The Collider

Agro-food Industry

Technology Watch Report

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This technology watch report on the agro-food industry has been drawn up by The Collider, Mobile World Capital Barcelona's innovation programme, in conjunction with the Vall Companys Group, Zyrcular Foods, with the supervision of IRTA and the input of thirty experts.

The Collider is the innovation area promoted by Mobile World Capital Barcelona which connects scientific and business talent to create new tech-based companies and contribute to providing solutions to the challenges facing industry and society.

The Collider team engages in partnerships with prestigious research centres and universities, consolidates and applies enhancement and transfer mechanisms and provides support for the creation and growth of new companies. Its unique value is that it mentors highly disruptive new tech solutions based on artificial intelligence, the Internet of Things, blockchain, virtual reality and smart connectivity in general as they are brought to market.

An initiative by

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Grupo Vall Companys is a family-owned agro-food group founded in 1956 which has become a leader in Spain. Supported by state-of-the-art information systems that provide its facilities and plants with connectivity and automation, its operating model involves the integration of its production process stages in order to achieve efficiency, safety, quality, wellbeing, health and sustainability objectives. **Zyrcular Foods** is company promoted by the shareholders of Vall Companys Group.

In collaboration with

Vall Companys GRUPO

IRTA is a Government of Catalonia research institute under the Ministry of Climate Action, Food and Rural Agenda. It is part of the system of CERCA centres of Catalonia.

With the supervision of

IRTA

1 Preface

Agro-food Technology, in the quest for global balance

By 2050, there will be 10 billion people living together on the same planet where fewer than 8 billion reside today. This is dramatic. We are talking about a 25% increase in the world's population which is not likely to be matched by a commensurate increase in resources. It poses a major challenge for humanity: how can we ensure access to food for this number of people? Can we do so in an environmentally sustainable way? How can we best achieve this balance?

The great global race is on to make all our processes more efficient. We need to shift towards building a production, processing and distribution system which uses fewer resources and generates less waste. Evidently, we also have to rethink the way we consume so as to keep waste to a minimum. Both work strands go hand in hand, but in this report we have chosen to address the former: how can we produce, process and distribute more efficiently? When we tackle an efficiency-related challenge, the answer will always lie in technology. It is our staunch partner at a key time for humanity in reshaping and enhancing our system's environmental, economic and social sustainability.

Agro-food encompasses the food industry in the broadest sense of the term. In Catalonia, it generates around €38.21 billion in turnover, making it the leader in the industrial sector and accounting for 16.28% of Catalan GDP. Getting it to go digital is crucial in sustaining this leadership and competitiveness and lending a hand in the quest for global efficiency to meet the right to food of everyone living on the planet. We are laying the foundations because Spain is already positioned as one of the major global powers in the FoodTech entrepreneurship ecosystem after this industry tripled its incoming investment in 2021 to reach €695 million, 220% more than the previous year.

Keeping this trend going calls for a decisive commitment from as many stakeholders as possible all singing from the same hymn sheet to position Catalonia and Spain as a flagship agro-food hub in southern Europe. It is a hub that is playing an active role in the global conversion of a still highly traditional sector into an efficient industry by maximising production and reducing resource use and waste generation. Areas such as the search for a protein alternative to meat and tapping high-impact technologies (AI, Big Data, sensors, blockchain, etc.) are a roadmap which is already happening

Here at Mobile World Capital Barcelona, we draw on our The Collider programme to bring the academic and corporate settings closer together and connect talent to forge synergies which help shape solutions that humanise technology to build a better society. This report outlines global trends we are working on, trends which will pave the way for a more competitive and efficient industry which can play a key role in striking a global balance between resource generation and use. Balance is possible; technology is our partner.

Carlos Grau
CEO of Mobile World Capital Barcelona

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Consolidating a benchmark Agrofood Hub

Food systems connect the life and health of plants, animals, people and the planet. Because innovations are by definition generators of added value, experts concur that the innovations associated with **agro-food value chains** are gradually meeting the need to attain more **sustainable**, balanced, fair and resilient systems.

The primary sector is an economic driver in both Spain and Catalonia while it also has a very high level of resource circularity and externality. Within this context, the application of technologies from biotechnology, agriculture and livestock digitalisation, artificial intelligence and its predictive functionality, robotisation and others including new materials may be the key to ensuring that agro-food makes even further progress towards the aforementioned parameters: more sustainability, more balance and greater fairness.

Innovative agro-food systems

There are very interesting advances in this direction in some countries such as the **Netherlands**. This country's agriculture and horticulture are among the most advanced and productive in the world. This is because it is fully aware of the challenges it is facing, and also because it has rolled out the 'Golden Triangle' made up of government, universities and the private sector which tests innovative farming models that incorporate new technologies. One example is the high-tech urban hubs which are being implemented in Amsterdam.

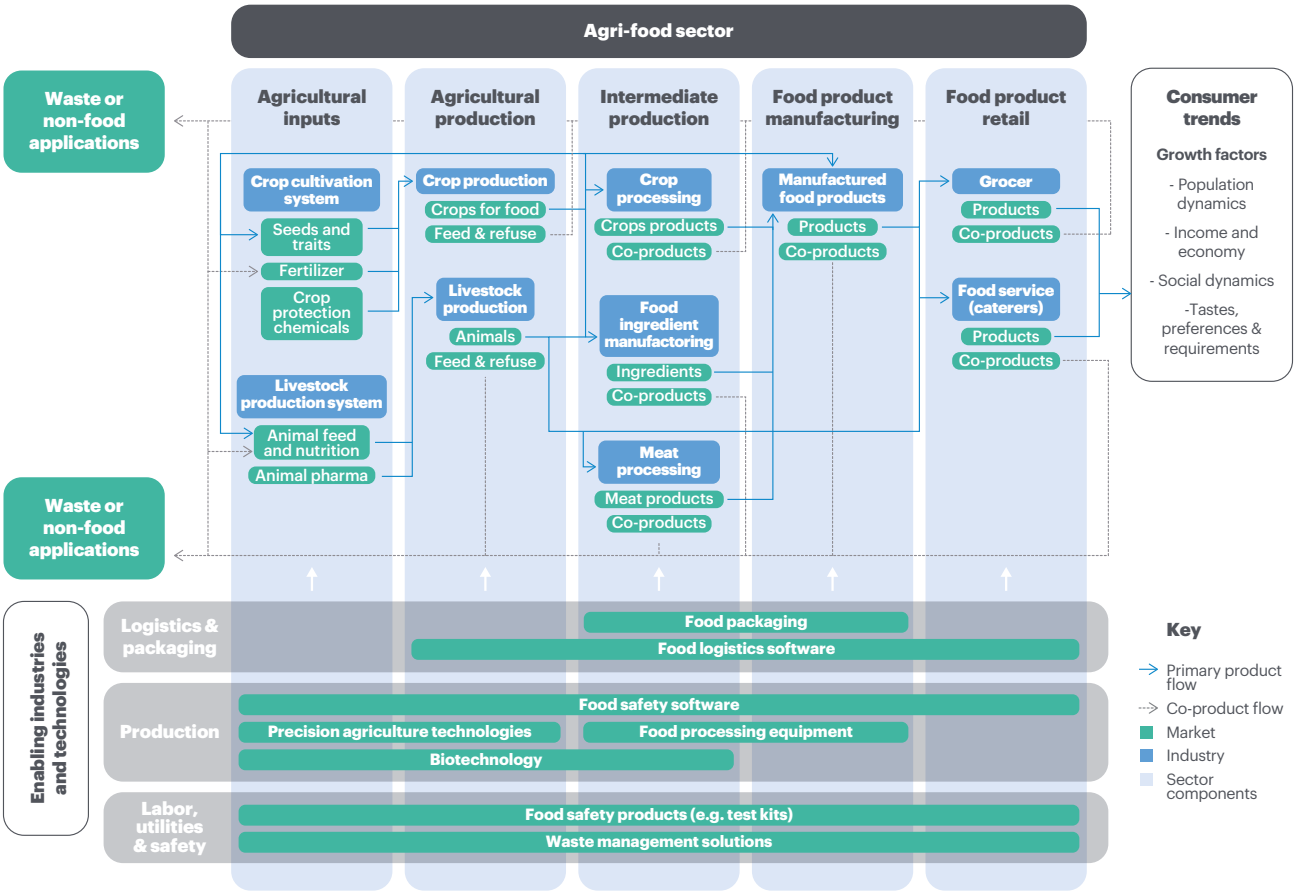
Denmark is another paradigmatic example of a region where crop and livestock farmers, companies, distributors, universities and government have been working together for years to turn its organic food sector into a global benchmark. It has secured the commitment of value chain stakeholders to champion quality, animal wellbeing and sustainability as priorities. The keys to its model are primarily research and innovation, facility technical development, the quality of the workforce and ground-breaking legislation. It is a successful model that has managed to raise the country's awareness to such an extent that organic foods now account for 80% of the public's consumption and it has become a global leader in exports.

Yet while European Research and Innovation Smart Specialisation Strategies pursue this goal, nonetheless actually building this type of consensus is a complex challenge that calls for not only individual responsibilities but also, and first and foremost, systemic approaches and **collective commitments.**

Foundations for consolidating a benchmark agro-food hub

These European examples show that in our setting we need to agree on models and to work together to bring them to fruition in order to consolidate a benchmark European Agrofood Hub. **Natàlia Mas**, Director General of Industry in the Government of Catalonia and CEO of ACCIÓ (Catalonia Trade & Investment), underscores the idea that "it is essential to weave networks of interconnection among local and international stakeholders in the value chain within the agro-food industry and the extensive support ecosystem". In fact, Catalonia and the continental region of southern Europe are benchmark food producers and processors. However, other European regions such as the Netherlands and Denmark have set up hubs and promoted themselves abroad as such.

Agro-food industry value chain



Source: Frost & Sullivan (2016). *Digital Transformation in the Global Food & Agriculture Market* – page 29

Fortunately, Catalonia already has **major precedents**. **Matilde Villarroya**, Secretary of Economic Affairs and European Funds in the Ministry of Economy and Finance of the Government of Catalonia, explains that "the Shared Agenda for the Economic Transformation of Lleida, the Pyrenees and Aran has made it possible to agree on a development and work model which engages regional stakeholders in implementing it".

Catalonia has drawn up a strategic plan which includes input from numerous agro-food value chain stakeholders in order to achieve a sustainable, safe, resilient and healthy food system with universal access. Indeed, the Strategic Food Plan of Catalonia (Pla Estratègic de l'Alimentació de Catalunya, **PEAC**) 2021-2026 represents a major step forward in this essential coordination of collective action. It is the outcome of many years of input from the Government of Catalonia through ACCIÓ (Catalonia Trade & Investment) and Prodeca to help agro-food businesses to grow in **international markets** and also of work done to drive specialised **clusters** such as the Foodservice Cluster, Catalonia Gourmet, FEMAC, INNOVAC and INNOVI.

Industry **fairs** also play an important role in fostering the ecosystem. They are led by Alimentaria which is accompanied by others including Alimentaria Foodtech, Hostelco, Hispack, Gastronomic Forum Barcelona, BioCultura, Seafood Expo Global, Free from Food Expo and the Olive Oil Fair. Local fairs are also important, such as Sant Miquel in Lleida and Sant Josep in Mollerussa

In Catalonia, the innovation drivers in this industry are companies, government, clusters, sector events and representatives of **consumers** and society. However, to consolidate a benchmark European hub, we also need the engagement of **research** and technology **centres, start-ups and investors.**

Jaume Sió, Head of the Technical Office of the Secretary General of the Ministry of Climate Action, Food and Rural Agenda of the Government of Catalonia, notes that "in **Catalonia we already have a benchmark European agro-food hub**. We just need to consolidate it and raise its profile based on the challenges facing society and businesses with a strong work and research focus." Here several experts point out that a powerful hub brand, name, vision and shared idea need to be built to position it and gain international recognition by emulating success stories such as the paradigmatic Silicon Valley.

Oscar Sala, director of The Collider, points out that "the digitalisation of the sector will enhance the international competitiveness of our agro-food industry. We have a mature ecosystem of innovation, a leader in Europe, and also excellent scientific production. If we combine both factors, we have the conditions to **become the next European Food Valley**."

According to **Santi Aliaga**, CEO of Zyrcular Foods, "Catalonia has to follow the new food trends and innovations and evolve from a traditional protein cluster to a global protein cluster. We have to unlock a project that goes from the farm to the table by integrating the value chain based on studying local seeds, crops, processing and protein concentrates, product manufacturing and innovation. We can also be a gastronomic benchmark in alternative protein products as well which will enable us to compete globally. Value has to be created across the production stages and not only in the end consumer stage."

The importance of research and transfer

Applied research and entrepreneurship are the keys to aligning food system priorities with people and the planet's limits; to stepping up the production of healthy, affordable foods in a sustainable way; regenerating the soil; fostering environmentally-friendly production systems, and reducing food waste.

According to **Gabriel Torres**, the Director of Innovation at Pascual, "the key areas guiding the sector's innovation are the sustainability of the planet, where this means reducing the carbon footprint throughout the entire value chain; circularity or making the most of resources and zero waste; advanced and personalised nutrition to lessen the impact of poor diet on illnesses; the 'Clean Label' and the zero mile in the shape of unprocessed and local foodstuffs, and Agrotech to incorporate digitalisation and automation. All of them are directly driven by consumers and their needs."

It is crucial to bring research and technology centres into the hubs to foster technological innovation. **Mireia Garcia**, the co-founder and Head of Ecosystem at Forward Fooding, notes that "at a global level, agro-food tech innovation is structured in several verticals: new food engineering; increasing soil sustainability; innovating in farmland; lowering food waste; promoting a circular food system; building a more efficient, traceable and transparent value chain; and personalised nutrition. The goal of all of them is to find alternatives that are socially, economically and environmentally more sustainable and that as a whole are capable of creating a more resilient food system than our current one."

In this sector, technological innovation has traditionally been sponsored by technology and equipment manufacturers. However, in order to promote more substantial and robust innovation in Catalonia, we need to include applied research centres more decisively in our ecosystem. Fortunately, Catalonia has outstanding **research and innovation groups and centres** such as IRTA, Agrotecnio, CRAG, CREAF, CTFC, the Fundació Alícia, el Bulli Foundation, Eurecat and Leitat. Their capacity to co-develop innovative tech solutions is essential in generating talent, capabilities, and business in large, medium-sized and small companies. While Catalonia has been a world leader in promoting the Mediterranean diet and a benchmark in gastronomy, it could now take the lead in each of the preceding links in the value chain including crops, animal husbandry, production and processing, study and innovation, the circular economy and reusing resources from the primary sector.

Creation and acquisition of start-ups

The creation of tech-based spin-offs by universities and centres aiming to reach the market is necessary yet perhaps no longer enough. To consolidate a benchmark agro-food hub, today it is vital to grasp and understand the increasing importance of **open innovation** paradigms.

Josemaria Siota, the Executive Director of the Entrepreneurship and Innovation Center at IESE Business School, says that according to a recent IESE study, "corporations are increasingly innovating via start-ups. They are taking advantage of the capabilities of corporate venturing enablers, outside players that connect established companies with start-ups and can be acost-effective driver in fast-tracking innovation. For example, Nestlé recently announced a partnership with Future Meat Technologies, a cultured meat start-up, to explore the potential of the components of cultured meat and incorporate them into future Nestlé products. Another example is the companies Migros, Bühler and Givaudan, which have launched a cultured meat partnership in The Valley in Kemptthal, Zurich. These companies are offering start-ups a product development laboratory as well as cell culture and bio fermentation capabilities to help them develop a product and launch it on the market."

These increasingly prominent actors from hubs include **venture builders** such as The Collider, private and corporate accelerators, venture clients and venture capital companies. **Santi Aliaga** adds that "it would be great if there were intercompany **tech transfer funds** to sponsor innovation projects and leverage their results". This type of partnership involving entrepreneurs working with stakeholders and companies enhances the value propositions of all parties.

Influence on small farms and the territory

Finally, the experts concur in noting that in order to consolidate an agro-food hub that is internationally recognised, we need to pay attention to the needs not only of large companies but also of medium-sized and **small farms**. It is particularly urgent to address their need to **access technology.**

For Catalonia to join the green and digital transformation, it is essential that innovation reaches small farmers and ranchers. Any innovation initiative in this sector that seeks to contribute to closing the current structural gap should bear Catalonia's family-based model in mind. **Connectivity** is one of the fundamental pillars of the capacity to absorb innovative technologies and solutions in the current scenario of digital transformation of the economy and society.

Additionally, these agro-food innovations must contribute to the **development of rural areas**. They can do this firstly by improving the productivity, efficiency and sustainability of primary production, and secondly by fostering the implementation of industries and services that can develop these innovations and supply them to end users. In short, by helping to raise incomes, thus making the sector and rural areas more appealing to women and the younger generations.

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Trends and innovations in agriculture and animal husbandry

According to the predictions by the United Nations Department of Economic and Social Affairs, the **world population** is expected to reach 8.6 billion by 2030, and **10 billion by 2050**. To guarantee a **sustainable future**, this gradual increase in the population is related, among other things, to the solving of four main challenges[1]:1) **feeding** the population, 2) reducing **food loss and waste** and optimising the risk of supply chain disruption, 3) protecting the **environment**, and 4) guaranteeing the **viability of** agricultural and animal husbandry **businesses**.

The growing demand should be met whilst maintaining the availability of natural resources. It is therefore necessary for the various stakeholders and political leaders to promote and adopt social and **technological innovations** in these areas.

To achieve sustainability in food production, production techniques and marketing channels must be implemented that generate **new opportunities** for agricultural and livestock farms, in both developed and developing economies.

The challenge of circular water management

According to the European Environment Agency, a third of European countries have low availability of water (less than 5,000 m3/capita/year). Indeed, water scarcity and quality, droughts, the effects of climate change and environmental pollution from wastewater and atmospheric emissions are major problems. This is borne out by the fact the Global Risks Report 2018, 13th edition, published by the World Economic Forum, identifies the water crisis as one of the main risks we face, even ahead of a possible food crisis.

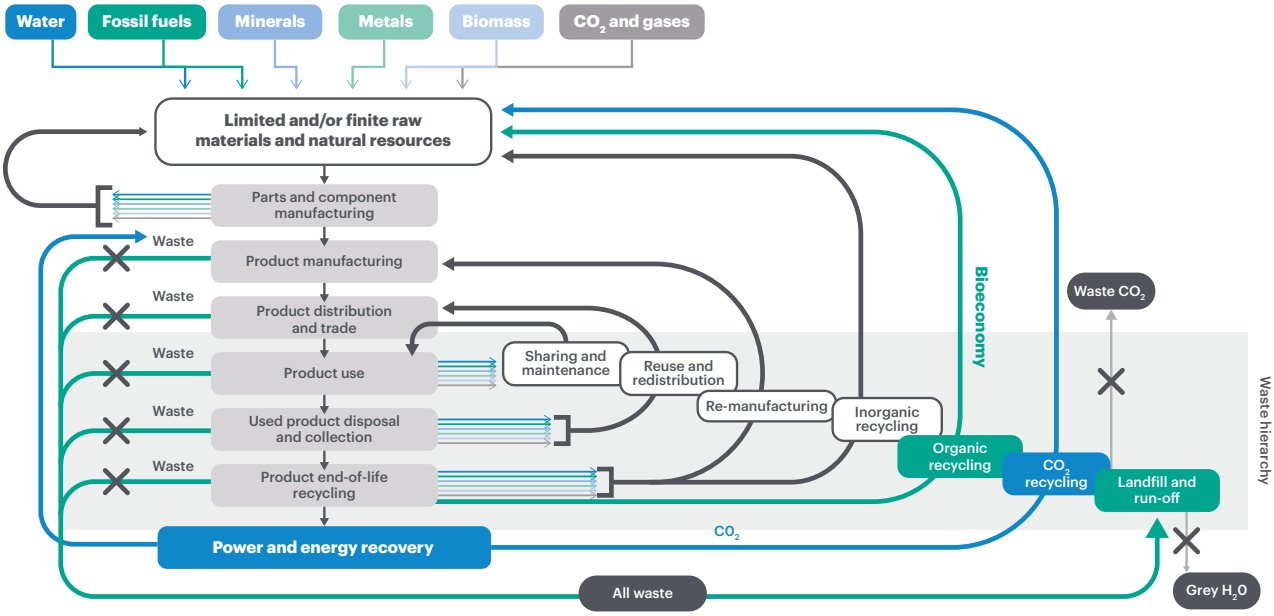
Ignacio Gavilán, Sustainability Director at The Consumer Goods Forum, identifies **four main challenges** in water management. “First of all, the fact that water is considered an inexhaustible public good, because it still rains, and the reservoirs are being filled. Secondly, pesticides, herbicides and chemicals used in agriculture sometimes find their way into water, depleting the oxygen content and leading to hypoxia. Thirdly, reduced wastewater treatment does not allow for water circularity. And finally, the fourth challenge: approximately 20% of the world’s aquifers are being overexploited and polluted”.

In this context, the trend is to explore innovative solutions that favour the transition to a **more circular water management model**. The recovery and use of wastewater treated for agricultural and industrial use is becoming a trend, because it offers a valuable alternative to the use of freshwater. Likewise, the treatment of water from agriculture and livestock farming helps mitigate water stress, the degradation of natural systems and treatment costs.

[1] Frost and Sullivan (2020) *Technology Innovation award - Controlled Environment Agriculture Industry.*

This is confirmed by **Sergio Ponsá**, Director of the BETA Technological Center of the UVIC-UCC: "Water management is one of the main challenges that needs to be addressed in the coming years. As the main water consumption sector, the agro-food industry must play a crucial role in the promotion of actions throughout the entire production chain in order to not only improve the quantity of water, but in particular the quality of water bodies. The sector still has plenty of room to implement technologies and solutions to reduce water consumption without affecting production. Measures must also be implemented to recover water for food production uses such as irrigation and cleaning, among many others. And here it must be said that in some cases the challenge is more regulatory than technological."

Circular Economy in Agrofood industry



Source: Frost and Sullivan (2019) - *Outlook of the Global Agriculture and Nutrition Industry - Adapting to Digitalization, Adopting New Business Models, and Searching for Palatable Meat Alternatives will Define the Agriculture and Nutrition Industry.* – page 56

The fact is that the circular economy is becoming increasingly important in political agendas. Proof of this is the **European Union Circular Economy Action Plan of 2015**, which was implemented in several countries and gave rise to the Spanish Circular Economy Strategy (EEEC), which proposes promoting sustainable water management, encouraging its use and reuse.

Emerging agricultural trends

Let us **take indoor farming** as an example. It is a current trend associated with the promotion of interesting innovations. Advanced greenhouses and vertical farms based on aeroponics and hydroponics present great R&D&I challenges, related above all to automation, mechanics and energy.

Lighting and ventilation strongly influence energy and water consumption, with a direct impact on the yields of these farms, which require very high financial investments. However, this **emerging agriculture based on controlled environments** can only be used with a limited variety of horticultural crops, despite disease control costs and risks associated with monoculture pests. These characteristics, related to long-term returns on investment, hinder the rate of adoption of advanced vertical farming techniques in small and medium-scale farms targeting local consumers.

Sophisticated initiatives such as this show that, at least in some countries, the agricultural sector has undergone major transformations. Especially since the 19th century, when mechanisation **expanded**, and, in particular since 1980, when one segment of the sector, pursuing maximised food production, progressively adopted digital technologies. Digitisation is, and will probably continue to be, a major innovation vector for the sector. However, over the last 20 years, the impact of **biotechnology** has revolutionised the sector.

Biotechnology and alternative proteins

Biotechnology is a clear trend in the agro-food sector, as well as a key area of innovation. According to **Enrique Cabello**, Cargill Regional Commercial Lead, France, Italy, Portugal and Spain grains and oils supply chain Europe: "Biotechnology will generate great benefits due to its impact on food security, protection of natural resources, animal welfare and increased profitability of farms. It will also have a direct impact on improving the transparency of the agricultural and food supply chain, expanding the portfolio of safe, healthy and environmentally friendly products. Its benefits will not be limited to nutrition but will also extend, for example, to medicine."

One of the fields with the most surprising advances is that of **in vitro meat production** based on cultured muscle cells, making it possible to produce meat without raising or slaughtering animals. In fact, **synthetic biology** allows biological systems to be designed with "ad hoc" functionalities. A synthetic chromosome has already been designed that can replace that of a bacterium, and some people claim that is just a matter of time before we use bacteria as **biofactories**, not only for therapeutic molecules but also for food purposes.

Jacint Arnau, senior researcher at IRTA, highlights the impact of biotechnology on sustainability, as well as the potential of **alternative proteins**: “Biotechnology can facilitate the production of more sustainable proteins for animal or human nutrition. The growth in cellular agriculture as a source of protein can be associated with the development of low-cost renewable energies that facilitate the microbiological transformation of a large number of coproducts. The possibilities of producing proteins based on mycelia, microalgae, yeasts and bacteria, open up a wide range of unexplored possibilities based on fermentation processes, which may be of key importance in creating sustainable proteins that reduce the need for water and land, as well as the generation of greenhouse gases. Moreover, biotechnology can help obtain more efficient plant varieties that are more sustainable and climate resilient for animal feed and finally reuse production waste more efficiently”.

Moreover, **genetic modification techniques** are used to add, delete, or modify DNA to silence, activate or modify an organism's genetic composition. This branch of biotechnology enables the editing of high-yield seeds that produce crops with specific features at apparently lower costs. **Teresa Capell**, Professor of Biotechnology at the University of Lleida (UdL), highlights their potential: “Genome editing techniques facilitate the production of pest-resistant plants, and they can be combined with the introduction of agronomic and nutritional characteristics that improve the plant. The farmer will produce more at lower cost and will be able to produce crops in areas where the water and soil quality are limited. One example of a product obtained using genome editing is gluten-free wheat, which is suitable for consumption by people with coeliac disease”.

It is to be expected that, in the coming years, long-term studies that correlate biological results with agricultural and socio-economic models will help clarify the benefits provided by genetically modified organisms.

Roberto Alvarez Abril, Head of Customer Engagement & Marketing Excellence MED at Bayer, also underlines the potential of biotechnology, referring to seeds to obtain “plants that require less water, tolerate salinity and heat, are more productive, resistant to pests and disease, and have specific nutritional characteristics. Let’s imagine, for example, gluten-free wheat, or maize with a higher vitamin content. If, moreover, we consider new genomic techniques (NGTs) for improving plants, or NGTs such as CRISPR, we obtain a wide range of possibilities. In biomedicine, they provide solutions for common or rare diseases and, in plants, they can incorporate the desired characteristics for both producers and consumers”.

So, biotechnology is a determining factor when it comes to increasing yield in the agro-food sector, as well as to reducing its environmental impact. According to **Andreu Martín**, CEO and President of Elian Barcelona and Executive Vice-President and General Manager, International at Benson Hill: “Biotechnology already makes a decisive impact when it comes to increasing the yield and quantity of food that has to be produced to meet the objective of feeding over 10 billion inhabitants on Earth by 2050.

However, it is not just a matter of more quantity, but also of improving the quality of what we produce. The regions considered to be at risk – including Catalonia and Spain –are responsible for working in biotechnology in order to produce more responsible food: high quality and sustainable. We are already on the way, because we have companies that work in biotechnology to supply the food chain with more sustainable products, which save production processes and, therefore, the wasting of natural resources such as water and soil, as well as emissions and energy consumption".

Precision agriculture

The concept "Smart Agriculture" refers to precision agriculture and digital agriculture, which both aim to **optimise the efficiency of farms**.

According to the International Society of Precision Agriculture (ISPA, 2019[2]), precision agriculture is a management strategy that gathers, processes and analyses **temporal, spatial and individual data** and combines it with other information to support management decisions according to estimated variability. The objective of this precision agriculture is to improve efficiency in the use of resources, as well as the productivity, quality, profitability and sustainability of agricultural production.

Precision agriculture allows for the **collection of data** in real time on the climate, soil and air quality, crop maturity, and equipment. This type of agriculture is mainly based on **GPS**. However, today, making the most of advances in information and communication technologies (ICT), farms across the globe are evolving from "simple" precision agriculture to smart agriculture.

Smart agriculture

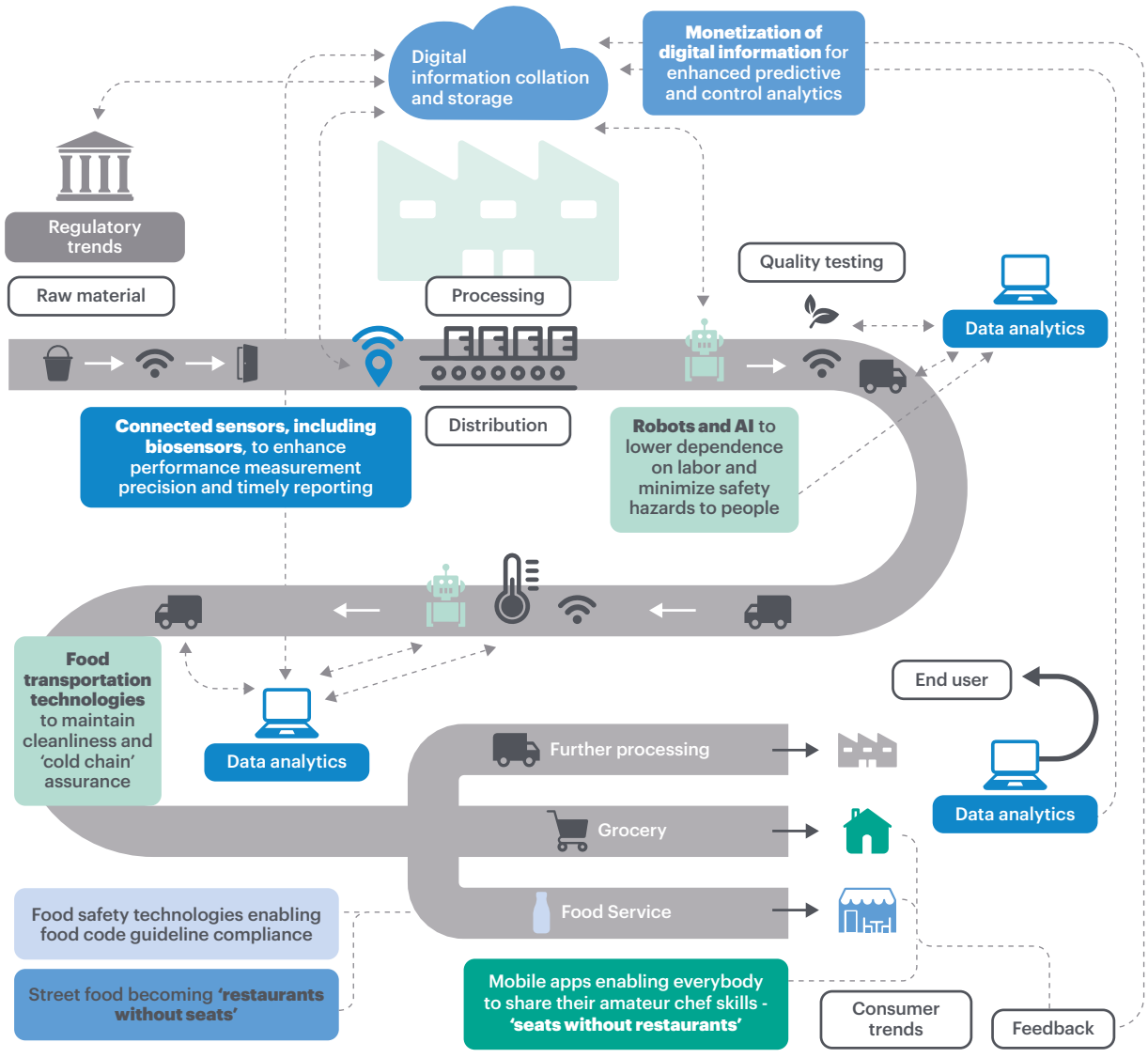
Unlike precision agriculture, smart agriculture involves **mass data communication in real time** among various digital technologies (automation, artificial intelligence, and robotics), to provide operative statistics[3].Smart agriculture paves the way for an efficient route for monitoring, tracking, analysing and optimising various agricultural assets and production processes.

In this paradigm, farmers **systematically monitor** the key parameters that have a direct impact on crop **yield**, animal rearing (temperature, humidity, nitrates, growth, diseases, animal welfare, etc. and the condition of the farms, using **sensors and other technologies**.

[2] International Society of Precision Agriculture: www.ispag.org/about/definition

[3] Frost and Sullivan (2020) *Novel Innovations Facilitating Digital Transformation of Agricultural Sector _ Utilization of Innovative Digital Technologies to Enhance Farm Productivity and Profitability.*

Smart agriculture andlivestock farming



Source: Frost and Sullivan (2019) - *Outlook of the Global Agriculture and Nutrition Industry - Adapting to Digitalization, Adopting New Business Models, and Searching for Palatable Meat Alternatives will Define the Agriculture and Nutrition Industry.* – page 39

David Giné, CEO at Semillas Batlle, confirms this: "Smart agriculture has a key advantage: it improves resource efficiency. This is because it allows resources to be applied in the best way possible in order to maximise the results. It is essential so as to achieve more productive varieties and the farms' maximum yield, always in a sustainable way. However, it must be borne in mind that the investment required by farms to be smarter clashes with the Spanish type of agriculture, which is based on smallholdings and without large farms in the hands of large companies. Instead, there are small farmers who find it hard to make major financial investments. The prices of many agricultural products need to be improved, and small farms must be helped to promote repayable investments".

In the agricultural sector, different types of sensors, including optical, electrochemical and mechanical sensors, enable accurate weather forecasts, the detection of crop stress and disease several weeks in advance, thereby reducing crop loss by around 25%.

Smart farms

Livestock farming is also gradually benefiting from sensors and connectivity. According to **Eudald Casas**, Manager of INNOVACC, the Catalan association of Innovation in the pig meat industry: "The introduction of sensors to obtain data in real time is currently the most powerful technological solution for farms in the pig sector. At the cluster, we promote innovative projects to implement sensors on farms, which among other things allow pollutant gases and CO2 to be controlled. Thus, they help improve the environment and the quality, control the yield and final quality of the meat, minimise the risks of diseases or death, promote genetic selection, etc. The introduction of sensors to obtain data in real time allows these data to be processed and helps improve the processes, products, genetics, environment and logistics. In short, it enables improvements throughout the entire process".

Joan Jovellar, Pig Breeding Director at Grupo Vall Companys, says that based on his own experience progress is already being made in rolling out ICT plus IoT and Big Data technology: "Digitalisation and the emergence of information technology are helping us to better manage farms both technically and financially by improving efficiency and efficacy. For example, in summer with high outdoor temperatures, **Farm 5.0** allows us to control indoor environmental parameters using solar coolers. This yields a 30% saving in water and a 20% reduction in droppings, a 16% increase in animal growth and a 3% improvement in the feed conversion rate, which means 6 kg less feed per pig and thus lower costs and less natural resource usage."

Technology providers, innovation drivers

So, in addition to sensors, **other technologies** are also worthy of note[4]:

- **Sensor fusion** technologies refer to the distribution of multiple sensors and their combination with wireless data processing hardware. This solution acts as a source for the detection, diagnosis and forecast of soil variations and crop evolution.
- Agriculture **drones** capture multispectral images and use advanced accessible usability capabilities. They enable aerial inspections of the scope, health and yield of farms and favour farmer decision-making.
- **Hyperspectral imaging technology** enables the extraction of imaging on the basis of wavelength analysis. Hyperspectral imaging (HIS) devices are capable of analysing all the pixels in the landscape and provide analysis of spatial and spectral details by combining all the data available. These devices provide knowledge related to crop and soil health prior to visual inspection.
- **Autonomous farm equipment** refers to lightweight, small, autonomous, energy-efficient machines working together to weed, fertilise and control pests and diseases, all the while collecting valuable data that can later be used to correct and improve the process.
- Other trends include agricultural **robots** and, for livestock, the growing use of cattle **biometry**.
- The storage and processing of the farm data in **cloud and blockchain platforms** enhances the farmers' decision-making ability. Over the next few years, an increase is expected in the automation of agricultural production with the capacity to assume the high expenditure involved: installation and maintenance costs, the costs of acquisition of specialists as well as for the management of cybersecurity risks.

Itis considered that the innovation drivers, and at the same time the great beneficiaries of these operations, will be equipment and **machinery suppliers**, providers of specialised **products** and, finally, **technological companies** that install connectivity, smart telephony, sensors, machine-to-machine (M2M) solutions, big data analytics, geomapping and other applications. The successful deployment of these technologies requires **collaboration** between the various stakeholders in the sector's value chains.

[4] Frost and Sullivan (2016) *Analysis of the Smart Agriculture Technology Market - Technology Integration in the Agriculture Ecosystem will Increase Production Yields and Drive the Technology Market*

4 Trends and innovations in the food industry

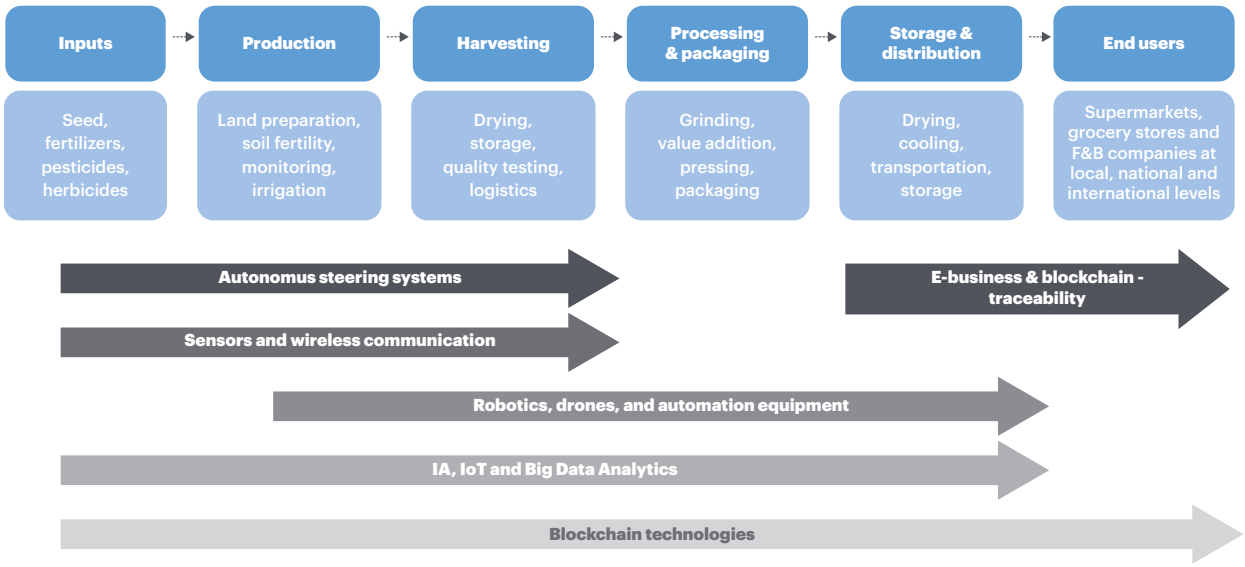
Globalisation has not only increased import and export activities, it has also created security threats to the food supply chain. The acquisition of raw materials and food ingredients from various suppliers has become normal, and the large geographical distances covered by some food products increase storage and transport risks. In a world with major regulatory differences between countries, the growing demand for exotic and new foods is also driving **food security** issues.

Security solutions in the agribusiness

In **agribusiness**, security issues are related to the need to manage the changing global socioeconomic environment, as well as its impact on the demand for secure agricultural production on a global level. However, this is also a question of resource efficiency in agricultural and food production driven by the growing need to improve **sustainability**, efficiency and **profitability**.

Quoting the FDA as the source, the Frost &Sullivan report (2017) "Opportunity in Global Food Safety Diagnostics Market" indicates that around 15% of the food consumed in the United States is imported, and that this has led to an increase in the level of pollution by mycotoxins and pesticide residues in the food supply chain. In addition to adulteration, other incidents may occur due to the inadequate follow-up of microbial contamination, the inability to trace products and ingredients because of the complex supply chain, and errors related to labelling.

Digitization of the Agrofood industry: Global panorama



Source: Frost and Sullivan (2019) - *Novel Innovations Facilitating Digital Transformation of Agricultural Sector* - page 17

In short, **food safety** paradigms are imposed in line with several factors: sensitivity to food fraud, regulatory requirements, the progressive culture of quality and risk management in the industry, the training of value chain staff, external impact and risk assessment practices, **supply chain** optimisation, social responsibility, and, finally, investment in new technologies.

Along these lines, the President of the Port of Barcelona, **Damià Calvet**, highlights the key role played by technology, "a basic tool for maintaining and developing **import-export traffic**, since it enables health and quality monitoring and the efficient distribution of the product. The digitisation and electronic transmission of documentation under protocols that make it 100% trustworthy, enables document inspection and the preparation of any measures required during importation".

From the use of chemicals on farms, food processing, storage and retail outlets, the trend is clear throughout the entire food supply chain: **food safety and traceability** are crucial, and therefore are expanding in the agro-food industry.

Digitisation and safety

"Smart Food" refers to food that, through the application of new technologies, preserves food safety, improves its nutritional value and health benefits, and is more in line with consumers' needs and preferences.

Cristina Rodríguez, Quality Manager at Europastry, highlights the links between safety, traceability and innovation: "Both traceability and food safety, in addition to guaranteeing the consumer's rights, are beneficial in terms of innovation for the agro-food industry. Traceability systems are established that make it necessary to have in-depth knowledge of the processes carried out in a company. This information is very valuable for advancing in the improvement of products, promoting the products' attributes, learning about and improving stock management and, finally, standardising or homogenising processes".

Along these lines, in recent years there has been an increase in the demand for profitable technologies for monitoring and sharing information on food production and products. The efficiency of the proactive control of expired or mishandled food, its traceability and alerts or corrective actions throughout the value chain have been linked, among other things, to the following **technologies**:

- barcodes and RFID
- sensors and chips
- microarray systems
- characterisation techniques (X-rays, ultraviolet, infrared)
- advanced diagnostic kits (single-domain antibodies, bacteriophages, PCR)
- robotics and automation in supports related to diagnostic kits

- programme solutions
- mobile device and smartphone applications for real-time monitoring
- cloud computing and cloud-based solutions
- software as a service (SaaS).

Automation of the food industry

It is thought that[5] **automation** will continue to be the main driver of the large-scale **agro-food industry**, a priori labour intensive, which strives to obtain greater yieldsat lower costs.

According to **Ricardo Márquez**, Director at Alimentaria FoodTech & Alimentaria México, "the development of Industry 4.0 reveals the need for the food and beverage production model to evolve .From improving the efficiency of resources and use of waste, to achieving a more sustainable and safe distribution model, with all that that implies: packaging, traceability, cold chain optimisation, etc.".

Trends in this area include:

- The main manufacturers of processing and packaging equipment are increasingly investing in automation to reduce manual handling and the impact of human error on food **safety**, as well as labour costs.
- Automation, which is also aimed at resolving **production incidents** by means of early warnings and guidance on the most suitable decisions to resolve them.
- The adoption of sophisticated, fast and continuous technological **quality control** solutions is the driving force behind the Internet of Things (**IoT**) for the production market and traceability.
- Greater **productive flexibility** is also a key advantage in Industry 4.0, which at one extreme allows for the personalisation of orders.
- Finally, the analytical functions of big data enable faster and more precise decisions to be made, and promote the **distribution and marketing** of agro-food products.

Along those lines, it is to be expected that semiautomatic and automatic equipment will see an increasing demand in this industry.

[5] Frost and Sullivan (2020) *Technology Innovation award - Controlled Environment Agriculture Industry.*

Investments in the manufacturers' technology

In the food and beverage manufacturing market, investments in process automation equipment and technology are a key competitive factor.

Josep Lagares, Metalquimia Executive President Chief Executive Officer, explains that **smart industry** is already a reality. "Big data and artificial intelligence will be of key importance for improving processes, visualising the product line and flow, to control traceability, to manage formulae and recipes, to manage incidents and, finally, for the maintenance system. Robotics, especially in meat processing plants, will also be consolidated, since the value proposition of robots is to reduce costs and accelerate production lines, increasing productivity and reducing labour costs. For some time, robots, collaborative robots and artificial vision have been used in the meat-processing industry, because they have helped to reduce costs. Moreover, robots are extremely hygienic; they reduce human contact with the food, which is one of the main sources of contamination in the industry".

In this field, it is expected that robotics, artificial intelligence and management control software, from food **processing** to its **packaging**, will play a more important role. It is expected that in the coming years a large number food processing plants will become digitised, because in this industry that deals with large volumes and small margins, the emergence of new technologies can bring increases in efficiency directly related to competitiveness. In addition to saving money and time, the Internet of Things (IoT) will focus on personnel and data security.

Next generation technologies

The report by Frost & Sullivan (2018) "Technologies Enabling Food Safety" considers that the **emerging technologies** with probable impact over the next five years are:

- **Synthetic biology** is an emerging technology that enables safer and healthier food as a result of the powerful combination of various disciplines such as biology, design, engineering and information technology. Synthetic biology techniques will be ideal for designing crops and foods that are resistant to diseases.

- **Artificial intelligence** (AI) is revolutionising the food industry, not just about risk and safety, but also in terms of the supply of raw material, the classification and storage of products, etc. The successful implementation of AI requires considerable technology readiness, not only within the organisation but also for associated stakeholders. Moreover, the practical application of technology, combined with the cost, the performance and user acceptance, continue to pose challenges in the wider adoption of AI.

- The implementation of **blockchain** technology will considerably strengthen the food safety infrastructure due to the impact it makes by nipping the problem of food contamination in the bud. With blockchain, incidents of fraud will be easier to investigate because of the availability of a database related to the food item's production and supply chain. Blockchain solutions are still in their infancy, and the lack of cases of proven use acts as a challenge for blockchain's deployment on a global level.

- Point-of-care (**PoC**) food safety **devices** can guarantee timely intervention in the event of contamination during operations to reduce wastage in the retail chain. Now, with a growing health awareness among the general population, consumers can use these devices to check the safety of restaurant foods, packaged foods or foods in markets, for example. Although PoC devices are already available on the market, in the future hand-held, lab-on-a-chip devices and IoT-connected devices are expected to appear.

- **Printed electronics** play a vital role in developing flexible components such as smart labels used for IoT applications. Advances in printed electronics will improve food and beverage consumption safety for consumers through the integration of different types of sensor and indicators.

- **Thermosonication** is a new process for treating food that involves the simultaneous application of ultrasound waves and moderate heat for the inactivation of enzymes and microbial growth. Thermosonication is more energy efficient than conventional heat treatment and safer and more reliable than the application of ultrasounds. It has gained prominence in recent years due to the fact that it is quick, precise, non-invasive and non-destructive.

Regarding AI, **Susana Pastor**, IT Barcelona Hub Manager at Nestlé, highlights its great potential in the food and beverage industry. "AI can virtually transform all processes. McKinsey & Company estimate that AI could be worth around 14% of the industry's global sales, in other words around USD 1.4 trillion.The main transformative value of AI is in operations (70%), more specifically in manufacturing and the supply chain, with process optimisation and predictive maintenance applications. This is followed by marketing and sales (25%) with the optimisation of the marketing mix and prediction of demand and sales; and the development of new products (5%), with better models for the creation of products based on consumer data."

Acquisition of technologies from other industries

It is expected that emerging technologies from other industries will also have a decisive influence on the future of the global food and beverage sector: biosensors, genomics, enzyme engineering, big data analytics, 3D-printing and packaging.

- Rapid advances in **biosensor** technology and its convergence with big data platforms will improve global food safety, and at the same time will provide new platforms for carrying out accurate food testing.It is also likely to affect the food packaging industry.
- Unlike other technologies that will make a visible impact in the short term, **genomics** is more likely to have a significant impact on global markets in the long term, influencing the substantial increase of the global production of food with modified genetic traits.
- It is likely that advances in **enzyme technology** will be driven by the increasingly significant use of genetic engineering platforms to improve the processing, extraction, yield and quality of a wide range of food and beverage products.
- **Big data** platforms will have a wide-ranging impact on various technological platforms for the use of emerging **sequencing tools** to improve global food safety in the near future.
- It is likely that **3D-printing** technologies will simplify the clean and efficient printing of both home-cooked food and gourmet products.The technological convergence of big data and robotics platforms will also help increase the development of innovations in 3D-printing.

Laura Gil, Digital Transformation Manager at Damm, complements this vision, highlighting three new trends: “Digital Twins, 3D-printing and 5G will mark the difference in Industry 4.0 and will be a key factor for guaranteeing smart, agile factories that are capable of adapting to constantly changing industrial environments. “Digital Twins”, because it allows future situations to be recreated in the current environment and decisions to be made based on real predictions.3D-printing, because it enables prototypes of end products and spare parts and machinery to be made, avoiding stoppages and increasing productivity. Moreover, **5G-based communications** will encourage remote work in the industrial sector. This will enable production to be diversified geographically, production and demand peaks to be reached, and avoid travel for repairs, etc.At present, thanks to the mixed and augmented reality, repairs and validations are carried out remotely, as well as more suitable practical training for the real work environment”.

Smart packaging

It is also thought that in the next few years, **safe, connected and sustainable packaging** will become more common and more widely used by manufacturers, driven to a great extent by consumer preferences.

However, there is a greater focus on sustainable, safe **packaging** solutions that extend the product lifespan. Consumer demands encourage rapid progress in packaging technologies with the following **emerging trends**:

- environmentally friendly packaging
- smart packaging technologies
- nanotechnology packaging
- use of hybrid materials
- use of biological materials, such as bioplastics
- active packaging systems
- edible packaging

Certainly, the evolution in **consumer demand** encourages rapid progress in the application of food packaging technologies and, more specifically, emerging trends in the use of environmentally friendly packaging that discourages waste: the use of hybrid materials; the return of paper, glass and metal to minimise the consumption of plastics; nanopackaging, etc. Increasingly aware of the human impact on the environment, consumers will continue to focus on the recyclability of materials, and companies will promote innovations in environmentally friendly materials as alternatives to plastics, which support this trend.

5
The consumers, a source of innovation

Although the food industry's constant investments in technological innovations are a differentiating factor that determines the growth of this market, the increase in consumer awareness of **safety, quality and sustainability** is also encouraging food and beverage producers, processers and distributors to offer more effective alternatives and new solutions.

Jaime Martin, CEO and Founding Partner at Lantern Innovation, sums up the current **consumer preferences and demands**, which "no longer simply strive for health, but rather a broader concept of wellness, which combines physical, mental and spiritual health. Moreover, we are increasingly aware of the impact of our purchasing decisions on people and the planet, and many are re-assessing how to achieve a better, more sustainable and more just food system."

The public is learning more about the types of food and beverages consumed, their impact on foodborne diseases, other syndromes and pathologies, and, in short, about their impact on **health and well-being**. The "farm to fork" paradigm is slowly being integrated, and consequently so are the demands for food safety guarantees in the different segments of the food industry value chain: production, processing, packaging, distribution, storage and preparation in homes.

Despite this new context, the **price** of products and society's **habits** are still limiting this factor. **Joan Riera**, Director of the Food Sector at Kantar Worldpanel, explains this with data: "The consumer demands good, healthy, sustainable, local and safe products. But they are not always prepared to pay a higher price for these products or to change any habits in order to consume them. For example: we buy over 70% of our ham packaged rather than going to the supermarket with a food container so as to reduce waste. And 75% of households consume kiwis every year, a product that mainly comes from other continents, which is a less sustainable option than consuming seasonal and local fruit. It is important to differentiate between what we say, what we want to do, and what we really do. Although we want to be healthy and sustainable, for the moment the data show that we are not as healthy or sustainable as we would like to be".

New consumer trends

The evolution in consumer demands drives advances in food packaging technologies and explains **new trends**[6]:

- **Alternative proteins:** Education and awareness also highlight the need for alternatives to meat, a wide range of substitutes and, in general, innovation in products based on alternative proteins: plant-based protein, cell-based protein, mycoprotein, insects, etc..
- **Diversity:** The speed at which consumers learn, facilitated by the digital content published on apps, social media and multimedia platforms, promotes the broader demand for food options.

[6] Frost and Sullivan (2019) *Outlook of the Global Agriculture and Nutrition Industry. Adapting to Digitalization, Adopting New Business Models, and Searching for Palatable Meat Alternatives will Define the Agriculture and Nutrition Industry.*

- **Functionality and health:** The trend is for foods with few ingredients, low in salt and sugar, gluten free and with limited processing. Consumer health requirements also drive the demand for plant-based drinks and functional foods.
- **Labelling:** The last points are in line with the demand for clear, transparent labelling, which is reliable and easy to read and understand.
- **E-commerce:** The role of intermediary and retail companies evolves as producers can be contacted directly.
- **Personalisation of orders:** e-commerce facilitates the personalisation of orders as well as the delivery of food and other value-added services.

The boom in functional foods

For years there has been scientific evidence about the relationship between food and health, particularly about cardiovascular diseases, some types of cancer and other degenerative diseases. In industrialised societies, where most of the population's basic nutritional needs are covered, there is an increasing demand for functional foods with traditional sensorial attributes, but which provide **health benefits or a help reduce the risk** of disease.

There has been a spectacular increase in the **range of functional products** on sale. There are many different possible ways of making functional foods. Among other things, they can be based on:

- the incorporation of ingredients, in general of natural origin, with biological activity in conventional food items
- the elimination of unwanted ingredients
- the modification of certain ingredients
- the increase in the concentration of an ingredient that is naturally present, with health benefits.

On the market we can find foods containing high concentrations of:

- fatty acids or sterols
- bioactive peptides
- antioxidants
- proteins
- prebiotic carbohydrates
- products enriched with minerals or vitamins
- products fermented using probiotic bacteria.

The **European regulation on nutritional claims and the health properties of foods** constitutes an important step forward in regulating the advertising and labelling of these foods. It establishes the rules the food industry has to follow to indicate whether a food has certain health properties. It is a regulation subject to obligatory application in each Member State with an important role being played by the European Food Safety Authority (EFSA).On a state level, the Spanish Agency for Food Safety and Nutrition (AESAN) plays a key role in assessing the scientific bases sustaining claims, as well as establishing "nutritional profiles".

Advances in personalised nutrition

In addition to continuing to study the molecular mechanisms of the effects of nutrition on health, in the future, there will be specific ongoing studies of interest to health on the components and ingredients of food as well as other positive health benefits of the consumption of functional foods. In this regard, advances in the study of the **interaction between genetic factors and nutrition** are essential.

The aim of nutritional genomics, nutrigenomics and nutrigenetics is to design a **personalised diet to prevent or treat diseases** by studying individual responses to certain diets in accordance with specific variations in the genome.

Consumer trends that drive the demand for personalised diets include health and well-being, weight control, sports and physical condition. The **strategic association with the healthcare sector** and interaction with different technological innovations will provide support for the growth of freedom and personalised nutrition markets.

Ignasi Papell, Food Industry Business Development Manager at Eurecat, indicates that "personalised nutrition will not arrive in the near future. We are already working on precision nutrition to refine dietary recommendations for specific sections of the population in accordance with different variables. However, it is necessary for the industry and distributors to join forces in order to offer personalised products, and to help consumers to choose those most suitable for them in line with their desired lifestyle. Finally, analysis costs, based on the omics sciences, must be reduced in order to make it progressively affordable to discover our genetic configuration, our metabolism and our microbiota so as to eat in the best possible manner, and to live longer and better".

Freedom Food is a rising trend

Consumer-driven food trends reinforce the search for healthier, organic and personalised foods and beverages, which encourage the convergence of technologies from other areas. In this context, the term **"freedom food"** is used to refer to products that are not only safe but also **green, healthy and ethical.**

Millennials are demanding food without undesirable attributes. The values of healthy nutrition and other factors such as allergic reactions and religious and cultural differences increase the demand for food that, despite being more expensive, they are increasingly willing to pay for. The demand for freedom food, with desirable attributes for human health and the environment is growing in its **different manifestations**:

- organic food, food free of synthetic products, pollutants and allergens
- sustainable, ethically produced food
- nutritious functional and nutraceutical food, of high quality and especially nutritious
- kosher and halal foods
- foods with animal welfare certificates

The preference for freedom food is growing worldwide, driven by this generation. According to Frost & Sullivan (2018) in "Freedom Foods and Personalised Nutrition: Market Overview; Challenges and Opportunities", **the global market** for these foods was over USD **4.6 trillion** in 2007.Although the market still faces **several challenges**, in particular regarding taste, texture and lifespan, it is hoped that research will continue to overcome these challenges, thereby reinforcing the demand and, therefore, the growth of this market.

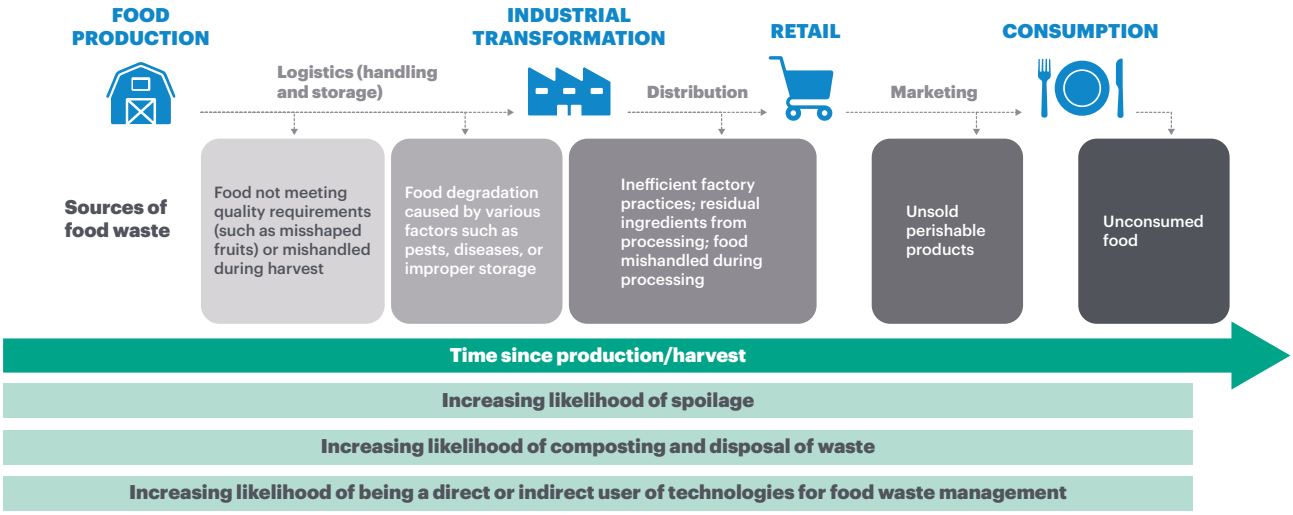
A growing segment of consumers in the food and beverage sector will continue to demand healthy, environmentally friendly products, which are ethically produced and highly nutritious. These products with high added value will **drive future innovation**. For example, it is predicted that **natural preservatives** will be highly sought after to reduce food spoilagea nd keep it fresh as long as possible without affecting its natural profile. However, above all, it will be of key importance to optimise the economic and environmental costs of food production, promoting **production** that is more **environmentally friendly**.

Sustainable production

It is predicted that not only will the way in which **sustainable** food is produced, processed and consumed be transformed, but also how it is moved, stored and **marketed**.

In this area, innovations related to **food waste** still have a long way to go. **Marta Angerri** Director of European Finance and Public Affairs, Sustainability and CSR at Grup Ametller Origen, highlights the fact that "food waste is an environmental and social problem: it is estimated that over one third of all the food produced is wasted. To reduce food waste, actions need to be undertaken across the entire food value chain. On the one hand, preventatively, adjusting production, offer and demand. On the other hand, by establishing corrective mechanisms, such as sales with discounts and donations to NGOs of products close to their expiry date. These actions can be complemented with projects such as "Too Good To Go", the app that enables establishments to offer customers products close to their expiry date at a third of the retail price".

Food waste in Agrofood Industry value chain



Source: Frost and Sullivan (2019) - *Outlook of the Global Agriculture and Nutrition Industry - Adapting to Digitalization, Adopting New Business Models, and Searching for Palatable Meat Alternatives will Define the Agriculture and Nutrition Industry*- page 49

Without a doubt, one of the main reasons for food shortages is food loss at different stages, including logistics. This has economic, environmental and social consequences due to its effects on the use of limited resources such as land, water and fuel. The production of quality **organic food** by small producers, which is distributed at local markets to meet local needs, is of significant economic, ecological and social value and seems to have a promising future. In Catalonia, in 2018 the land given over to organic food production saw 5% year-on-year growth, and the number of organic operators (marketers, importers, producers and processors) increased by almost 9%[7]. Over 60% of the destinations for most of the sales of these products were in Catalonia and Spain.

However, many companies, both agricultural and livestock rearing, still face the **challenge of selling** better, whether this be because they are not reaching the right market, due to infrastructural shortcomings in the food chain, or due to the precariousness of their own structures. In this respect, according to **Teresa Botargues**, Advisor in Economic Transformation at Diputació de Lleida, "local sales of organic and high quality products by small producers require measures in order for them to continue to grow and become consolidated. The support and size of the distribution networks of local products, the development of shared infrastructures and the promotion of initiatives to connect local production and consumers are some of the measures proposed in the Strategic Food Plan for Catalonia 2021-2026 (PEAC) to achieve this goal".

The trends indicate that, faced with the progressive supply options, the consumer of organic products will buy online or else choose the points of sale based on different factors such as accessibility, convenience, choice, value-added services and the level of social and environmental commitment.

[7] Generalitat de Catalunya (2019) Informatiu especial sobre Producció i Consum local d'Aliments Ecològics [Special newsletter on the Production and Local Consumption of Organic Food] - Setmana Bio per l'alimentació ecològica [Organic Week for ecological food].

Innovative gastronomy

In this context, **committed gastronomy** in entities, educational centres, associations, companies, and restaurants that form part of the "Slow Food" movement will also help put consumers in touch with local organic producers, becoming examples of outstanding social innovation. The report "Good food is good business. Opportunities driving the future of affordable nutrition" developed by the Institute for the Future (IFTF) and commissioned by the Bill & Melinda Gates Foundation, forecasts that by 2030 the definitions of food safety will include longer-term dimensions and will encourage people to recognise the wealth of knowledge in the world's food traditions.

This is confirmed by **Begoña Rodríguez**, Director at BCC Innovation, the gastronomy technological centre at the Basque Culinary Center: "In the field of gastronomy, we can clearly observe a back to the roots trend, to giving greater importance to products, with less focus on preparation techniques. People are looking for the "perfect product": high quality; the one most suitable for preparing each dish. And in this respect, vegetables and pulses play a special role. They are the undisputed stars of cuisine and will continue to be in the coming years. Along these lines, "BCC Innovation" has developed a project to recover local varieties that used to be grown on our land years ago. The project has involved the use and cultivation of new varieties of products such as tomatoes or peppers and has allowed restaurant owners to broaden the range of products they use, and producers to diversify their crops and improve the use of their land. In general, it has helped boost the promotion of our country's biodiversity".

Large food companies with advanced R+D capacities are probably well placed for helping to create the basis for scientific evidence on traditional diets and the micronutrients they provide. These **scientific research** methods can also be applied to discover completely new foods and techniques that may affect food health and accessibility.

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Authorship

This report is based on research carried out by **Roser Salvat Jofresa**[8], who also wrote it

[8] Roser Salvat Jofresa et al. (2019) Smart Food Technological Watch Report, and Roser Salvat Jofresa et al. (2020) Smart Rural Technological Watch Report. Ed. PRUAB.

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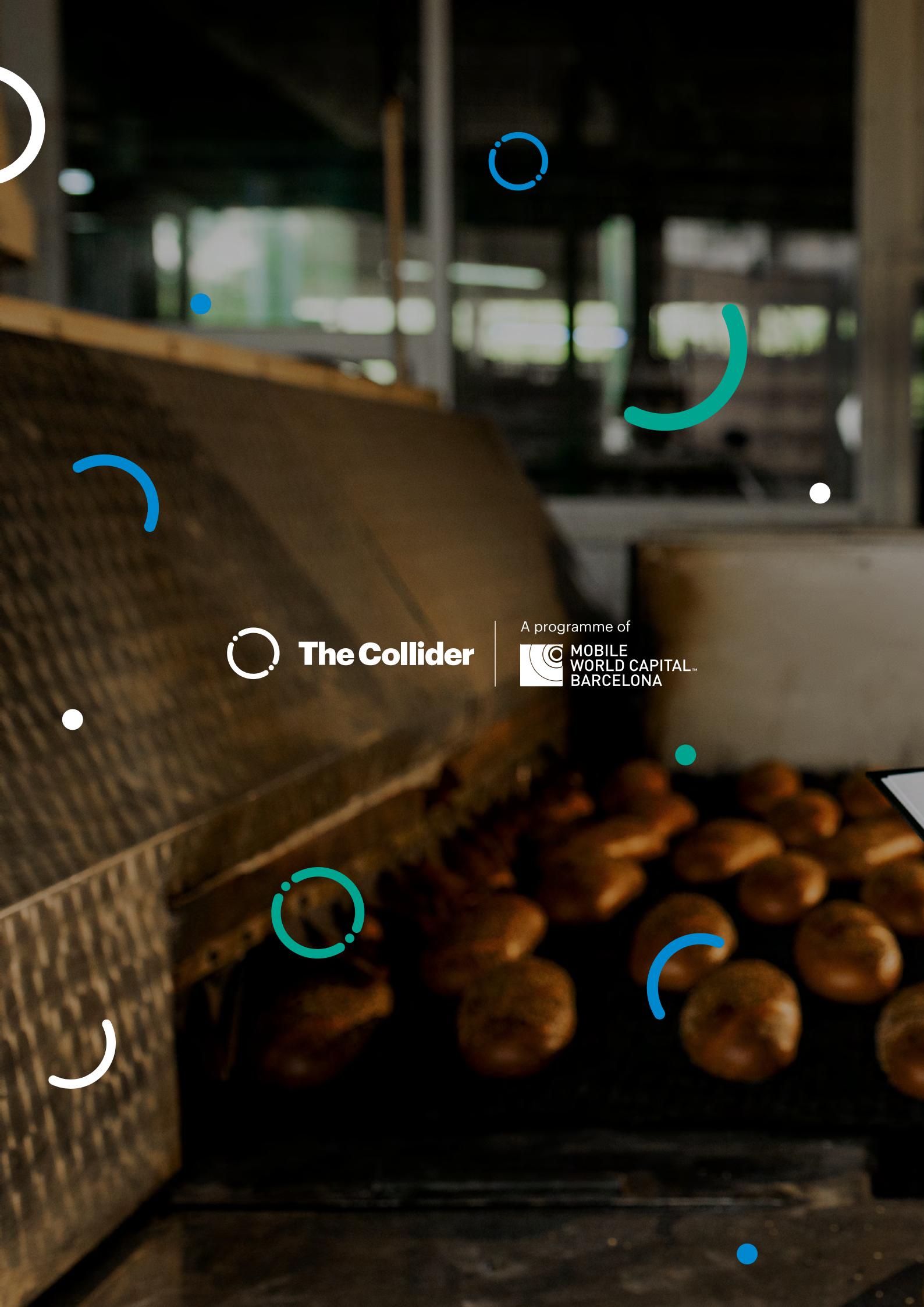
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