Aplikacija industrije 4.0 – prilika za novi iskorak u svim industrijskim granama / Application of Industry 4.0 – an opportunity for a new step forward in all industrial branches

Karabegović, Isak

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Smart and sustainable food processing sector by integration of the concepts of the technologies behind Industry 4.0

Amra Bratovčić*

Abstract: *The aim of this review was to evaluate possibilities of implementing concepts of Industry 4.0 including big data optimization, integration of sensors, artificial intelligence, and Internet of things (IoT), leading to the lowest possible costs and the highest possible output through smart control of the process, sustainable production, and monitoring. Sensors are vital components of Industry 4.0 and different types of detectors and sensors are used in the food packaging industry to convey information about food quality and to increase food safety. The paper will discuss time-temperature indicators, visual (color) indicators, O_2 and CO_2 indicators, freshness indicators, pH indicators, poison indicators and a radio frequency indicator that automatically detect and track the product. Based on credit card use it is possible to reveal the behavior of the customers and consumers. Virtual shops are popular for office workers. By using artificial intelligence, it is possible to create a robotic kitchen, which can cook according to the wishes of users, while 3-D printing technologyis used to cut food in certain shapes.*

Keywords: *Smart packaging, colour sensors, digitalization, food safety (time-temperature, freshness, radio frequency and pH) indicators.*

1. Introduction

The world is moving towards Industry 4.0, known as the Fourth Industrial Revolution, i.e., toward automation and artificial intelligence. Figure 1 schematically presented the concepts of Industry 4.0 which focuses on the digital transformation of the industry.

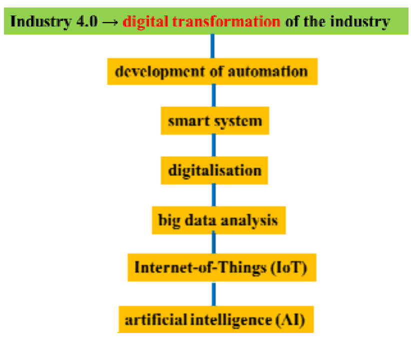

Figure 1. Concepts of Industry 4.0

*University of Tuzla, Faculty of Technology, Department of Physical Chemistry and Electrochemistry, 75000 Tuzla, Bosnia and Herzegovina
E-mail: amra.bratovcic@untz.ba

Industry 4.0 was first introduced at Hanover Fair by Germany, as the concept of a technology-driven manufacturing process integrated with information and communication technologies to strengthen its national competitive position in the manufacturing [1]. Figure 2 shows the integration of the processes offered by the technologies behind Industry 4.0 that can help food manufacturers enhance food safety, better manage their supply chains, ensure the greatest profitability in a complex, competitive world, or be able to respond flexibly to changing consumer demands.

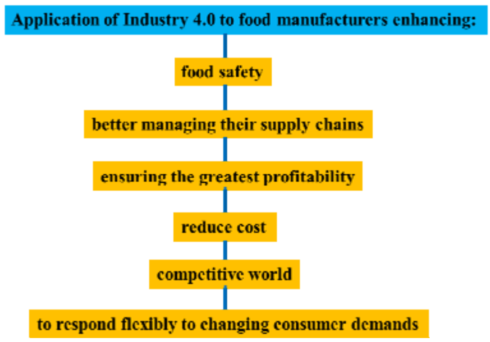

Figure 2.The integration of the concepts of Industry 4.0 in the food sector

It will help food manufacturers to gain an understanding of the full opportunities available, and the sorts of investments or changes in existing processes they might need. Industry 4.0 involves pulling together recent opportunities presented by digitalization, the Cloud and the Internet of Things (IoT), leading to smarter solutions for factories and processes. Industry 4.0 brings together computers driven by machine-learning algorithms in an entirely new and connected way –the latest in a series of points-in-time which have allowed for a transformation of the manufacturing process. Each of these leaps has, in its turn, allowed businesses to: increase productivity, reduce costs, deliver increased profitability more swiftly, and more quickly respond to the changing demands of their customers. According to the ReportLinker, the Internet of Things (IoT) and traceability for the food and beverage manufacturing market was estimated at $4.08 billion in market revenue in 2017 and is assumed to reach $8.43 billion by 2025, expanding at a compound annual growth rate (CAGR) of 9.5% [2]. Industry 4.0 allows businesses to optimize the four levels of their operations which are things, equipment, manufacturing operations management, and business systems. Things consider individual pieces of equipment such as sensors collecting data which allows businesses to monitor how a particular part is performing. The equipment allows the company to monitor and control the operation of the entire machine or line of machines. Manufacturing operations management is related to a business that connects and monitors the performance of the whole factory. Lastly, business systems, where a company monitors the planning and performance of the whole enterprise, or of multiple factories within its business.
Positive results of the application of Industry 4.0 concept, such as the use of all data from the entire system and improved analysis, as well as their greater interconnectedness, allow for better traceability and transparency, leading to the lowest possible costs and the highest possible output.

From a food manufacturer's perspective, Industry 4.0 allows adapting their own technology, making new investments, storing and examining data, and making the most of real-time analytics to help guide decision making, rather than simply relying on historical data. Application of these concepts in the food and beverage industry may lead to an increase in food safety and quality, and improve productivity. The use of nanoparticles in foodpackaging to improve physical performance of food, and nanoparticles as antimicrobial agents and nano-biosensors for pathogen detection has recently been reported [3, 4]. For example, full traceability and transparency in the entire food production process can be achieved through the communication of smart machines, which will certainly ensure greater food safety and help the company to meet regulatory needs in the most efficient way. Another example is saving time and increasing production capacity as well as shortening the delivery time to the end customer, if machines can be supported and controlled remotely and be able to self-diagnose a problem. Self-driving vehicles reduce manpower costs, can speed up deliveries and make the manufacturing process more efficient. The possibilities offered by Industry 4.0 are therefore enormous [5,6]. The adoption and implementation of Industry 4.0, however, require overcoming a number of practical challenges. In most cases these refer to the lack of modernization and automation in place with traditional manufacturers. When implemented, Industry 4.0 technologies will have a huge impact on the efficiency, productivity and profitability of businesses [7]. Food manufacturing is today still handled in a centralized manner. However, in the future, machines and raw materials will independently organize the manufacturing process and communicate with one another over corporate divisions in a manner similar to social media networks [8].

Figure 3. Organization of manufacturing process through the communication between machines and raw materials

Twenty-first-century consumers investigate their products on their smartphones and frequently select them on purpose, depending on the nutrients they want tohave in their diet. Therefore, to encourage consumers to purchase their products, manufacturers and retailers must choose point-of-sale (POS) solutions that empower them to impact purchase decisions at the retail outlet itself. One example is POS displays that is incorporated with customers' mobile devices (POS is ‘’point-of-sale’’ and refers to the actual transaction that occurs when the customer buys the product).

Figure 4. POS for mobile device

Hazard and Operability Analysis is a common approach used in chemical engineering to systematically evaluate process safety and identify the possible improvement of the existing system. Lim et al. 2021 [9]proposed 23 recommendations including the use of IoT (Internet of things) devices, smart image processing technology, smart monitoring, smart forecasting, cloud computing, traceability, smart contract, and cybersecurity to improve the palm oil industry with Industry 4.0 technologies to achieve a higher standard in sustainable production. Analysis from the review suggested the combination of IoT devices and cloud computing that can enable smart CPO production forecast, while the combination of IoT devices, image processing and cloud computing can optimize harvest routes in oil palm plantations. The implementation of blockchain technology from Industry 4.0 across palm oil industry offers stakeholders a robust traceable system to develop a sustainable profile and certification of the product. In order to analyze the massive amount of data from IoT devices, cloud computing was proposed for big data analysis instead of physical computing facilities,since almost none of the existing oil palm plantations and processing plants have adequate computing capability for AI and big data analysis. The image processing technology was proposed to improve the operational efficiencies, such as detection of fruit ripeness and faulty equipment.
Yu et al., 2021 developed a conceptual model that captures the relationship between supply chain relationship capital, enterprise green management, and financial performance. The findings indicate that for companies in the digital transformation of Industry 4.0, supply chain relationship capital positively affects enterprise green management, which subsequently enhances financial performance. Furthermore, they provided practical guidance for companies to effectively implement green management programs and exploit their relationship capital [10].

2. Smart packaging with detectors and sensors

Smart packaging refers to a system that can create, receive, record, draw, and communicate between the product and the consumer. Smart packaging in foodstuffs refers to a type of packaging that contains intelligent agents such as detectors and sensors to convey information about food quality and helps make decisions to increase safety, improve quality, collect information, and warn of food problems. Sensors can be used to determine physical, chemical, or biological variables. Detectors provide information about product quality by environmental conditions and indoor food gases. Detectors can also be attached to the closed surface of food, which accelerates the

detection of metabolites formed during storage [11]. This type of packaging is used to convey information about foodquality and increase the safety of foods. Smart systems create conditions to increase shelf life, high security, and excellent product quality.
Examples of techniques that depend on the intelligent packaging system include temperature and time indices, gas metering indices, labels, and radio frequencies. Types of smart packaging include smart packaging based on measuring the external conditions of the package or smart packaging based on direct measurement of food quality inside the package. Smart packaging indicators are either incorporated as labels on packaging materials or printed on the package to increase product availability by monitoring product quality [12]. The nature of active agents is very different and includes organic acids, enzymes, antibacterial and antifungal compounds, natural extracts and so on. The most important active systems include oxygen adsorption systems, carbon dioxide release and adsorption systems, humidity regulation, the release of antioxidants and antimicrobials, and release or absorption of flavour and odour substances. In fact, active packaging refers to packaging that, in addition to the benefits of conventional packaging as new packaging, changes packaging conditions in order to extend the shelf life or improve the safety and sensory properties of the food product while maintaining its quality.

2.1 Sensors in the food industry

A key factor for the development of an intelligent system is automation which can be achieved by the sensors. Different types of sensors (position, flow, pressure, temperature, force) are used in many sectors, such as medical, industry, aerospace, agriculture, daily life and are available in the market at affordable costs. The objective of Industry 4.0 is to increase efficiency through automation. A sensor is a device that detects the input stimulus, which may be any quantity, property, or condition from the physical environment, and responds to a measurable digital signal. For example, the input stimulus could be pressure, force, flow, light, heat, motion, moisture, or any one of a vast number of other environmental phenomena. The response output is usually an electric form of a signal, like the voltage, current, capacitance, resistance, frequency, etc., which is converted to readable display or transmitted by electronic means over a network for reading or other dispensation [13,14].

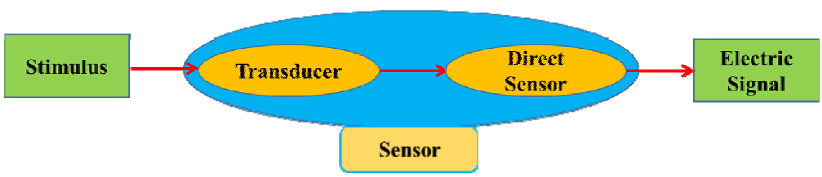

Figure 5. Schematic diagram of a sensor with input & output signal

Sensors are vital components of Industry 4.0, allowing several transitions, such as changes in positions, length, height, external, and dislocations in industrial production facilities to be detected, measured, analyzed, and processed. Smart factories will also enhance sustainability by tracking real-time output, whereas automated control systems will minimize potential factory maintenance costs. It can also be seen that digitalization can improve production mobility, which gives advanced manufacturing firms a

competitive advantage. The fourth revolution is synonymous with intelligent factories, Cloud-based manufacturing, potential factory, smart production and automated manufacturing. Sensors help to improve product quality and decrease production costs, while at the same time acquiring a new market. Intelligent sensors change how manufacturers capture and communicate data, especially when paired with IoT. As a result, they help in manufacturing and production of quality goods more rapidly. [15-17].
Sensors are commonly used in everyday life. Sensors are also highly capable of processing onboard; they can assess atmosphere conditions and appropriately change operations. These decisions are based on vast quantities of evidence and can be analyzed more rapidly and precisely than anybody can expect. This eliminates all of the risks associated with human error and ensures that production and quality can be increased with minimum monitoring. There has recently been discussion of the example of nano-enabled packaging of food which represent a form of packaging technique that controls temperature, moisture, pH, and freshness of the fabric within the packet, contains information for consumers, and controls the environment to increase the time period of the product [18]. Industry 4.0 concepts are available for industrial applications, from factory management to agile production lines, intelligent manufacture, stock tracking and supply chain control. Companies seek self-optimized and integrated production processes; the highest priority is the processing and reviewing data at lower field levels. It offers attractive commercial opportunities for sensors since they facilitate the IoT paradigm in the industry [19, 20]. Sensor technologies are helpful in industries for the analysis of compressed air and equipment which depends on compressed air. Intelligent sensors and warning maintenance can detect the exact pressure of these devices if fluctuations indicate a problem. In addition, these sensors can sense tensile strength and vibration from the other side of the coin, making them suitable for automation [21, 22].
There are countless uses for intelligent sensors. They should be inside ovens, furnaces, or ovens to make sure the appliances get warm enough. They may even be within a cooling room to ensure the pre-packaged temperature or on food packing. In Industry 4.0, there is a need for an integrated and smart network that moves towards intelligent production. Sensors can capture and analyze data to make effective decision-making, while self-optimization is possible for automation in production lines. In many sectors, real-time chemical sensors would open up a new age of process control. Most certainly, the sectors in question are pharmaceutical and chemical, where smart sensors are deployed widely. Innovation and digitalization are moving across the globe. Sensor technology for industrial robotics is one of the main innovations enabling robots to choose paths and interpret environmental changes and evaluate properly, as do people, in dynamic circumstances [23]. Pressure sensors are usually electro-mechanical devices that measure the pressure of gases or liquids and provide signals to the inputs of control and display devices. The temperature sensor is an electronic device that detects thermal parameters of its environment and converts the input data into electronic data to record, monitor or signal temperature changes. A temperature sensor typically relies on Resistance Temperature Detector (RTD) or Thermocouples to detect the temperature changes. A thermometer is the most common temperature sensor used to measure the degree of hotness or coldness. These sensors are frequently used in the automobile sector, aviation sector, medical sector, computers, cooking appliances, and other daily life applications. Humidity sensors measure the amount of water in the environment and

convert these measurements into signals that can be used as input stimuli. It is generally used in the meteorology, medical, automobile, heating, ventilation and air conditioning (HVAC), and manufacturing industries. Gas sensors are fixed or portable electronic devices used to sense the presence and properties of a range of gases and relay signals to the controller in the form of an output signal. These sensors act as a vital device to detect harmful gasesand provide a vital way to monitor gas concentration and environmental information with many safety concerns [24]. The light sensor is also known as a photoelectric device that converts detected light energy (photons) to electrical energy (electrons). These are invaluable tools in numerous industries. However, different light sensors, such as photo-resistors, photo-diodes, photo-transistors,etc., operate slightly differently and have a unique application.

2.1.1 Colour sensors

Among different sensors, colour sensors and biosensors are widely used in the food packaging industry.Colour sensors are a type of photoelectric sensors, which emit light from a transmitter, and then detect the light reflected from the detection object with a receiver. These sensors help build colour sensing applications in image processing, colour identification, industrial object tracking, medical diagnosis systems, health fitness systems, industrial process control, etc.Colour sensors are used as labels in intelligent packaging. Colour sensors enable control of product quality, tracking of critical points, and gathering more information about packaging [25]. It is necessary to use more sensitive dyes for the production of colour-based smart films. In this regard, natural dyes have advantages over synthetic chemical dyes because natural dyes are more sensitive to environmental changes. Natural dyes such as Alizarin, Curcumin, Betaine, Beta-Carotene have been used to produce smart films [26, 27]. In cellulose and agar composites, the pigment chauconin has been used by Roy and Rhim (2020) [28], while Asdagh and Pirsa (2020) [29] used beta-carotene in composites with xenon essential oils and pectin to provide intelligent colour films.

2.2 Indicators

Indicators are materials or instruments that indicate the presence, absence, and concentration of different analytes by means ofchange in a property, such as change in colour [30].

2.2.1 Time-temperature indicators (TTI)

Designing intelligent packaging systems in terms of time-temperature indicators is a prominent method in packaging technology. The importance of these detectors is that the consumer can detect inappropriate food temperatures. If food is exposed to high temperatures, the food can spoil quickly. This identifier can be placed on food containers or separate packages as a small label. When these detectors are in an unsuitable condition, an irreversible change such as a colour change will occur. Time-temperature indicators are valuable for cold and frozen foods because storage, transportation and distribution have a significant impact on the quality and safety of frozen food products. TTI technology is currently used in food products in the UK. The expiration time indicator is used to measure the expiration time of food packaging at a specific temperature. These indicators provide information about the first opening or first use of food.

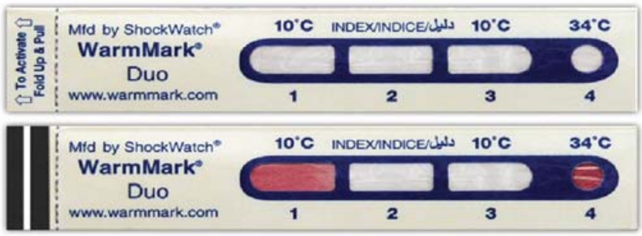

Figure 6.Time-temperature indicator system

The expiration time is very useful for products such as sauces that are stored in refrigerators [31]. Figure6 shows the time-temperature indicators system.

2.2.2 Visual indicators

With visual indicators, colour is changed in response to heat exposure. Their main mechanism of action is chemical diffusion, polymerization, and enzymatic reactions. These products are used as protection against inappropriate temperatures during transport and storage. These indicators are a sign of quality for the manufacturer because they confirm that the product is delivered to the consumer in optimal conditions [32-34].

2.2.3 Radio frequency indicator (RFID)

RFID is an advanced system that is used to automatically detect and track the product. In an RFID recorder system, it receives data from an RFID signal emitted by radio waves, and then the data is transmitted to a computer for analysis. The RFID fragment consists of a small microchip connected to a small antenna [35].

2.2.4 Poison indicators

In general, the main problem with poison indicators are pathogenic microorganisms that are present on the food in very low concentrations and are not evenly distributed throughout the food. Therefore, a highly sensitive poison identifier is used that is in full contact with the food [36].

2.2.5 Seal/Leak Indicator

The gas composition in the food package is changed as a result of food activity or leakage from the outside, which often changes the nature of the enclosed food and environmental conditions. O_2 and CO_2 indicators can be used to monitor food quality as a seal/leak indicator to evaluate the effectiveness of the oxygen absorbents. The color change of many O_2 and CO_2 indicators is the result of chemical or enzymatic reactions, and the color change indicates that there is too much oxygen in a sealed food package. The main problem of these indicators is that storage must be done under anaerobic conditions because they deteriorate rapidly in the presence of air [37].

2.2.6 Freshness indicator

The freshness or ripeness indicator indicates spoilage or destruction of packaged products. Recent detectors directly provide information about the quality of microbial growth or chemical changes in a food product. The microbial quality is determined by the reactions that take place between the in-pack detectors and the microbial growth metabolites. Detection of chemical spoilage of food is provided on the basis of recent detectors, which are developed on the basis of target metabolites that are associated with microbiological degradation. There are several types of freshness indicators, which are based on the colour change of the indicator in response to microbial metabolites produced during spoilage. The response of these indicators to the freshness of food products can be measured by tracking colour changes. The colour of the active center of these indicators is compared with the reference colour [38]. These markers detect different volatile compounds such as diacetyl, amines, carbon dioxide, ammonia, and hydrogen sulfide that are produced during food storage. A colorimetric bromocresol purple dye-based pH-responsive indicator was developed to monitor the quality of chicken breast meat by direct surface contact. To prevent direct contact of the dye with the chicken breast and to improve its colour change sensitivity, it was immobilized with polyvinyl alcohol and a high-absorbance material. The color of the pH indicator changes from yellow to blue and finally purple to indicate spoilage, which can be easily detected by the naked eye. The as-prepared pH indicator exhibited a good response to pH changes on the surface of chicken breast meat, and no migration of the dye from the indicator onto the surface of the chicken was observed. This pH indicator exhibits excellent feasibility for real-time, direct-contact monitoring of the freshness and quality of various foods [39]. Changes in the concentration of hydrogen sulfide or organic acids such as N-butyrate, L-lactic acid, D-lactate and acetic acid during storage are used as specific markers for meat products, fruits and vegetables. Compounds formed during microbial growth (carbon dioxide and hydrogen sulfide) and biogenic amines indicate the freshness of meat and fish. Biogenic amines (putrescine, cadaverine, histamine, etc.) are formed by the degradation of protein in foods containing amines. Therefore, biogenic amines are an indicator for food degradation, and in fact an indirect indicator of the freshness of meat and fish.

The two pH indicators used are methyl red (MR) and Bromo cresol purple (BCP). The beef decay could be detected clearly and easily by the dual-colour indicators, where the MR change from red to yellow, while the BCP change from yellow to purple. The label responds accurately to the beef freshness, in terms of its pH change due to the deterioration, as shown by both colour change at room and cooler temperatures. Similar situation is with the other parameters, such as total volatile basic amine (TVBN), total viable count (TVC), and sensory evaluation. These levels were reached at 8 h and 7 days as the threshold of spoilage at room and cooler temperature, respectively [40]. Figure7 shows a sample of freshness indicator application in food packaging.

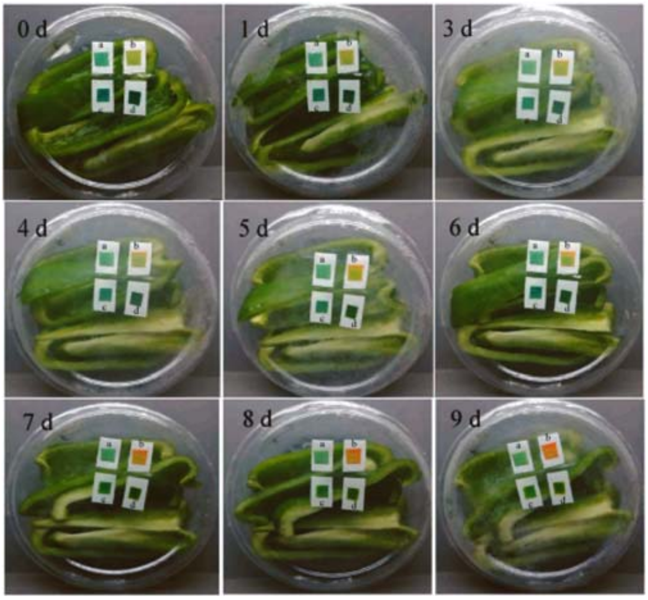

Figure 7. Freshness indicator application in food packaging

2.2.7 Smart packaging with a pH indicator

The pH indicator is a type of smart packaging. It is one of the innovations that is gradually expanding. A change in pH is a major indicator of the freshness and chemical state of a food product. Food spoilage is associated with changes in pH values. Therefore, a relationship between freshness or food quality and pH can be established [41]. In regard to fruits, vegetables and dairy products, the pH changes due to changes in the concentration of organic acids during storage. Similarly, because of microbial metabolism and the growth of bacteria in high-protein foods (meat, seafood, etc.), volatile nitrogen compounds such as dimethylamine, trimethylamine, histamine, tyramine are produced and alter the pH. Multifunctional food packaging films were developed based on chitosan (CS), nanosized TiO_2 and black plum peel extract (BPPE). Effects of TiO_2 and/or BPPE on the physical and functional properties of CS film were investigated. Results showed BPPE contained nine phenolic compounds with 23.29% of anthocyanins. The physical property of CS film could be significantly altered by incorporating TiO_2 and/or BPPE. Notably, CS-TiO_2, CS-BPPE and CS-TiO_2-BPPE films all possessed higher barrier properties against water vapor and UV–vis light, and better mechanical strength than CS films [42]. Recently, several studies have focused on the development of intelligent packaging systems as visual indicators for monitoring the quality of fresh food based on pH changes. The pH indicators usually consist of two parts, a solid base and a pigment that are sensitive to pH changes. These pigments are extracted from various sources of fruits and vegetables. The pH changes when a particular food begins to decline. This change is one of the indicators of product quality. At the beginning of the degradation process, the pH changes, and changes of the colour indicator on the packaging are observed. Therefore, a package that shows the pH of food before purchase or consumption is an action that ensures the quality and safety of the product for the consumer. Multifunctional packaging, which in addition to being smart, has antioxidant and antimicrobial properties, has recently received more attention in the field of food packaging. The composite film of green tea extract/furcellaran/gelatinasis a sample of smart packages with pH indicator with antioxidant and antimicrobial properties. This film shows the pH and changes colour in acidic and alkaline conditions. It is used for smart packaging, and at the same time has the ability to prevent spoilage of packaged food. Recently, a carrageen an-based color film with Lyciumru the nicum Murr has been developed for the intelligent packaging of liquid foods. The extract used in this film was used as a pH indicator to indicate the freshness of the milk. This film shows different colours in different pH ranges and is used as a pH indicator in food packaging. It was also found that this film is suitable for showing the freshness of food products [41]. In another application, films made from natural chitosan and anthocyanins as pH indicator were able to show the pH of the environment in acidic, neutral and alkaline conditions. The inclusion of natural polyphenolic compounds (such as anthocyanins) as pH indicators, in addition to the smartness of the film, creates antioxidant and antimicrobial properties in the film, which indicates the multipurpose applications of this type of film.

2.3 Edible and inedible films in intelligent packaging

An important issue with the use of indicators in food packaging is whether these indicators are in contact with the food (outer packaging film) or there is no direct contact between the food and the indicator (inner packaging film). Based on this, the indicators are divided into two parts. The first part is completely organic and edible indicators where all components of the indicator are edible and there are no restrictions on the use of these indicators in food packaging. Examples of such detectors are pH indicators that use proteins or polysaccharides as the polymer base of the indicators and anthocyanins as the colour indicators of the pH change (these detectors are completely edible). These types of indicators can be used both in contact with food and in non-contact with food.

Some indicators have chemicals in their structure. These types of indicators, although they have an edible polymer base (such as a protein film or polysaccharide), use non-edible chemical indicators or have a non-edible polymer base and an edible indicator. These types of indicators can only be used in food packaging when there is no direct contact between the detector and the food. For example, a polymer-based starch or cellulose-based indicator containing a chemical pH indicator such as phenolphthalein. The use of these types of indicators in food packaging can be dangerous and should be used with extreme caution. As an example of intelligent packaging in which the indicator (as an edible film) is in direct contact with the food is presented by Chavoshizadeh, Pirsa, and Mohtarami. They used the edible film of wheat gluten, containing chlorophyll pigment as an indicator of the expiration date of sesame oil. They reported that in this package, the indicator was in direct contact with sesame oil and showed the expiration date of sesame oil by changing the color from green to yellow.

Figure8-A shows the intelligent packaging system with an indicator (wheat gluten containing chlorophyll) in contact with food (sesame oil) [43].

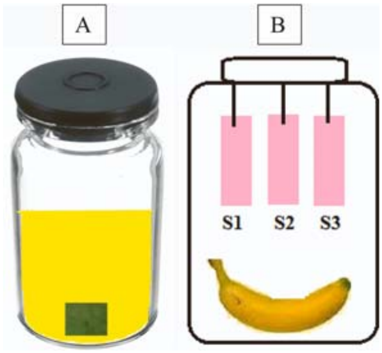

Figure 8. Intelligent packaging system with an indicator in direct contact with food (A) and intelligent packaging system with detector without direct contact with food (B)

In addition, as an example of smart packaging in which the detector (as a non-edible film) is not directly related to the food, [44] used the non-edible ethylene indicator to estimate the shelf life of bananas. According to them, the ethylene indicator was not in direct contact with food, and the ethylene gas released from the banana changed the colour of the indicator and was used to estimate the shelf life of the banana. Figure8-B shows the intelligent packaging system with the indicator (cellulose-containing permanganate) in no direct contact with the food (banana). The integration of software applications, wireless labeling and cloud platforms empowers consumers to examine product labels with their smartphones to assure the product's originality or to gain information concerning ratings or product videos. They only need a Near Field Communication (NFC)-enabled device. The data that these intelligent labels give manufacturers includes demographic information, location, likes, social shares and the actual amount of data retrieval. Forward-thinking organizations are also testing strategies such as expanding the shelf life of fresh products or reducing food and packaging waste.
All over the world, the business sector pays great attention to the use of digital technology to improve communication between all participants in the supply chain.Namely, the application of this new technology can significantly improve all processes related to the source of raw materials to the final delivery. For example, consumer preferences for different types of foods can also be incorporated into mass customization processes with speed and efficiency.

3. Consumer behavior based on credit card data

Based on the analysis of credit card and membership card data of retail companies, patterns of consumer behavior by segments and profits can be identified.In addition, they can find out which of their ready-to-eat meal products are popular, and invest in expanding the automation of these production processes instead of labor.

3.1 Downstream businesses and direct access to consumer data

Modern trade is one of the downstream businesses. Nowadays, much more resources are allocated to online stores than in the past, as they require much less investment than opening new branches. Examples are Amazon, Tesco and Wal-Mart, as well as Big-C, Central Online and Tops. Through e-commerce, companies can access data that will enable them to improve quality and develop new services. These data refer to age, education, income, and the type of food often ordered, among other parameters.
For example, virtual shops have been setup in underground train stations byTesco South Koreain order to drive up purchases by office workers. This idea came from a data analysis that showed that office workers spend most of their time working so they do not have time to shop at retail outlets, but they also do not shop online either.

Figure 9. Virtual shops in underground train stations

With the application of artificial intelligence, it is possible to create a robotic kitchen, which can cook according to the wishes of users, while displaying food and its nutritional value on its screen. It is possible to store recipes in the robot kitchen, but also the kitchen can even learn how to prepare a certain dish by imitating the user's cooking.

Figure 10. Use of artificial intelligence to create a robotic kitchen

There is an idea to develop microchips that will enable communication between food ingredients and food packaging, robotic cuisine and other artificial intelligence-improved cooking utensils.

In addition, consumer demands today are higher than in the previous period. They have become more demanding in their food choices because they have acquired certain knowledge and accordingly seek to harmonize their eating habits. Most of them try to avoid a certain type of food because of an allergic reaction, while others want to avoid high-fat foods, sugar, and gluten or are fans of organic products. Manufacturers will have to upgrade their production processes accordingly to meet consumer demands. This means that, in order to centrally process data and accurately calculate harvests, organic producers will have to invest in connecting soil quality measurement systems, various types of seeding machines, as well as automated irrigation systems, detection and elimination of chemicals, and moisture detection systems. Their systems will also need to be able to track stocks and anticipate consumer demand in order to grow and deliver fresh organic products to retail stores on time, reduce waste from overstocks and satisfy health-conscious consumers. Due to the various types of products, services, and dining experiences, the food industry is more complex than many other industries. Creativity or innovation involves new methods of presentation and development of new products.For example, 3-D printing technology can be used to cut food in certain shapes, thus shortening the time and increasing the consistency of the product. The application of nanotechnology, in terms of applying food packaging sensors which change colour, indicates food quality and thus can better manage the expiration date of food in warehouses, but also prevents consumers from eating spoiled food. Therefore, if companies want to secure their competitive advantage in the long run, investments in these advanced technologies are necessary and cannot be ignored in the 4.0 era. [45].

4. Conclusion

Sensor application usually provides data measurement and device architecture control devices. Intelligent sensors offer real-time, practical input to managers, developers, and engineers to improve production, performance and manufacturing versatility.

This technology is essential for various industries, providing vital information on pressure, temperature, velocity, gas, and location in order to deeply affect various processes or systems. Sensor producers have made constant progress in sensor precision, reliabilities, response times, robustness, miniaturization, communications and efficiencies with the spread of sophisticated electronic control systems.

Intelligent packaging systems provide food security by informing retailers and end users about potential food problems during transportation and storage, and ensure food safety for customers. Indicators (TTIs, freshness indicators and leakage indicators) provide information on the freshness, microbiological quality, safety, temperature status, and shelf life of food. Sensors are the most advanced packaging systems that provide fast, reliable and accurate information about the safety and quality of food products, which try to counteract the negative changes of food products. On the other hand, barcodes and tags provide fast information on product authentication and tracking, thereby increasing distribution efficiency and speed. Research today has been trended towards renewable organic and natural materials for use as nanocomposite biomaterials in food packaging.

In general, smart packaging helps increase the safety, quality, durability, authenticity, traceability, and stability of food products.

5. References

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