Article

A Guide for the Food Industry to Meet the Future Skills Requirements Emerging with Industry 4.0

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Abstract: The food industry has recently faced rapid and constant changes due to the current industrial revolution, Industry 4.0, which has also profoundly altered the dynamics of the industry overall. Due to the emerging digitalisation, manufacturing models are changing through the use of smart technologies, such as robotics, Artificial Intelligence (AI), Internet of Things (IoT), machine learning, etc. They are experiencing a new phase of automation that enables innovative and more efficient processes, products and services. The introduction of these novel business models demands new professional skills requirements in the workforce of the food industry. In this work, we introduce an industry-driven proactive strategy to achieve a successful digital transformation in the food sector. For that purpose, we focus on defining the current and near-future key skills and competencies demanded by each of the professional profiles related to the food industry. To achieve this, we generated an automated database of current and future professions and competencies and skills. This database can be used as a fundamental roadmap guiding the sector through future changes caused by Industry 4.0. The interest shown by the local sectorial cluster and related entities reinforce the idea. This research will be a key tool for both academics and policy-makers to provide well-developed and better-oriented continuous training programs in order to reduce the skill mismatch between the workforce and the jobs.

Keywords: skills; workforce; food industry; Industry 4.0; digitalisation

1. Introduction

The term “food industry” encompasses any company that produces, processes, manufactures, sells and serves food, beverage and dietary supplements [1]. It refers to 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) [2].

In recent times, the food industry has gone through rapid and constant changes caused by the recent industrial revolution, Industry 4.0. The term “Industry 4.0” has been used to refer to the innovative production processes which are partly or completely automated via technology, and devices communicating autonomously with each other along the value chain activities [3]. Thus, it is basically based on intelligent networking of machines, electrical equipment and novel Information Technology (IT) systems enabling processes optimisation and increased productivity of value creation chains [4,5]. The digital transformation is the key element of the ongoing industrial revolution [4,6]. Here,
the digitalisation concept does not refer to a simple transfer from “analogic” to digital data and documents. It rather represents the networking between the created interfaces, the business processes, the data exchange and management [7]. Therefore, rapidly growing digitalisation has been extremely transforming the dynamics of most industries, including the food industry. The manufacturing models are changing through the development of smart technologies such as advanced robotics, a new generation of sensors, Artificial Intelligence (AI), Big Data, Internet of Things (IoT), Machine Learning, Cloud Computing, Machine to Machine (M2M) communication etc. The use of these key enabling technologies (KETs) facilitates a new phase of automation that results in innovative and more efficient processes, products and services. The aforementioned digital technologies could be ex novo applied to a new plant, as well as can be adapted to existing plants [8].

Up to now, despite all the challenges, Industry 4.0 has been regarded as a great opportunity for the progress of the food sector [2,9–11]. There have been successful attempts to keep up with the next industrial revolution. Technological developments have enabled higher efficiency rates during the manufacturing stage and lower production costs, thus, generating products with greater added value, which is critically important when there is a high level of competition among manufacturers [9]. Moreover, food security has recently been a great concern and food safety has been a top priority internationally. IoT technology, one of the key technologies of Industry 4.0, has been proven to be a solution to this concern, as it allows to identify the product and provides its traceability from cultivation to the production chain during food processing [10]. It was also demonstrated that the adoption of Industry 4.0 within the food supply chain environment of the food sector could contribute immensely to the achievement of sustainability [11]. The integration of more 4.0 technologies such as AI, Big Data, Machine Learning, M2M (and others mentioned in the previous paragraph) will lead to a faster industrial transformation in the food sector. It will change the business abruptly, facilitating the production of higher quality food products in a shorter time and at a lower cost.

The main condition for defining the expected evolution of skills requirements is to draw a general portrait of the future food industry by clarifying the industrial changes brought up by Industry 4.0. First of all, thanks to the real-time data provided by the smart and automated production systems, the workers will be able to make more accurate decisions in a short time, dealing with complex situations in the near future. Due to the advanced robotics technology, simple and monotonous tasks will be taken by collaborative robotic systems while operators carry out more qualified work and make critical decisions [12]. Concurrently, the significance of human intervention in the maintenance and supervision of machines will increase [12]. Industrial organisations will become more team-oriented due to the integration of artificial intelligence tools, and the traditional top-down hierarchal structures will lose strength. Teamwork between co-workers as well as between workers and assistant systems will be more and more important [13]. In general, the job profiles will be demanded to carry out tasks with a much broader scope. Therefore, the workers will be expected to have a wider knowledge and expertise in several subjects [12].

The main observed consequence of the mentioned technological changes is the fast-growing demand for technological skills [12,14,15]. They include basic digital skills as well as advanced technological skills, such as programming [14]. Additionally, awareness of data security and data protection will gain more importance as a result of this demand [12]. The demand for social and emotional skills (which the machines are a long way from learning) will also rapidly increase due to the adoption of the advanced technologies [12,14] As stated, due to the increasing automation and digitalisation of industrial processes, the workforce will be responsible for more complex tasks. The execution of those tasks will require numeracy, solid literacy, problem-solving, and information and communication technologies (ICT) skills as well as soft skills of autonomy, collaboration and coordination [15,16].

Demand for cognitive skills will be mainly altered from basic to higher ones; the increasing automation of machines will decrease the amount of the tasks that demand basic cognitive skills (such as
basic data processing) [14]. Higher cognitive skills, such as creativity, critical thinking, teamwork, problem-solving, decision-making, lifelong learning, and so on will become very crucial [12,14].

Furthermore, skills such as managing complexity, complex information processing and abstraction for obtaining a simplified representation of the bigger picture will be demanded from the near future workforce [15]. Skills such as decision making, critical thinking and independent problem solving will be considered crucial especially in reviewed technical profiles, such as production operators and control technicians [12]. Moreover, the demand for managerial, communication and organisational skills will increase significantly [12,15].

The required physical and manual skills for the job profiles will be redefined depending on the range of automated work activities. In general, the demand for physical and manual skills will also drop, but it will still remain the largest category of workforce skills in the near future [14].

Green skills are considered key to maintain the competitive edge of the European manufacturing industry as a result of the increased focus on environmental awareness and sustainability. Therefore, in the near future in Europe, the workforce (including the food industry) will be expected to master green skills.

Overall, as a result of Industry 4.0, the near-future workforce is expected to have more accentuated social, emotional, higher cognitive and technological skills, than basic cognitive, physical and manual skills [14]. The general trend points to a greater need for technological knowledge and less administrative and technical knowledge.

In conclusion, the food industry demands new professional skills from its workforce. Therefore, there is a high demand for a continuous update of the qualifications, skills and knowledge of its workforce in order to create a highly qualified, multi-skilled labor force that can handle all the technological progress [17,18]. Through this updating process, the food industry workforce of today and tomorrow, will be able to adapt to digital transformations, changes in production processes and newly introduced working practices and patterns of which are mostly connected with computer sciences [19,20]. Addressing the current skill needs and foreseeing the future skill requirements of the sector is the first step of the continuous skills update of its workforce. In this work, we have achieved this through the generation of a sectorial database. After that, a strategy should be developed for reducing the skills gaps between the jobs and the workforce. It should involve not only attracting and developing the new talents needed, but also re-skilling current employees through well-organised training and education programs, as well as re-designing work processes [3].

The food industry has been lacking a specific roadmap that guides the sector through the industrial revolution 4.0. The sector urgently needs a strategy for establishing and meeting current and future skills requirements. Therefore, the food industry needs to develop tools for implementing new skills and competences, for which reviewing the approaches already taken by the other sectors (construction, steel, automotive, etc.) would be very beneficial. Additionally, the sector needs to identify directives for education policy-makers, so that related degrees, subject syllabuses, and continuous training programs become aligned with these skills needs. Our work is developed in order to fill this gap. In this work, we firstly introduced a strategy adapted from several European sectorial projects to meet the future skills requirements and create a highly qualified and competent workforce. After, we focused on identifying the current and near-future key skills and competencies demanded by the professional profiles (engineers, operators and managers) of the food industry. We used ESCO’s (European Skills, Competences, Qualifications and Occupations) research as the main source for identifying the current food sector-related job profiles and needed skills for each profile. Then we generated an automated database for the current skills of these profiles using Visual Basic for Applications (VBA) in the excel format. During the development of the future skills and competences, we analysed all the job profiles present at the database one by one and we selected the ones which will be transformed by digital technological developments. We benefited from respectable European references through collecting data from the European ICT Professional Role Profiles framework and several strategic sectorial and inter-sectorial European projects. After identifying the additional skills that will be needed for each
profile in the near future, we added them to our database and completed the update for the near-future skills requirements for the job profiles. Ultimately, we generated an automated database for current and future skills requirements for each professional profile, which can be used as a fundamental framework by the food sector through all the midterm-future changes caused by Industry 4.0. Therefore, the target end-users of the developed database are the companies of the food sector, the training centers and universities that are responsible for designing and delivering convenient training programs to provide the aforementioned skills needs.

We believe that our work will be a key tool providing guidelines to the food industry to build a workforce meeting the future skills requirements and guiding the sector leaders as well as the academia to offer better oriented and well-developed continuous training programs.

2. Materials and Methods

In this chapter, first of all, we present a strategy for the food industry to meet the current and future skills requirements in order to overcome the challenges coming with Industry 4.0, make good use of digitalisation and keep up with the latest technological innovations.

The activities encompassed by this long-term skills strategy should focus on making the workforce pro-active to the implementation of new technologies that help to optimize food manufacturing and increase efficiency. In order to reduce the time required for the full digital transformation process, these activities should constantly supervise the implementation of industrial skills in training programs and develop the required tools for that implementation [20–22].

The industry-driven proactive strategy should involve the next steps in order to achieve a successful digital transformation in the industry:

1. The first step is evaluating the current state of the digital transformation of the food industry [20], and analysing the key trends about the upcoming technological developments [21]. After identifying the main technological developments and the related required skills and competencies, a future scenario can be developed. Economic development related to digital transformations should be also considered [11,20]. The manufacturing processes and workforce that are affected by the digital transformation will be determined.

2. This step involves identifying the skills and professional job profiles that will be needed in the future and determining the skills gaps that are created by the current and the foreseen technological developments [20,21]. The most crucial part of this step is to identify the skills demands of the industry in proactive ways, taking skills gaps and shortages into account [20]. An automated database of the sector-related job profiles defining the needed skills and competencies will be generated. It will enable an internationally common ground and mutual recognition for the needed skills and jobs in the food industry.

3. As the next step, the training and curricula requirements will be determined considering the skills gaps, and then, the training programs will be created for the selected skills and job profiles [21]. New methods should be discovered to implement education content in a rapid and effective way, not only in the companies but also in the formal education and training institutions. Training programs should be upgraded and updated continuously to reach a higher quality [20]. Talent management and recruitment processes should be also included in the training process [20].

4. Better matching between skill requirements of the food industry and skills provided by training centers will be assured [21]. New standards will be developed for the sector skills recognition [20].

5. The next step will be finding out new methods to attract more talented people to the food industry and improve the opportunities for a more diverse talent pool, and overcome recruitment challenges [20–22].

6. The final step is called monitoring. All the adjustments coming with the strategy will be monitored continuously to adopt upcoming new developments [9].

This work involves the first two steps of the strategy.
During the execution of our work, to develop the database presented herein, we used the ESCO database and the European ICT Professional Role Profiles framework (generated by the Council of European Professional Informatics Societies (CEPIS) and European Committee for Standardization (CEN)) as the main data sources. We also took several strategic sectorial and inter-sectorial European projects as a reference, in some of which we directly took part or acted as collaborators: ESSA (steel sector) [20], DRIVES (automotive sector) [21], APPRENTICESHIPQ (Procedures for Quality Apprenticeships in Educational Organisations) [22] and SMeART ((Digitalization of Small and Medium Enterprises, SMEs) [23]. Therefore, it is compulsory to give definitions of the references in order to clarify our study. ESCO is the European multilingual classification of Skills, Competences, Qualifications and Occupations. In other words, it is a dictionary that describes, identifies and classifies professional occupations, skills, and qualifications relevant for the labor market, education and training [24]. It is directly linked to the International Standard Classification of Occupations (ISCO) which is a classification of occupation groups managed by the International Labor Organization (ILO), since the information and data in ESCO are based on an original work published by the ILO under the title “International Standard Classification of Occupations”, ISCO-08. CEPIS is a non-profit organisation seeking to improve and promote a high standard among informatics professionals in recognition of the impact that informatics has on employment, business and society [25]. CEN is an association that brings together the National Standardisation Bodies of 34 European countries supporting standardisation activities in relation to a wide range of fields and sectors [26]. The European ICT Professional Role Profiles framework was generated with the help of these two organisations in order to contribute to a shared European reference language for developing, planning and managing ICT professional needs in a long-term perspective and to maturing the ICT profession overall [27].

Additionally, during the generation of the automated database for the job profiles, VBA was used as the programming language in Microsoft Word Excel file.

3. Results and Discussion

Our aim was to generate an automated database for skill requirements (current and near-future) for all the professional profiles related to the food sector.

We based our work on ESCO’s research using it as the main source for identifying the current sector-related job profiles and needed skills for each profile. First, we selected the professional profiles related to the food industry in the ESCO database which is in word excel format. Once all the sector-related job profiles were extracted and integrated into a new excel file, the automation process was carried out using VBA and an automated database was generated in the excel format. This database included only the current skills needs of the job profiles.

During the development of the future skills and competences, we collected data from the European ICT Professional Role Profiles framework and benefited from several strategic sectorial and inter-sectorial European projects. In order to incorporate the near-future skills requirements of the job profiles into the database, we studied all the job profiles one by one and selected the ones which will be transformed by the digital technological developments. During this process, we used the aforementioned European projects as a guide to analyse what kind of job profiles related to these sectors (steel, automotive, smart engineering etc.) have undergone modification through digital transformation. We observed that job profiles that have common roles in all of the industrial areas (food, steel, automotive, etc.), such as project manager, production manager etc. will need the same kind of modifications in their skills requirements in the future. For that purpose, we identified job profiles in the food industry with equivalent roles in other sectors that have already undergone changes, and we selected their future skills requirements. Later, we also identified future skills needs for profiles that are specific to the food industry through a detailed analysis. Then, we added the new skills and competencies to our database and updated the needed skills for the altered job profiles. Furthermore, the European ICT Professional Role Profiles framework provided us the specific job profiles of which skills have undergone changes through Industry 4.0 as well as the additional skills
that will be required by these profiles in the near future. We added the mentioned future skills of the professional profiles that were already present in our database and completed the update for the near-future skills requirements for the job profiles. Figure 1 demonstrates an example tab of the generated database for the food industry. In this specific case, the ‘food grader’ professional profile is used as an example. The first four rows of the table show a hierarchical order of the occupational groups; in this case, the job profile ‘food grader’ belongs to the ‘Food and beverage tasters and graders’ group, which is a part of the bigger occupation group ‘Food processing and related trades workers’, and so on. The database also provides a weblink to ESCO’s webpage where we can find all the introduced data related to the job profile. In the table, we can also see alternative names used for the same job profile in food sector and the ISCO number of the profile, which can be interpreted as an international code of the occupation for the International Standard Classification of Occupations (ISCO). Additionally, the table shows the essential and optional knowledge and skills currently needed for the job profile, as well as the future skills that we introduced after a detailed analysis.

The skills that are currently demanded by the food sector and extracted from the ESCO database are in black, while the future skills (essential and optional) that are generated with the help of ICT Professional Role Profiles framework European Union sectoral projects and several other sources are in red. The complete version of the table (Figure 1) is provided in Figure S1 in Supplementary Materials.

Since this is an automated database, we can call it a smart table. For example, in the excel table of Figure 1, when a job profile is introduced in the cell related to the professional job profile (changing ‘food grader’ to another profile), all the data related to the new profile appears automatically in the table, replacing the information related to the ‘food grader’ profile. The automation of the database allows us to reach the current and future skill needs of any professional profile immediately. This makes the database a very functional tool during the development of the training programs.

Tables 1–3 present a brief view of the last version of the automated database: the professional job profiles related to the food industry, their definition, ISCO numbers and the key skills demanded by these job profiles. All the data here is provided by ESCO. Table 4 demonstrates our contribution to the database: future skills requirements demanded by the mentioned job profiles. These newly introduced skills are mainly transversal and technological ones generated by Industry 4.0 and they are highlighted in the red colour since they represent our addition to the database. We used 7 job profiles as an example. The complete version of the documents, Tables 1–3, can be found in the Supplementary Materials as Figures S2–S4 respectively.
Craft and related trades workers
  Food processing, wood working, garment and other craft and related trades workers
  Food processing and related trades workers
  Food and beverage tasters and graders

| Professional Job profile: | food grader |
|-------------------------|-------------|
ESCO link: [http://data.europa.eu/esco/occupation/b4306d87-7992-47fc-914a-4485a4e7003c](http://data.europa.eu/esco/occupation/b4306d87-7992-47fc-914a-4485a4e7003c) |
Alternative labels: food product grader

Description: Food graders inspect, sort and grade food products. They grade food products according to sensory criteria or with the help of machinery. They determine the product’s use by grading them into the appropriate classes and discarding damaged or expired foods. Food graders measure and weight the products and report their findings so the food can be further processed.

ISCO number: 7515

### Essential
- knowledge
  - food preservation
  - food product ingredients
  - food safety standards
  - risks associated to physical, chemical, biological hazards in food and beverages

### skill/competence
  - apply requirements concerning manufacturing of food and beverages
  - assess nutritional characteristics of food
  - keep up-to-date with regulations
  - perform food risk analysis
  - perform food safety checks
  - perform sensory evaluation
  - prepare visual data

### Optional
  - knowledge
  - advise on food preservation
  - analyse samples of food and beverages
  - apply scientific methods
  - develop standard operating procedures in the food chain

### Future skills
  - data analysis and mathematical skills
  - quantitative and statistical skills
  - basic digital skills
  - cybersecurity
  - inspecting and monitoring skills
  - use of digital communication tools
  - critical thinking and decision making
  - adaptability and continuous learning
  - complex information processing and interpretation
  - IoT technology
  - collaborative/autonomous robots
  - big data
  - cloud computing
  - sensors technology
  - machine learning
  - traceability

### Optional
  - adaptability and continuous learning
  - teaching and training the others
  - active listening
  - process analysis

**Figure 1.** An example tab of the automated database generated for the job profiles in the food industry.
Table 1. A brief view of the automated database (in excel format) including the description, alternative names and ISCO numbers of the professional profiles related to the food industry.

| ESCO Occupation          | Food Production Manager | Food Production Operator | Food Safety Specialist | Food & Beverage Packaging Technologist | Food Production Engineer | Food Analyst | Food Technician |
|--------------------------|-------------------------|--------------------------|------------------------|----------------------------------------|--------------------------|--------------|----------------|
| web link to ESCO         | http://data.europa.eu/escoclassification/foodproductionmanager | http://data.europa.eu/escoclassification/foodproductionoperator | http://data.europa.eu/escoclassification/foodsafetyspecialist | http://data.europa.eu/escoclassification/foodbeveragepackagingtechnologist | http://data.europa.eu/escoclassification/foodproductionengineer | http://data.europa.eu/escoclassification/foodanalyst | http://data.europa.eu/escoclassification/foodtechnician |
| Alternative labels       | no alternative labels   | food production manager/factory worker | food production controller/trainee food safety specialist/factory safety controller/senior food safety specialist/scientist | food and beverage packaging expert/factory and drinks packaging specialist/factory and drinks packaging expert | food engineer | food researcher/factory research specialist/factory analysis expert/factory analysis specialist | food tech expert/factory technology expert/factory technology specialist/factory tech specialist |
| Description              | Food production managers oversee and monitor production and have overall responsibility for staffing and related issues. Hence, they have a detailed knowledge of the manufacturing products and their production processes. On the one hand, they control process parameters and their influence on the product and on the other hand, they ensure that staffing and recruitment levels are adequate. | Food production operators supply and perform one or more tasks in different stages of the food production process. They perform manufacturing operations and processes to foods and beverages, perform packaging, operate machines manually or automatically, follow predetermined procedures, and take food safety regulations on board. | Food safety specialists organise processes and implement procedures to avoid problems with food safety. They comply with regulations. | Food and beverage packaging technologists assess appropriate packaging for various food products. They manage matters in relation to packaging while ensuring customer specifications and company targets. They develop packaging projects as required. | Food production engineers oversee the electrical and mechanical needs of the equipment and machinery required in the process of manufacturing food or beverages. They strive to maximise plant productivity by engaging in preventive actions in reference to health and safety, good manufacturing practices (GMP), hygiene compliance, and performance of routine maintenance of machines and equipment. | Food analysts perform standardised tests to determine the chemical, physical, or microbiological features of products for human consumption. | Food technicians assist food technologists in the development of processes for manufacturing foodstuffs and related products based on chemical, physical, and biological principles. They perform research and experiments on ingredients, additives and packaging. Food technicians also check product quality to ensure compliance with legislation and regulations. |
| ISCO Number              | 1321                    | 8160                     | 2263                   | 2141                                   | 2141                      | 3111         | 3119           |
Table 2. A brief view of the automated database (in excel format) including essential skills, knowledge and competences needed by the professional profiles related to the food industry.

| Food Production Manager | Food Production Operator | Food Safety Specialist | Food & Beverage Packaging Technologist | Food Production Engineer | Food Analyst | Food Technician |
|-------------------------|--------------------------|------------------------|----------------------------------------|--------------------------|-------------|----------------|
| essential               | essential                | essential              | essential                              | essential                | essential   | essential      |
| knowledge               | knowledge                | knowledge              | knowledge                              | knowledge                | knowledge   | knowledge      |
| financial capability    | food safety principles   | food legislation       | packaging engineering                  | electrical engineering   | food safety principles | food and beverage industry |
| food and beverage industry | food preservation       | packaging functions    | electronics                            | food safety standards   | food preservation |
| food legislation        | food storage             | packaging processes    | food storage                           | food science             | food product ingredients |
| quality assurance       | product package          | quality assurance      | food toxicity                          | functional properties of foods |
| methodologies           | requirements             | methodologies          | labatory-based sciences                | Lombardy-based sciences |
| skill/competence         | skill/competence          | skill/competence       | skill/competence                        | skill/competence         | skill/competence |
| analyse production       | administer ingredients   | control food safety    | analyse packaging requirements         | apply GMP                | apply GMP   |
| processes for improvement| in food production       | regulations             | | analyse characteristics of food products at reception |
| analyse trends in the    | develop food safety      | apply GMP              | apply HACCP                            | | apply HACCP |
| food and beverage industries | programmes              |                        | analyse samples of food and beverages  | | apply HACCP |
| apply control process    | apply HACCP              | apply HACCP             | apply requirements concerning         | apply GMP                | apply GMP   |
| statistical methods      |                         |                        | manufacturing of food and beverages    |                         | apply requirements concerning manufacturing of food and beverages |
| apply HACCP              | be at ease in unsafe    | keep task records      | configure plants for food              | apply requirements     | clean food and beverage |
| environments             | environments             | care for food aesthetic| industry                               | concerning manufacturing of food and beverages |
| apply requirements       | carry out checks of      | maintain personal      | identify innovative concepts in        | assess nutritional      | ensure public safety and security |
| concerning manufacturing | production plant         | hygiene standards      | packaging                               | characteristics of food  | |
| of food and beverages    | equipment               |                         | develop food production processes      |                         | |
| communicate production   | clean food and          | monitor packaging      | disaggregate the production plan       | identify the factors     | |
| plan                    | beverage machinery      | operations             |                                    | causing changes in food | |
| control of expenses      | disassemble equipment   | plan inspections for    | disassemble equipment                  | manage all process       | |
| ensure cost efficiency   | ensure refrigeration     | prevention of          | attend to detail regarding              | engineering activities  | |
| in food manufacturing    | in the supply chain     | sanitation violations  | food and beverages                     |                           | |
| identify hazards in the  | ensure sanitation        | prepare reports on     | manage all processengineering activities|
| workplace                |                          | sanitation             | blend food ingredients                  | |
| implement short term     | follow production       | monitor packaging      | manage delivery of raw materials       | |
| objectives               | schedule                 | operations             |                                        | |
|                          |                          |                        |                                        | |
Table 3. A brief view of the automated database (in excel format) including optional skills, knowledge and competences needed by the professional profiles related to the food industry.

| Skill/Competence | Food Production Manager | Food Production Operator | Food Safety Specialist | Food & Beverage Packaging Technologist | Food Production Engineer | Food Analyst | Food Technician |
|------------------|--------------------------|--------------------------|------------------------|----------------------------------------|--------------------------|-------------|----------------|
| Adapt production levels | adjust drying process to goods | analyse samples of food and beverages | assess HACCP implementation in plants | analyse work-related written reports | analyse packaging requirements | adjust production schedule | |
| Advocate for consumer matters in production plants | administer materials to tea bag machines | assess food samples | detect microorganisms | assess HACCP implementation in plants | analyse trends in the food and beverage industries | administer ingredients in food production | |
| Apply foreign language for international trade | apply different dehydration processes of fruits and vegetables | audit HACCP | develop new food products | be at ease in unsafe environments | analyse work-related written reports | analyse packaging requirements | |
| Assess environmental plans against financial costs | apply extruding techniques | develop food policy | develop standard operating procedures in the food chain | ensure compliance with environmental legislation in food production | apply scientific methods | analyse production processes for improvement | |
| Ensure continuous preparedness for audits | apply preservation treatments | ensure correct goods labelling | ensure correct goods labelling | ensure full functioning of food plant machinery | assess environmental parameters at the workplace for food products | analyse work-related written reports | |
| Hire new personnel | check bottles for packaging | monitor sugar uniformity | keep up-to-date with regulations | food plant design | assess food samples | apply control process statistical methods | |
| Lead process optimisation | check quality of products on the production line | use instruments for food measurement | label foodstuffs | lead process optimisation | assess shelf life of food products | apply food technology principles | |
| Manage medium-term objectives | conduct cleaning in place | participate in the development of new food products | write work-related reports | check quality of products on the production line | be at ease in unsafe environments | | |
| Manage staff | dispose food waste | interpret extraction data | detect microorganisms | | | |
Table 4. A brief view of the automated database (in excel format) including the future skills requirements of professional profiles related to the food industry.

| Food Production Manager | Food Production Operator | Food Safety Specialist | Food & Beverage Packaging Technologist | Food Production Engineer | Food Analyst | Food Technician |
|-------------------------|--------------------------|------------------------|----------------------------------------|--------------------------|-------------|----------------|
| future skills essential | future skills essential | future skills essential | future skills essential | future skills essential | future skills essential | future skills essential |
| advanced communication and negotiation skills | advanced data analysis and mathematical skills | data analysis and mathematical skills | basic digital skills | basic digital skills | data analysis and mathematical skills | advanced data analysis and mathematical skills |
| leadership and managing others | use of complex digital communication tools | quantitative and statistical skills | advanced data analysis and mathematical skills | advanced data analysis and mathematical skills | quantitative and statistical skills | use of complex digital communication tools |
| adaptability and continuous learning | Interpersonal skills and empathy | basic digital skills | cybersecurity | advanced IT skills & Programming | basic digital skills | Interpersonal skills and empathy |
| critical thinking & decision making | adaptability and continuous learning | cybersecurity | use of complex digital communication tools | use of complex digital communication tools | cybersecurity | adaptability and continuous learning |
| personal experience | teaching and training others | inspecting and monitoring skills | advanced IT skills & Programming | cybersecurity | inspecting and monitoring skills | teaching and training others |
| active listening | active listening | use of digital communication tools | entrepreneurship and initiative taking | advanced communication skills | use of digital communication tools | active listening |
| work autonomously | basic numeracy and communication | critical thinking and decision making | adaptability and continuous learning | leadership and managing others | critical thinking and decision making | basic numeracy and communication |
| quantitative and statistical skills | basic data input and processing | adaptability and continuous learning | critical thinking & decision making | entrepreneurship and initiative taking | adaptability and continuous learning | basic data input and processing |
| complex information processing and interpretation | advanced literacy | complex information processing and interpretation | basic numeracy and communication | adaptability and continuous learning | complex information processing and interpretation | advanced literacy |
| process analysis | complex information processing and interpretation | process analysis | basic data input and processing | teaching and training others | process analysis | complex information processing and interpretation |
| creativity | process analysis | initiative taking | advanced literacy | critical thinking & decision making | initiative taking | process analysis |
| complex problem solving | creativity | advanced IT skills & Programming | quantitative and statistical skills | active listening | advanced IT skills & Programming | creativity |
| basic digital skills | complex problem solving | traceability | complex information processing and interpretation | complex information processing and interpretation | traceability | complex problem solving |
| advanced data analysis and mathematical skills | IoT | adaptability and continuous learning | process analysis | process analysis | adaptability and continuous learning | IoT |
| cybersecurity | Manufacturing Execution System (MES) | IoT technology | creativity | creativity | collaborative/autonomous robots | Manufacturing Execution System (MES) |
### Table 4. Cont.

| Food Production Manager | Food Production Operator | Food Safety Specialist | Food & Beverage Packaging Technologist | Food Production Engineer | Food Analyst | Food Technician |
|-------------------------|--------------------------|------------------------|----------------------------------------|--------------------------|-------------|-----------------|
| use of complex digital communication tools | traceability | cloud computing | complex problem solving | complex problem solving | IoT technology | traceability |
| advanced IT skills & programming | cybersecurity | big data | traceability | traceability | big data | cybersecurity |
| interpersonal skills and empathy | cloud computing | sensors technology | collaborative/autonomous robots | collaborative/autonomous robots | cloud computing | cloud computing |
| entrepreneurship and initiative taking | big data | machine learning | IoT technology | IoT technology | sensors technology | big data |
| Manufacturing Execution System (MES) | collaborative/autonomous robots | collaborative/autonomous robots | big data | big data | machine learning | collaborative/autonomous robots |
| IoT technology | | | | | | |
| cloud computing | | | | | | |
| big data | | | | | | |
| machine learning | | | | | | |
| deep learning | optional | optional | optional | optional | optional | optional | optional |
| adaptability and continuous learning | personal experience | personal experience | personal experience | interpersonal skills and empathy | personal experience | personal experience |
| training and teaching others | initiative taking | active listening | teaching and training others | personal experience | active listening | initiative taking |
| sensors technology | augmented reality | work autonomously | work autonomously | work autonomously | teaching and training others | augmented reality |
| collaborative/autonomous robots | machine learning | augmented reality | active listening | quantitative and statistical skills | augmented reality | machine learning |
| traceability | | | | | | |
| machine learning | | | | | | |
| augmented reality | | | | | | |
4. Conclusions

Having a qualified workforce that can handle the growing technology is the major key condition for the food industry to overcome the big industrial revolution challenge. It can only be achieved through addressing the current skill needs and foreseeing future skill requirements of the sector and providing the most convenient training and education programs to reduce the skills gaps between the workforce and the industry needs.

In this work, firstly, we introduced an industry-driven proactive strategy adapted from several European sectorial projects to achieve a successful digital transformation for the food industry. It can serve the sector as a guideline to meet future skills requirements.

Our work aimed to address the near-future changes in the professional skill requirements of the food industry facing Industry 4.0. In this framework, each job profile related to the food industry in the ESCO database was analysed, whether they will undergo a change due to digitalisation or not. Then, based on the obtained answer, the skills requirements of each profile are updated depending on the range of automation of their work activities. Moreover, we identified the qualifications demanded by each professional job profile benefiting from highly acceptable European sources.

We generated an automated database for skills requirements (current and near-future) for the professional profiles related to the food industry, which can be used as a fundamental framework by the sector through all the midterm-future changes caused by Industry 4.0. Finally, it is worth mentioning that the obtained results have raised the interest of the Basque Food Cluster.

For all these reasons, we believe that our work can be a sectorial and academic guideline to prepare convenient and well-developed training programs to deliver the needed skills. Applying the successful training programs created through the food industry—academia collaboration, the gap between what is expected by the industry and what is delivered by the workforce will be bridged. The food industry will win over the new talents who gain the required specific qualifications and full expertise of the sector through these specific training programs. The training of current employees in the sector will cause the food industry to keep up with the industrial changes and global competitiveness. Therefore, the workforce with updated qualifications will increase the production efficiency of the sector.

The food industry is always searching for new projects and lines of investigation, with a special focus on those concerning the sector’s digitalisation. A major part of these researches would be ideally wider versions of our work; they would include training and educational programs created to deliver the demanded industrial skill requirements which were addressed by our research. Therefore, we believe that our work can be used as a roadmap for the next generation of projects in this area.

Supplementary Materials: The following are available online at http://www.mdpi.com/2304-8158/9/4/492/s1,
Figure S1: an example tab of the automated database generated for the job profiles in the food industry, Figure S2: a brief view of the automated database (in excel format) including the description, alternative names and ISCO numbers of the professional profiles related to the food industry, Figure S3: a brief view of the automated database (in excel format) including essential skills, knowledge and competences needed by the professional profiles related to the food industry, Figure S4: a brief view of the automated database (in excel format) including optional skills, knowledge and competences needed by the professional profiles related to the food industry.

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Abbreviations

| Abbreviation | Description |
|--------------|-------------|
| AI           | Artificial Intelligence |
| IoT          | Internet of Things |
| ESCO         | European Skills, Competences, Qualifications and Occupations |
| CEPIS        | Council of European Professional Informatics Societies |
| CEN          | European Committee for Standardization |
| ESSA         | Blueprint “New Skills Agenda Steel”: Industry-driven sustainable European Steel Skills Agenda and Strategy |
| DRIVES       | Development and Research on Innovative Vocational Educational Skills |
| APPRENTICESHIPQ | Mainstreaming Procedures for Quality Apprenticeships in Educational Organisations and Enterprises |
| SMeART       | Knowledge Alliance for Upskilling Europe’s SMES to Meet the Challenges of Smart Engineering |
| SMEs         | Small and Medium Enterprises |
| ISCO         | International Standard Classification of Occupations |
| ILO          | International Labor Organization |
| ICT          | Information and communications technology |
| VBA          | Visual Basic for Applications |
| HACCP        | Hazard analysis and critical control points |
| GMP          | Good manufacturing practice |

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