FoodBev SETA

Food & Beverages Manufacturing
Sector Education and Training Authority

Overall study on the Fourth Industrial Revolution (4IR) and the Food and Beverages Manufacturing Sector- considering the impact and cost.

Overall study on the Fourth Industrial Revolution (4IR) and the Food and Beverages Manufacturing Sector- considering the impact and cost.

Abstract

The food and beverage manufacturing industry is a significant and important contributor to global GDP but is also subject to significant global competition. The adoption of Fourth Industrial Revolution (4IR) technologies, as a collection of tools to assist the technological advancement in the manufacturing sector is essential. Manufacturing technology evolution is rapid and, with the fourth industrial revolution, ever accelerating. The ability of companies to review and identify appropriate, beneficial technologies, and forecast skills required, is a challenge. The massive and diverse global knowledge base, together with the lack of appropriate enablement skills, and the complexities associated with screening in technologies makes technological implementation a challenge.

This research reviews smart knowledge management, combined with AI as a methodology for knowledge extraction, classification, and adoption. This research develops a knowledge base of 18 FoodBev manufacturing processes, adopts a two-tier Natural Language Processing (NLP) protocol to identify technological substitution, and provides the best contemporary technological (4IR) solution. This paper defines the development and enablement of a Python enabled toolset to provide intelligent technological substitution, and associated skills required, in the FoodBev manufacturing sector in SA.

1. Introduction

The Food and Beverage (FB) manufacturing industry significantly contributes to the global economy. In South Africa, the sector plays a fundamental role in economic growth, and employment creation. Based on FB's gross domestic product (GDP) contribution, it is the third largest manufacturing sector in South Africa, comprising 27% of the country's manufacturing GDP (FoodBev SETA, 2021). The sector encounters numerous challenges including changing consumer preferences, compliance with regulations, escalating population growth, and rapid advances in disruptive technology courtesy of the advent of Industry 4.0. While the sector is growing, it is still unknown how adopting rapidly evolving technologies impacts on the sector's growth potential and skills requirements. Most importantly, with rapidly evolving technologies it is challenging to identify contemporary substitute production technologies.

Technological innovation is a cornerstone of the FB manufacturing industry. Reference (Zhou , et al., 2021) categorises the mechanism and path of the rise of manufacturing value chain into innovation- and technology-driven effect. Firms like Boeing have achieved a dominant role in their respective manufacturing industries due to their smart value chains, created by adopting Industry 4.0 technologies such as Big Data Analytics (BDA), Internet of Things (IoT), and robotics.

2. Purpose

The South African Food and Beverage Manufacturing (SAFBM) sector can adopt advanced technologies across entire value chains, so as to realise a competitive advantage, overcome production bottlenecks, improve productivity and efficiency (Zhou , et al., 2021 ; Mittal , et al., 2018). One crucial constraint is that of the speed of new technological advancements. There is no clearly demarcated means for implementing new Industry 4.0 technologies or substituting already existing technologies in manufacturing entities (Mittal , et al., 2018), thus inferring that the overall impact of Industry 4.0 on the sector has significant opportunities; ultimately indicating a research gap. The core purpose of this study is to identify the value of technological substitution in the SAFBM sector. The additional purpose is to provide a digital toolset to expedite technological identification and identify associated skills.

3. Objectives

The key research objectives are defined below;

1. This research study seeks to address the research gap through exploring the overall impact of Industry 4.0 implementation in the SAFBM sector.
2. Further the research seeks to explore digital tools to identify, existing or new Industry 4.0 technologies can be introduced to the benefit of the sector, this is with due consideration of the rapidly changing landscape.
3. Finally, the research seeks to map skills associated with newly identified technologies.

4. Research Questions

The key research questions are;

1. What is the impact of digital/ technologies on the SAFBM sector.
2. Can a digital tool be developed, to mitigate identifying new technologies, in a rapidly evolving technological space associated with SAFBM.
3. Can the toolset identify the associated skills required for the identified technologies.

The research is initiated by an extensive literature review to explore the impact of Industry 4.0 on manufacturing value chains; followed by a detailed methodology entailing technologies substitution framework is developed for the manufacturing sector. An automated digital tool facilitating identification of the most suitable technologies for substitution for optimisation is developed so as to facilitate global competitiveness of the SAFBM.

5. Literature

The food and beverage manufacturing industry encompasses any company that produces, processes, manufactures, and sells food and beverage products (Akyazi, et al., 2020; Luque , et al., 2017) . Agricultural production and food processing are rapidly growing industries due to escalating global population growth, multiplicity of consumer desires, and diverse consumer needs for processed foods (Jassim , et al., 2020). In South Africa the food and beverages manufacturing sector accounts for R522.7 billion in terms of income contribution (Akyazi, et al., 2020).

Over the years the sector has experienced a significant increase in food and beverages trade (FoodBev SETA, 2021). Between 2019 and 2020 SAFBM has generated the largest share of revenue exports, when compared to others in the manufacturing sector. Exports revenue increased from R49.7 billion to R77 billion driven largely by South Africa's weaker domestic currency. Imports experienced slower growth than exports with a slight increase of R2.5 billion from R70 billion in 2019 to R72.5 billion in 2020 (FoodBev SETA, 2021). While the sector is growing, it is still unknown how adoption of the rapid-evolving Industry 4.0 is impacting its growth.

5.1. The FB Industry and Industry 4.0

The Food and Beverage Manufacturing Cycle (FBMC)is an essential value chain loop. FBMC basic concept is maximum value addition at optimum efficiency and cost-effective production means, from processing of agricultural goods into ready-for-consumption commodities. Market forces have increased opportunities for product differentiation and value adds for raw goods due to escalating global population and increased demand for processed foods (Jassim , et al., 2020). The primary objective of food manufacturing and preservation is to maintain food quality and safety from farm to fork, by monitoring and controlling the factors that lead to food corruption or inefficient production processes (Jassim , et al., 2020) across the value chain. The emergence of Industry 4.0 and associated technological drivers can enable this primary objective (Hasnan & Yusoff , 2018).

Industry 4.0 (4IR) refers to innovative production processes which are partly or completely automated via technology, and devices communicating autonomously with each other along value chain activities (Mittal , et al., 2018). It is premised on intelligent networking of machines, electrical equipment, and novel Information Technology (IT) systems' thus, enabling process optimisation and increased productivity of value creation chains (Akyazi, et al., 2020). Digital transformation is a key element of the ongoing industrial revolution. Digitalisation does not refer to simple transfer from "analogic" to digital data and documents; but rather represents networking between created interfaces, business processes, data exchange, and management (Bogner , et al., 2016). Manufacturing models are changing through development of smart technologies such as new generation of sensors, Artificial Intelligence (AI), Machine Learning, Cloud Computing, and Machine to Machine (M2M) communication. Utilisation of key enabling technologies (KETs) to new or existing plants facilitates a new phase of automation resulting in innovative and more efficient processes, products, and services (Akyazi, et al., 2020).

Industry 4.0 is a great opportunity for the progress of the food sector (Luque , et al., 2017). Reference (Hasnan & Yusoff , 2018) indicates nine Industry 4.0 technologies and approaches applicable to the food industry namely: big Data and analytics, autonomous robots, simulation, horizontal and vertical integration, cybersecurity, Industrial Internet of Things (IIoT), cloud augmented reality and additive manufacturing. Adoption of Industry 4.0 technologies will lead to faster industrial transformation, and change the business abruptly, facilitating fast production of higher quality food products at a lower cost (Akyazi, et al., 2020).

5.2. Impact of 4IR in the food and beverages manufacturing sector.

The actual current implementation of technologies results in benefits and challenges. A classified analysis of the impact of 4IR on food and beverages manufacturing through citing examples are detailed in Figure 1 and unpacked;

Figure 1: 4IR Impact areas

Intelligent manufacturing - "Smart Factories" intertwine virtual and physical worlds by applying innovative digital technology such as Cyber Physical System (CPS), Internet of Things (IoT), Industrial Internet of Things (IIoT), cloud computing, advanced robotics, artificial intelligence, hi-tech sensors, data capture and analytics, 3D printers, software-as-a-service and advanced marketing models (Hasnan & Yusoff , 2018). Many systems and functions found in a food and beverage enterprise are embracing Industry 4.0 technologies, such as Enterprise Resource Planning (ERP), Manufacturing Execution System (MES), Food Quality Assurance, Research and Development, Facilities Management. Systems (inclusive of physical devices such as manufacturing equipment and sensor devices and ICT monitor and analyse processes, detect deviations, and trigger corrective adjustments with minimum human interaction (Hasnan & Yusoff , 2018). Using Artificial Intelligence (AI) techniques, system learn from past experience through collected datasets, adjust to new inputs from surroundings, perform human-like tasks and memorise inputs for future optimisation (Hasnan & Yusoff , 2018).

Quality Control - Digital image processing as integrated into robots, consists of a series of processes beginning with (1) real-time image capture through contactless means, (2) visual representation in the computer, (3) automatic analysis and (4) generation of control commands based on results or measurement readings. This is particularly beneficial for food quality inspection such as to verify labelling accuracy, colours, height, or volume (Hasnan & Yusoff , 2018). Analytical monitoring activates necessary adjustments based on detected deviations so as to fulfil food safety standards and allow early detection of defect which subsequently reduces food waste and costly recalls. Simultaneously, the technology stores data automatically for documentation and evidence in the event of customer complaint (Hasnan & Yusoff , 2018).

Food Traceability System - Traceability is costly and challenging as value chain complexity increases. The complexity can be linked to unique characteristics of food materials undergoing dynamic transformation from raw material to individual food products (Hasnan & Yusoff , 2018). Radio Frequency Identifiers (RFID) has been applied in chicken meat tracing. The system is applied through the complete chain from the farm to slaughterhouse, processing factory, and retailer. Traceability data is gathered and registered through RFID readers and sent to a central database (Hasnan & Yusoff , 2018). At specific places, there are devices where consumers can read data about the chicken meat from the central database. A cheaper alternative for smart traceability system is the Quick Response (QR) code, whereby consumers obtain information related to the food item by scanning the code. This is also done by using a reader application installed on a smartphones (Hasnan & Yusoff , 2018).

Manufacturing Design - Industry 4.0 is taking simulation to another level in plant operations. Simulation software leverages real-time data and models physical manufacturing ecosystems in a virtual model to include materials, processes, machines, processing lines, humans, and material handling systems (Hasnan & Yusoff , 2018). Testing, analysing, and optimisation is performed in the virtual world before any physical changeover is conducted at the actual factory. An example is the design of a new brewery that allows the entire production process to be simulated and various planning strategies and scenarios are simulated evaluated beforehand. Reliable decision-making leads to effective cost planning. Down times, and production failures can be initiated as early as start-up phase (Hasnan & Yusoff , 2018)

Automation for Repetitive Tasks - Loading/unloading, assembly, packaging, palletisation, sorting, and piling, are common in the food sector and are the robot's "specialisation" (Hasnan & Yusoff , 2018).Despite the slow robotic implementation progress in replacing human workforce, potential of the robots is encouraged by robot manufacturers due to benefits such as meeting food safety and hygiene requirements, improving resource efficiency, maintenance simplification and preventing human injuries (Jassim , et al., 2020). The gripper technology is a sub-system of an equipment that comes into contact with a gripped object; with advantages such as not leaving visible marks on items after gripping and hygiene standards. Such technology has eliminated the need for pipes or tubes that are difficult to clean (Hasnan & Yusoff , 2018).

Marketing - Augmented Reality (AR) is reshaping marketing. Current mobile technology improvements in built-in cameras, sensors, computational resources, and mobile cloud computing enable AR on mobile devices. AR supports the consumer to personally engage with products as if the products were proximal to them. This cuts costs in term of logistics, resources, advertisement materials and marketing personnel (ref). The technology stores and provides instantaneous data about customer behaviour and feedback without conventional post-purchase survey (Hasnan & Yusoff , 2018).

Training – Augmented Reality supports enhanced learning and training. Trainees can comprehend the subject faster than conventional learning thus, preventing trainees from disturbing real production activities (Hasnan & Yusoff , 2018).

Customer management – Accomplishing individual customer preferences has affected areas like order management, product design, R&D, commissioning, shipment, utilisation, and recycling of products. With the increasing individualism in customer requirements, technologies for additive manufacturing or 3D printers can be used in food fabrication (Hasnan & Yusoff , 2018). Products are manufactured by a 3D food printer, where raw ingredients are deposited by layers in a sequential process according to the recipe, configured shape and layout (Hasnan & Yusoff , 2018). Binding printers can adhere materials together with edible cement. 3D food printers is much more high-tech featuring nozzles, lasers, syringe, and robotic arms working with powdery material to produce customised patterned chocolate or geometrically different pastry (Hasnan & Yusoff , 2018).

Technological developments enable higher manufacturing efficiency rates and lower production costs, which is critical for manufacturing organisations' competitive advantage. Moreover, food security and safety has recently been a great concern and a top global priority (Olajaire , 2020). 4IR technologies facilitate overall optimisation of the FB processing cycle and improves food security. A key consideration is the identification and implementation cycle for new technologies or the process of digitalisation.

5.3. Digitalization

Digitisation is the transformation of products and services via the usage of digital technologies to enhance their features or replace them entirely (Oliveira , et al., 2021). Several emerging Industry 4.0 technologies are converging to provide digital solutions. Prior works have proposed maturity models for implementing these technologies (Mittal , et al., 2018). Others have studied the impact of these technologies on industrial performance (Dalenogare , et al., 2018). Although these studies provide useful insights into different implementation aspects of digital manufacturing, none provide a holistic understanding of the implementation process (Frank , et al., 2019).

Reference (Frank , et al., 2019) proposes a conceptual framework for Industry 4.0 implementation as illustrated in Figure 2. The centre of the framework places "front-end technologies" which transform manufacturing activities based on emerging technologies (Smart Manufacturing) and products (Smart Products); thus, concerned with operational and market needs. It considers raw materials and product delivery (Smart Supply Chain), and new ways in which workers perform activities based on emerging technologies support (Smart Working). Front-end layer relies on 'base technologies' layer which allow front-end technologies to be integrated in a complete manufacturing system.

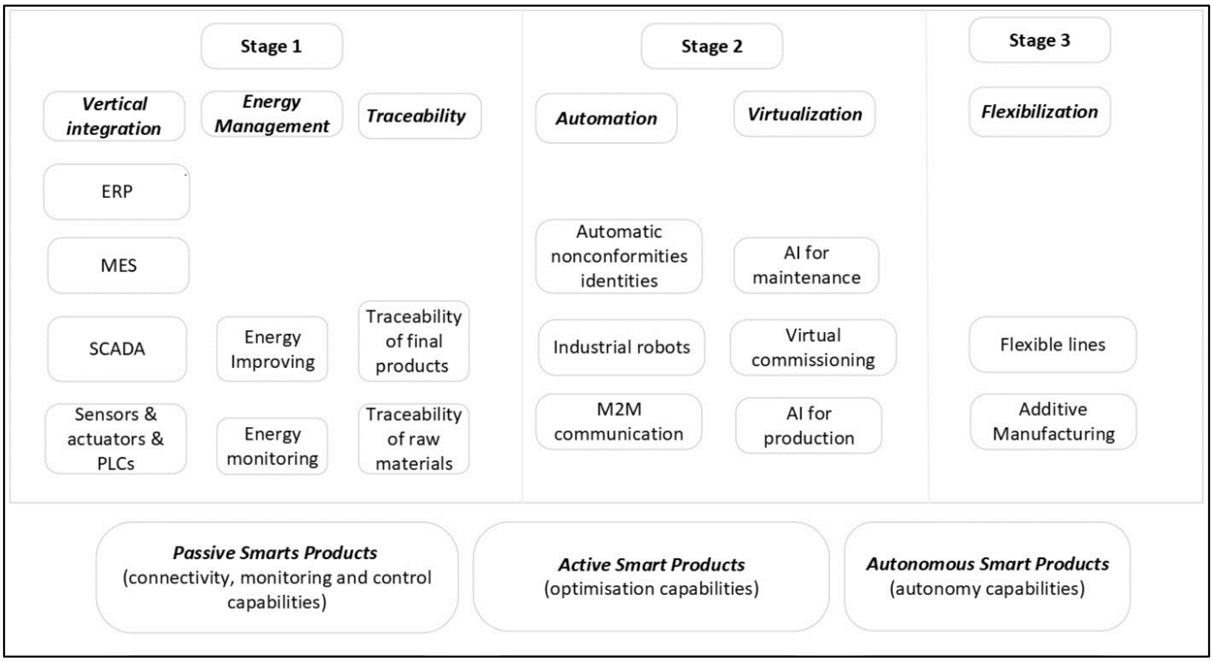

Figure 2: Theoretical framework of Industry 4.0 technologies

Frank (Frank , et al., 2019) identifies stage one to be vertical integration from sensor to ERP with an important aspect around the systems layers i.e. ERP, MES, SCADA, and Sensor. The subsequent stages includes automation and visualisation. The research team explore the application of Frank's (Frank , et al., 2019) work further in the methods section.

5.4. Knowledge extraction for digitalisation

Despite the rapid rate at which Industry 4.0 technologies are evolving, it is challenging to decipher which ones (existing or current) can be implemented in FB manufacturing, across entire value chains (Chaix , et al., 2019). Further, there is a wide array of information on food and beverage manufacturing processes scattered across the internet in diverse formats such as internet sources, journal publications, and white papers (Chaix , et al., 2019). Searching for specific production process information is time consuming and strenuous, thus researchers need tools to assist their bibliographic search in such large collections (Chaix , et al., 2019). Common bibliographic search engines use keyword queries that are too limited to consider such variability. A keyword query such as *cheese* fails to retrieve all relevant information. For instance, they miss documents where the proper cheese name ("Brie") is used instead of the term "cheese". Queries that include all cheese names are impractical to build and maintain. Moreover, keyword queries are unsuitable for retrieving processes and waste or by-products produced during manufacture (Chaix , et al., 2019). The rapid evolution of Industry 4.0 technologies and the vast availability of FB manufacturing information on a wide array of formats thus presents a challenge in gathering precise information on FB manufacturing processes or the associated technologies Industry 4.0 technologies utilised.

5.5. Mapping skills associated with newly identified technologies

The main observed consequence of technological changes on the food industry is the fast-growing demand for technological skills such as basic digital skills and advanced technological skills, such as programming (Bughin , et al., 2018). Awareness of data security, data processing and data protection gains more importance due to this demand. The demand for social and emotional skills (which machines are a long way from learning) is also rapidly increasing due to adoption of advanced technologies. Due to increasing automation and digitalisation of industrial processes, the workforce is responsible for more complex tasks. Execution of these tasks requires numeracy, solid literacy, problem-solving, information and communication technologies (ICT) skills, and soft skills of autonomy, collaboration, and coordination. Higher cognitive skills, such as creativity, critical thinking, teamwork, problem-solving, decision-making, and lifelong learning, is becoming very crucial. Skills such as decision making, critical thinking and independent problem solving will be especially critical in technical profiles, such as production operators and control technicians. Demand for managerial, communication and organisational skills will increase significantly (Akyazi, et al., 2020; Bughin , et al., 2018).

5.6. Summary of literature review

The overall impact of technologies, on the SAFBM sector includes improved efficiencies and better food security. Key benefits includes innovative production and products. High level impact as classified in literature are;

- Developing Intelligent manufacturing

- Improved Quality Control
- Improved Food Traceability Systems
- Optimized Manufacturing Design
- The Automation of Repetitive Tasks
- Efficient and effective Marketing
- Optimized, effective Training
- Improved Customer Management

The knowledge covered in the literature review alludes to the time consuming and mammoth task of identifying Industry 4.0 technologies that can be implemented or substituted in the FB manufacturing industry. This is due to the wide array of information on the internet, as well as journal databases, however finding the correct technological substitute is a time-consuming and colossal task. This formulates the second and dynamic aspect of this study.

In essence the research gap thus is the lack of a systematic manner of extracting information of Industry 4.0 technologies that can be substituted in FB manufacturing sector A knowledge/content extraction tool or technique is thus required that enables the optimised search of Industry 4.0 technologies that can be used or substituted in the FB manufacturing sector. The research gap can thus be addressed by creating a digital tool that can be used to optimise the extraction and storage on Industry 4.0 technologies that can be implemented or used to submit current existing technologies in the food manufacturing industry. The knowledge tool must also identify appropriate skills for each of the identified technologies.

6. Methodology

6.1 Introduction

The research methods of this study is quantitative and premised on knowledge management (Smith , et al., 2022) which is subdivided into extraction of unstructured knowledge, and manipulation of knowledge so that it is managed in a structured manner. Literature highlights the availability of immense information on the FB industry manufacturing processes, existing mostly in unstructured formats (Chaix , et al., 2019). Literature reveals the availability of vast Industry 4.0 technologies for leverage in improving production efficiency across the entire value chain. However, knowledge extraction and management of relevant content of applicable Industry 4.0 technologies for leveraging in the FB industry is a time consuming and colossal task (Affolter , et al., 2019 ; Khan , et al., 2021). The methodology thus seeks to consolidate both knowledge extraction and management in order to develop a smart digital tool that facilitates efficient and automated digital extraction of information (Smith , et al., 2022). The search is premised on a multi-tier, optimised keywords NLP search so as to extract relevant information (Affolter , et al., 2019 ; Chaix , et al., 2019). Knowledge extraction and content management methods are complemented by systems such as ERP and MES, and AI using Structured Query Language (SQL) and Natural Language Processing (NLP) (Affolter , et al., 2019 ; Smith , et al., 2022).

6.2 Research Methodology

Due to the conglomeration of methods, it would be ideal to define the research methods adopted for this study through an illustrative research framework, bringing together all the adopted tools and methods. Figure 3 illustrates the research framework adopted in developing the digital smart technological substitution and associated skills tool for the Foodbev manufacturing sector.

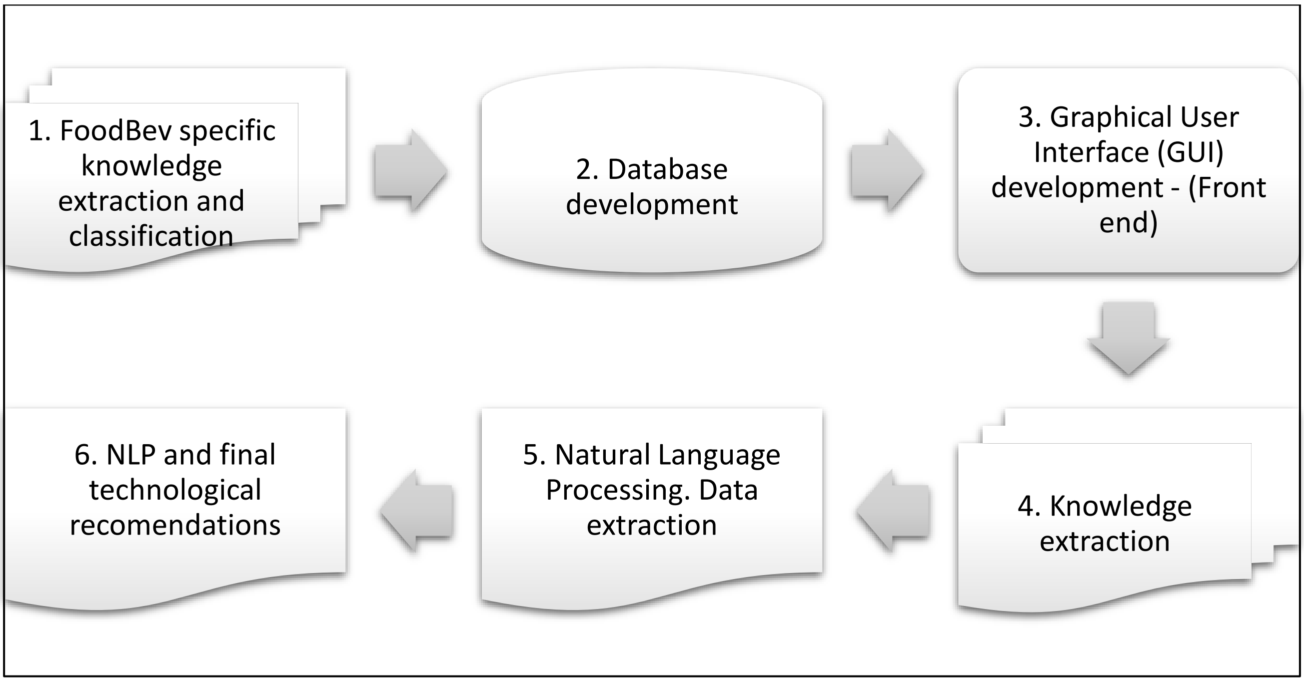

Figure 3: Research Methodology Block Diagram

Foodbev Specific Knowledge

Background information gathering commences with an extensive literature review so as to collate information on the FB manufacturing value chains categories. The current structure of the Foodbev sector in SA is referenced. The construct of the background is based on Frank (Frank , et al., 2019), where the process and the systems are considered. Figure 4 illustrates the structure for the initial data extraction

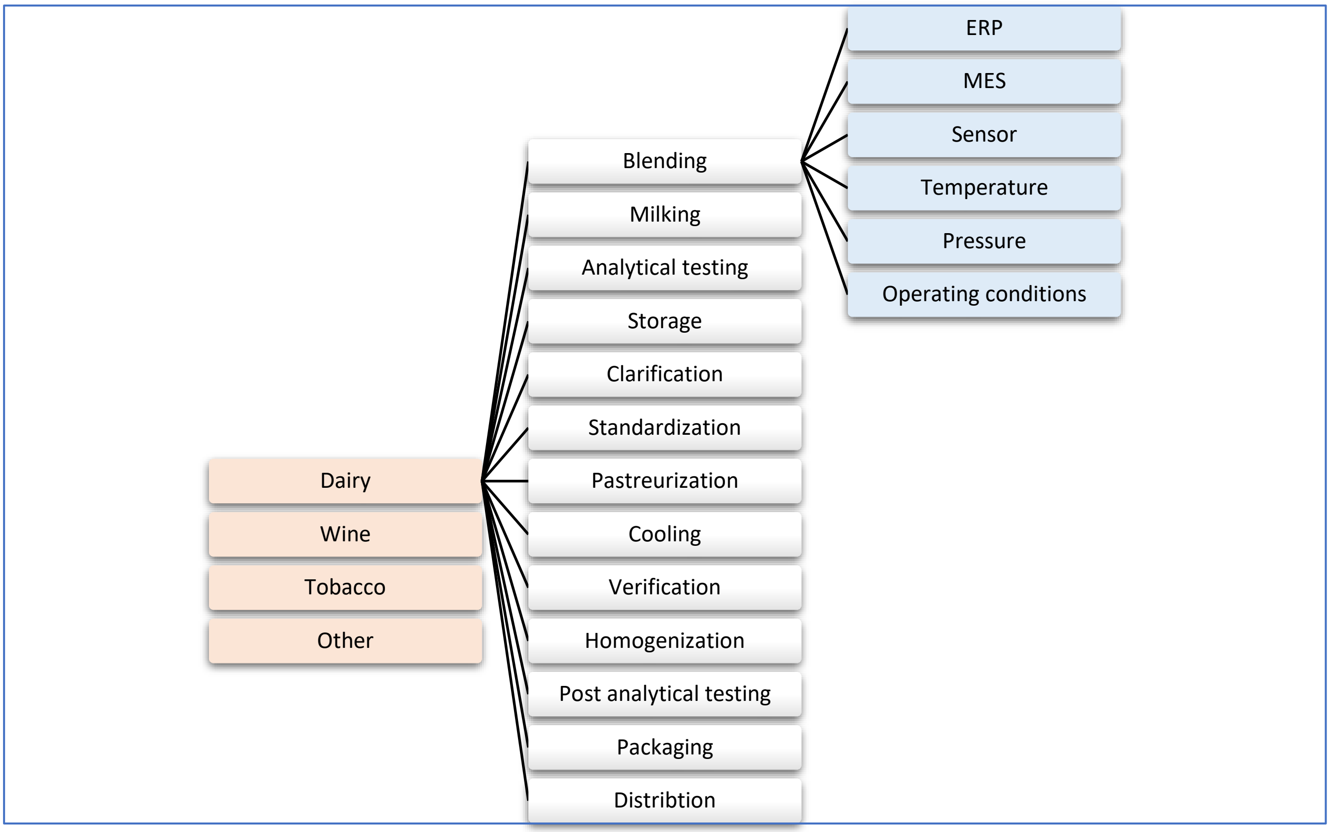

Figure 4: Data extraction structure as modified from Frank (Frank , et al., 2019)

Sources of information include peer reviewed journal publications, and South African FoodBev SETA website. The knowledge is both qualitative and quantitative. Qualitative information is gathered via summarising all the FB value chains categories such dairy (Olajaire , 2020), whereas quantitative information is gathered by collating all the variables that are monitored or controlled during production such as pressure and temperature. This knowledge provides a foundation upon which the research and development of the digital knowledge management tool is based and defines the overall structure with alignment to Frank (Frank , et al., 2019).

Upon summarising the FB value chains categories, further knowledge gathering is executed to gather process steps of each value chain category, from raw materials procurement to final packaging and distribution of manufactured product. MES and ERP are typical system software that are used in manufacturing settings to assist smart and efficient product production. Identifying MES or ERP tasks that are relevant for each process activity is critical in offering insight into which Industry 4.0 technologies may be offered for replacement. The information acquired for each value chain category is saved on multiple sheets in an excel file to improve readability and migration of this information into a SQL database as explained in successive steps. Refer to Figure 4 for the structure adopted in configuring the tables.

Database migration

The data recorded in the excel sheets are transferred to Structured Query Language (SQL) database. This enables the storage and accessing of all information (value chains process steps and variables monitored) from a single database (Affolter , et al., 2019), unlike the multiple sheets in excel. Furthermore, using other programs, such as the development of a Graphical User Interface (GUI) or Python extraction is simple to retrieve the information stored in the SQL database.

Graphical User Interface (GUI) formulation

A GUI is created to enable the user to easily extract the required information from the database, without requiring knowledge of use of SQL (Affolter , et al., 2019). The stored information in the database is used to concatenate key phrases that are subsequently employed in the program for knowledge extraction. As a result, a (GUI) is developed to make the program user-friendly and allow users to concatenate a string of key phrases to use in search of particular information. The GUI is essential a facilitated mechanism to develop a search string based on current FB specific information.

Knowledge extraction

The concatenated string is used by the knowledge extraction program. The program written in Python programming language extracts academic articles from Google Scholar and downloads the most recent and most cited peer reviewed articles or publications. The data is stored on the search server, in PDF format, for further analysis.

Natural Language Processing (NLP)

Natural Language Processing (NLP) is then used to process the downloaded articles. Using NLP, the program can then extract information and insights from the papers, classify and manage the documents, which reduces the work of going through several publications that may or may not include important or relevant information.

NLP and final data filtering

The data extracted from the NLP is packaged and presented to the search user. This includes keywords from the papers. The user selects relevant keywords and Phyton extracts and packages the papers for the consumption of the user. In this contract a dictionary of skills required is also compiled and the

NLP also identifies skills related keywords. This forms the bases of the skills recommendations to be sent to the user together with the relevant filtered papers.

7. Results

7.1 Results discussion

The methodology is applied in a structured manner in order to achieve the goals of this study. The block diagram in Figure 5 below illustrates a summative discussion of the results findings as explained in successive paragraphs below:

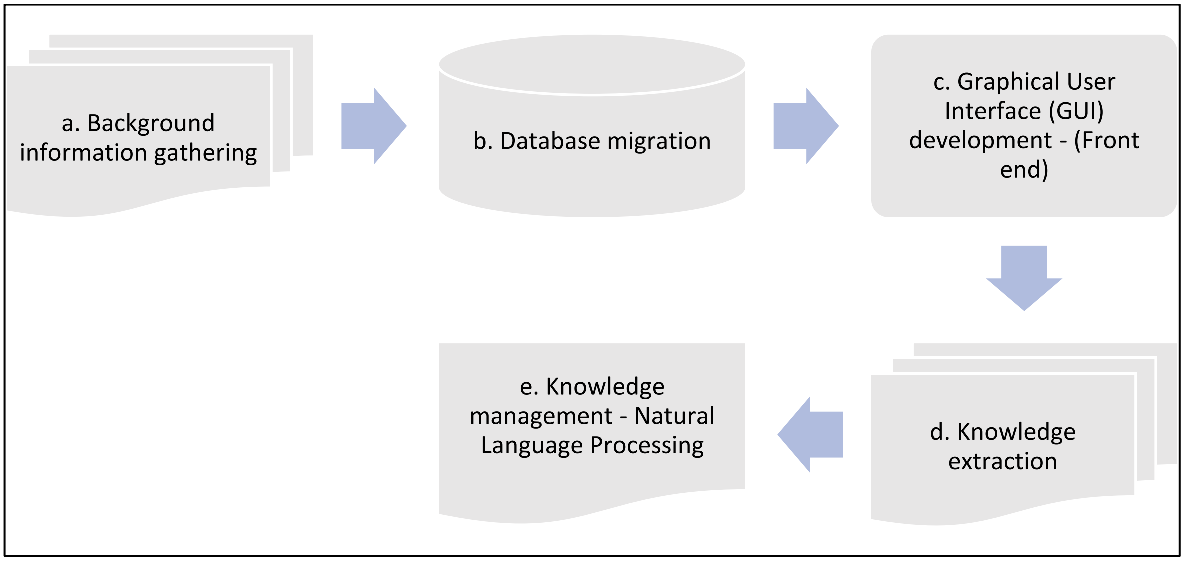

Figure 5: Summative Block Diagram of the Results Discussion this is the methodology diagram and cannot be in the results

a. Background information gathering

FoodBev SETA website categorises FB manufacturing value chains into five (5) chambers: (1) Baking, Cereals, Confectionery, and Snacks (BCCS); (2) Beverage Manufacturing; (3) Dairy Manufacturing; (4) Manufacture of Food Preparation Products; and (5) Processed and Preserved Meat, Fruit and Vegetables. **A** Further literature review is conducted to unearth knowledge on sub-categories (or processes) of the aforementioned five value chains, by filtering journal publications. (Olajaire , 2020) further categorises the five FB value chain categories into sub-categories illustrated in Table 1 below:

Table 1: FB categories and sub-categories summary table maybe this table should go in the methods section as it is the starting and aligned to SETA structure

Chamber	Manufacturing processes
Manufacture of breakfast products	Manufacture of cereals

Manufacture of beverages	Brewing (beer/malt) Wine and spirits Alcohol Beverages (soft drink/ mineral water/juices)
Manufacture of dairy products	Milk Cheese/ yogurt/ butter Ice cream Whey
Manufacture of food preparation products	Farinaceous products (macaroni and noodles); Tobacco Maize sugar Coco, chocolate, and sugar confectionary Coffee and tea
Production, processing and preservation of meat, fish, fruit, vegetables, oil and fats	Processing and preservation of meat and fish products Canned, preserved, processed vegetable and fruit Cooking fats, margarine, edible oils

It is thus deduced that from the five (5) FB value chains categories eighteen (18) sub-categories (or processes) in total are further identified as shown in Table 1 above.

Sequential production steps for each of the eighteen sub-categories are then gathered from literature, and eighteen excel spreadsheets of collated information compiled. Figure 6 illustrates an Excel sheet for beer production, a more detail file is appended. The first column (titled process) identifies each step manufacturing production step. Each step was documented so that as one searches for technology substitution information, precise technologies employed in each step are identified. Variables monitored during production (time, temperature, and pressure), MES and ERP systems were also captured.

	A	B	C	D	E	F	G	H	I	S	T	U
1	Process	Raw Materials	Products	Temperature (Degrees Celcius)	Time	Pressure (kPa)	MES			ERP		
2							Operations or Detailed Scheduling			Sales Distribution or Marketing	Materials Management or	Planning/Ma
3	Milling	1. Malted Barley	1. Beer	Room Temperature		Atmospheric						
4	Mash Turn Heating	2. Unmalted Grain	2. Malt	62 - 70	30 - 120 (Minutes)	Atmospheric						
5	Lauter Turn	3. Yeast		Room Temperature		Atmospheric						
6	Wort Drying	4. Water		Room Temperature		Atmospheric						
7	Filter Wort Boiling	5. Hops		Room Temperature	1 - 1.5 (Hours}	Atmospheric						
8	Whirlpooling			Room Temperature		Atmospheric						
9	Fermentation			15 - 21	4 - 6 (Days)	Atmospheric						
10	Filtering and Pasteurisation			70		Atmospheric						
11	Packaging			Room Temperature		Atmospheric						
12	Distribution			Room Temperature		Atmospheric						

Figure 6: Data capture for the beer sub-category (or process)

b. Database Migration and Front-End

Upon collecting the processes' information in excel spreadsheets (Figure 4), the data is migrated to a SQL database. Essentially, all the information from the eighteen Excel spreadsheets is now stored in one SQL table called "Product-Process", as illustrated in Figure 5 below. Switching from Excel to a SQL database improves the efficiency of the information extraction process. As stated previously, other applications such as the one shown in figure 6 below can access data stored in SQL tables more easily than data saved in Excel spreadsheets. There are more advantages to using SQL over Excel, for example, Excel is slow when dealing with huge data sets. This may not be an issue presently, but as we further develop the database in the future and add more FB manufacturing processes (from the FoodBev industry), data volumes will increase thus SQL will be advantageous. Adding more products necessitates the creation of more Excel spreadsheets, which would result in even more complications, such as storage. Parts of this should go in the method, justifying why moving from excel to SQL

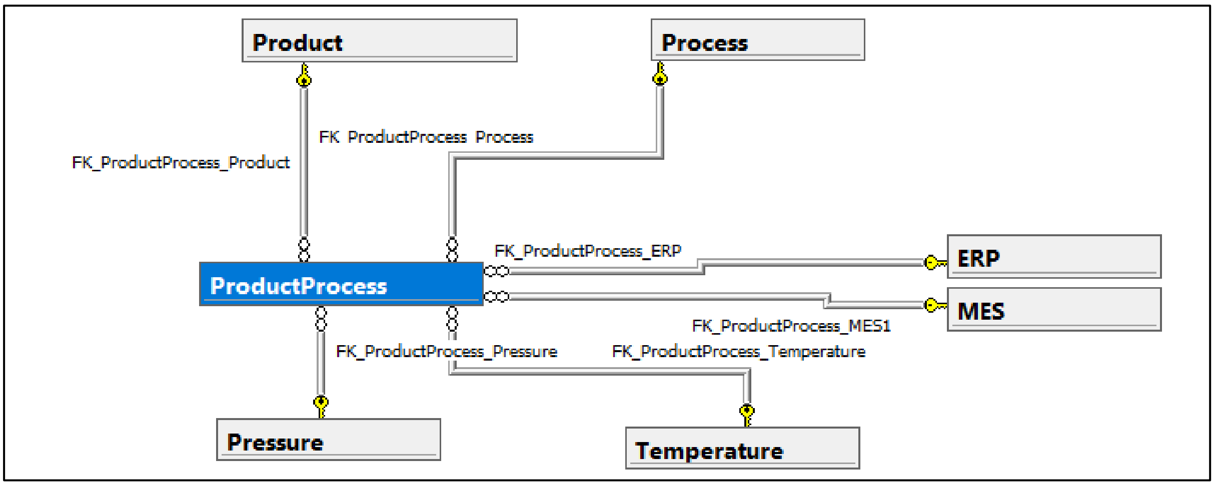

Figure 7: SQL database diagram illustrating the migration of collated information for all 18 processes

c. GUI development

Post the development of the SQL database the excel process structures and supporting data is imported into SQL. The Python coding is configuration to call up the data from SQL. The product type, process step, operating conditions, 4IR system etc is extracted and displayed in the Graphical User Interface. The user is guided through to configure their search for new technologies based on their exact current needs.

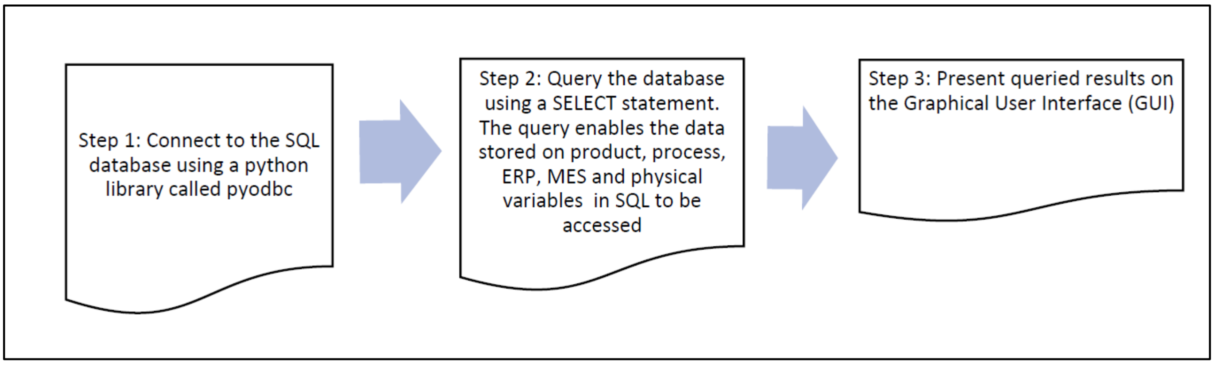

Figure 8: Front-end application developed using python

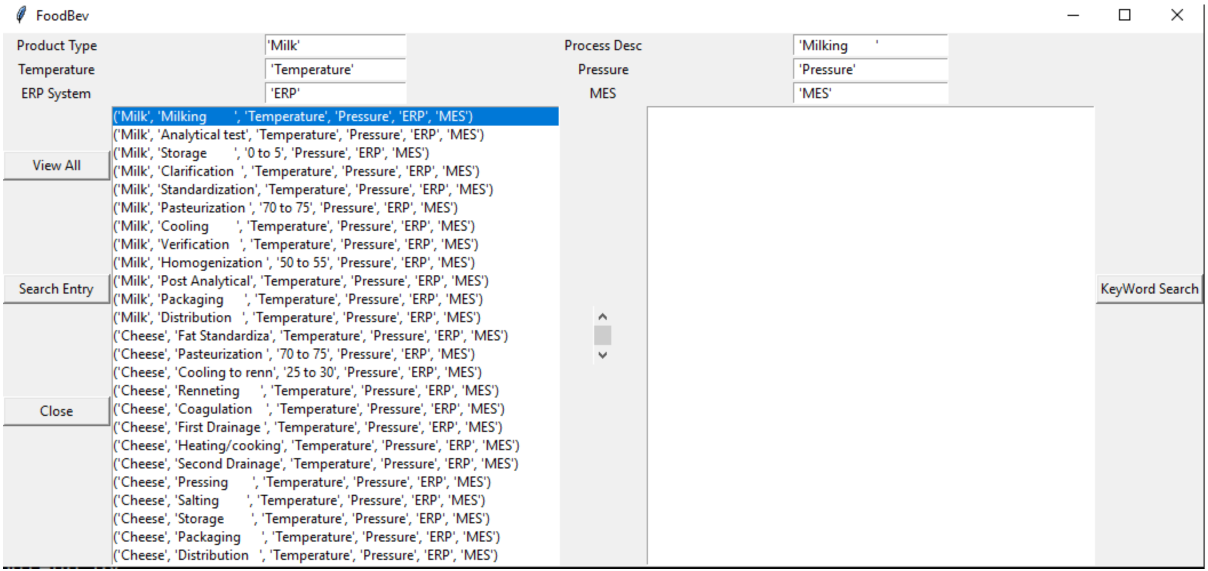

Figure 9: Front-end application to enable user-friendly applicability

The system assists in navigating the user in a sequential, structured, and detailed manner. The user keywords once selected is displayed in the right hand block of the GUI. The user validates his search and executes by pressing the "Keyword search" Icon. See Figure 8 above.

TITLE-ABS-KEY ("Chocolate" AND "manufacture" AND "coaching" AND "Temperature" AND "Pressure" AND "ERP" AND "MES")

TITLE-ABS-KEY ("Diary" AND "manufacture" AND "tempering" AND "Pressure" AND "ERP" AND "MES")

TITLE-ABS-KEY ("Chocolate" AND "manufacture" AND "moulding" AND "Temperature" AND "Pressure" AND "ERP" AND "MES")

TITLE-ABS-KEY ("Chocolate" AND "manufacture" AND "shaping" AND "Pressure" AND "ERP" AND "MES")

TITLE-ABS-KEY ("Dairy" AND "manufacture" AND "baking" AND "Temperature" AND "Pressure" AND "ERP" AND "MES")

TITLE-ABS-KEY ("Chocolate" AND "manufacture" AND "enrobing" AND "Temperature" AND "Pressure" AND "ERP" AND "MES")

Figure 10: Keyword configuration for "Google scholar"

The user keywords is converted into a logical search string. The search string is exported by Python into Google scholar. The search is then executed in Google Scholar. The search seeks papers with the user specified strings and searches for the most recent 50 papers and the top cited (also 50 papers). With this extraction configuration the possibility of extracting content that is relevant, effective, and recent is very high. Our Google Scholar constraint is set at the last 10 years of publications.

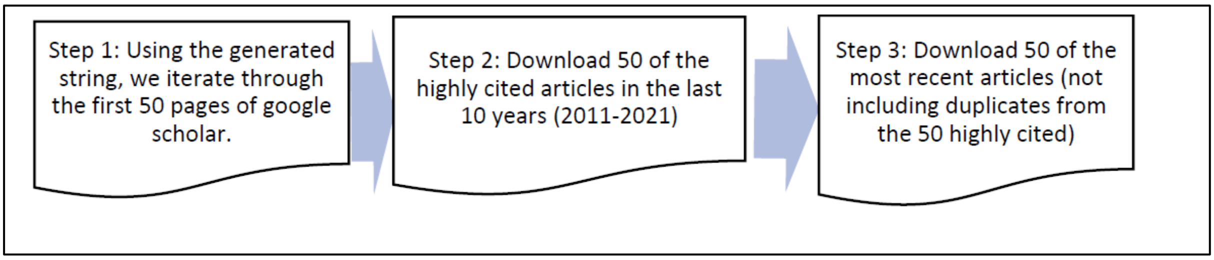

Figure 11: Python steps for finding and downloading papers

The papers are listed into 2 SQL tables, downloaded, and stored. The first SQL is listing the highest cited and the second the most recent. Each paper is stored with a unique ID, the Paper Title, the URL of the extracted paper, the number of citations, the published year. Python is then configured to filter and remove duplicates. The final list of papers are then stored as a directory based on the keywords searched. Figure 11 illustrates the paper index as stored.

	paper title	url of paper	citations
0	[BOOK][B] Enterprise resources planning and be...	https://www.taylorfrancis.com/books/mono/10.12...	318
1	[PDF][PDF] The effectiveness of the accounting...	https://core.ac.uk/download/pdf/234629231.pdf	46
2	Towards a sustainable interoperability in food...	https://www.sciencedirect.com/science/article/...	22
6	Evaluasi Penerapan Enterprise Resources Planni...	http://www.openjournal.unpam.ac.id/index.php/k...	21
8	Implementasi Enterprise Resources Planning (ER...	https://36.89.132.147/index.php/teknoif/articl...	14
5	The importance of critical success factors of ...	https://scholar.archive.org/work/2gtmcdgn4rbmt...	11
3	Designing green procurement system based on en...	https://ieeexplore.ieee.org/abstract/document/...	10
9	Application of structuration theory and activi...	https://su-plus.strathmore.edu/bitstream/handl...	9
10	[PDF][PDF] Enterprise Resources Planning Effec...	https://www.researchgate.net/profile/Maha-Alkh...	5
4	The impact of implementing enterprise resource...	http://repository.petra.ac.id/19173/4/21.The_i...	4
7	The Impact of Enterprise Resources Planning Im...	https://www.e3s-conferences.org/articles/e3sco...	3

Figure 12: Index of stored papers

The next step is the NLP on all of the papers indexed for the search. The NLP is configured to exclude “common words” and the research team have developed a protocol that stores common words in a reserve list.

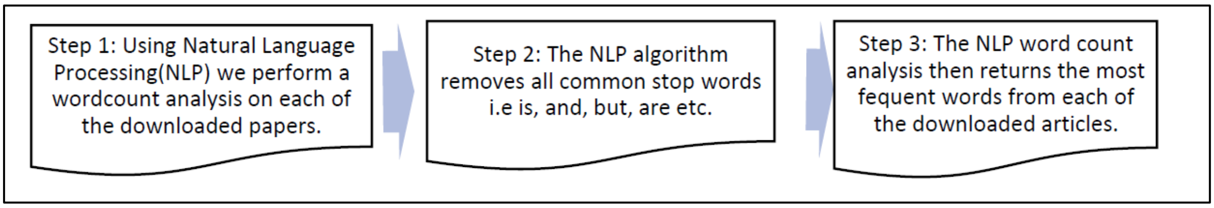

Figure 13: Activities associated with NLP processing in Python

Upon review the new common words can be added to the master common word list. This ensures the system becomes more focused. The remaining words found in the list of papers are then filtered, classified, consolidated, and exported to the user and displayed in the form of a GUI. A typical result is illustrated below with the paper (table headers), keyword (the vertical axis).

Table 2: NLP analysis

	High pressure processing technology in dairy processing A review	High Pressure Carbon Dioxide Used for Pasteurization in Food Industry	High Pressure Processing Technologies for the Pasteurization and Sterilization of Foods	High Pressure Processing and Its Impact on Milk Proteins	The role of emerging technologies to ensure the microbial safety of fresh produce milk and eggs
pressure	137	113	188	66	34
milk	89	21	13	27	67
food	70	86	114	28	22
treatment	61	53	28	20	28
inactivation	5	61	76	1	10
temperature	15	43	66	20	15
effect	19	39	60	10	3
processing	28	23	89	7	22
product	30	14	52	7	79
cavitation	0	0	0	0	2
protein	31	22	13	26	2
cell	20	69	17	35	2

The Keywords filtered out are now presented to the person conducting the search to provide an opportunity to refine his search based on the available knowledge. The GUI for the author refinement is illustrated below. Intelligent manufacturing

Figure 14: Tier 2 NLP GUI for knowledge filtering

As the search keywords are selected the Python code filters and provides a final shortlist of papers. The user then has the option to receive the full papers for review. The Phyton code extracts a skills related NLP and presents the user with the associated skills as required by the technologies identified. The outputs of the python model and filtering provides technological insights for Foodbev process substitution. Among the key objectives of the research, beyond technological substitution, is skills forecasting. Here the research team adopt NLP once again to review the final recommended papers

8. Data extraction: Sample of results

The research team seek to conduct a set of trial runs for the identification of digital substitutions and skills. For this purpose 4 searches, with variable constraints, are conducted. The results in table 3 below. It can be seen that the Python system is capable of identifying the technological substitutes and associated skills. The papers extracted are analysed for further propositioning of value.

Table 3: Paper extraction results

Item	Results Summary 1	Results summary 2	Results summary 3	Results summary 4
1. Search string	Fish ↓ Thawing ↓ Temperature ↓ New Technologies	Beer ↓ Milling ↓ New Technologies	Tobacco ↓ Manufacture ↓ Automation	Chocolate ↓ Manufacture ↓ Quality Control ↓ Automation
2. Results	50 articles according to citation and publication year data frames			
2b. Keywords	60 non-common keywords identified	70-non common keywords identified	76 non-common keywords identified	70 non-common keywords identified
3.User-selected keyword	Treatment	Design	['analysis', 'information', 'system', 'online', 'legal', 'structured', 'unstructured']	['precision', 'analysis', 'processing', 'mechanical', ' additive']
3b.Results	2 journal articles	2 journal articles	1 journal article	3 journal articles
4.Summary of articles according to technology identified; benefits and impacts in the value chain.	Pulsed Electric Fields (PEF) (Gomez , et al., 2019) **Benefits** – Promising technique for disrupting biological cells in the food matrix of fish products without any detrimental effect on food product attributes **Impact** - PEF has capacity to produce foods with great nutritional and sensory quality and shelf-life.	Hazard Analysis Critical Control Points (Singh, et al., 2018) **Benefits** – Simple, specialized method to prevent health hazards emanating from consuming contaminated food & beverages. **Impact** - Prevention of possible hazards and to improvement of production processes	Convolutional Neural Networks (Marzan & Ruiz Jr , 2019) **Benefits** – Utilises image processing techniques in the classification of tobacco leaves, to classify according to grades **Impact** – effective and accurate grading to outperform current manual methods of grading tobacco leaves.	3D printing (Zhenbin , et al., 2017) **Benefits** – also known as additive manufacturing (AM), solid freeform fabrication (SFF), is characterized by layer by layer material deposition mode based directly from a pre-designed file. **Impact** – customized food designs, personalized nutrition, simplifying supply chain, and broadening of the available food material.
	Qualitative spectroscopy & chemometrics (Ghidini , et al., 2019) **Benefits** – Resolution of key authenticity issues of fish and seafood products, with focus on species substitution, geographical origin falsification, production method or farming system misrepresentation, and fresh for frozen/thawed product substitution **Impact** – As an innovative technology it makes counterfeiting or falsifying of fish products difficult thus organisational competitive advantage.	Replacement of malted by raw barley (Kok , et al., 2018) **Benefits** – Raw barley can be processed by hammer mills (roller mills also). Hammer mills ensure efficient extraction in raw barely compared to malted, by producing finer grist & larger surface area for enzymatic hydrolysis of endosperm. **Impact** – economic driven impact with added advantage of improved sustainability, by reducing reliance on the malting process and its associated costs.		3D printing (Kouzani , et al., n.d.) **Benefits** – Three-dimensional (3D) food printing is emerging as a method for making foods for people with special mealtime needs. **Impact** – Modifying foods to standard consistencies, and manual design and assembly of foods for the daily requirements of people with dietary challenges such as dysphagia.
				Cloud manufacturing (CM) (Fisher , et al., n.d.) **Benefits** – Service oriented business model to share manufacturing capabilities and resources on a cloud platform via collaborative design, greater automation, improved process resilience and enhanced waste

				reduction, reuse, and recovery. **Impact** – Achievement of cost and environment impact reductions, as manufacturing becomes more integrated and complex.
Skills	Electrical skill: Operating short pulse high voltage machinery (Gomez , et al., 2019) Spectral analysis: Nuclear Magnetic Resonance spectroscopy, Infrared Spectroscopy and Raman Spectroscopy (Ghidini , et al., 2019) Chemometrics: Mathematical, Statistical, and analytical skills (Ghidini , et al., 2019)	Analytical Skills (Singh, et al., 2018)	Photography - to take pictures of the leaves (Marzan & Ruiz Jr , 2019) Computer literacy for uploading the pictures so the CNN code can do the analysis (Marzan & Ruiz Jr , 2019)	Food Science (Zhenbin , et al., 2017) Process Control (Fisher , et al., n.d.) IT (Fisher , et al., n.d.)

Item	Results Summary 5	Results Summary 6
1. Search string	Sugar → Harvesting → Automation	Meat → Curing → Technology
2. Results		
2b. Keywords	69 non-common keywords identified	70-non common keywords identified
3.User-selected keyword	[‘Agriculture’, ‘Technology’]	[‘Salting’, ‘Processing’]
3b.Results	2 journal articles	2 journal articles
4.Summary of articles according to technology identified; benefits and impacts in the value chain.	<u>Adoption of automation and robotics in precision agriculture</u> (Azimi Mahmud , et al., 2020) **Benefits** – adoption of robotics and automation towards the maintenance of food security in the future. Robotics equipment has enabled farmers to execute agricultural operations in a timely manner such as planting, inspection, spraying with minimum costs. **Impact** – Precise farm management using modern technologies	<u>Ultrasound instrument for meat salting in pork</u> (Inguglia , et al., 2017) **Benefits** – decrease in enhancement of salt diffusion by ultrasound thus reducing NaCl uptake in meat during processing. **Impact** – enhancement of salt distribution during meat processing thus compliance to quality standard of processed meat
	<u>Robotics in packaging of farm produce via HSV analysis</u> (Dewi , et al., 2020) **Benefits** – fruit sorting robot based on colour and size for agricultural product packaging systems. Sorting made possible by image processing whereby colour is recognised by HSV analysis and diameter is known in the grayscale image and setting thresholding.	<u>Near Infrared Spectroscopy (NIRS) for salted composition diagnostics</u> (Kartakoullis , et al., 2019) **Benefits** – Smartphone based Near Infrared Spectroscopy NIRS to diagnose minced meat at different temperatures.

	Impact – As an innovative technology it makes product packaging faster.	**Impact** – adoption of smartphone-based spectrometer which has accurate quality control purposes
Skills	Robotics (Dewi , et al., 2020) Electrical Engineering and Computer Science (Azimi Mahmud , et al., 2020) Agronomy (Azimi Mahmud , et al., 2020)	Food Science (Kartakoullis , et al., 2019)

9. Discussion

The research team identifies the challenges associated with transition to digital in the Foodbev industry as essential for sustainability. In order to facilitate enhanced, structured and expedited skills and technological responses the research team conduct a global literature search identifying 4IR centric technological substitution methods. The literature study highlight the impact of technology on the SAFBM sector and includes operational efficiencies and food security improvements. The review also identifies the limitation of static analysis in terms of impact.

The research team develop a Python enabled, AI based global search engine to mitigate the rapid technology challenges. The development and enablement protocol is detailed. A sample of five searches is presented, providing evidence of technological substitutions. The associated skills are also presented.

The research teams recommendations based on this research are;

1. Enablement of the toolset developed by piloting the system in order to allow the AI models to gather learning data. This can be a permanent tool and FB data source.
2. Embedding of the AI based toolset into the Foodbev website. This would be based on advanced integration to the UJ servers. Operations must be designed for.
3. Skills development and support for internal adoption of the advanced toolset for technological substitution must be accommodated
4. A campaign be embarked upon so as to raise awareness of all users of the toolset. This would deliver value to large, small and medium businesses. Facilitating rapid technological evolution.
5. The tool is data rich and can be used as FB source of skills data and sector evolution.

Bibliography

Affolter , K., Stockinger , K. & Bernstein , A., 2019 . A comparative survey of recent natural language interfaces for databases. *The VLDB Journal,* 28 (5), pp. 793 - 819 .

Akyazi, T. et al., 2020. A Guide for the Food Industry to Meet the Future Skills Requirements Emerging with Industry 4.0. *Foods,* 9(4), p. 492.

Azimi Mahmud , M. S., Zainal Abidin , M. S., Emmanuel , A. A. & Hasan , H. S., 2020. Robotics and Automation in Agriculture: Present and Future Applications. *Applications of Modelling and Simulation,* Volume 4, pp. 130 - 140.

Bogner , E., Voelklein , T., Schroedel , O. & Franke , J., 2016 . Study based analysis on the current digitalization degree in the manufacturing industry in Germany. *Procedia CIRP ,* Volume 57 , pp. 14 - 19 .

Bughin , J. et al., 2018. *A Skill Shift, Automation and the Future of the Workforxe,* Washington, DC, USA: McKinsey & Company.

Chaix , E., Deleger , L., Bossy , R. & Nedellec , C., 2019 . Text mining tools for extracting information about microbial biodiversity in food. *Food Microbiology ,* Volume 81 , pp. 63 - 75 .

Dalenogare , L. S., Benitez , G. B., Ayala , N. F. & Frank , A. G., 2018 . The expected contribution of Industry 4.0 technologies for industrial performance. *International Journal of Production Economics ,* Volume 204 , pp. 383 - 394 .

Dewi , T., Risma, P. & Oktarina , Y., 2020. Fruit sorting robot based on color and size for an agricultural product packaging system. *Bulletin of Electrical Engineering and Informatics,* 9(4), pp. 1438 - 1445.

Fisher , O. et al., n.d. Cloud manufacturing as a sustainable process manufacturing route.

FoodBev SETA, 2021. *Sector Skills Plan for Food and Beverages Manaufacturing Sector 2022/2023,* Johannesburg: FoodBev SETA.

Frank , A. G., Dalenograe , L. S. & Ayala , N. F., 2019 . Industry 4.0 technologies: Implementation patterns in manufacturing companies. *International Journal of Production Economics ,* Volume 210, pp. 15 - 26 .

Ghidini , S., Varra , M. O. & Zanardi , E., 2019 . Approaching Authenticity Issues in Fish and Seafood Products by Qualitative Spectroscopy and Chemometrics. *Molecules ,* 24(9).

Gomez , B. et al., 2019. Application of pulsed electric fields in meat and fish processing industries: An overview. *Food REsearch International,* Volume 123, pp. 95 - 105.

Hasnan , N. Z. & Yusoff , Y. M., 2018. Short review: Application Areas of Industry 4.0 Technologies in Food Processing Sector. *2018 IEEE Student Conference on Research and Development (SCOReD),* pp. 1 - 6 .

Inguglia , E. S. et al., 2017. Influence of extrinsic operational parameters on salt diffusuin during ultrasound assisted meat curing. *Ultrasonics.*

Jassim , H. A., Ahmed , A. F. & Ghilan , M. S., 2020 . The value added for the manufacturing of potato chips and the factors affecting them within the value chain of potato crop for the spring season of 2018. *Plant Archives ,* 20 (1), pp. 861 - 870 .

Kartakoullis , A. et al., 2019 . Feasibility study of smartphone-based Near-Infrared Spectroscopy (NIRS) for salted minced meat compositon diagnostics at different temperatures. *Food Chemistry ,* Volume 278, pp. 314 - 321 .

Khan , S. R. et al., 2021. Digital technologies, circular economy practices and environmental policies in the era of COVID-19. *Sustainability,* 13(22).

Kok , Y. J. et al., 2018 . Brewing with malted barley or raw barley: what makes the difference in the processes?. *Applied Microbiology and Biotechnology .*

Kouzani , A. Z. et al., n.d. 3D Printing.

Luque , A., Estela Peralta , M., de las Heras , D. & Cordoba , A., 2017 . A State of the Industry 4.0 in the Andalusian food sector. *Procedia Manufacturing ,* Volume 13, pp. 1199 - 1205 .

Marzan , C. S. & Ruiz Jr , C. R., 2019 . Automated Tobacco Grading Using Image Processing Techniques and a Convolutional Neural Network. *International Journal of Machine Learning and Computing ,* 9(6).

Mittal , S., Khan , M. A., Romero , D. & Wuest , T., 2018. A critical review of smart manufacturing & Industry 4.0 maturity models: implications for small and medisum-sized enterprises (SMEs). *Journal of Manufacturing Systems,* Volume 49, pp. 194 - 214.

Olajaire , A. A., 2020. The brewing industry and environmental challenges. *Journal of Cleaner Production,* Volume 256.

Oliveira , L., Fleury , A. & Fleury , M. T., 2021 . Digital power: Value chain upgrading in an age of digitization. *International Business Review ,* 30(6), p. 101850 .

Singh, K. et al., 2018 . HACCP Implementation on beer production from barley. *Journal of Pharmacology and Phytochemistry ,* pp. 140 - 145 .

Smith , E., Papadopoulos , D., Braschler , M. & Stockinger , K., 2022. LILLIE: Information extraction and database integration using linguistics and learning-based algorithms. *Information Systems,* Volume 105, p. 101938.

Zhenbin , L., Zhang , M., Bhandari , B. & Wang , Y., 2017 . 3D printing: Printing precision and application in food sector. *Trends in Food Science & Technology .*

Zhou , Y., Zhuo , C. & Deng , F., 2021 . Can the rise of the manufacturing value chain be the driving force of energy conservation and emission reduction in China. *Energy Policy ,* 156 (112408).

Appendix 1: Excel construct of Foodbev data

ERP						MES												PCN	IoT	ERP											
Finance	Planning	Maintenance	Logistics	Quality	Human Resources	Operations or Detailed Scheduling	Resource Allocations and Status	Dispatching Production Unit	Performance Analysis	Maintenance Management	Process Management	Quality Management	Data Collection/Acquisition	Product Tracking and Genealogy	Labour Management	Document Control	Optimisation			Sales Distribution or Marketing Sales or Supply Chain or Order Management	Materials Management or Procurement or Supplier Relationship or Inventory Procurement	Production Planning/Manufacturing/Manufacturing Management	Quality Management or Enterprise Performance or Technical Foundation	Service or Enteprise Service	Human Resources or Human Capital Management or Workforce	Financials or Financial Management Solution or Financial Accounting or Financial Management	Controlling or Time and Expense Management	Asset Management or Enterprise Asset Management	Project System or Projects or Project Management	Workflow Prompt Actions or Order Management	Industry Solutions Best Practices or Contracts or Subcontact Real Estate

Item	Process	Process Description	Raw Materials	Products
			1. Corn	bran
			2. Wheat	germ
			3. Oat	grits; Corn
				4. Flour
1	Corn	Harvesting, sorting, cleaning & packing and taking for processing		
2	Tempering Chamber	strength. High moisture tempering is an example.		
3	Degerminator	Detaching bran and germ from the endosperm in maize		
4	Dryer	Drying and cooling of degerminator		
5	Aspirator	Screening process to remove fines, dust and lightweight material. If foreign material has same size and shape as that of good product, use of air to separate by density is an alternative process. Rolling and grading process also done.		
6	**Corn Bran**	Final product		
7	Packaging			
8	Transport and Distribution			
1	Corn	Harvesting, sorting, cleaning & packing and taking for processing		
2	Tempering Chamber	of corn by addition of control amount of moisture		
3	Degerminator/Tails	Detaching bran and germ from the endosperm in maize		
4	Dryer	products obtained from the degermer http://courseware.cutm.ac.in/wp-content/uploads/2020/06/Corn-Milling.pdf		
5	Aspirator	Screening process to remove fines, dust and lightweight material. If foreign material has same size and shape as that of good product, use of air to separate by density is an alternative process.		
6	Gravity Table			
7	**Corn Germ**	**Corn Germ is resultant product**		
8	Blending and Packaging			
9	Transport and Distribution			
1	Corn	Harvesting, sorting, cleaning & packing and taking for processing		
2	Tempering Chamber			
3	Degerminator/Tails	Detaching bran and germ from the endosperm in maize		
4	Dryer			
5	Aspirator	Screening process to remove fines, dust and lightweight material. If foreign material has same size and shape as that of good product, use of air to separate by density is an alternative process.		
6	Gravity Table			
7	Separator/sifters			
8	**Small grits, Corn meal & Corn flour**	**Small grits, Corn meal & Corn flour**		
9	Packaging			
10	Transport and Distribution			
1	Corn	Harvesting, sorting, cleaning & packing and taking for processing		
2	Tempering Chamber			
3	Degerminator/Tails	Detaching bran and germ from the endosperm in maize		
4	Dryer			
5	Aspirator	Screening process to remove fines, dust and lightweight material. If foreign material has same size and shape as that of good product, use of air to separate by density is an alternative process.		
6	Gravity Table			
7	Separator/sifters			
8	**Flaking grits**	**Small grits is an example**		
		Corn meal is an example		
		Corn flour is an example		
9	Packaging			
10	Transport and Distribution			
1	Wheat intake	Harvesting, sorting, cleaning & packing and taking for processing		
2	Separator			
3	Aspirator			
4	Disc separator			
5	Scourer			
6	Washer/stoner			
7	Tempering bins			
8	Scourer			
9	Corrugated bins			
10	Separator			
11	**Flour**			
1	Wheat intake	Harvesting, sorting, cleaning & packing and taking for processing		
2	Separator			
3	Aspirator			
4	Disc separator			
5	Scourer			
6	Washer/stoner			
7	Tempering bins			
8	Scourer			
9	Corrugated bins			
10	Separator			
11	Purification system			
12	Reducing rolls			
13	Separator			
14	**Bran**			
Pate nt			**Wheat**	
1	Wheat intake	Harvesting, sorting, cleaning & packing and taking for processing		
2	Separator			
3	Aspirator			
4	Disc separator			
5	Scourer			
6	Washer/stoner			
7	Tempering bins			
8	Scourer			
9	Corrugated bins			
10	Separator			
11	Purification system			
12	Reducing rolls			
13	Separator			
14	**Patent flour processing**			
Ger m/flo			**Wheat**	
1	Wheat intake	Harvesting, sorting, cleaning & packing and taking for processing		
2	Separator			
3	Aspirator			
4	Disc separator			
5	Scourer			
6	Washer/stoner			
7	Tempering bins			
8	Scourer			
9	Corrugated bins			
10	Separator			
11	Purification system			
12	Reducing rolls			
13	Separator			
14	Purification system			
15	Reducing rolls			
16	Separator			
Rice millin			**Wheat**	
1	Paddy	Harvesting, sorting, cleaning & packing and taking for processing		
2	Paddy pre-cleaner			
3	Paddy husker	**Husk is a resultant product**		
4	Paddy separator	**Brown rice is a resultant product**		
5	De-stoner			
6	Abrasive whitener			
7	Friction whitener	**Rice bran is a resultant product**		
8	Separator/sifters	**Brewers rice is a resultant product**		
9	Water mister			
10	Length grader	**Milled rice, Head rice, Second heads and Broken rice are resultant products**		
Oat millin			**Oat**	
1	Cleaner and grader	Harvesting, sorting, cleaning & packing and taking for processing		
2	Dehuller			
3a.	Hulls	**Oat fiber is a resultant product**		
3b.	Scourer			
4	Kiln			
5a	Reducing rolls	**Whole oat flour is a resultant product**		
5b	Groat streamer			
6a	Flaking roler mill	**Oat flakes/quick oats/instant oatsrolled oats are resultant produtts**		
6b	Groat cutter	**Oat bran and cut oats are resultant products**		

13 Autumn Street,
Rivonia, 2128,
South Africa

PO Box 245,
Gallo Manor 2052,
South Africa

www.foodbev.co.za

+27 11 253 7300

+27 11 253 7333

info@foodbev.co.za

higher education
& training

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA