011; VERDOW; BEULENS; WOLFERT, 2014) are verified.

Although several studies on the subject are identified in the literature, there are still difficulties in understanding some limits of the MC adoption (PILLER et al., 2005) and the application of its concepts in companies (FOGLIATTO et al., 2012; FETTERMANN; ECHEVESTE, 2014). This difficulty is more critical in the food industry (FISHER et al., 2005; MATTHEWS et al., 2006; BOLAND, 2006). This area presents restricted amounts of studies with orientations of MC use in food production (MCINTOSH et al., 2010). This lower number of studies can be explained by differences in food production processes and product characteristics, such as perishability, and the physical (MCINTOSH et al., 2010) and chemical modifications that may compromise the operations efficiency and the quality of products (WEDZICHA; ROBERTS, 2006). In addition to the scarcity of information that guides the MC implementation in the food industry, there is a need to gather the literature on this topic, which is still dispersed in different study areas, such as the identification of consumer needs (ADEIGBE et al., 2015; NAGPAL; LEI; KHARE, 2015; WOLF; ZHANG, 2016), processing methods (FISHER et al., 2005; MATTHEWS; MCINTOSH; MULLINEUX, 2011) or studies related to the value chain (MERTINS et al., 2012; VERDOW; BEULENS; WOLFERT, 2014).

Despite these difficulties, an increase of customization food products offered on the market can be observed, for example, in companies such as Subway, McDonald's and Domino's (NAGPAL; LEI; KHARE, 2015). The growth of MC use in food products (NAGPAL; LEI; KHARE, 2015), together with the lack of studies and the difficulty of its application in the area (BOLAND, 2006; MCINTOSH et al., 2010; WEDZICHA; ROBERTS, 2006), as a research opportunity on the subject.

Through of literature review, this article aims to identify opportunities for new products, processes and services associated with customized food products, as well as implementing improvements to already customized foods. From this introduction are presented the procedures of data collection used in the literature review. Subsequently, in the results section, MC applications are presented in food and discussion of barriers and their potential enablers. Finally, the final considerations section presents the research opportunities and conclusions of the study.

2. Method

A systematic review of the literature was carried out to achieve the research opportunities. The use of this research approach ensures that systematic error is limited, casual effects are reduced, and the legitimacy of data analysis is reinforced (REIM et al., 2015). The research was carried out based on the method of systematic review developed by Kitchenham (2004), widely used in the literature (KEELE, 2007; BEECHAM et al., 2008; BENAVIDES et al., 2010).

The research question used in this paper is: What are the applications, barriers and enablers for MC implementation in food sector? We conducted research on five major databases of scientific journals: Science Direct, Scopus, Emerald Insight, Proquest and Web of Science. The review on MC performed by Fogliatto et al. (2012) used the search terms "mass customization" and "mass customisation" to search for articles. This study considered the same terms used by Fogliatto et al. (2012) in addition to the isolated terms "customization" and "customisation", all combined with the words "food" or "nutrition". The search was performed in databases incorporating titles, keywords and abstracts. The search process of identified 439 articles, which after filtering procedure (Figure 1) resulted in 52 different articles analyzed. Procedures embraced during this filter excluded articles that did not have title, abstract or text adhering to the subject studied. The selected articles were not filtered by the date of publication, since the majority (49 articles) of the articles selected were published after 2000.

Studies in MC literature frequently address the benefits of its application (HART, 1995; KOTHA, 1995; SALVADOR et al., 2009), the barriers or difficulties to its implementation (PINE II; VICTOR; BOYNTON, 1993; ZIPKIN, 2001) and also the enablers that contribute to its

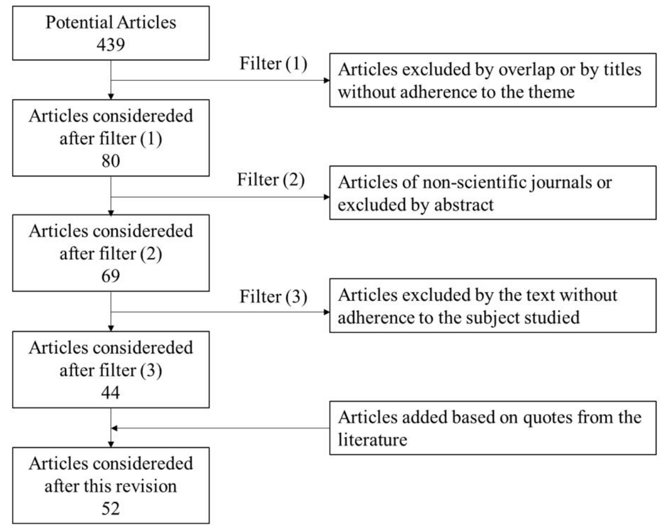

Figure 1. Procedure for filtering articles considered for this review.

success (SILVEIRA; BORENSTEIN; FOGLIATTO, 2001; PILLER; MULLER, 2004; FOGLIATTO et al., 2012). Following this same procedure, a research was carried out to identify in the articles the benefits, barriers and enablers for the MC application in the food sector. Data collection was effectuated based on the full analysis of the articles considered in this review. The complete procedure of the systematic review was carried out between March 2016 and January 2017. The results obtained from the literature review are presented below.

3. Results and discussions

As a way of analyzing the topics addressed in each publication were established four different categories of research topics. In the first category, called general (G), articles are included that develop the objective of exposing CM characteristics and visions including the food sector. They are articles that present studies on the food market, mention the food industry, or use industry data to compose the study. The second category of articles, called processing (P), includes topics addressed to an analysis of characteristics and alternatives of manufacture and processing for food product customization. The third category of articles, called customer (C), incorporates the theme of analysis of the relation of CM with the interactivity of the consumer and their perception of values on the customized food product. Finally, the fourth category of articles, denominated value chain (V), is formed by studies that focus on the analysis of the relation of CM with the supply chain and logistics of the food industry. Each of the articles reviewed was classified according to the topic addressed in one of these categories of study, and the results of this classification are presented in Table 1. Also, the study title, authors, publication vehicles,

Table 1. Dates and categorization of the articles selected for the research.

Title	Authors/Years	Periodic / Congress	Categories	Cit.
Food quality and safety: consumer perception and demand	Grunert (2005)	European Review of Agricultural Economics	C	949
The mass customization decade: An updated review of the literature	Fogliatto, Silveira and Borenstein (2012)	International Journal of Production Economics	G	272
Trends in food packaging and manufacturing systems and technology	Mahalik and Nambiar (2010)	Trends in Food Science & Technology	P	151
Future of food engineering	Sun (2007)	Journal of Food Engineering	G	134
Postponement and the reconfiguration challenge for food supply chains	Van Hoek (1999)	Supply Chain Management: An International Journal	P, V	116
Food for thought: How will the nutrition labeling of quick service restaurant menu items influence consumers' product evaluations, purchase intentions, and choices?	Burton, Howlett and Tangari (2009)	Journal of Retailing	C	102
Transparency in complex dynamic food supply chains	Trienekens et al. (2012)	Advanced Engineering Informatics	V	92
Information–communication technologies open up innovation	Awazu et al. (2009)	Research-Technology Management	G	71
A study of the supermarket industry and its growing logistics capabilities	Kumar (2008)	International Journal of Retail & Distribution Management	C	67
Service design and operations strategy formulation in multicultural markets	Pullman, Verma and Goodale (2001)	Journal of Operations Management	C	65
Brand leadership and product innovation as firm strategies in global food markets.	Gehlhar et al. (2009)	Journal of Product & Brand Management	G	52
Consumer response to and choice of customized versus standardized systems	Bharadwaj, Naylor and Ter Hofstede (2009)	International Journal of Research in Marketing	G	47
Competing through operations and supply: The role of classic and extended resource-based advantage.	Lewis et al. (2010)	International Journal of Operations & Production Management	V	47
The rise and fall of McDonaldization	Taylor and Lyon (1995)	International Journal of Contemporary Hospitality Management	G	35
Late customisation: issues of mass customisation in the food industry	McIntosh et al. (2010)	International Journal of Production Research	G,P	35
Layered Manufacture: A new process for constructing solid foods	Wegrzyn, Golding and Archer (2012)	Trends in Food Science & Technology	P	28
Personalizing foods for health and preference	German, Yeretzian and Watzke (2004)	Food Technology	C	22
Innovation in the food industry: Personalised nutrition and mass customisation	Boland (2008)	Innovation	G,C	22
Benchmarking leagility in mass services: The case of a fast food restaurant chains in Iran	Rahimnia, Moghadasian and Castka (2009)	Benchmarking: An International Journal	C	20
A user-friendly general-purpose predictive software package for food safety	Halder et al. (2011)	Journal of Food Engineering	P	18
Additive manufacturing for the food industry	Lipton et al. (2015)	Trends in Food Science & Technology	P	17
Does the tourism/hospitality industry possess the characteristics of a knowledge-based industry?	Pizam (2007)	International Journal of Hospitality Management	G	15
"Tailoring" customization services: Effects of customization mode and consumer regulatory focus	Wang, Kandampully and Jia (2013)	Journal of Service Management	C	13
Psychological determinants of consumer acceptance of personalised nutrition in 9 European countries	Poínhos et al. (2014)	PloS one	C	13
Mass customisation of food	Boland (2006)	Journal of the Science of Food and Agriculture	C	10

Table 1. Continued...

Title	Authors/Years	Periodic / Congress	Categories	Cit.
A customizable wireless food ordering system with realtime customer feedback	Samsudin et al. (2011)	IEEE Symposium on Wireless Technology and Applications (ISWTA)	C	10
The challenge to customize	Coulston, Feeney and Hoolihan (2003)	Journal of the Academy of Nutrition and Dietetics	G	9
Situated and mobile displays for reflection on shopping and nutritional choices	Reitberger, Spreicer and Fitzpatrick (2014)	Personal and ubiquitous computing	C	8
Nutrition monitor: a food purchase and consumption monitoring mobile system	Dorman et al. (2009)	International Conference on Mobile Computing, Applications, and Services	C	8
Effects of meal variety on expected satiation: Evidence for a 'perceived volume'heuristic	Keenan, Brunstrom and Ferriday (2015)	Appetite	C	7
The design of food processing systems for improved responsiveness and late customisation	Fisher et al. (2005)	Advances in integrated design and manufacturing in mechanical engineering	P	6
A review on 3D printing for customized food fabrication	Sun et al. (2015)	Procedia Manufacturing	P	6
Mass customizing the retail experience	Coupe (1995)	Progressive Grosser	G	5
Food and Beverage Marketing to Latinos: A Systematic Literature Review	Adeigbe et al. (2015)	Health Education & Behavior	C	5
Towards software mass customization for business collaboration	Verdow, Beulens and Wolfert (2014)	2014 Annual SRII Global Conference	V	4
Effects of standardization and innovation on mass customization: An empirical investigation	Wang et al. (2016)	Technovation	G	4
A new application for food customization with additive manufacturing technologies	Serenó et al. (2012)	The 4th Manufacturing Engineering Society International Conference (Mesic 2011).	P	3
Does competition lead to customization?	Hsu, Lu and Ng (2014)	Journal of Economics behaviour & organization	G	3
MIRA: Enabler of mass customization through agent-based development of intelligent manufacturing systems	Sorouri, Vyatkin and Salcic (2014)	2014 IEEE International Conference on Robotics and Automation (ICRA)	P	2
Information customization and food choice	Balcombe et al. (2016)	American Journal of Agricultural Economics	C	2
Consumer interest in specialty beers in three European markets	Donadini et al. (2016)	Food Research International	C	2
Contrasting opportunities for mass customisation in food manufacture and food processes	Matthews, McIntosh and Mullineux (2011)	Mass Customization	G, P	1
Towards Information Customization and Interoperability in Food Chains	Mertins, Jaekel and Deng (2012)	International IFIP Working Conference on Enterprise Interoperability	V	1
Implementing a cooking and dietary management system using RFID technology	Chen, Liang and Lin (2014)	Mathematical Problems in Engineering	C	1
Postponement application in orange juice companies: case studies	Ferreira and Alcântara (2015)	International Journal of Logistics Systems and Management	P, V	1
To Choose or to Reject: The Effect of Decision Frame on Food Customization Decisions	Nagpal, Lei and Khare (2015)	Journal of Retailing	C	1
Asses the degree of mass customization strategies implementation in food and beverages, shareholding industrial companies in Jordan	Sultan et al. (2011)	International Journal of Recent Research and Applied Studies	G	0

Table 1. Continued...

Title	Authors/Years	Periodic / Congress	Categories	Cit.
Applications of SPE-MIP in the Field of Food Analysis-4.20	Manesiotis et al. (2012)	Chemistry, Molecular Sciences and Chemical Engineering	P	0
Objective measures of meal variety lacking association with consumers' perception of variety with self-selected buffet meals at work	Haugaard, Brockhoff and Lähteenmäki (2016)	Food Quality and Preference	C	0
Postponement adoption in manufacturers of tomato-derived products	Ferreira and Alcantara (2016)	British Food Journal	P, V	0
User-Interface Design for Individualization Services to Enhance Sustainable Consumption and Production	Hankammer et al. (2016)	Procedia CIRP	C	0
The effect of customization and gender on customers' attitude	Wolf and Zhang (2016)	International Journal of Hospitality Management	C	0

year of publication, and quantity of citations (Cit.) according to the *Google Scholar* database.

From the results presented in Table 1, the two articles that have the largest number of citations, do not have as main theme CM for the food industry. The most cited article, Grunert (2005), developed his study to analyze the relationship between quality, safety perception and consumer demand for food products. It was considered for this review, because it has adherence with CM, due to its analysis of the perception of the consumers, identified as a relevant characteristic to be studied in the adoption of the CM by a company (SILVEIRA; BORENSTEIN; FOGLIATTO, 2001). The work of Fogliatto, Silveira and Borenstein (2012), the second with the largest number of citations, presents a literature review on CM including studies on its application in the food sector (MCINTOSH et al., 2010; BOLAND, 2008). In his review of the literature, Fogliatto, Silveira and Borenstein (2012) performs an analysis on the barriers and facilitators for the adoption of CM in several sectors of the industry, being used as reference of analysis of the present study.

Through this review, a growing number of publications have been verified that address the theme, justifying its relevance, especially when they approach the category of subject adhering to the interaction analysis with clients. The analysis of journals confirms the dispersion of studies on MC in food products in the literature. Journals are verified from several areas of concentration, with emphasis on operations management and food engineering.

In the literature is observed the presence of products that use different inputs sources, further evidenced the adoption of MC in food products viability with different processing types.The review of MC applications in food considered in this study identified 44 applications. The higher frequency of studies could be observed in the fast food category (12), wich can be verified several food products, such as MC application for pizza production (WEGRZYN et al., 2012; LIPTON et al., 2015; NAGPAL; LEI; KHARE, 2015; SUN et al., 2015), hot dogs (RAHIMNIA; MOGHADASIAN; CASTKA, 2009; PULLMAN; VERMA; GOODALE, 2001), hamburger (PULLMAN; VERMA; GOODALE, 2001; WOLF; ZHANG, 2016), salads (NAGPAL; LEI; KHARE, 2015) and ready restaurants dishes (SAMSUDIN et al., 2011; CHEN et al., 2014). The MC applications also can be verified in: beverages category, such as juices (FERREIRA; ALCÂNTARA, 2015), beers (DONADINI et al., 2016) and wines (Van Hoeck); Condiments category, such as tomatoes products (FERREIRA, ALCÂNTARA, 2016) and olive oil (BALCOMBE et al., 2016); candies category, such as cakes, chocolates, cokies (WEGRZYN et al., 2012; LIPTON et al., 2015; SUN et al., 2015) and ice cream (SOROURI et al., 2014); and dairy foods category with a higher frequency of studies about MC applications in yoghurts (FISHER et al., 2005; MCINTOSH et al., 2010; MATTHEWS; MCINTOSH; MULLINEUX, 2011).

3.1. Barriers to embracing MC in food companies

New products development with commercial viability requires technological and market possibilities be effectively considered in product design (ULRICH et al., 2003). The need to meet these technological, market and management possibilities can be analyzed in form of barriers (DOUGHERTY, 1992). The study about barriers can be found in several studies about the theme (PINE II; VICTOR; BOYNTON, 1993; MACCARTHY; SUN; BRAMHAM, 2003; PILLER; MULLER, 2004; ZIPKIN, 2001; SALVADOR et al., 2009; DAABOUL et al., 2011). Barriers can also be termed as other forms in the literature, such as success factors (HOLLAND; LIGHT, 1999; SILVEIRA; BORENSTEIN; FOGLIATTO, 2001; FOGLIATTO et al., 2012) and difficulties or limits (ZIPKIN, 2001). The literature on MC directed to the food sector incorporates new barriers to MC embracing in companies, mainly due to the peculiarities of food processing (BOLAND, 2006; MCINTOSH et al., 2010; MATTHEWS; MCINTOSH; MULLINEUX, 2011). In studies on the subject, can be verified as barriers to MC implementation in food sector: *(i)* the perishability of food, which considers the useful or shelf life of a food (KOUKI et al., 2013; NEUSCHULZ et al., 2015); *(ii)* processing, referring to restrictions to produce customized food products (FISHER et al., 2005; MATTHEWS; MCINTOSH; MULLINEUX, 2011; MCINTOSH et al., 2010) *(iii)* nutritional values, referring to the difficulty of transcribing the characteristics of customized product (GERMAN; YERETZIAN; WATZKE, 2004; BOLAND, 2008; BALCOMBE et al., 2016; REITBERGER; SPREICER; FITZPATRICK, 2014); and *(iv)* custumers perception, related to the value adding process of the food product customization (PULLMAN; VERMA; GOODALE, 2001; NAGPAL; LEI; KHARE, 2015; WOLF; ZHANG, 2016) (Table 2).

3.2. Food perishability and its enablers

The difference between processes of industry in general and the food industry processes may explain the lesser exploration of the literature on MC in the food sector (BOLAND, 2008; MCINTOSH et al., 2010; MATTHEWS; MCINTOSH; MULLINEUX, 2011). While for the industry in general, the product has its performance measured by its functionality, for food industries, the sensory characteristics (such as texture and appearance) are relevant to its quality (FISHER et al., 2005; BOLAND, 2006).

Perishability is a factor to be considered in the production of food (FISHER et al., 2005; BOLAND, 2006). All foods are naturally decomposed, altering the chemical and physical characteristics of food products (BOLAND, 2008; MCINTOSH et al., 2010; TRIENEKENS et al., 2012; MATTHEWS; MCINTOSH; MULLINEUX, 2011; SUN et al., 2015; FERREIRA; ALCÂNTARA, 2016). Among the opportunities identified to overcome the perishability of custom foods are: the application of generally mentioned as additives (MATTHEWS; MCINTOSH; MULLINEUX, 2011; LIPTON et al., 2015) which has as one of its objectives to increase the shelf life; the use of special packages (MATTHEWS et al., 2006; LIPTON et al., 2015; SUN et al., 2015; FERREIRA; ALCÂNTARA, 2016) that promote protection against mechanical shocks, undesirable chemical modifications and still make possible the use of modified or controlled atmosphere; and the embracing of the postponement in the value chain (VAN HOEK, 1999; FERREIRA; ALCÂNTARA, 2015, 2016), which may favor the reduction of security stocks (WONG et al., 2011) avoiding the obsolescence of food products already manufactured.

Food products need rapid production and distribution while preserving their quality, and should be produced according to legal requirements (MATTHEWS; MCINTOSH; MULLINEUX, 2011). Specific equipment for adequate food transport makes food products more susceptible to distribution costs than inventory costs (FERREIRA; ALCÂNTARA, 2016). In addition, the product quality control requires strict inspection for hygiene process in companies to ensuring the food safety (GRUNERT, 2005; HALDER et al., 2011; SULTAN et al., 2011). Thus, the complexity of specific laws for food processing is also a factor that may inhibit MC implementation in the system (MCINTOSH et al., 2010).

3.3. Foods processing and its enablers

Chemical and physical changes can also occur induced by industrial processes such as maturation cycles (MCINTOSH et al., 2010; MATTHEWS; MCINTOSH; MULLINEUX, 2011) and thermal processes (MAHALIK; NAMBIAR, 2010). These activities are usually used by the food industry to processing the product, also contributing to the elimination of microorganisms (MAHALIK; NAMBIAR, 2010). Restrictions on how food material can be processed without impairing its quality (taste, appearance and nutritional value) impose limits on the use of process technology (MCINTOSH et al., 2010). Physical state (liquid, solid, pasty) or shape food can also affect product customization (MATTHEWS; MCINTOSH; MULLINEUX, 2011). Thus, food sensitivity may be considered a barrier to the development and use of technologies that help to customize food, both automation for physicochemical transformation processes, as well as production control operations (FISHER et al., 2005).

The growing demand of customized food (BOLAND, 2008) and the short life cycle these products have, resulting from rapid imitation by competitors (SUN, 2007; LEWIS et al., 2010), directs the food processing industry to maintain a high variety of products (FISHER et al., 2005). These market characteristics of the customized food products create the need for operations and supply systems flexible enough to produce a greater quantity of food products at a low cost (SALVADOR et al., 2009; LEWIS et al., 2010). Other difficulties may also arise due to demands aligned to short or seasonal periods (MATTHEWS; MCINTOSH; MULLINEUX, 2011). For this, chain postponement may be a viable alternative, as presented by Ferreira and Alcântara (2016), case of tomato derivatives production, which can be frozen in the form of pulp, for use in periods when the raw material is scarce.

The development of software for process simulation could predict the changes in the quality of food products subjected to operations. Nevertheless, the availability of systems with this feature is still limited in food industry,

Table 2. Barriers to MC adoption in food production.

Authors	Food perishability			Food Processing						
	Chemical modifications	Physical modifications	Food Decay	Sensitivity to handling, internal transport company and in the supply chain	Recovery of post process ingredients	Cycles of maturation /seasonality	Food safety	Incompatibility between ingredients	Identification and preservation of the nutritional values of customized food products	Identification of the perceived value of the customized food product customers
Van Hoek (1999)			x	x						
Pullman, Verma and Goodale (2001)										x
Coulston et al. (2003)									x	
German et al. (2004)									x	x
Grunert (2005)			x				x			x
Fisher et al. (2005)	x		x	x				x	x	
Nowak-Wegrzyn (2007)									x	
Sun (2007)	x		x	x			x		x	
Boland (2008)	x		x	x						x
Kumar (2008)			x							
Awazu et al. (2009)				x						x
Dorman et al. (2009)									x	x
Rahimnia, Moghadasian and Castka (2009)			x	x						
Gehlhar et al. (2009)									x	x
Mahalik and Nambiar (2010)	x	x	x	x						
McIntosh et al. (2010)	x	x	x	x	x	x	x	x	x	x
Reitberger, Spreicer and Fitzpatrick (2014)									x	x
Samsudin et al (2011)										x
Halder et al. (2011)			x				x			
Matthews, McIntosh and Mullineux (2011)	x		x	x		x	x	x	x	x
Mertins et al. (2012)			x	x						x
Serenó et al. (2012)				x						
Trienekens et al. (2012)	x	x	x	x					x	
Wegrzyn et al. (2012)		x	x	x				x	x	
Verdow, Beulens and Wolfert (2014)				x						
Sorouri et al. (2014)				x						
Poínhos et al. (2014)										x
Chen et al. (2014)									x	x
Haugaard, Brockhoff and Lähteenmäki (2016)										x
Keenan et al. (2015)									x	x
Lipton et al. (2015)			x	x						
Nagpal, Lei and Khare (2015)			x					x	x	x
Sun et al. (2015)			x	x						
Ferreira and Alcântara (2015)		x	x		x	x				
Adeigbe et al. (2015)									x	x
Ferreira and Alcântara (2016)		x	x		x	x				
Balcombe et al. (2016)									x	x
Donadini et al. (2016)								x	x	x
Hankammer et al. (2016)										x
Wolf and Zhang (2016)										x

very reason that software developers have added strength to invest resources in the development of specific food processing capabilities (HALDER et al., 2011). A feature of the software, in general, is that components in a virtual environment can be multiplied easily and at low cost (VERDOW; BEULENS; WOLFERT, 2014), which enables customization. Halder et al. (2011) present a realistic software that simulates food production processes, predicting microbiological and chemical changes, enabling greater control of food safety.

Technology investments for automation of assembly operations, in cases where food sensitivity is not so relevant, can also be considered an effective solution to make production more flexible (SUN, 2007). Sorouri et al. (2014), proposed the use of a sighting system (Modular Intelligent, and real-time Agent), in which the client request is entered into a software that relates to a robotic interface operations, permitting a mixture of ingredients to manufacture the ice cream. Another opportunity for process automation was highlighted by Awazu et al. (2009), using a technology which each consumer can customize their order from a different set of flavors with the help of the internet, and a machine that quickly makes samples for consumer analysis. This opportunity would be an alternative that allows the reconfiguration of chosen flavor for the product.

Still with the objective of achieving flexible processes, the development of monitoring and control systems can also be an alternative (SUN, 2007). The provision of correct information and semantic interoperability enable coordination of the activities in the supply chain (MERTINS et al., 2012). Verdow, Beulens and Wolfert (2014) proposed the use of an online platform (FLS), which can facilitate the customization from the aid to communication control requirements between the companies, forming a network of business to business (B2B) organized and secure.

Another possibility of allying technology to customize food products is the use of additive manufacturing processes through 3D printers (SERENÓ et al., 2012; WEGRZYN et al., 2012; SUN et al., 2015; LIPTON et al., 2015). With this operation, products can be manufactured, having greater flexibility for customization nutrition, flavors, shapes and textures (LIPTON et al., 2015). This type of technology has potential to produce customized objects, without the need for qualified personal knowledge of operators, representing cost savings when compared to traditional manufacturing systems (SERENÓ et al., 2012).

3.4. Identification of nutritional values of customized food products and its enablers

Analyzes performed by Stewart-Knox et al. (2013), suggest that personalized nutrition is perceived as beneficial to human health. Researchers mention the possibility of applying a set of nutrigenomic techniques to study the relationship between the gene of each individual and the type of food recommended (GERMAN et al., 2004; BOLAND, 2008), which would become important for the Characterization of a personalized diet (BOUHLAL et al., 2017). When genetic characteristics of a consumer are used as influencers of their nutritional medium, the need for customization increase, since the diets tend to meet increasingly specific requests due to the infinite amount of genomes.

This need for personalization demonstrates, to a certain extent, that nutritional information compose a factor can influence the evaluation of a product, consumer perception and the intention to buy (BURTON; HOWLETT; TANGARI, 2009; TOMINC, 2014). In this case, product customization may make it difficult to build your nutritional table in processes where predicting the quantities of components is not accurate. The way in which the nutritional table is prepared and presented to consumers can have a positive impact on client's decision (NAGPAL; LEI; KHARE, 2015; BALCOMBE et al., 2016). The use of intelligent technologies (smart technologies) can facilitate the way consumers collect, process and use this information from the nutritional table when purchasing a food product (BALCOMBE et al., 2016). These technologies can be considered as an enabler for the customization of nutritional information. A technological possibility is the use of mobile app NUTRIFLECT that recognizes nutritional characteristics of a set of foodstuffs, having the capacity to provide nutrient information (calories and daily values), which facilitates the decision-making process of consumers (REITBERGER; SPREICER; FITZPATRICK, 2014). Can also be observed the use of barcode identification scanner technologies to recognize products and nutritional characteristics such as Think and go (VIMEO, 2018), IPIIT (APP STORE, 2018) and Ultimate Food Value Diary Plus (ULTIMATE..., 2018). Another technological possibility is the use of RFID (Radio Frequency Identification) system, which has a greater capacity of data storage in its NFC tags (transponder), when compared to barcode label (CHEN et al., 2014). Still, more accurate scanners technologies can be found on the market, which identify food product characteristics by recognizing a color pattern (Object Recognition Scanner– TOSHIBA (NEW…, 2018), or recognize specific molecules present in the food (TELLSPEC, 2018).

3.5. Identification value perceived by customers to customized food product and its enablers

Food consumers have demanded specific products adjusted to their individual needs and preferences (NYSTÉN-HAARALA; LEE; LEHTO, 2010). For the acceptance of food customization, consumers can be influenced by hedonic and utilitarian attributes (NAGPAL;

LEI; KHARE, 2015); health and taste (BHARADWAJ; NAYLOR; TER HOFSTEDE, 2009; TRIENEKENS et al., 2012); ecological factors (GEHLHAR et al., 2009; HANKAMMER et al., 2016); promotion feelings (WANG; KANDAMPULLY, J.; JIA, 2013); customization level offered (WOLF; ZHANG, 2016); cultural characteristics (PULLMAN; VERMA; GOODALE, 2001; ADEIGBE et al., 2015; DONADINI et al., 2016); and also factors such as waiting time and price of product (PULLMAN; VERMA; GOODALE, 2001).

One of the requirements for MC adoption is the understanding of what customer really needs. Some tools are recommended to help consumers identify their needs, minimizing complications for their decisions (MERTINS et al., 2012; SHABAH, 2015). These tools help to assist customers to realize the product customization, to identify their needs and translate it into product specifications (SILVEIRA et al., 2001; PILLER; MULLER, 2004). As an example, wireless network technologies combined with the mobile devices promote infrastructure for integration and communication between information related to customer order of customized product and food manufacture (SAMSUDIN et al., 2011; DORMAN et al., 2009). Regarding the use of graphic user interface for product's customization, consumers need a solution space which consumer can act creatively by limiting the combination of product characteristics only those which can be effectively achieved, ensuring that user's project to be possible (BIGLIARDI; GALATI, 2013).

Alternatively, graphical interface applications can promote interaction between consumer and food production. For the use of POSIFoods, reporter by Boland (2008), the design of the final product must involve the consumer. Reitberger, Spreicer and Fitzpatrick (2014) use interactivity of actual product with a mobile application (NUTRIFLECT), which would facilitate access to this information. Chen et al. (2014) achieve customization in a manufacturing approach, conducting an experiment with the RFID, in which there is the integration between a database with nutritional information, and a weight conversion scale, which would enable many processes aiming at the satisfaction of customizing diets in meals prepared to order.

The use of these applications generate a large amount of data to be analyzed. The technologies generally referred to "Big data" are proposed as a way to capture, store and analyze a large amount of data (GUO et al., 2014). The analysis based on big data provides a boost to the development of adaptive services (including e-services, for example) and digital manufacturing (cloud computing, intelligent robotics and innovative materials), which together enable the promotion of mass customization (TIEN, 2012). The research activity on the internet through technology big data can provide important information on the characteristics of human behavior (MCDANIEL et al., 2015) and the like are performed consumer activities. Understand the future direction of nutrition research, it remains firmly in science and technology agendas worldwide (FERGUSON, 2016). This behavior information is essential for convergence of human and economic development, enabling the production and consumption of affordable nutritious foods by promoting the modernization of food systems (DUBÉ et al., 2014).

4. Research opportunities

In order to identify the value perceived by the customer in customized food were also identified several studies (KEENAN et al., 2015; NAGPAL; LEI; KHARE, 2015; WOLF; ZHANG, 2016; BALCOMBE et al., 2016). These studies analyze the relationship between the variety of foods offered at meals with nutrients (Keenan et al., 2015) or the perception of consumers (CICIA et al., 2002; MURPHY et al., 2004; HAUGAARD; BROCKHOFF; LÄHTEENMÄKI, 2016). Nevertheless, the ability to customize food products and benefit to the customer is still little explored in studies. Matthews, McIntosh and Mullineux (2011) mention consumers easily customize some products and, this facility could be a barrier to MC adoption by food industries. Thus, studies of the development on what conditions occur add value to the customized food product are presented as a research opportunity.

Nutritional information constitutes another determining factor in the customized product evaluation (BURTON et al., 2009). Personalisation can hinder the production of the nutritional table depending on food industry embracing the process. However, the way this table is customized and presented to consumers can affect customer decision (NAGPAL; LEI; KHARE, 2015). Reitberger, Spreicer and Fitzpatrick (2014) suggest the use of a mobile app that recognizes customized food products and provides its nutritional information. This technology appears promising due to the demand for customized food according to their nutritional content.

Hankammer et al. (2016) indicate a greater customer preference for sustainable food products. Despite the integration of food industry and sustainability of projects, are still checked environmental impacts resulting from the food industry operation (SUN, 2007). In this sense, studies about the effect of postponement in production chain, suppliers' certification and traceability development of food industry products (MERTINS et al., 2012) could have a positive effect on both product reliability and in preserving the environment.

Chain postponement is a factor that influences the customization level available in food products. The customization applied to packaging stage or products labeling would be an alternative to the customization of the product without the need for economic efforts to adapt the production system (MATTHEWS; MCINTOSH; MULLINEUX, 2011; SMIGIC, 2016). However, other studies focused on food processing, as Ferreira and Alcântara (2015, 2016), seeking to identify viable strategies for postponement of the chain at different process stages. Fisher et al. (2005) and Matthews, McIntosh and Mullineux (2011) suggest the incorporation of custom flavors in the last stages of operation. In this way, the possibility of customization in final processing appears as a MC development opportunity applied to the food industry.

Can also be identified alternatives for manufacturing customized food, as the additive technology incorporated into the process (WEGRZYN et al., 2012; LIPTON et al., 2015; SUN et al., 2015). Difficults to 3D printer adoption in food processing are reported in the literature (LIPTON et al., 2015). Lipton et al. (2015) emphasize complications for the maintenance of texture and shape before thermal processing and high perishability of ingredients compatible with the printer. These factors can be exploited to optimize this technology and expand limits of its use.

One of the challenges for research in food engineering is the development of products and processes through the use of tools and knowledge, such as biotechnology, genetic engineering and computational materials science, in particular through a better understanding of the relationship between molecular structure and functional properties of biological materials (SUN, 2007). Phase genetic crosses between animals or plants may accomplish the customized food, since according Trienekens et al. (2012), food quality begins to be distinguished from the stage of farming. Also mention the possibility of using technologies SPE (Solid-phase extradition) (MANESIOTIS et al., 2012), which is presented as an opportunity for removal the product not only contaminants but also for the extraction of allergenic particles to some human bodies. It may also be noted studies for the use nanotechnology use, which enables the creation of new materials with vast opportunities for customization, such as, for example, in food industry, the use of nano-additives (TIEN, 2012) and food or packaging nano-modified (SIEGRIST et al., 2008), which may also pose risks to consumer perceptions about the benefits of this technology because of the loss of naturality of food (SIEGRIST et al., 2008).

5. Conclusions

This article aims to identify opportunities for new products, processes and services associated with customized food products, and the implementation of improvements to processes and products in which customization is already present. As a limitation of the present study use only the datas base Science Direct, Scopus, Emerald Insight, Proquest and Web of Science. With the limitation considered, a systematic review of the literature was performed, resulting in 52 articles considered in this research. Alternatives have been identified for use of technologies that enable processes such as additive manufacturing (SERENÓ et al., 2012; WEGRZYN et al., 2012; SUN et al., 2015; LIPTON et al., 2015), and to encourage interactivity between consumer and manufacturing, by integrated computer systems (BOLAND, 2008; REITBERGER; SPREICER; FITZPATRICK, 2014; CHEN et al., 2014).

As contributions, this study has promoted the gathering of information that enable the Mass Customization (MC) adoption in food companies, and which have scattered in different study areas. In addition, this search also contributes to the lack of studies on subject for food domain (FISHER et al., 2005; MATTHEWS et al., 2006; BOLAND, 2006; MCINTOSH et al., 2010), indicating main companies' difficulties to the MC adoption in food sector, as well to identify opportunities for future research on topic in food area. For practical means, as a contribution, development considerations may assist the MC adoption in food production. Matthews, McIntosh and Mullineux (2011) questioning the expense increase for MC application would not be feasible due to the low-profit margins of food products, literature still has many points to be explored that could enable mass customization in food products. Thus, this study contributes to direct the development of new products, processes and services in the food industry aligned customization. Its enables innovations in food production area, and find what customer needs, promoting the growth of industry profitability.

Future research can be informed of opportunities already mentioned above, such as research related to the perception of customer value across the range of products offered; labeling development and nutritional table of customized products; narrowing of personalized nutrition and nutrigenomics studies; environmental impacts; research that align technologies (such as nanotechnology and genetic technology) to enable the MC to process food; study materials to enable additive processes; and feasibility customize food from compounds that may be added in the final product of the process operations.

In order for many of these research opportunities to be better explored, it is necessary to verify the value aggregation of these possibilities in client's perception. In this way, customized foods attributes, such as: nutritional information for client (as a nutritional table), different packaging types, number of product/component options offered, nutritional requirements options, environmental factors and use of different technologies. All that are mentioned as research gaps need to be analyzed with a focus on aggregating value to the customer. These customization possibilities may lead to a greater aggregation of value, however, at an excessively high level they can also confuse the customer and reduce their perceived value, resulting in the phenomenon known as mass confusion (CHEN; WANG, 2010).

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