Impact of PLM System in the New Food Development Process Performances: An Empirical Research

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Abstract. Over the last few years, the food industry has become increasingly more relevant since it represents excellence not only at the European level, but also for the worldwide economy. Starting with this consideration, the main objective of this paper is to provide some elements that could support food companies to be successful in the market. In 2016, during the last PLM conference, the first results of a wider research were presented with the aim to understand how the PLM solution has been adopted into the food industry, and its limits and challenges of the deployment in this sector. This paper presents how the study has evolved through this year. Starting from this point, the impacts and effects from the use of the PLM solution on the New Food Development (NFD) process performances have been described. To identify these effects, a questionnaire was developed and used as a framework to support the data gathering process; each section of the questionnaire is described in the paper. Furthermore, the results of a preliminary empirical research based on a case study are shown. The results of this work will help both food companies and PLM vendors. Indeed, it will support PLM vendors to understand the food industry vision about their NFD process and performances. On the other hand, food companies will be able to better understand their NFD process, their NFD process performances and how they can use the PLM solution to affect their performances.

Keywords: New Product Development (NPD), Product Lifecycle Management (PLM), Food Industry, New Food Development (NFD), PLM for the Food Industry, NFD process performances

adfa, p. 1, 2011.

1 Introduction

Although food is considered a very important sector, companies operating in this area have to face several challenges to maintain and increase their competitive advantage [1] [2]. This paper starts from the results obtained in a previous study [3]. The aim of the previous study was to understand if the PLM solution is adopted in the New Food Development (NFD) process. In order to achieve this objective, we focused on: (i) the level of knowledge of the PLM solution in this sector, (ii) the main phases and activities characterizing the NFD process and (iii) the PLM functionalities supporting the NFD process. This paper presents how the study evolved throughout 2016. The first step of the current research is concerned with the analysis and adoption of the PLM solution in the NFD process. While the second step regards the analysis of the impacts and effects from the use of the PLM functionalities on the NFD performances. To identify these effects a questionnaire was developed, putting in evidence the NFD activities performances and how the PLM functionalities support the NFD process. Before it could be sent to the companies, the questionnaire had to be tested and validated, to verify the alignment with the defined expectations. In this paper, the results from the first pilot case has been presented. Thanks to this pilot case, the questionnaire has been revised and updated, in order to be submitted to the food companies sample. The paper starts, in section 2, with a literature review about the level of knowledge from the PLM solution in the food sector. The following section, section 3, describes a preliminary empirical research, which defines the research methodology, as well as the meaning and scope of the difference from each part of the questionnaire. In section 4, the results of a Pilot Case have been presented and developed with the aim to test our questionnaire. Section 5 is dedicated to the discussion of the pilot case's results. Finally, session 6 concludes the paper, presenting some thoughts about future research.

2 State of the art on the knowledge of the PLM solution in the food sector

This first section of the paper adopts a qualitative methodology based on a literature review. The aim of the review is to understand the level of knowledge of the PLM solution in the food sector from a scientific point of view. The analysis was performed by following three main steps: (i) identify the keywords to be used, (ii) choose the database sources and (iii) analyse the results that were found by combining different keywords.

Starting from step one, three clusters of keywords were chosen and applied to retrieve the articles of interest. The first keyword group consisted of: "Product Lifecycle Management" and "PLM", while the second was composed of the following: "Food industry", "Food sector" and "Food". Keywords from each group were then combined, in order to expand the research results as much as possible. The searches were done separately for each keyword and applied to the journals' abstracts, title and keywords. Besides, authors did not set any restrictions related to time, but only for type, including articles and books sections. Furthermore, *Scopus* was chosen as the abstract and citation database of peer-reviewed literature. Sixty-two articles were collected, which became fifty-two after removing duplicates. The abstracts form each remaining article and book

were then carefully read to assess criteria of relevance; articles that used the keywords in another semantic way were excluded. After evaluating of the abstracts, ten studies remained in the final selection of articles. These articles were extracted and read thoroughly, in full length. At the end, only three articles were considered in line with our field of interest.

The 3 interesting articles give a generic overview of how food companies could benefit from the use of the PLM solution. In fact, a complete discussion about how the PLM functionalities are used in the food industry has not yet been treated in literature.

Both Overbosch and Blanchard [5] and Granros [6] work's deal with the PLM solution on Quality and Food Safety Management topics. Pinna et al. [3] proposed a list of PLM functionalities supporting the product development process activities for the food industry. This study gives a brief overview about the usefulness of the IT solutions by the food companies to support the NFD process.

The fact that no articles dealing with the use of the PLM solution within the food industry have yet to be found, clearly shows the presence of a literature gap in this field. This is the reason why this study strives to address this topic.

3 Preliminary empirical research

3.1 Theoretical framework and research questions

The main objective of the whole study is to understand how the use of the PLM functionalities impact the NFD process performances. To achieve this aim, we proposed a methodology based on four different activities:

- *A1:* to identify the main Critical Success Factors (CSFs) driving the company strategy supporting the NFD process
- *A2:* to identify which are the main performances evaluating the NFD activities
- *A3:* to understand how PLM functionalities support the NFD activities
- *A4:* to identify how PLM functionalities impact the identified performances

To provide an answer for each of these actions, a questionnaire was developed, with a section dedicated to each of them.

Figure 2 shows the theoretical framework and the logic sequence (steps 1 to 5) used to develop the 4 different sections of the questionnaire.

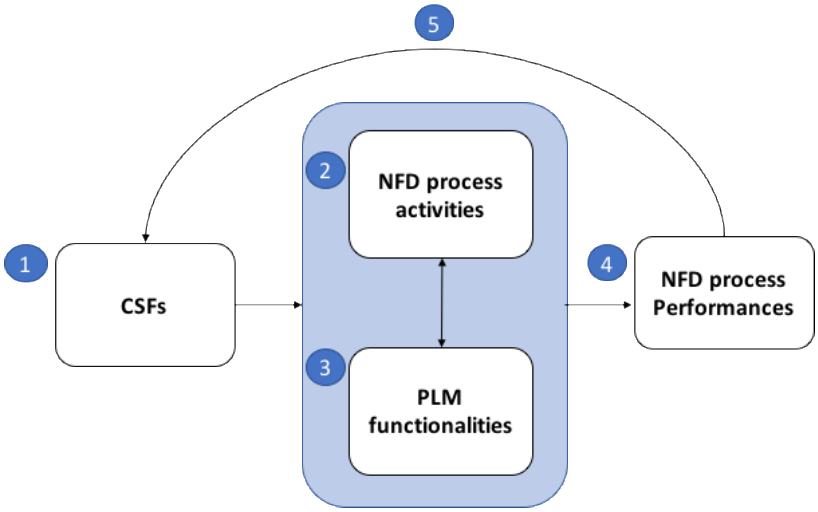

Fig. 1. – Research theoretical framework

The first step identifies the CSFs that lead the strategy of the company. Step 2 allows us to analyse the PD process and its coherence with the strategy. Step 3 is focused on the links between activities of PD process and the PLM functionalities. Finally, in step 4, NFD performances are identified, trying also to understand the possible influence that PLM functionalities could have on them.
Table 1 shows the main research question and the research sub-questions. The latter corresponds to each section of the questionnaire.

Table 1. Main Research Question and Research Sub-Questions

RQ: How do PLM functionalities impact on the NFD process performances?	
sRQ1	Which are the main Critical Success Factors (CSF) driving the company strategy?
sRQ2	Which are the main performances evaluating NFD activities?
sRQ3	How do PLM functionalities support NFD activities?
sRQ4	How do PLM functionalities impact the identified performances?

3.2 Methodology – research strategy

In this work, Case Study is utilized as a research strategy. A multiple embedded case study will be developed. Specifically, the companies sample must respect the following characteristics:

- They must be classified as "*big companies*", due to the fact, large companies have a more formalized and structured NPD process. In addition, being the PLM solution costly for companies, it is largely used by large companies rather than small companies
- They must *use a PLM solution to manage their NFD process activities*

Questionnaires were used as a research tool. It was developed between September and November 2016. In December 2016, it was tested and validated through a Pilot Case. Moreover, in January 2017, the sample of food companies was fully defined. The selected sample was made up of about 20 companies. In order to have a complete view of how the PLM solution is used to support the NFD process, actors who mostly interface with this solution were chosen (R&D and IT managers). When initially trying to contact firms to conduct interviews, difficulty arose with finding a qualified employee, as well as working with their availability. During this phase, the collaboration with a PLM vendor leader in the food industry was very important.

The questionnaire was then submitted in the form of an interview. A standard protocol was followed and identified to be valid for each case study. The interview process took place from January 2017 until June 2017, and was then followed up with a results analysis.

As mentioned before, in order to validate and test the questionnaire, a first pilot case was developed, with the aid of Poult. Results of our pilot case is presented in the following section.

4 Pilot Case: the Poult group

A pilot case study helps to refine the data collection plans with respect to both the content and the procedures to be followed. It assists to develop relevant lines of questions and provides some conceptual clarification for the research design as well [7]. For these reasons, it is important to explain the “Selection of the Pilot Case” and the “Scope of the Pilot Inquiry”. Concerning the first question, Poult has been chosen as the pilot case because it showed an interest to use PLM to manage its NFD process and also because it has already collaborated with the academia. In fact, some researchers were collaborating with the company on the PLM topic. This provides easy access to the case. The company was also selected because a study on their NFD process, information management and the actors involved in the NFD process had already been carried out. About the scope of the Pilot Inquiry, this pilot case has been chosen to improve its conceptualization of different types of PLM functionalities for different NFD performances and their related organizational effects.

4.1 Critical Success Factors (CSF)

The first step of our proposition is the identification of CSFs. Usually, CSFs are used to define key areas of activity and to identify the strategic indicators of the company [8]. These strategic indicators allow us to evaluate the “strategical interest” of the of PLM solution deployment. Since Poult wants to reduce the customer answer time and to ensure better continuity between the "product" innovations and their putting into production, the company CSFs are:

- the *sharing of information* by setting up a unique product repository enabling the company to maintain centralized, reliable and up-to-date information
- the *optimization of its processes* by sharing and capitalizing on knowledge
- the deploying a *structured methodology*, to develop new product

- the *analysis and the anticipation of the risks* linked to the product/process data

4.2 NFD phases and activities

The phases and activities described in the previous study [3] describe a generic and standard NFD process. Nevertheless, some differences can be noticed when comparing companies. Since the different sections of our questionnaire are linked with the phases and activities of the NFD process, a check concerning the coherence of the terminologies and the related meanings is needed. In Table 2 the process phases and activities of Poult are presented.

Table 2. NFD process phases and activities of Poult and actors involved

NFD macro-phase	NFD activities	Actors
Customer's or internal (Poult's project) request for proposal	Send external NFD request Send internal NFD request Receive customer or internal request and carry out a preliminary study	Customers General (innovation challenge) Marketing "Product family" (R&D, marketing, trade, production
Project launch	Plan the project Develop the recipe	R&D (Project Manager) General (innovation challenge)
Product Test & Feasibility	Test recipe (Lab and Industrial Testing) Study internal feasibility Study external feasibility	R&D (Project Manager + R&D technician) Production Customer Laboratory
Production, Launch and Commercialization	Manufacture, Launch and Commercialize	General (quality, production, trade, R&D….)

Table 3 shows the comparison between the standard process identified in the previous study [3] and the NFD process of Poult.

Table 3. Comparison between our standard process and Poult NFD process (Y: correspondence, N: difference)

NFD macro-phase	NFD activities	Y/N
Planning	Plan the project	No, unless developing a new product is a result of an internal need (exceptional case: the need usually arises from a customer)
	Define the recipe	No, unless developing a new product is a result of an internal need (exceptional case: the need usually arises from a customer)
Recipe Definition	Study Idea Internal Feasibility	No
	Develop the Recipe	Yes
	Study Recipe Internal Feasibility	Yes
Product Test & Feasibility	Make a Prototype	Yes
	Study Product internal feasibility	Yes

	Study Product external feasibility	Yes
Industrialization	Industrialize	No
Production, Launch and Commercialization	Manufacture, Launch and Commercialize	Yes

Overall, the description of generic NFD process seems to be similar to Poult's. Moreover, differences have been observed concerning two phases:

- *Plan the project*: Poult Company mainly sells its products under private label, which is to say that the retailers are the ones that impose their idea and define their need. Company in-house teams reflect on the product to be created, so that it adapts to our customers' strategy (mainly the retailer). Thus, the macro phase planning is mainly generated when they enter a process of development for a new product, following a need expressed internally (either by the marketing department after market study or after the innovation challenge conducted internally). In the case of an internal need, the company is a source of proposal and once the product is created, it is presented to the identified customers (retailers)
- *Define Recipe*: A first estimation of the technical and financial feasibility is carried out during phase zero, and then another during the definition of the recipe. In addition, the industrialization phase is carried out in parallel with the production phase and feasibility tests. In general, the production manager checks whether the manufacturing line can manage the production of the new product with all its technical and financial characteristics or not. Once the project team agrees, a small quantity of the products (industrial tests or laboratories) is produced to check if everything is okay before sending the samples to the customer and/or panel. If the customer seems satisfied with the products sent, then the product is ready to be launched on the market

Once the various phases characterizing the Poult NFD process and the gap from the general process have been identified, it will be possible to go on with the identification of performances.

4.3 Main performances characterizing the NFD activities

The main objective of this section is to understand how the food companies evaluate their NFD activities and how they define their performances. The results of this phase will help food companies to better understand their NFD activities, their NFD process performances and to support them in monitoring NFD activities over time. Mapping the KPIs characterizing each activity and assigning a grade of importance to each of them will allow to identify the most relevant NFD activities. Keeping the focus on the relevant activities, will provide greater value to the whole process.

In the specific case of Poult, the performance measurement remains an open question where there are multiple and shared opinions. The most widely used indicators within the Poult Group is related to the production (*overall rate of return*) and supply chain (*customer satisfaction*). Concerning the R&D, the main objective is to reduce the time and cost of the product development project. For this purpose, R&D focuses on projects

general indicators, for example: the number of products that have emerged, the percentage of projects carried out in relation to the number of projects undertaken. The most important indicator for R&D remains the rate of satisfaction of the tasting panels. Table 4 shows the NFD process performances for each phase interested and the related relevance.

Table 4. Poult NFD process activities and related performances

NFD activities	NFD process performances	Relevance
Study Product internal feasibility	Indicator Tracking panels referenced products Indicators panels new referencing *Customer satisfaction rate* = Total satisfactory panels / Total panels received	4
Study Product external feasibility	The percentage of projects carried out in relation to the number of projects undertaken	3
Manufacture, Launch and Commercialize	***Production***: TRG is the product of 3 rates. TRG = availability rate (TD) x efficiency rate (TE) x quality rate (TQ) ***Supply chain***: Litigation: number of lines in dispute / total number of order lines Delivered during the same period…	3

The column "Relevance" defines the degree of importance of the indicator (KPI), according to this scale: 1=Not important; 2 =Low importance; 3= Important; 4= Very important

4.4 How do PLM functionalities support NFD activities?

According to the results obtained in 2016 [3], nine main PLM functionalities, supporting the NFD process, are taken into consideration. In this context, these functionalities are considered as a metrics of classification. Starting from these assumptions, we present the results related to the section of the questionnaire focusing on PLM functionalities (Table 5). The main objective of this section is to understand how PLM functionalities support the different NFD activities. The results obtained will help food companies to better understand the potentiality of the PLM categories and the impact on the NFD process activities. In fact, to use properly PLM functionalities, food companies must first understand the meaning and the capabilities of each and then to understand which activities of NFD process are supported. The knowledge about the main process activities and how the PLM functionalities support the analysed activities will allow food companies to maximize the benefits from the adopted solution.

Table 5. PLM functionalities and NFD main activities, the Poult Pilot Case

PLM functionalities	NFD main activities supported	Actors Involved (BU)
CAD design management	Not used	-
CAD for packaging design	Not used	-
Formula and recipe management	Develop Recipe	R&D (Project Manager)
Label management	Study Product Internal Feasibility	R&D (Project Manager) Quality

PLM team collaboration	Not used	-
Product portfolio and program management	Not used	-
Report specific to the industry	Study Product Internal Feasibility Study Product External Feasibility	R&D (Project Manager) Quality
Regulatory compliance	Develop Recipe Study Product internal feasibility	R&D (Project Manager) Quality
Specifications management	Not used	-

4.5 Relation between PLM functionalities and NFD process performances

Finally, once both Value Added (VA) activities and PLM functionalities have been identified, it is possible to define the influence that each functionality has on each performance. In particular, the most interesting part for companies will be to focus on the value-added activities previously identified. In this way, companies can understand which are the performances that mostly represent their process and which must be kept under control. After that, thanks to the relation between PLM functionalities and NFD activities it is possible to identify the link between them. In this way, companies can select the PLM functionalities which mainly influence their value-added activities, and thanks to the monitoring of the related performances, they can identify the relative impact. This final step allows food companies to better understand how they can use these functionalities to improve their NFD activities, and consequently trying to achieve the main goals defined by the previous CSFs. Moreover, in order to achieve the best results, it is necessary that those who use the software functionalities have full knowledge of the tools they are using, including the relative capacities and capabilities. Below, in table 6, the results related to the Poult Pilot Case are presented. The relation between PLM functionalities and performances could be positive, negative or neither: positive relation means that the use of the PLM functionalities has improved the performances, negative relation that the use of the PLM functionalities has decreased the performances and no relation means that the use of the PLM functionalities has no influence on the performances.

Table 6. Evaluation of the impact of PLM software categories on NFD process performances, the Poult's results

NFD activities	PLM functionalities	NFD process performances
Develop Recipe	*Formula and recipe management* *Regulatory compliance*	No performance measured
Make a Prototype	No PLM functionality supports this activity	No performance measured
Study Product internal feasibility	*Label management* *Report specific to the industry* *Regulatory compliance*	The percentage of projects carried out in relation to the number of projects undertaken

Study Product external feasibility	*Report specific to the industry*	Indicator Tracking panels referenced products Indicators panels new referencing *Customer satisfaction rate* = Total satisfactory panels / Total panels received
Manufacture, Launch and Commercialize	No PLM functionality supports these activities	***Production***: TRG is the product of 3 rates. TRG = availability rate (TD) x efficiency rate (TE) x quality rate (TQ) ***Supply chain***: Litigation: number of lines in dispute / total number of order lines Delivered during the same period

For this specific case, the analysis had to be restrict to the information that Poult highlights as important. In fact, only two of the NFD activities are both supported by PLM functionalities and measured by performance indicators. These phases are: "study product internal feasibility" and "study product external feasibility". Unfortunately, it is not possible to assign a relation between the use of PLM functionalities and NFD performances, due to these PLM functionalities having been deployed in the Poult group recently. Thus, the company is not in position to establish a precise analysis on the relations between the introduction of a PLM solution and the NFD process. Nevertheless, they assume that the implementation of a PLM within the Poult Group will influence the processes, and particularly the activities carried out within the R&D and quality services. Indeed, the construction of a single raw materials database will make it easier to research and use the data during the formulation phases. Improved data quality on raw materials results in less error in formulation. Within the quality department, the implementation of a PLM tool will allow automatic documentation in relation to the product/process from the data entered in the repository.

5 Research Results discussion

The Poult Pilot Case helped us test, validate and refine the first version of the questionnaire. In this concern, changes have been done to the preliminary form proposed:

- *CSFs section has been moved*. In the first version of the questionnaire this section was positioned at the end. Interviewees proposed to move this section to the beginning in order to have a more complete view of the company, as well as to define the strategical objectives and to link the next sections, while keeping this information in mind
- *NFD process comparison.* A question about the comparison between the general NFD process proposed and the current one of the company was introduced. This was done in order to better contextualize and customize the questionnaire based on the interviewed company
- *Link between CFSs and NFD performances*. This section has been deleted because it didn't add relevant information to the main research question defined

The other sections of the questionnaire were aligned with the Poult point of view. It was decided in some cases to improve the quality of the questions, in terms of presentation, but the meanings have not been changed. Concerning the Poult Case Study, what it could be said is that the main phases that have to be taken under consideration are the internal and external studies of product feasibility. These phases are managed with the support of some PLM functionalities, as Label management, Report specific to the industry and Regulatory compliance. In order to measure the performances of these activities three performances have been identified: the percentage of projects carried out in relation to the number of projects undertaken, the indicator tracking panels referenced products and indicators panels new referencing. Being a pilot case, the fact that it was not possible to identify a relation between PLM functionalities and NFD performances is not so relevant, because of the main scope of the inquiry. As said before, the scope of the pilot case is not data collection oriented (to answer the research question), but is used to refine, test and validate the case study tool (questionnaire).

6 Conclusions & Further Research

This study is part of a wider research project, whose main objective is to understand the influence of the PLM functionalities on NFD performances. The methodology used to achieve the research goal is case study. In order to obtain a methodologically efficient work, it is important to design a good research tool, which in this case is a semi-structured questionnaire. This paper shows the results relating to the final phase of the questionnaire design: The Pilot Case. The pilot case has been developed with the aid of a French company. Various corporate figures (R&D, Marketing and Production) have participated in this process, in order to obtain different points of view and a more complete improvement of the instrument. The results of the pilot case helped mostly to better refine it in terms of questions and structure. In fact, the results influenced the move of some sections within the questionnaire (because it seems to give a better logic sequence) and to eliminate other parts (because they don't add so much value). Nevertheless, some results have been obtained from the Poult interview, in particular: the most important NFD process phases for Poult are "Study Product Internal Feasibility", "Study Product External Feasibility" and "Manufacture, Launch and Commercialize". Nonetheless, only the phase of "Study Product Internal and External Feasibility" is supported by different PLM functionalities. The Manufacture, Launch and Commercialize activity is measured by different performances but no PLM functionalities are used to support it. It would be interesting to better investigate why they made this choice.

In conclusion, it is possible to say that the proper use of this research tool will allow food companies to: (i) better understand the NFD processes and activities, (ii) define, discover and monitor the NFD performances by giving them a relevance, (iii) understand how the use of PLM tool can support the NFD process and (iv) understand how the PLM functionalities can affect the various activities of the process and as a result the performance associated with them. As the next research step, the questionnaire will be submitted to different food companies that are currently using the PLM functionalities, and then their answers will be analysed and evaluated in order to obtain a final answer to this research. From a scientific point of view, this work will help to fill a gap in literature about the use of the PLM in the food sector (in particular in support of NFD

process). Moreover, also the results related to the NFD process performances, NFD process phases and activities and PLM functionalities supporting the NFD process will allow to enrich the contents about these topics, lacking in the scientific literature. Furthermore, from the practitioner point of view, this study will help PLM vendors to understand the food industry vision about their NFD process and performances. In addition, food companies will be able to better understand their NFD process, their NFD process performances and how they can use the PLM system to affect their internal performances. Fundamental element to achieve good results from the use of PLM functionalities is the knowledge of the tools. Food companies that want to manage their processes through these capabilities must therefore make sure they know the related potential in such a way that they can make the most of these functionalities.

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