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## State of the Industry 4.0 in the Andalusian food sector

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### Abstract

The food industry is a key issue in the economic structure of Andalusia, due to both the weight and position of this industry in the economy and its advantages and potentials.

The term Industry 4.0 carries many meanings. It seeks to describe the intelligent factory, with all the processes interconnected by Internet of things (IOT). Early advances in this field have involved the incorporation of greater flexibility and individualization of the manufacturing processes.

The implementation of the framework proposed by Industry 4.0. is a need for the industry in general, and for Andalusian food industry in particular, and should be seen as a great opportunity of progress for the sector. It is expected that, along with others, the food and beverage industry will be pioneer in the adoption of flexible and individualized manufacturing processes.

This work constitutes the state of the art, through bibliographic review, of the application of the proposed paradigm by the Industry 4.0. to the food industry.

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## 1. Introduction

The use of technological facilitators, information analysis and connected machines will allow industry to develop their role in a much more efficient, robust and collaborative way. This trend is transforming the industry into a new generation, called Industry 4.0. [1].

Food industry would also be benefited from the implementation of the paradigm proposed by Industry 4.0. [2]. Those benefits include technological development and dynamization of the economy, production flexibility making configuration changes that do not affect production time, personalization that allows satisfying client requests even under low production volumes, optimization of the decision making process by real time handling of information, an increase in productivity and efficiency of resources throughout an exhaustive tracking along the entire productive process and the creation of new business opportunities, specially in derived or supportive services.



Fig. 1. Industry 4.0.

European industry digitalization pretends to benefit from all the advantages of a digital single market in order to strengthen the competitiveness in the field of digital technologies and to ensure that every European industry, from any sector or location, no matter its size, can fully benefit from digital innovations. The construction of the Spanish model for the industry of the future covers the development of the digital solution local offer, the digital solution local offer and differential competitive levers to favour the Spanish industry and drive its exports.

In the food industry it is known the difficulty entailing food manufacture for many reasons: perishable products, legislation is a key factor, alerts and crisis may occur, it is necessary a strict food security control, commercial margins are tight due to competitive pressure, etc. To all of that it should be added that the consumer is increasingly demanding, with changing tastes, interacts via social media, searches for customization and an exclusive treatment.

Digital technologies have answers to the previous stated questions, as it is the appropriate processing of information, data, machines, people and organizations interoperability along with new business models integrations and the so called “big data” allow us to interpret the information in order to have a support in the continuous decision-making process both at the operative and the strategic level. [3]

The food industry is in constant change and technology plays an important role in this field. Scientific and technical advances enable food and beverages manufacture that better adapt to consumer demands in a safe way, with more sustainable and efficient productive processes, covering demand of global markets.

Food technology advances chosen by a group of experts [4], by the role they are playing and will play in the future of food industry are:

- Internet of things (IoT), Artificial Intelligent and Big Data
- Microencapsulation and nanoencapsulation for the last generation ingredient design
- Chemical image for quality control and food security
- Bacteriophage, new biological methods for food security
- Pressure as a tool for food process transformation
- Proteomics
- Active packaging, the skin of the 21st century food

Constant pressure on prices in the food industry has forced it to constant innovation, as well as the necessary traceability of products has forced the involved machines to be interconnected. Greater flexibility will allow the production to adapt to each customer and a quick adaptation to changing product specifications. Energy use could also be controlled and monitored, so that it can be optimized to best levels.

## 2. Methodology

This work constitutes the state of the art, through bibliographic review, of the application of the proposed paradigm by the Industry 4.0. to the food industry.

The term food industry is used to refer to companies that produce, process, manufacture, sell and serve food, beverage and dietary supplements [5]. In particular it includes all stages of the process, including design, construction, maintenance and delivery of solutions to the customer in the industry of animal nutrition and the food industry (food and drink).

In the food business, innovation is the driver for growth. The objective is to serve the world with good and healthy food, produced in an efficient and sustainable way, without harming the environment, offering innovative solutions with clear added value. [6]

Technological development has made it possible to manufacture products with an increasingly high level of added value, and competition from manufacturers with low production costs has resulted in a greater demands for efficiency during the manufacturing stage. [7]

The whole innovation system and its components have recently experienced major progress, consequently reducing the gap between the state of implementation of Industry 4.0 in Andalusia and the rest of EU regions. This fact is mainly due to a significant effort by the public research sector.

Furthermore, food security problems are a great concern. For example, many relevant episodes have taken place causing public alarm in China. Thus governments have made food safety a top priority.

In the past few years, the rapid development of the Internet of Things IoT has greatly helped the food supply chain in practical significance. IoT is an inevitable choice to improve the logistics, and if the situations before and after the implementation of new networking technologies to the management of food logistics are compared, it can be concluded that its application has a large stimulative effect. For example it is possible to identify and establish the traceability from cultivation to the production chain in food processing environments, providing the supply chain effective information to its identification and traceability [8].

To make the most of a region such as Andalusia, it is necessary to increase the entrepreneurship of students and researchers, promoting and improving the quality and quantity of the research groups of excellence and enhancing the creation of scientific and technological parks where companies which have their origin in public research can contribute to the increase of wealth and employment in the region [9].

The Andalusian food industry is not only strategic for fulfilling the function of quality food products supply to our population but it is also a great employment generator, being high the employee added value in most cases. It should not be forgotten that partly because of the crisis, we have started to look into foreign markets, progressively achieving the penetration into other economies, positively improving the commercial balance. On the other hand, due the high level of immersion of R&D into our food industry, we are located among the best of Europe in terms of traceability and food security, along with the increasing valorisation of Spanish gastronomy, place our sector in a very good position on the international scene. All of this, added to our autonomous community tourism, also causes that millions

of tourists that visit Spain every year, discover our culinary culture and wish to have our products available in their home countries.

However, our industry suffers, among other factors, of a great atomization. Lack of appropriate business sizing diminish our competitiveness in the international market, and the lack of a strong leadership dissolve the overall efforts. Furthermore, the complex sector legislative network with excessive regulation at all institutional levels makes its fulfilment more complicated, especially due to the lack of homogeneity. On the other hand, access to funding and costs involved are higher every day, making the growth of our business higher and complicating its opening to new markets. Even though our products are greatly appreciated by the foreign consumer, it has been verified the shortfall of our products in international markets, due to differentiation problems and its added value, as we have not been capable to differentiate ourselves from the products coming from other countries. However, differentiation among our own products is so high that unskilled consumer does not know how to distinguish between all of them, scarcely knowing the differences between the varieties.

It should be pointed out that, in addition, even being a relevant strategic sector and very important for our region, society does not fully perceive its importance, and this situation may distance it from public agencies and scientific and academic institutions.

If we are able to overcome these obstacles, having into account the growth of new consumer markets, mainly in emerging countries and also in other countries that are starting to look our healthy diet favourably, our industry could feed these markets and grow exponentially consolidating as a large exporter of food products. [10]

An exhaustive study has been performed, in the field of existing knowledge in the area of the industry food, under the approach of Industry 4.0. An objective is to obtain a fixed picture of the current state of the issue in relation to the food industry, and specifically Andalusian food industry, in order to be able to detect lacks and niches of opportunity in a sector which is vital for the industry and society, integrating the Industry 4.0 paradigms.

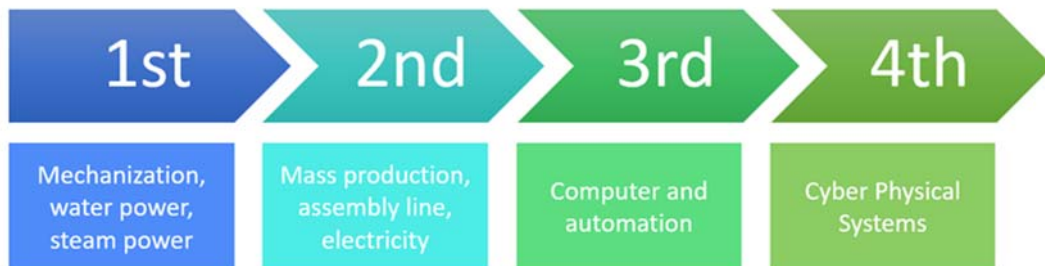


Fig. 2. Industrial revolution.

The paper tries to make a synthesis of research or work carried out on the subject, in order to learn how it has been treated. For example, what types of studies have been carried out, the characteristics of the subjects, how the data have been collected, in which places have been carried out and which designs have been used. Background are the point of departure to delimit the problem by making it possible to clarify, judge and interpret the problem raised [11].

### 3. Results and discussion

This paper reviews [12] and analyses the research works focused on that topic showing the trends emerging in it in the last fifteen years; in particular, it has been deeper focused on the sustainability of machining processes.

During the second half of the 20th century, the agriculture has been very successful in food supply to the growing human population. In the staple crops, such as wheat and rice, there has been a significant performance increase, costs have been fallen, food production has normally exceeded population growth and chronic hunger has decreased. This growth in food production derives from scientific advances and technological innovations that include the development of new variety of plants, use of fertilisers and pesticides and the growth of irrigation infrastructure.

Notwithstanding its success, our food production systems are in the process of eroding the fundamental basis that hold them. Paradoxically, technological innovations, practices and policies that explain the productivity increment, are also eroding productivity basis. On one side they have abused and degrades natural resources: soil, water and genetic diversity. On the other side, they have developed a dependency on the use of non-renewable resources, such as oil, and they are promoting a system that eliminates the responsibility of the employees in the food production process [13].

Furthermore, food business know that the management of environmental factors is increasingly relevant, and probably, in the future it will be among the factors that determine sustainability and competitiveness of the company.

Food industry generates a great amount of production waste of organic nature, mainly constituted of those raw material parts that are not useful in the elaboration process. These materials may be discarded as wastes, with its consequent economical cost, or it can be revalued as sub-products, with its consequent environmental and economical cost.

On the other hand, primary and secondary packaging have become part of our daily way of living, in many cases because they make our lives easier, in others because they are essentials to apply certain techniques of food conservation and protection; to the point that it becomes difficult to imagine the commercialization of any food product without any kind of package. This entails a certain paradox, because, even though the packaging constitutes a very important tool to obtain safe, attractive and comfortable food, it can also have a negative effect on the environment if they are not properly managed. [14].

Sustainable manufacturing engineering may be considered nowadays as a new body of knowledge in development; the interest in the scope of sustainability in the life cycle of products and processes, is driving its fast growth.

The incorporation of the new cleaner technologies proposals, production methods focused in the best environmental practices, as well as the optimization of the best techniques available, requires the restructuration of frameworks in order to be assumed by the manufacturing engineering in an efficient way. A correct integration of ecological and social dimensions at an operational level, apart from optimising the manufacturing processes regarding environmental criteria, should maintain and improve economical viability and technique achieved so far. However, actions and solutions that are balanced and oriented to impact, consume and emission reductions are quite different depending of the level of the operations and tasks (process, production plant, supply chain...). This situation has determined an complexity increment of design, implementation, optimization, and management of manufacturing processes and a lack of integration of the three dimensions of sustainability (economical, ecological and equity) in its life cycle. [15].

It is considered that what is thought to be the next industrial revolution is being incubating. Along with it, terms such as internet of things (IoT), cyber-physical systems, smart factories or Industry 4.0, are used to describe a more dynamic and complex industrial environment, highly distributed and reconfigurable, with redundant data profusion and that should be confronted, in a holistic way, analysing the system to control, the digital controller with its control algorithm and the rest of intervener software (real-time operating system, network protocols...) as a single hybrid system of great complexity and geographically extended. [16].

The use of new technologies in the agrifood sector has intensified in recent decades. Thus, technologies have been launched for aseptic treatments, vacuum conservation, modified atmospheres, high pressures, microwaves, active packaging, biotechnology and a long etcetera. Nonetheless, compared to other manufacturing industries that are equally important, such as automobile, pharmaceutical and chemical, the majority of the food and beverage industry shows clear proof of lack of standardization and integration of factory industrial software and hardware, as well as lacking definitions and standardization on its automation platform. Therefore, one of the pending challenges of sector industrialists is to better understand automation systems and production and energy management systems. They should analyze their benefits and possibilities to be able to outline real measurement ratios in the areas of traceability, quality, productivity, line performance, analysis and allocation of production and energy costs, and so forth, aligning them with business targets in order to measure and take corrective actions in a continuous improvement process. Our important food industry, constantly evolving and innovating, must have enough breadth of focus to prioritize training its senior managers, engineers and technicians in order to understand and apply this concept of digital factory and be able to fully use all the advantages it provides and that will make us stronger and more competitive in the complex global environment [17].

Digitalization constitutes a key opportunity in order to improve the competitiveness of Spanish industry in an increasingly global market. It is necessary to undertake a deep transformation so that Spain in general, and particularly Andalusia, will not fall behind in this new industrial revolution.

Digital enablers are the facilitators of Industry 4.0. They are elements that enable the digital transformation of the industry.

They are at the same time the origin of the challenges that Industry 4.0 sets out and the tools to confront them.

They are the set of technologies that make possible that this new industry takes advantage of all its potential. In effect, this allow the hybridization between the physical and digital world, in other words, it binds the physical and virtual world together in order to make of the industry an intelligent industry.

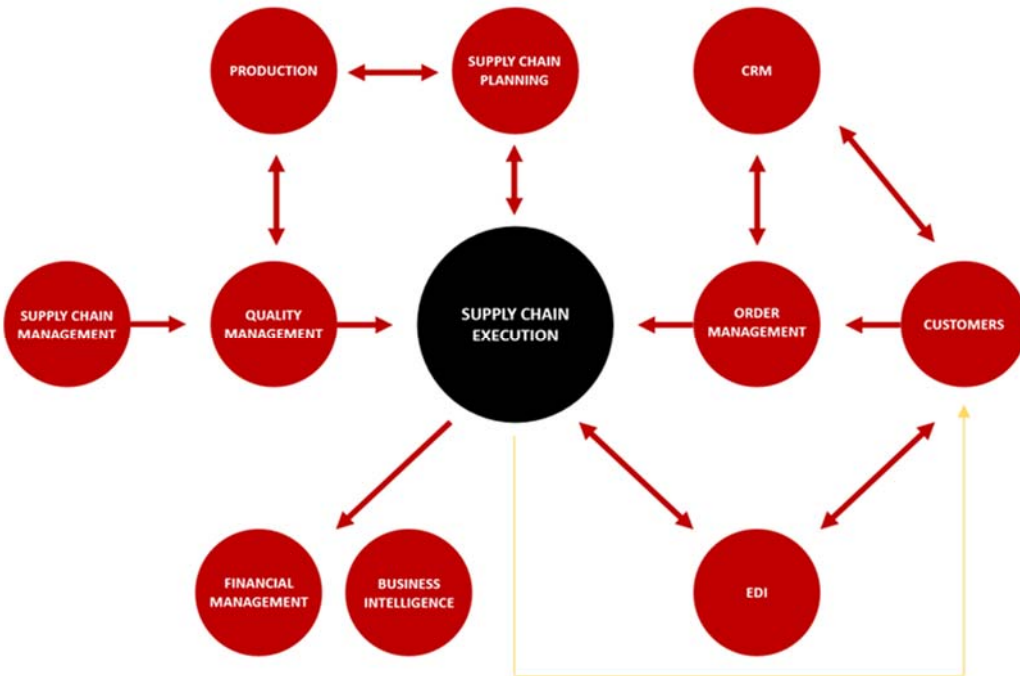


Fig. 3. Factors that influence the supply chain execution.

The resulting information from this hybridization is processed with the following enabler category, that communicate and prepare the data of the previous layer so that it can also be processed by management applications. The improvements in communications infrastructures that allow the communication anytime and anywhere, the tools and mobility applications as well as the cloud computing, are the technologies that shape this second layer of digital enablers, in which cybersecurity tools that allow the protection of the plant's infrastructure from the different threats become particularly relevant.

Finally, there are digital enablers that process the obtained information in the two previous stages and apply intelligence managing that information. CRMs, ERPs, production applications, bid data logistic (massive data analysis) take part in this group of digital enablers.

The most relevant digital enablers in Industry 4.0 can be considered as follows:

- Internet of Things (IoT) and Cloud Computing: The use of IoT technologies is the base of Industry 4.0. It consists in equipping the machines and industrial objects with sensor systems and electronics, as well as embedded software and connectivity. This allows the objects to collect and exchange data using the internet infrastructure. In the new smart industries, the information will be on the cloud not on the computers or servers of the company
- Additive manufacturing and 3D printing: The incorporation of additive manufacturing (pieces or objects built from 3D models through material addition and thanks to 3D printers) to production chains is becoming a reality,

allowing greater customization in the design of the parts to be manufactured, cost reduction in material usage, rapid prototyping...

- Industrial Big Data: the manufacturing operations generate massive data quantities, so it is an ideal environment to implement Big Data systems. Big Data allows machinery failure prediction, anticipate maintenance operations, improving process optimization, identifying the client consume patterns...
- Vision technologies (Augmented Reality/Virtual Reality/ computer vision) will allow improvements of maintenance works, manufacturing control and training processes of employees.
- Automation and intelligent robotics: A new generation of industrial robots that will work in a friendly way with the operators without security risk.
- Cybersecurity: The role of cybersecurity is fundamental in Industry 4.0. As it is being discussed there are many technologies used and many industrial objects that will be connected to interchange information and be able to control production systems, so that adequate protection measures should be applied to prevent attacks that may alter the correct operation of the factories with the consequent economic risk that it may imply. [18]

#### 4. Conclusions

The implementation of the framework proposed by Industry 4.0. is a need for the industry in general, and for Andalusian food industry in particular, and should be seen as a great opportunity of progress for the sector.

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