PRODUCTION SYSTEM IN FOOD INDUSTRY: A LITERATURE STUDY

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ABSTRACT

Food industry plays an important role in order to satisfy community needs with respect to availability, distribution and quality of food. To meet the needs of different consumers, manufacturers need to adapt products and services to fit their needs. Food processing industry has the typical characteristics, due to the nature of the food products that are relatively perishable, bulky and seasonal; therefore these characteristics have to be handled properly. This paper aims to review the previous studies on the food industry, production system in food industry, as well as the possibility of mass customization application in food industry. Production patterns of food processing industry are marked with different products structure, in which a small number of raw materials can be used to produce a variety of end products according to customer's request. System of food processing industry generally involves a two-stage process i.e.: processing and mixing. The processing stage often involves processing of intermediate product. While on mixing stage, intermediate products are blended into a formulated final product. Literature study shows that the study on the production system in food industry discussed the scope of production planning and scheduling, make to stock-make to order strategy, the concept of decoupling point, the concept of postponement, as well as related issue of the mass customization (MC) application in the food industry. So far, there are not many studies of mass customization on food industry. Therefore it is necessary to study the possibility of mass customization application on food industry, the advantages, as well as the strategies that can be performed related to the characteristics of typical food industry. Furthermore, to develop appropriate production systems and production planning to handle an increase in variation of products.

Key words: food industry, production system, mass customization, perishable product

1. INTRODUCTION

Food industry has the potential and strategic role to satisfy customers by improving the availability, access, and quality of food consumption. Food industry has certain characteristics of raw materials, i.e., perishable, bulky, and seasonal. In addition raw material of agricultural product has various quality. Therefore, appropriate handling required by the type of product and the corresponding typical characteristics (Hariyadi P., 2012).

In addition, the customers' needs and wants are changing from time to time. The changes of customers' needs and wants tend to be more varied, both in terms of design, quality, and delivery process. Varied of customers' needs and wants are demanding the company to be able to produce a product which varies. This is in line with the pattern of production in the food processing industry is characterized by a different product structure, in which a small amount of raw materials used to produce a variety of end products in accordance with customer demand (Akkerman & van Donk, 2009). Therefore, it becomes impossible or inefficient when producing different kinds of final products are individually. Alternatively, is to process up to a certain stage and then make variations (van Donk, D.P., 2001 & Soman, et al., 2004).

Food industry has distinct characteristics compare with other manufacturing industries. According McIntosh, et al. (2010), there are several factors to distinguish between the food industry to other manufacturing industries, i.e., chemical change, maturing cycles/delay and food product decay. With these differences, food industry production system has a distinctive character as well. Therefore we need a study of the relevant literature on food industry production system.

This paper aims to review previous studies related to the food industry, i.e.: production systems of the food industry, as well as the possibility of the application of mass customization concept in the food industry.

2. METHOD OF THE STUDY

The initial step in this literature study is to find and collect the articles through the online journal according to research topics, including through ScienceDirect, Tandfonline, ProQuest, ebooks and Google Scholar. Keywords that are used are: food industry, production systems, perishable products, and mass customization. At this stage there are 45 articles, which includes 39 journals and 4 proceeding articles. List of journals and proceedings of this literature search results are shown in Table 1.

Articles that have been collected are sorted by topic and its method of use. Topics are sorted by using the term, namely: food industry, production systems, and mass customization. While the methods used are sorted by types, namely: modeling, experiments, case studies, and conceptual/literature review. The sorting results as shown in Table 2.

Table 1. List of journals and proceedings, frequency of appearance

No.	Name of Publications	Frequency
1.	Computer Aided Design	1
2.	Computers & Chemical Engineering	2
3.	Computers & Industrial Engineering	1
4.	Computers in Industry	1
5.	Engineering Application of Artificial Intelligence	1
6.	EurOMA International Conference on Operations and Global Competitiveness	1
7.	European Journal of Operational Research	1
8.	Food Control	1
9.	Harvard Business Review	2
10.	International Journal of Production Economics	11
11.	International Journal of Production Research	5
12.	IIE Transactions	1
13.	Journal of Business & Economics Research	1
14.	Journal of Food Engineering	1
15.	Journal of Operations Management	3
16.	Mathematics and Computers in Simulation	1
17.	Management Science	1
18.	Manufacturing & Service Operations Management	1
19.	OR Spectrum	1
20.	Proceeding of The Sixth International Conference on Machine Learning and Cybernetics	1
21.	Systems Engineering Procedia	2
22.	Systems Engineering – Theory & Practice	1
23.	Omega - The International Journal of Management Science	1

Table 2. Sorting articles result by topic areas and methods used

Method	Topic Area			
	Production System in Food Industry	Production System	Mass Customization	MC in Food Industry
Modeling	11	5	5	-
Experiment	1	-	-	-
Case Study	5	-	2	-
Conceptual/ Literature Review	3	1	9	3

3. FOOD INDUSTRY

Agroindustry is industry that process raw materials come from agricultural output. Agroindustry aims to add value to agricultural products through the manufacturing process. Agroindustry has typical raw materials with characteristics, namely: seasonality, perishability, and variability (Austin, 1981).

Seasonality

The majority of agricultural products is seasonal and highly influenced by the climatic conditions so that aspects of the continuity of the production of industrial agriculture is not assured. Raw material of industrial agriculture is only available on certain period, thus leading to problems related to the supply-demand imbalance, which will ultimately give rise to problems of supply, production scheduling, marketing and supply chain.

Perishability

The natures of agricultural products are perishable and bulky so it required packaging and transport technology to be able to resolve the issue. Agroindustry products it requires speed and accuracy in handling and storage, as it can affect the nutritional quality of food products.

Variability

The typical characteristics of agricultural products are the variability in the quantity and quality. The quantity is uncertain because the weather changes or damage to crops or livestock from disease. The quality varies because of the difficulty of doing the standardization of agricultural products. This variation gives rise to additional problems in the scheduling of production and quality control.

Industrial agriculture generally can be classified into four categories, they are: (1) agro-industries of agricultural processing, (2) agro-industries that manufacture agricultural machinery and equipment, (3) agro-industries of agricultural inputs (fertilizers, pesticides, herbicides and other) and (4) agricultural sector services agroindustry (support services). Agro-industry of agricultural processing is part of agro-industries, which process the raw materials are sourced from plants, animals and fish. The processing in question includes the processing of the process of transformation and preservation through a physical or chemical change, storage, packaging, and distribution. Processing can be either simple processing such as cleaning, selection (grading), packing or may be a more sophisticated processing such as milling, powdering, extraction and refining, the frying process (roasting), spinning, canning and other fabrication process. Food industry is part of the agro-industries of agricultural processing.

4. FOOD INDUSTRY PRODUCTION SYSTEM

Production system for food products generally involves a two-stage process i.e: processing and mixing (Akkerman & van Donk, 2007; Akkerman, et al., 2010). The processing stage produce intermediate products or semi-finished products, while on mixing stage blends intermediate products final product. For example, in flour processing, various types of flour milled from several varieties of grain to produce flour that is suitable for a wide range of food processing industry-based flour (Akkerman, et al., 2010).

Akkerman, et al. (2010) researched flour companies that supply flour products for a wide range of food processing industry-based flour. Figure 1 shows the outline of flour production process. Grains and other supplementary material prepared, mixed and milled to get intermediate products. These intermediate products are then blended to produce various types of flour that have different specifications and finally packed into big or small pockets.

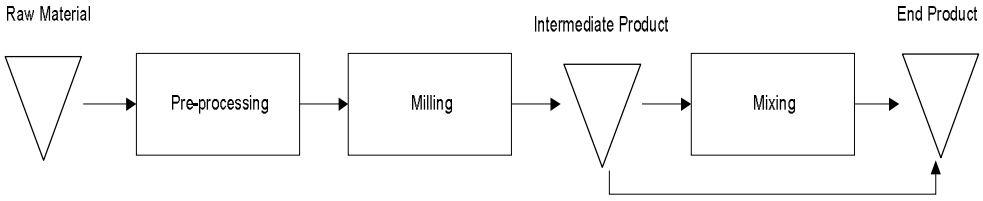

Figure 1. Flour milling production process
(Source: Akkerman, et al., 2010)

The final product may consist of one or several intermediate products. For the final product that consists of just one intermediate product only requires the specification of the product as the intermediate product (see Figure 2, line A). While the final product which consists of several intermediate products, requires mixing of the intermediate products to produce the final (see Figure 3, line B). Figure 3 illustrates an example of a production system that involves two types of intermediate product and three types of end products. Symbol of the circle represents material and the square symbols represent process operations (Kilic, O.A., et.al, 2013).

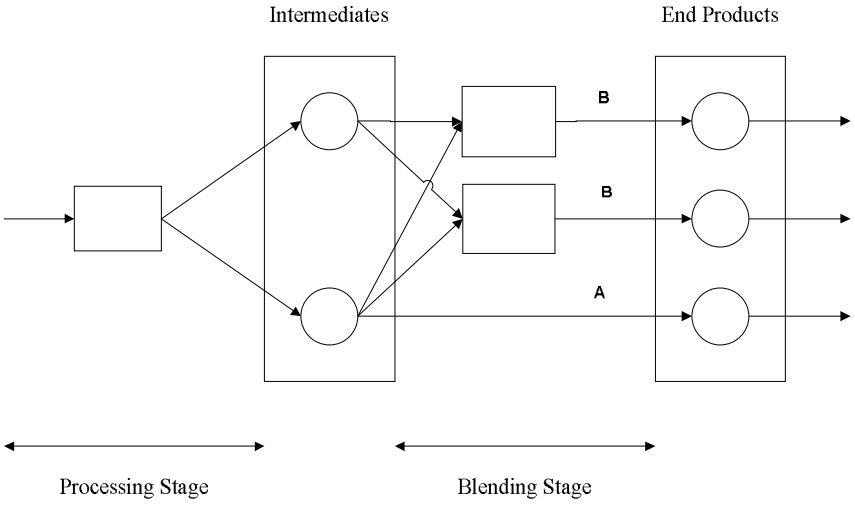

Figure 2. Examples of production systems in food industry
(Source: Kilic, O.A., et al., 2013)

Soman, et al. (2007) tested conceptual framework of production planning and inventory control based on the strategy of make-to-order (MTO) and make-to-stock (MTS). The framework is applied in case studies on companies that produce of 230 products on a single line with limited capacity. The result is improved a conceptual framework and decision analysis tools. In particular, short-term scheduling issues need more attention, and heuristic methods are used to resolve the issue. Meanwhile van Donk, et al. (2005), using MS Access/Excel for consolidates various theoretical concepts like ABC analysis to use for managers to be helpful in their decision-making.

Entrup, et al. (2005) developed Mix-Integer-Linear Programming (MILP) model that integrate the shelf life of products in production planning and scheduling and also storage capacity to store intermediate products before mixed into end products. This research is based on a case study of yoghurt industry. Three MILP models for production planning were presented to apply a combination of discrete and continuous time representation.

Akkerman and van Donk (2009) studied correlation of product variability and demand in a two-stage food production system (processing and packaging). The results of the simulation showed that there is a growing correlation in processing, but gives only a small effect on the type of packaging related product demand.

In general problems in production system of agricultural products are processing, packaging and storage. So, the producers usually chose the make-to-order strategy for the packaging stage and using the make-to-stock strategy to processing stage. Condition of the MTO/MTS is linked to the customer order decoupling point (CODP) (Akkerman, et al., 2009).

Therefore, the product variations cause several problems, i.e.: amount and composition of products, improve operational efficiency, product quality, flexibility, and cost. The development of models to support decisions related to these issues has been developed by Akkerman, et al. (2010). Food processing companies can produce the same end product in a different way: first alternative is blended then process, the second alternative is processed then mixed. In addition, the end product can be mixed from different raw materials or intermediate products.

In addition, Rajaram and Karmaker (2004) analyzed the planning and scheduling of batch multiproduct operations in the food processing industry. These operations are found in many applications including the creation of sorbitol, modified starch, and sugar. Unlike discrete manufacturing, batch size in this operation cannot be defined unilaterally, but is often determined by the equipment size. Some batches of the same product are often run in order to minimize the setup costs and quality.

5. MASS CUSTOMIZATION

5.1 Mass Customization Concept

The concept of mass customization (MC) was introduced in the late 1980s and followed up with an increase in flexibility and optimization elements of cost and quality (Silveira et al., 2001). Gilmore and Pine in the Silveira et al. (2001) mentioned there are four types of application of MC, i.e.: (1) collaborative (designers communicate with customers/individuals to equate the perception about the customers/individuals needs/wants), (2) adaptive (the company offers standard products but still possible is customization according to customers' needs/wants), (3) cosmetic (the company provides standard products but packaged specifically for each customer), and (4) transparent (products tailored to the customers' needs and wants).

The application of MC is not always ends successfully, there are some experiences of the MC application did not provide optimal results. For example the car company Nissan has been providing design steering wheel with 87 variants, apparently customers don't want that much variants, and customers don't like being faced with too many choices. In the meantime the computer company Amdahl that cannot be attained purpose because it does not have a process that is flexible, dynamic networks, nor anything that could support the MC implementation (Pine et al., 1993).

Ahlstrom and Westbrook in Selladurai (2004) reported that the adoption of MC in a company has disadvantages, i.e.: an increase in the materials cost, increased manufacturing costs, on time delivery, reduced performance supplier, and a decrease in the quality of the product. In addition to these disadvantages, companies that implement MC found many advantages, among

which are: increased customer satisfaction, increased market share, increased knowledge of customers, manufacturing cost reduction and increased profit.

Therefore, although there is the story of an unsuccessful application of MC in some cases, but in reality many companies who have implemented the MC strategy in the production system. Some companies managed to effectively implement MC within the production process which are Dell Computers, Motorola, IBM, 3Com, Sun Microsystems, Proctor and Gamble, Toyota, General Motors, Ford, Chrysler, Hewlett-Packard, and many other companies (Selladurai, 2004).

Based on researches, Silveira et al. (2001) stated that the success of MC depends on several things, including: (1) the existence of consumer demand will be variety and customization, (2) support of market conditions, (3) supply chain readiness, (4) availability of technology, (5) product is customizable, and (6) Knowledge must be shared. Therefore the implementation of MC should consider a variety of factors and conditions of the company. Lampel and MacCarthy in Mintzberg et al. (2003) mentioned there are five strategies for MC implementation, namely: pure standardization, segmented standardization, customized standardization, tailored customization and pure customization. Which strategy will be applied in a company depend on the condition of the company.

The company implemented the strategy of MC will be faced with a more complex and dynamic production environments, so often have to adjust the production process (Kakati in Huang et al., 2008). The flexibility of the production process surely will support the achievement of business objectives of MC. Nevertheless the selection of new technology is not easy, because of cost elements.

The success of the implementation of MC is also inseparable from the knowledge and experience of the company. How companies adapt and perform adjustment is not easy and takes time (Huang et al., 2008).

Determination of the Customer Order Decoupling Point (CODP) is also required for the implementation of MC (Jian-hua et al., 2007). Due to the process of market demand estimates should be precisely defined, the company must be able to precisely determine how products are manufactured with the concept of Make to Stock (MTO) and Make to Order (MTO). With increasing differentiation of the required product or service the customer will make increasingly complex production process.

Industries that successfully implementing MC is computer industry (Pollard, D., et al., 2008). Computer's company Dell and HP is a pioneer of application of MC for production systems. To support the successful implementation of MC, Dell's supply chain involves three parts, namely: Supplier relationship management (SRM), Supply chain management (SCM), and Customer chain management (DCM).

MC model development for production systems in the textile and clothing industry has been done by Watcharapanyawong, K., et al., 2011. The model developed suggests a link connections associated with customers' need at the industry level, most of which is an Original Design Manufacturer (OEM). There are three main engagement, namely: customers, OEM, and suppliers, associated with framework in developing of MC.

Dong, B., et al. (2012) have reviewed MC implementation in garment industry. This paper solved the problem by providing standards and modules products. Semi-finished products manufactured with mass production concept. At this stage, the key success factor for the company is to keep production cost as low as possible. In the next stage, produced in the form of customized products tailored to customer.

5.2 Mass Customization Application in Food Industry

Increased customers' needs and wants will increase the demands of products variety. It is one of the things that encourage a shift from mass production manufacturing strategy to mass customization. The application of mass customization (MC) in the field of food industry has not been studied extensively. There are some researches that have been published, which talk about the possibilities of applied concept of MC on the food industry, namely the Boland (2006) discussed the application MC of perspective on the food sector; Fisher, et al. (2005) discussed the design of food processing systems to improve corporate responsibility with respect to variations of the product; Matthews, et al. (2006) investigated about food processing flexibility; and McIntosh, et al. (2010) discussed the issue of related application MC in the food industry.

Research on the application of MC in the food industry is still lacking, due to differences in manufacturing processes in the food industry when compared to other manufacturing industries. In relation to the concept of postponement, packaging is considered the most stage makes it possible to apply the concept of MC. McIntosh, et al. (2010) has identified 13 key factors that differentiate between the food industry and other manufacturing industries, namely: (1) chemical change, (2) Food product decay, (3) Maturing cycles/delay, (4) Mixing product and assembling products, (5) Recycling/recovery, (6) Cleaning/purging, (7) Packaging, (8) Simplifying product design for MC, (9) Access, (10) Delicate foodstuffs (handling), (11) Legal provisions (sell-by date and others), (12) Economics of scale, and (13) Distribution.

According to Akkerman and van Donk (2009), the pattern of production in the food industry is characterized by a different product structure, in which a small amount of raw materials used to produce a variety of end products according to customer's request. Therefore, it becomes impossible or inefficient when producing different kinds of final products are individually. Things are generally done to reduce the effects of various types of products in operational performance in food processing production system is producing some or all of the final product with the blending of a number of intermediate products selected (van Donk, D.P., 2001 and Soman, et.al., 2004).

The pattern is in line with the concept of mass customization (MC). MC is a production system that uses cost and speed as well as the mass production to meet the needs of the products or services individually, or can be said to be a production system that combines mass production and individual demand (Xu, 2007). According to Silveira et al. (2001), MC is related to the ability of the company to provide a product or service through a flexible processes. The focus MC is on the design of a product or service on an individual basis to meet the needs and wants of each customer through a process of integration and flexibility (Duray et al. 2000 Frutos and Borenstein, 2004), therefore, to apply the MC sometimes also need to adjust the production process.

Mass Customization is not always appropriate for companies, it depends on the product that is produced and the intended market. As delivered Pine et al. (1993), there are some products that are not demanding any customization, such as petroleum, natural gas, and flour. Similarly for products or services from Government or public facilities. But with growing customers' needs and wants, also imposes demands on a variety of products. Products such as flour, with the development of process technology of flour-based food products arising out of customers' needs would be a variant of flour products. Nowadays, many variants available in the market a product of good wheat protein content in flour (high protein, moderate protein, and low protein) as well as the type and weight of different packaging adapted to the customers' needs.

Mass customization regards customer satisfaction while maintaining production costs, product prices, and quality products. So, the application of MC should not increase production cost which impose the price increase. Therefore, a company that will implement the MC should prepare the production system design to meet these demands. According Pollard, et al. (2008),

there are several advantages of MC, i.e.: maximized market share, cut cost of inventory and material waste, increase cash flow, shorten time of responsiveness, and ability to supply a full line of products or service with lower costs.

According to Matthews, et al. (2011), there are three main strategies associated with MC, namely: manufacturing flexibility, modularization and postponement. Based on these strategies can be identified the possibility of application of MC on certain types of food products as shown in Table 3.

Table 3. Potential for application of MC technique

Strategy	Yoghurt Production*	Potato crisp production*	Batter based puddings**
Modularization	P	Y	P
Manufacturing postponement	N	P	N
Assembly postponement	P	P	P
Packaging postponement	Y	P	-
Labelling postponement	P	P	P
Time postponement	N	Y	-
Place postponement	N	Y	N

P: possibility of application; Y: definite potential for application; N: no potential for application; -: no information.
Sources: * : McIntosh, et al., 2010
**: Matthews, et al., 2011

The possibility of application of the existing strategy would depend on several things, i.e.: the nature of the raw materials, processing, and the properties of the final product. Processing of yoghurt cannot apply manufacturing postponement strategy because it involves fermentation process where the process cannot be put off. Similarly for the time postponement strategy, yogurt has a relatively short shelf life. Unlike for potato crisp products, the process of making potato crisp can be postponed. In addition, the potato crisp has a relatively long shelf life. The labelling postponement strategy is the most frequently applied strategy for all food production systems.

6. CONCLUSION

The food product has potentially to be developed because of the customers' needs and wants for food will continue to increase and more diverse from time to time. Changes to the customers' needs and wants are likely to become increasingly diverse, both in terms of design, quality, and delivery process. Consequently, the company must be able to produce variety products to meet customers' needs and wants.

Food industry has to choose appropriate strategy of production systems to meet customers' needs and wants. Literature study suggests different strategies of the production system in food industry, they are: production planning and scheduling, MTS-MTO strategy, the concept of decoupling point, the concept of postponement, as well as the application of mass customization-related issue (MC) in the food industry. So far the study of the application of MC concept on food industry has not been applied extensively. Therefore, it is necessary to research about the possibility of the application of MC on the food industry.

Application of mass customization concept in the food industry needs to be examined more thoroughly. Not all of the production system in the food industry can implement the concept of MC, depending on the characteristics of raw materials, processes, and end products, as well as the customers' needs and wants. Therefore, the food industry needs to develop appropriate production systems and production planning to handle an increase in variation of products.

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