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Lean product and process development and Set-Based Concurrent Engineering in the dining industry: the experience of an American-Asian fusion restaurant

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1. INTRODUCTION

Continuous improvement methodologies and practices in the hospitality industry are at the core of the development of new products and processes. The food industry particularly has several examples of innovative product development that are part of society's life, to name a few: pasteurized milk, infant formula, canned food, and gluten-free foods (Mishra 2016). However, scholars have been neglecting studies involving both products and process areas (Farrington et al. 2018). Product and process development are critical activities employed by most companies to remain competitive, regardless of the industry type or size. Through the new product development processes, companies seek commercial viability, competitiveness, profitability, and effectiveness, and therefore innovation plays a central role (Hébert and Link 2006).

Among different product and processes development approaches, those improved by the Toyota automaker gained prominence (Liker 2004; Monden 2011; Shingo and Dillon 1989). The Lean Product and Process Development (LPPD), based on Toyota's Product Development System and introduced in the early nineties, focused on a tripod, based on value, knowledge, and improvement (Womack et al. 1990). Also, Set-Based Concurrent Engineering – SBCE played an essential role in the development and design of new products in Toyota (Ward et al. 1995). In this latter approach, creators explicitly communicate and share their set of alternatives instead of presenting a single *point to point* design, in which the designing process moves step by step. The success of these models helped Toyota to reach the leading position in the car manufacturing industry in the last decade.

Despite the significant contributions of these models to improve efficiency in the manufacturing sector and increasing academic production, their implementation in other industries is scarce. Recent studies discuss the application of lean principles in health care, (Drotz and Poksinska 2014; Poksinska et al. 2017; Tay 2016; Vinodh 2018), financial services (Delgado et al. 2010; Vashishth et al. 2017) and public sector (Antony et al. 2016; Antony et al. 2017), but none in the dining industry. According to Harrington (2004), in the dining business, innovation has not been clearly articulated regarding products and processes. Restaurants business owners recognize the importance of innovation. However, they find difficulties in establishing a systematic practice to create and design new menus (Ottenbacher and Harrington 2007). The food and hospitality businesses require continuous innovation process in order to attract consumers and thereby create a sustainable business model (Chattopadhyay and Shah 2014; Cho et al. 2018).

Levitt (1972; 1976) criticized the transference of manufacturing logic for servicing operations. Notwithstanding, a sequence of works, especially in the 2000s brought the universal contribution of lean thinking for organizations: Middleton (2001) in the software development, Comm and Mathaisel (2003) in the context of academia, Swank (2003), Leite and Vieira (2015) and Smith et al. (2017) for servicing business. Those authors suggested that principles of lean thinking are universal and can bring benefits to the organization. Therefore, service companies can improve efficiency implementing manufacturing principles in their operations, mainly due to the *mass customization* effect - the use of flexible processes and structures to produce varied and individually customized products at the low cost of a standard product. (Bowen and Yiungdahl 1998).

Thus, is it possible for restaurant owners and chefs to implement innovative process and product development, based on consolidated practices such as LPPD, and SBCE? Recommendations of LPPD practice could be added to the chef's innovative process so that product development would create more value for the customer. (For example, how SBCE

could improve the screening process and consequently the trial and error process?) Likewise, is it possible to identify similarities in the product development process of renowned chefs, like Michelin-starred chefs, and those concepts? The innovative process in an American-Asian fusion restaurant in the City of Sao Paulo, Brazil, will be studied based on those questions. Through an action-research approach, it aims to contribute with the theoretical basis of the innovation process in the dining industry (which can also be found as a *foodservice industry* in the literature), adding knowledge to the past works of Harrington (2004) and Ottenbacher and Harrington (2007).

2. LITERATURE REVIEW

The following section reviews the classical literature regarding LPPD and SBCE, as well as the application of the innovation process in the dining industry.

2.1 LPPD: Lean Product and Process Development and SBCE: Set-Based Concurrent Engineering

The term *Lean* was coined by Krafcik (1988) and most popularized through the Womack et al. (1990) best-selling management book *The Machine that Changed the World*. It is *Lean* in terms of outputs as the process that *compared to mass production it uses less of everything – half the human effort in the factory, half the manufacturing space, half the investment in tools, half the engineering hours to develop a new product in half the time* (Womack et al. 1990 p.13). Researchers involved in the MIT International Motor Vehicle Program discovered that Toyota Motors trained and empowered its workers to implement the Kanban and just-in-time system, solving any problem related to the flow of production. They found that the lean concept demands more communication in all directions to improve quality, reduce costs, and production time. Based on the Toyota lean production system, the LPPD has its roots in the maximization value while minimizing waste. According to Khan et al. (2011), the LPPD has been addressing the needs of European manufacturing companies for going beyond lean manufacturing and incorporating lean thinking in the product design development process (Khan et al. 2011).

Companies had been applying this practice to improve manufacturing processes (Baines et al. 2006; Khalil and Stockton 2010), but just a few applied lean thinking to product and process innovation (Al-Ashaab and Sobek 2013). This model is based on five concepts: value focus (VF), knowledge-based environment (KBE), continuous improvement – *Kaizen* (CI), chief engineering (CE) and Set-Based Concurrent Engineering (SBCE), being the latter the guide of the LPPD model as shown on Figure 1.

SBCE is defined as a process where sets of solutions for different sub-assemblies and components are developed in parallel (Ward 2007). The parallel development starts narrowing according to the progress of testing and prototyping, generating a knowledge base, which will support coherent opinions in the decision process (Al-Ashaab et al. 2016; Sobek et al. 1999). Based on the works of Morgan and Liker (2004), Sobek et al. (1999), Ward et al. (1995) and Ward (2007) we can propose that SBCE has five categories and a set of principles which are i) Strategic value research and alignment; ii) Map the design space; iii) Create and explore multiple concepts in parallel; iv) Integrate by intersection and v) Establish feasibility before commitment.

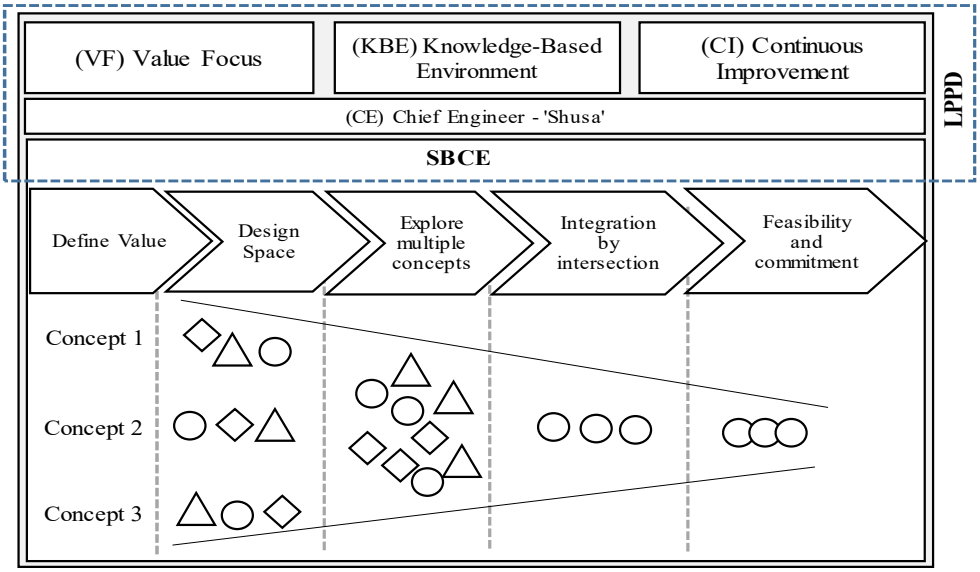

Fig 1 SBCE and LPPD concepts and processes

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Strategic value research regards the capture and identification of customer value and innovation, reflecting those in the company strategy. *Map the design space* defines frontiers between feasible and infeasible aspects of the development, which can be related to the definition of the scope. *Create and explore multiple concepts in parallel* regards the capacity of the development team to utilize acquired knowledge to evaluate the different sets of design solutions and constraints. *Integrate by intersection* is the exploration and testing of different sets, eliminating weaker solutions. Finally, *Establish feasibility before commitment* will wrap-up the findings, decide for the final set, and release for the team commitment. Along with these five principles, there is the concept of *Trade-Off Curves* (ToC), which is a crucial tool to support decision-making in the product development process. For example, ToC can support identifying the feasible area of development, generate a set of designs, compare alternative design solutions, trade-off, and narrow down the set of solutions (Morgan and Liker 2006; Oosterwal 2010; Sobek et al. 1999; Ward and Sobek II 2014).

2.2 Innovation process in the dining industry

The traditional view of the innovation process was proposed by Utterback (1971) and consisted of a set of steps and practices which are i) idea generation, ii) problem solving, iii) implementation and iv) diffusion. Other authors like Wheelwright and Clark (1992) contributed to the development of the funnel concept: generation and screening a broad range of inputs with further refining selection of subsets to reach the product concept. Cooper (1990; 1993; 2008) coined the concept of product development organized in sequential stages, or as he called *stage-gates*, which is a system or process that maps out *what needs to do* as well as *how to do it*, in

order to *win the game*. In the idea of Cooper, the innovation process has predefined phases: idea and discovery stage, scoping the case, business case, development, testing, and launching.

A stage-gate process, if well implemented, can boost-up the organization's product development and innovation process (Trott 2005). However, the stage-gate process received some criticism, being considered time-consuming, bureaucratic, and restricting learning opportunities (Grönlund et al. 2010). Pich et al. (2002) and Rice et al. (2008) proposed that projects and product design have a high level of uncertainty, and consequently, traditional approaches may not be adequate. Besides, in the specific case of Project Management literature, Shenhar (2001) proposed that a standardized process or system like the prescriptive-type of a stage-gate system may find some challenges to the innovative processes.

Based on those pieces of evidence, it seems that there is no consensus in the literature on what model or idea should be implemented to innovate products and processes in the industrial sector. In the food product development, disagreements are more apparent. For Rudolph (1995), Pyne (2000), and Stewart-Know et al. (2003), the current models of innovation in the food product development are based on manufacturing concepts, which do not reflect the peculiarities of a foodservice operation. Foodservice is unique since it requires efforts in the areas of service and product innovation process (Ottenbacher and Harrington 2009). Moreover, innovation in foodservice occurs in several areas, such as products, services, processes, management, and marketing (Lee et al. 2016) and, therefore, an organic model integrating strategic planning, marketing, food science, and operations is required.

There is evidence that innovation can help foodservice businesses to improve quality and reputation and, at the same time, improve profitability (Ottenbacher and Gnoth 2005). Furthermore, speed, interaction, and iteration difficult competitor's imitation (Fuller 2011; Harrington 2004; Lee et al. 2018; Ottebacher and Harrington 2007). Harrington (2004) proposes an innovative model for the food industry broken into four main phases: i) culinary innovation formulation; ii) innovation implementation; iii) evaluation and control; and, iv) innovation introduction. These four main phases are composed of 17 elements in a process.

Culinary innovation formulation is the conceptualization, development, launch, and ongoing management of new culinary innovation. Six elements summarized below compose this stage: *Setting the stage*, which is the process to align firm objectives with external environment demands, plan organization, and potentialize the communication tools and plans in order to have the best interaction with consumers and suppliers. *Selection of the team* looking for members from different functions. *Planning and linking* customer needs and innovation with technical and functional demands. *External environment considerations*, which considers competitors' actions, regulation, markets, seasonality, and trends.*Internal organization*, which analyses the capability of the available resources, knowledge and experiences, understanding strengths, and weaknesses; and, *product or innovation definitions*, which gather and link prior elements to define the concept and the *innovation-line* proposed by the business.

The *innovation and implementation* phase is composed of four elements, which are: *Formulation*; *Prototyping*; *Benchmarking,* and *Sensory Analysis*. A key point in this phase is the iterative process of the four elements because the characteristics of foodservice business require a dynamic approach and quick response. Accordingly, the formulation and prototyping of a new product may be tested during a seasonal menu. At the same time, similar competitor's menus can be benchmarked while customer experiences and feedbacks are collected either internally or externally. The *evaluation and control* phase consists of an iterative process in which customer feedbacks feed the innovation process so that a product can be adjusted quickly. *Consumer testing* is a necessary procedure to create a direct feedback link with the innovation formulation process. The following three elements are related to the stability and robustness of the production. *Scale-up*, similar to a traditional manufacturing process, consists of the process of increasing the production volume, on a larger scale, ensuring that quality and productivity

will be constant. *Process development and production transference* will ensure that developed products will have a minimum variation during the *mass-production* process. Therefore, aspects like the consistency of the production process, quality loss of the product under a sort of circumstances (e.g., box condition, weather variation and served plate), easiness for employees to reproduce the original recipe; and, availability of ingredients in all locations (in case of branch stores, for examples) are analyzed carefully (Harrington 2004; Schonberger 1994).

The final step is the rollout of the process, which is similar to the development of any other standard product. In this phase, the product will be *introduced in the market* to compete against other products, and therefore, frontline employees must be adequately trained (Rudolph 1995). Foodservice businesses are represented by hosting and serving staff, bartenders, *maîtres,* and managers. The role of those employees is essential for the iterative innovation process because they will be the link between the customer and product developers. The foodservice innovation process designed by Harrington (2004) was further improved by Ottenbacher and Harrington (2007), based on Michelin's innovation model, which has seven main steps: idea generation, screening, trial and error, concept development, final testing, training, and retail.

Idea generation is based on pillars like inspiration sources, product considerations, and complemented by the tacit creativity skills of the chef. Inputs of this process can be, for example, the literature, chef personal experiences, education, visiting, and being in contact with new technologies, concepts, and other restaurants.

Screening is related to making projections of the idea being concretized. It means projecting if the creation will fit the operation, chef style, customer demands, and acceptance. It is a distinct process, which also occurs in the later stages of the creational process, serving as a *check gate*. However, unlike the generic innovation process, the screening of chefs is an informal process (Ottenbacher and Harrington 2007). *Two main sub-processes comprise trial and error,* which are a mental trial and error (*cooking in your head)* and a practical trial (*giving a shot)* giving inputs to *Concept Development.* This process will provide improvements to the creation by introducing ideas coming from market research (formal or informal, regarding pricing and customer needs), preparing formal recipes, thinking about differentiation factors (for example, an authentic cooking style, distinct harmonization, or concept).

Final testing is performed through the preparation of the creation and tests it on one or more sources like trustful employees, partners, and regular customers. It may consider the entire aspect of the experience a part of the taste and appearance of the creation, considering the atmosphere of the experience and the service provided. *Training and Retail* (or commercialization) processes are essential to assuring the stability of the innovation process since the former will assure the quality level of the production in a "mass production" situation. At the same time, the later will give essential inputs for iteratively to improve the product development process.

3. RESEARCH METHOD

For this study, we employ the action research method, understanding that this is the best approach to integrate the theory and practice in the work. Action research goes beyond the notion that theory can inform practice and, a theory can and should be generated through practice (Brydon-Miller et al. 2003) and should influence social changes. Dining (foodservice) business innovation and production are mostly practical activity, in which the *learning by doing* system is very present. Consequently, the action research comes as a new method to search the possibility for restaurant owners and chefs to implement innovative process and product development based on consolidated practices such as LPPD, which also includes SBCE. Furthermore, if it is possible to identify similarities in the product development process of renowned chefs, like Michelin-starred chefs, Harrington's Culinary Product Development Model with those based on the LPPD approach commonly used in the manufacturing industry.

To look for answers for these questions, we developed action research divided into five phases: i) Semi-structured interviews and ii) Observation and mapping that comprises the Part I of the study. In this part, the focus of our investigation is to understand the *as-is* process of the restaurant's product development. Part II of the study comprise the iii) Training and implementation, iv) Observation and mapping – Part II; and v) Compilation of results and feedback. The focus is to understand the *to-be* enhanced process and assess the benefits and improvements in the creation and launching of a new product. A schematic view of the method and action research phases is shown in Figure 2.

Moreover, an adherence matrix of the restaurant's product development process and LPPD components, which are value focus (VF), knowledge-based environment (KBE), continuous improvement (CI), chief engineer (CE), and set-based concurrent engineering (SBCE) is proposed. The entire investigation process took six months to be completed, corresponding an entire cycle of three creational processes in the selected restaurant, from product conceptualization to customer feedback. The application of the three methods explains the selection of three creational processes – Harrington's Culinary Product Development Model, Michelin-starred model, and LPPD model. We selected an Asian-American fusion restaurant, located in Sao Paulo – Brazil, which has the concept to serve, on top of the regular menu, a monthly variable menu. This type of *fast-moving* and the *fast-changing* menu is adequate for our research purpose because, in practice, the innovation, product release, and market evaluation process occur at least 12 times per year. Among all the items in the restaurant's menu, we selected the burger because the concept of this dish – composed by several *sub-assemblies* like the bun, the burger, topping, cheese, sauce, vegetable – is very close to the concept of the innumerous components to manufacture a car. Details of each phase with some discussions of respective findings are considered in the following items.

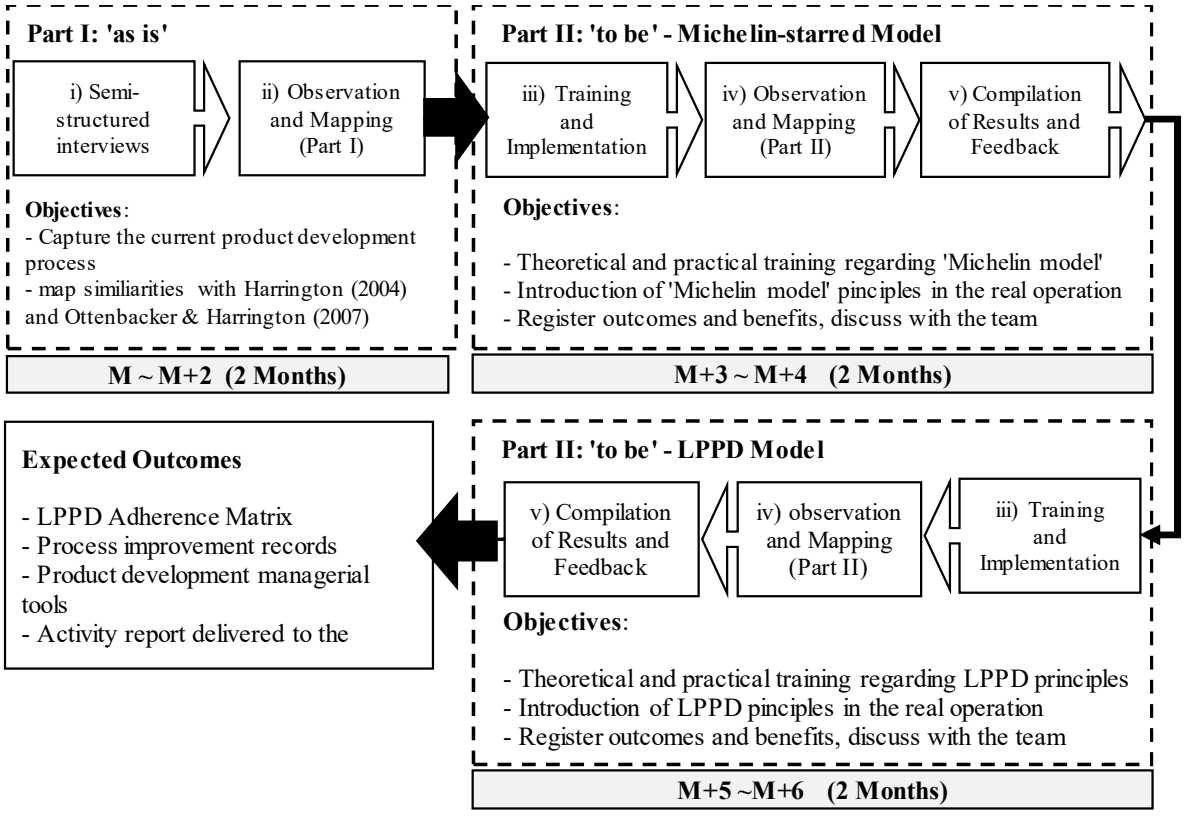

Fig 2 Action research phases and scheme

4. RESULTS

4.1 Results of part I – interviewing and mapping

The first step of this research consisted of semi-structured interviews with the chef in charge of a restaurant's creation and the operations manager, who are also owners and partners of the restaurant. The chef had formal education in gastronomy and worked for famous restaurants in Brazil, including the only two-star Michelin restaurant in the city of Sao Paulo until 2017 (The Michelin Tire Corporation 2017). Also, he is a professor at a gastronomy school and investor in other restaurants and burger shops in the city. His partner at the Asian-American fusion restaurant has formal education in business. He worked in the automotive industry in finance and marketing areas. He is the manager in charge of operations, finance, and administration of the restaurant.

Each semi-structured interview took about 90 to 120 minutes and was performed at the interviewee's place of business. The interviews had the objective to gather information regarding the experiences of the interviewed persons, to understand their current practice of innovative product development as well as the current process of menu and dishes creations. Additionally, in this interview, we tried to capture intangible and essential aspects of the creational process like their inspiration source, their influences, style of the chefs, which may contribute to our research in further steps.

We analyzed the content of the interviews to find a response pattern, as well as to identify the recurrent terms and concepts in the dining innovation process. We also reviewed the transcribed interview and responses in order to elaborate on a *road map* or process flow of the innovation process in the restaurant. This step was essential to sketch the process, which was further confirmed through the observation on the actual floor. The interviews were essential to draw the flow of product creation but also to note that in the concept, idea, and supplier search phase, the chef mentioned *focus on concept, customer's experience, and happiness* while the manager focused on *costs, processes' stability and training*. Both said that the following phase, *trial, and error* concentrates on *the main conflicts between the creational process and the controlling process*.

The observation and mapping process consisted of the record of the situation before the implementation of new processes, which can be considered the *as-is* situation. It was divided into two main sub-processes according to the stage of the product development process. First, related to the conception, creative process, trial, error, and testing, which occurs outside the restaurant environment, usually at the Chef's residence. Moreover, the second one, which is composed of the trial and error, production preparation, training product launching, and product sales and feedback process. For the first sub-process record, we collected samples of recipes and registered the trial and error process performed by the chef. Recipe book scratched by the chef was also observed, aiming to find relevant inputs for our process mapping. We accompanied the chef in some dinners and shopping at food markets, in order to observe how the creational process of chefs receive interesting inputs interacting with other environments. This process was inspired in the study made by Ottenbacher and Harrington (2007, p.449) in which *visiting colleague's restaurants* was identified as the most popular source of ideas, according to Michelin-starred chefs and *Visiting food markets* was also mentioned as one of the inspiration sources. The current creational process of the restaurant is very similar to the one prescribed by Ottenbacher and Harrington (2007) Michelin-starred process. Table 1 summarizes the current adherent practices.

Concept			Currently Applicable?	Comments
Michelin Development	1. Idea Generation	1.1. Product Consideration	Yes	- Food product is the basis of strategy and idea. For example, chef keeps strong ties with "Canastra" famous cheese producer in São Paulo, Brazil. - Creativity skills based on seasonal products and Japanese / American sports theme influence
		1.2. Inspiration Sources	Yes	
		1.3. Tacit Creativity Skills	Yes	
	2. Screening	2.1. Screening Criteria	Yes	Seasonality of products, quality, fit with cooking style (Chef's specialty are meats), cost (controlled by operations manager), were observed.
	3. Trial and Error	3.1. Cooking in your head	Yes	Individual parts of the creation are intensively tested. There is an image training of the harmonization and presentation. Though, *amuse guele* (free appetizer) practice is not common.
		3.2. Giving it a shot	Yes	
	4. Concept Development	4.1. Informal Market Research	Yes	Informal market research performed through visits. Concept is not formalized utilizing recipe date file. Operational issues and differentiation factors (presentation, for example) are developed.
		4.2. Formalize Concept	**No**	
		4.3. Differentiation Factors	Yes	
		4.4. Operational Issues	Yes	
	5. Final Testing	5.1. Operational Issues	**No**	Although operational issues are mapped in previous stages, during the test they are not performed. Multiple sources of testing involves partners, trustful employees.
		5.2. Multiple Sources of Testing	Yes	
	6. Training	6.1. Operational Issues	Yes	Training occurs, but interviewees recognize that training time should be longer than current the current one.
		6.2. Communication & Testing	Yes	
	7. Retail	7.1. Assessment - Satisfaction	**No**	A target sales quantity is fixed and popularity is measured by achievement of target. Customer satisfaction in not measured formally, just a tacit knowledge.
		7.2. Assessment - Popularity	Yes	

Table 1 Adherence to current operation with Michelin model

Like the outcomes suggested by Ottenbacher and Harrington (2007), the success of the process is coming from the chef's tacit skills. Thus, essential processes of knowledge management, storage, and formalization are weak. This process is twofold: while the chef in charge gains agility in the development process, the knowledge basis is not shared among key persons in the business, which interferes negatively in the innovation process.

Thus, from the mapping process, it was possible to assess that the model proposed by Harrington (2004) *culinary product innovation process* had low applicability to the case studied because i) the process to select and conduct the team is unfeasible - *the culinary innovations team in a real-time setting will be involved in every phase of the process and closely tied to continuing daily operations* (Harrington 2004) - the extraordinarily fast-moving and fast-changing menu, and the human resource constraints, create barriers dor activities allocation; ii) According to the chef, the *culinary innovation formulation* as the preliminary step of this model is *challenging to be implemented*, because the short lead time required to develop a new product is not sufficient to adequately capture external environment variables like seasonality, regulations, competitors' actions, customer preferences, in a participative and iterative way as prescribed by Harrington (2004) work.

Consequently, the process relies on a sequential process, usually centered in the figure of the chef; iii) regarding other processes, they *seem to be more appropriate for businesses with a larger scale developing serial products* according to the chef and partner-manager. Finally, as one last outcome from the mapping process, it was possible to define the six *patterns of sub-assemblies* and development flow of each component of the seasonal burger, which is detailed in Figure 3.

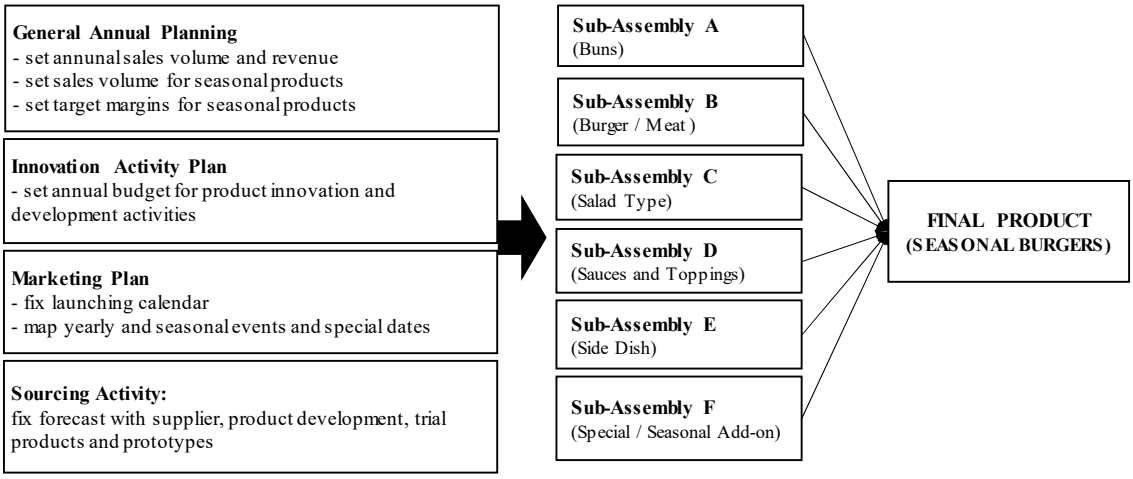

Fig 3 Sub-Assemblies and sourcing activities

For each sub-assembly of the final product (burger components), the chef in charge, the partner-manager, and the operations manager oversee the product development. The product-launching calendar is shared and discussed with each sub-assembly supplier in advance so that those suppliers can have sufficient time for their development process. For example, the restaurant shares the product-launching calendar, which can include commemorative menus and seasonal thematic burgers. The supplier, in turn, prepares a basket of products, for example, a variety of cheese blends, which are candidates to match the seasonal product launchings. This practice favors the chef's creational process, giving him the flexibility to make different combinations as well as providing sources of inspiration.

However, some processes, which are very common in the LPPD, and Process Development, were missing. Because the innovation process of the restaurant relies on the tacit knowledge of the chef, the level of formalization is deficient. For example, the catalog of mains suppliers for each sub-assembly was not available; there was not a database registering developed and underdevelopment sub-assemblies (for example, a sauce list, a list of cheese blends). Thus, although the criteria to select the best combination of ingredients (sub-assemblies) occur in order to maximize customer satisfaction and stable profitability, the entire process lacks formal procedures and methodology, meaning that an essential part of the value capturing may be lost. For example, in the case of sub-assembly 'B' (Burger / Meat) the selection criteria of the best meat blend and receipt were not uniform and not in aligned with the objectives of that product (i.e., prepare a burger which lowers the necks in the production process through reduction of the grilling time). Such aspects were explored during the second part of the research, where we provided theoretical and practical training of product creation and innovation process based on Ottenbacher and Harrington (2007) works and LPPD model. The training was followed by the observation of the process, implementation, and feedback activity.

4.2 Results of part II – training, observation, and feedback

These steps consisted on the instruction and training of innovative product creation process based on three approaches: LPPD product development processes according to the literature; Culinary Product Development approach proposed by Harrington (2004), and Michelin-starred process as proposed by Ottenbacher and Harrington (2007). The primary purpose of applying those product development approaches to the creative process of our sample was to observe how chefs, managers, and employees would react when a new process is introduced. Therefore, we aimed to observe if successful cases of those creational process would improve the

performance of the restaurant concerning product development lead-time, quality improvement, and customer value creation improvement.

The literature of action research proposes that working collaboratively with other leads to community and organizational changes in which participants grew to appreciate how their interrelatedness creates a power greater than a sum of individual powers (Kasl and Yorks 2002; Reason and Bradbury 2001). In this study, the training activity took four hours, divided into two hours of theoretical training (seminar format) in which every staff of the restaurant learned the basic concepts of Michelin-starred creational process and Culinary Product Development, as well as LPPD model. One-hour *hands-on training* consisted of self-evaluation of the current creation, production, and customer service process, in which every employee was encouraged to revise his process and propose efficiency improvements. Finally, an hour feedback session was promoted where employees, chefs, owners, and researchers discussed the results, findings, and contributions of the activity.

The feedback activity was recorded in order to support the construction of the mapping process in the following step and gathered directly from the chef and the manager, through social communication application. Interesting points to note from this phase were the opinion of the owner-chef contrasted with those of the manager. For the first, *a formal process is challenging to apply to the actual floor, especially in our business. We must be very agile in the creational process. I believe that the customer demands novelties and seeks new gastronomic experiences. Of course, a well-prepared classic is essential, but the novelty is the key to have your business in evidence in a fast-moving market like the one we are experiencing.*, while for the second, *introducing established concepts from other industries will always bring some positive contribution. In our business, we are informal with processes, and innovation usually wastes too much time with the trial and error process*.

Also, we compare the perceptions, pros, and cons, of Michelin chef's creational process, Culinary Product Development model, and LPPD model from owner-chef and owner-manager point of view. Table 2 summarizes the perception of the product development model from the owner-chef and owner-managers point of view. During the process mapping works, it was stated that concepts like *knowledge-based environment, continuous improvement*, and all principles of SBCE except *define* value were not adopted. Still, after the implementation of *to-be* process based on LPPD and the presentation of positive achievements, owner-chef showed concerns about the *knowledge-based environment* and *feasibility and commitment* concepts, believing that both practices would speed down the product development process and consequently lose the timing of new launchings.

Concept / Principle			Reference	Existing during as-is mapping?	Owner- Chef	Owner / Operations Manager
					Favorable for implementation	
1. LPPD	1.1	Value Focus	Khan et al (2011)	Yes	Yes	Yes
	1.2	Knowledge-Based Environment	Maksimovic et al. (2014)	**No**	Neutral	Yes
	1.3	Continuous Improvement	Mohd Saad et al. (2013)	**No**	Yes	Yes
	1.4	Chief Engineering	Al-Shaab et al. (2013)	Yes, owner chef as "Shusa"	Yes	Yes
	1.5. SBCE	Define Value	Morgan and Liker (2006) Sobek et al. (1999) Ward et al. (1995) Ward (2007)	Yes	Yes	Yes
		Design Space		**No**	Yes	Yes
		Explore Multiple Concepts		**No**	Yes	Yes
		Integration by Intersection		**No**	Yes	Yes
		Feasibility and Commitment		**No**	**No**	Yes

Table 2 Introduction of LPPD – adherence, and comments

During the training process, it was also possible to create an overall approach using Trade-off Curves (ToC) within the SBCE model, as shown in Figure 4. In this example, the step called

Define Value aligned the product development with company strategy and tentatively translated customer value to the product. Once those values are fixed, the product developers moved to the *Design Space* step, where essential characteristics of the product and which improvements on those characteristics were needed. Then, developers defined a feasible region, called product acceptance area in order to select the best product. Considering the selected values of percentage of fat, grilling time and cost, product *B2* was the only suitable for the project because the intersection of attributes will increase the possibility of customer satisfaction (taste of the product – juiciness of the meat), efficiency in the preparation time (best grilling time) and profitability (lower cost).

As mapped during the phase I mapping process, the annual plan sets the target indicators and targets for each launching. In the studies case, the product had to improve the grilling time (due to some workforce and training time constraints), achieve better profitability compared with other seasonal products planned for the year (because the launching month has a historically lower volume of sales). Finally, from the *technical* point of view, the meat had to achieve an appropriate percentage of juiciness to harmonize with other sub-assemblies. Therefore, the percentage of fat in the meat blend must be introduced precisely.

The following step, called *Explore Multiple Concepts*, consisted on combining the selected burger type (B2) with other innovative sub-assemblies, as shown in Figure 4, such as buns, salad type, and sauce type, to finally propose a basket of product alternative which we called *P's* (P1 to P10). Then, in the *Integration by Intersection* phase, the development team proceeded with the evaluation of this first basket of developed products in order to look for intersections or convergences with other seasonal dishes in the restaurant's menu, seeking for synergy gains in the sourcing and production. A final set of three plates (P4, P6, and P9) formed the set of final products, finally moving to the *Feasibility and Commitment* phase. In this final phase, the final specification of the product is defined as satisfying customer requirements and decision criteria. Furthermore, the knowledge stored during the entire decision process could be reused in future projects; hence, discarding knowledge would be prevented.

Observation and mapping aim to observe the real operation running after the training of chefs, managers, and employees. Unlike the previous *Observation and Mapping*, Part II consisted of the record of the situation after the implementation of new processes, which aims to achieve the *to-be* situation trained in the previous step. As presented in Figure 2, we promptly discarded the *Culinary Product Innovation Process* due to the lack of adherence processes and therefore advanced with the application of the *Michelin product development* process and LPPD model. Each model demanded two months of a development cycle. Chef's creational process was observed and registered, so it is compared with the creational process before the training session and therefore processes efficiency gains, as well as improvements in the customer value. The same process was conducted with trial and error, production preparation, training product launching, and product sales and feedback process.

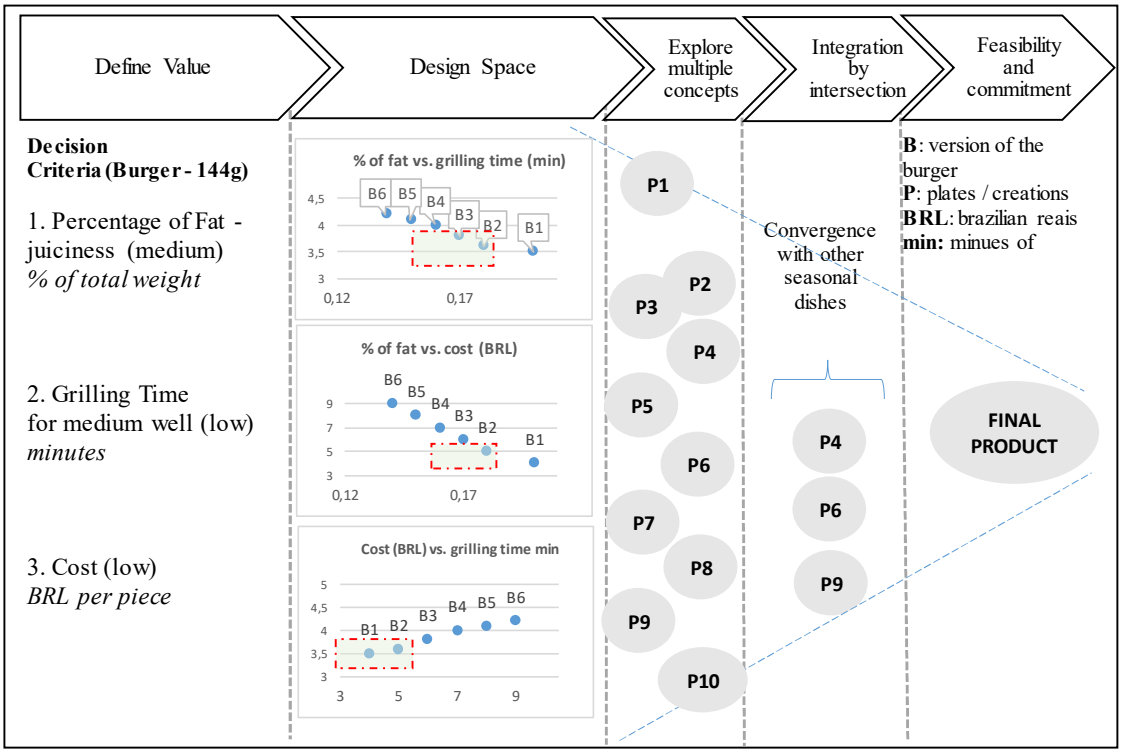

Fig 4 ToC within SBCE approach

For results compilation process, we analyze the lead time of a creational process, from the first idea generation until the filing of customer feedback (if there are any); which is measured in days and divided into the several steps involving the development of a new product in the foodservice business. Improvement in the process is perceived when the restaurant can reduce the total days demanded to create a new dish and reduce the waste in the process. In terms of lead-time improvement, it was possible to achieve a reduction of eight days in the conceptualization and formation of the idea for a new dish, through the reduction supplier search process. The lead-time reduction considered the actual lead-time of the restaurant, which was more similar to the Ottenbacher and Harrington (2007) Michelin model *versus* the new model proposed by LPPD.

The maintenance of a knowledge basis regarding under-development dishes, as explained during the Training phase, allowed chef and operational manager to optimize the combination of ingredients in the best season available. Part of the gain in the total lead-time, four days, was converted to the production preparation and training process, which was one of the concerns of the owners. However, it is essential to mention that the eight days reduction was not entirely resulted from the introduction of LPPD. Since we conducted the LPPD experiment after the two-month development cycle of the Michelin model, some gains from the improvement of the knowledge curve should be considered.

Finally, as for the Culinary Production Development Model, despite the relevant work of Harrington (2004), the application in our concrete case showed that in business with a smaller scale, which at the same time requires more dynamic responses and sometimes informal practices, the adherence is low. For example, prescriptions of *Planning and Linking Process* like *food safety and dietary issues, regulations, culinary identities, consumer research* are not performed by the book – it occurs in such a small scale and intensity that is implicitly executed during other activities of the product development process.

5. DISCUSSIONS AND CONSIDERATIONS

In this work, we aimed to investigate if it is possible to restaurant owners and chefs to implement innovative processes and product development based on consolidated practices such as LPPD. Moreover, if it is possible to identify similarities in the product development process of renowned chefs, like Michelin-starred chefs, and LPPD approaches. Our findings suggest that the Michelin chef's creational process is the closest and most adherent model for small to medium size scaled restaurant, with a high frequency of seasonal products launched during a year, but with the prominent possibility to introduce good practices from LPPD model.

In the list of adoptable practices, we can include the improvement of the product development process through the implementation of SBCE practice, as shown in the *training, observation, and feedback* section. It includes the preparation of decision flow based on Trade-Off Curves (ToC's), definitions of values, analysis of intersections, and creation of a product development knowledge database in order to improve the concurrent engineering process of the menu. From the outcomes of our action research, we propose that SBCE can be the ideal enabler to start the introduction of LPPD model in the culinary innovation because despite the uniqueness of the developed product (artisanal culinary product), the concept of sub-assemblies and assemblies, which is present in the industrial production, the process is similar. We could note the adoption of concepts like Trade-off curves and the analysis of different intersections of feasible sets of products, as described in Figure 4. Therefore, the five SBCE principles proposed by Kahn et al. (2011) and described in section 2.1 can be applied to decide on a product based on avoidance of educated guesses and grounded on a knowledge base gained from simulations, prototyping, and tests.

Other LPPD principles such as Value Focus (VF), Knowledge-Based Environment (KBE), Continuous Improvement (CI), and Chief Engineer (CE) were noticed during the action research, though we could not collect sufficient evidence in the application of those concepts. For example, the Chief Engineer (CE) role could be attributed to the restaurant's chef because he is responsible for technical leadership throughout the entire product development process. Though the chef does not consciously recognize this function, nor he has the interest to assume such responsibility. This lack of self-consciousness is a thick barrier to be surpassed before considering this enabler as fully adopted by the restaurant.

Value Focus (VF), which has the objective to increase the value of the process through the satisfaction of stakeholders' expectations, is performed at an informal level, as perceived on the statements of the chef and operations manager during the interviews, as explained in our *training, observation and feedback* section. In sum, the necessity to be dynamic and agile in the development process imposes an obstacle to introducing 'less practical and tangible' tools, which will not bring concrete and immediate outcomes. The same notion is perceived in the enablers Continuous Improvement (CI) and Knowledge-Based Environment (KBE). Therefore, the application of those principles in the culinary innovation process is highly recommended for further studies.

Limitations of this work consist of the size and location of the business as well as the action research duration, which considered three complete product development cycles. Distinct culinary styles in other locations may bring different outcomes. Thus, increasing the number of product development cycles may influence the learning curve of the participants, which may also lead to distinct conclusions. Finally, this work opens the path to create a new Product Development Model focusing in the foodservice industry, a hybrid model, which can concatenate the agile and dynamic practice of using the tacit skills and knowledge from renowned chefs with the precise and sober process of the manufacturing industries lying on LPPD principles.

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