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Research on food safety information training system based on component algorithm

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Abstract

In today's world, new food safety concerns emerge and develop on a regular basis, and antimicrobial food resistance is challenged by changes in the environment, food production, and transportation, as well as new and emerging diseases. As travel and trade have grown, international pollution has become more prevalent. The Hazard Analysis Critical Control Points system is a globally recognized food safety system. This technique allows potential dangers in the food manufacturing process to be identified and controlled. By continuously monitoring and managing each of the essential control points when it comes to food production, the program focuses on preventing possible dangers. According to an increasing number of papers and studies in the food sciences addressing topics like authenticity, contamination, deception, nature, and record-keeping of foods, including the rising use of instrumental methods, principal component analysis (PCA) is by far the most common approach in data analysis and interpretation. In conclusion, the PCA program delivers two essential elements: loadings and scores. The loadings indicating which factors are significant in explaining patterns in sample grouping, and the scores offer a sample location.

Keywords: food industry; food safety; principal component analysis; HACCP.

Practical Application: In today's world, new food safety concerns emerge and develop on a regular basis, and antimicrobial food resistance is challenged by changes in the environment, food production, and transportation, as well as new and emerging diseases. As travel and trade have grown, international pollution has become more prevalent. The Hazard Analysis Critical Control Points system is a globally recognized food safety system. This technique allows potential dangers in the food manufacturing process to be identified and controlled. By continuously monitoring and managing each of the essential control points when it comes to food production, the program focuses on preventing possible dangers. According to an increasing number of papers and studies in the food sciences addressing topics like authenticity, contamination, deception, nature, and record-keeping of foods, including the rising use of instrumental methods, principal component analysis (PCA) is by far the most common approach in data analysis and interpretation. In conclusion, the PCA program delivers two essential elements: loadings and scores. The loadings indicating which factors are significant in explaining patterns in sample grouping, and the scores offer a sample location.

1 Introduction

Food safety hazards refer to factors that may potentially damage or endanger food safety and quality, including biological, chemical, and physical hazards, which pose risks to human health and life safety. Once the food contains these hazard factors or is contaminated by these hazard factors, it will become potentially hazardous foods, especially foods that may have microbiological hazards (Bouzembrak & Marvin, 2019; Lehel et al., 2021; Omari et al., 2018; Molajou et al., 2021). International pollution has become more likely as travel and trade have expanded. Food safety is becoming increasingly globalized, and the need to reinforce countries' food safety systems is more pressing than ever. Food that is safe to eat contains no microbiological, chemical, or physical pollutants during transportation, preparation, or storage and does not make people sick. Food safety is ensuring that the food we eat is fully safe and free of microbial, parasite, and chemical contamination (Birawida et al., 2018; Flynn et al., 2019; Panghal et al., 2018; van der Fels-Klerx et al., 2018; Pouladi et al., 2020). The importance of food safety has been emphasized to the point where the World Health Organization began a campaign in 2015 to encourage better food safety from farm to fork. With the advancement of technology, the use of chemicals, pesticides, antibiotics, and hormones in food production has expanded substantially in developing countries, resulting in irrefutable impacts on human health and the prevalence of numerous diseases. Food safety, according to activists, is achieved when all members of a community have constant access to food, both physically and financially, to ensure that they get the nourishment they need to live a healthy and productive life. Food security is one of the four dimensions of food safety: "availability, accessibility, usability, and sustainability." The importance of food security is demonstrated by the fact that 600 million people (or one out of every ten people) get sick each year from eating contaminated food, and the World Health Organization reports 420,000 fatalities due to contaminated food each year (Fritsche, 2018; Jaffee et al., 2018; Omari et al., 2018; World Health Organization, 2019; Weinroth et al., 2018; Elsheikh, 2020; Singh et al., 2020). It turns into. The World Bank research, on the other hand, estimates that compensation costs for unhealthy food consumption in low- and middle-income nations are around $95 billion per year. This data emphasizes the growing importance of natural human

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rights in terms of food safety and the need for governments to pay attention to these rights to protect them.

Food safety refers to the requirement that food be prepared and consumed in accordance with current standards and not be detrimental to human health in any way. Food safety management system means an organization associated with the food chain to sanitation standard operating procedures (SSOP), hazard analysis and critical control point (HACCP) system, good manufacturing practices (GMP), and Codex Alimentarius Commission (CAC) integrated into the management elements required by the organization, and the management system and behavior that put consumer food safety as the focus. Food safety management standards are guidelines for identifying and monitoring food safety organizations. Other management standards, such as ISO 9001, are used in conjunction with these controls. Meanwhile, ISO 22000, which is applicable to all producers, assists in the manufacture of dependable goods by establishing a trustworthy layer in the global chain of food production. The standards for a system to ensure food safety are outlined in ISO 22000 (Panghal et al., 2018; Silva et al., 2016). ISO 22000 serves as a road map for demonstrating an organization's ability to control food safety threats and assure food safety. This map can be used by any organization that participates in the supply chain, regardless of its size or location. Although there may be differences in the specific details of each system, each system will have a lot of content that meets its own specific purpose or scope of application. FSSC 22000, BRC, SQF, and IFS are still the most comprehensive, and there will be a detailed comparison and introduction below (Table 1) (Bomba & Susol, 2020; Sansawat & Muliyil, 2011; Soares et al., 2015).

The ideas of the Hazard Analysis and Critical Control Point (HACCP) system, as well as application processes created by the Codex Alimentarius Commission, are incorporated into ISO 22000. Hazard analysis is an effective key to conduct a hazard analysis food safety management system to aid the company in establishing an effective control measures combination of knowledge required, thanks to the auditable requirements, which combine the HACCP plan and the preparatory program. All hazards required by ISO 22000, including those linked to the types of processes and equipment utilized, identification, and assessment, are reasonably expected to arise in the food chain (Figure 1) (Reilly & Käferstein, 1997).

The HACCP system is an internationally recognized and accepted food safety assurance system, mainly for the safety control of microbial, chemical, and physical hazards in food. The Food and Agriculture Organization of the United Nations and the World Health Organization began to strongly recommend this food safety management system in the late 1980s. The HACCP system consists of the following seven principles:

1. Conduct hazard analysis and determine control measures;
2. Determine critical control points (CCPs);
3. Establish critical limits for CCP;
4. Establish a monitoring system for CCP;
5. Establish corrective measures to be adopted when monitoring shows that a particular CCP is out of control;
6. Establish verification procedures to confirm the effectiveness of the HACCP system;
7. Establish a file system related to the above principles and all procedures and records in their application (National Advisory Committee on Microbiological Criteria for Foods, 1999).

Table 1. Major global food safety standards.

Requirements	IFS	SQF	BRC	FSSC 22000
Food safety management system	Quality and Food Safety Management System	Food safety management system, document control, and records	Food safety and quality management system	Food safety management system
	Responsibilities of senior management	Management commitment	Senior management commitment and continuous improvement	Management responsibility
	Resource management	Management responsibility, training	Personnel	Resource management
	Planning and production process	Specification and product development to achieve product safety	Food safety and quality management system, product control	Food safety planning and realization
	Food defense, procurement, product development	Food defense, purchase, and service, food safety plan	Supplier and raw material approval and performance monitoring, product design, safety	Management of purchased materials, product information, food defense
	Measurement, analysis, and improvement	Verification, corrective and preventive actions, equipment calibration	Internal audit, corrective and preventive measures, calibration	FSMS approval, verification, and improvement
Good operation requirements	Resource management, planning, production process	Identity retention products, product ID, traceability and withdrawal, basic principles of food safety	Site standards, product control, process control, personnel	Product safety planning and realization, ISO/ TS22002-1 prerequisite program requirements
Hazard Analysis and Critical Control Point (HACCP)	Product safety management	Specification and product development to achieve product safety	Food Safety Plan_HACCP	Product safety planning and implementation, FSMS approval, verification, and improvement

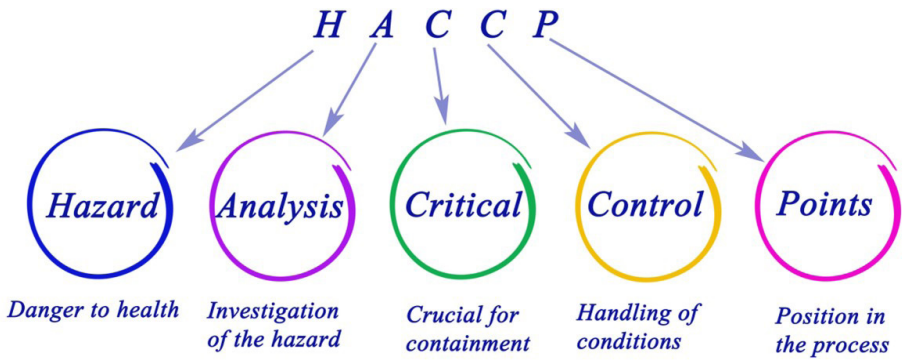

Figure 1. HACCP definition.

One of the most basic points in the HACCP standard can be summarized as hazard risk assessment and identification of critical control points, as well as preventive measures taken against these hazards. The HACCP standard is a set of conditions and systems used to assess the risks that may occur during the food transportation process from the production and food use stages. HACCP is essentially a risk management tool used to manage food safety risks. The HACCP system allows you to detect hazards and implement control measures, enabling you to manage the entire supply chain during the production process. The HACCP plan complies with the requirements of the Codex Alimentarius Commission (CAC) established by the World Health Organization and the Food and Agriculture Organization of the United Nations, which brings together international food standards, regulations, and guidelines to ensure fair trade. It can also be used to support the requirements of management standards, such as ISO 22000 food safety management.

HACCP is a globally recognized food safety standard that provides food safety against chemical, microbiological and physical risks. In order to ensure the safety of food using HACCP, the purpose is to ensure that critical control points and preventive measures are applied in hazardous and high-risk areas and prevent or maybe evaluate at various stages of production. The HACCP system allows organizations to analyze the hazards that affect food safety; it enables them to concentrate on the system identification of critical control points and the implementation of critical control limits in the food production process (Kohl, 2020; Trafialek & Kolanowski, 2017).

Its risk management activities include:

- Risk assessment;
- Risk management option assessment;
- Executive management decisions;
- Monitoring and review.

In the food field, HACCP has:

- Correctness: In the food and beverage industry, through the use of HACCP, any food safety goals set by the (International) Food Code Committee or the National Risk Prevention Manager can be ensured;
- Preventive: Hazard analysis can clearly identify and control potential hazards to prevent harm to consumers (Fayaz et al., 2020; Liu et al., 2021).

The HACCP system has huge potential advantages, the most important of which is the obvious improvement in food safety performance and a higher degree of assurance in terms of legality. The ultimate goal of the HACCP system is to ensure food safety by identifying and controlling food safety hazards rather than through inefficient and negative quality control. HACCP certification allows companies to achieve the following:

- Provide customers with confidence and prove that food is produced through safe processes;
- Prove that all reasonable precautions have been taken;
- If the country where the customer is located has strict food safety legislation, allow the customer to request certification and evaluation of the supplier;
- Reduce the number of audits required by customers, saving cost and time;
- Reduce waste and product recalls;
- Improve relations with food safety authorities;
- Improve efficiency.

This certification can help companies communicate more effectively with stakeholders and other relevant parties. It can also show the company's food safety commitments under the requirements of corporate governance, corporate responsibility, and financial reporting (Zimon et al., 2020). ISO 22000 is an internationally recognized standard that integrates the ISO 9001 approach to food safety management with HACCP to assure food safety at all levels, as we previously stated. All countries are concerned about food safety, which is why ISO 22000 certification provides a guarantee of food safety. As a result, ISO 22000 is accepted in a wide range of countries. This control union certification standard establishes a globally valid certification for food chain categories such as food production,

feed production, storage and distribution, and packaging and packaging materials manufacture.

2 Material and methods

PCA is a statistical technique that allows you to look at so-called multivariate data (data with several variables). Each variable can be thought of as a distinct dimension. If your dataset has more than three variables, it may be challenging to view the data in a multidimensional "hyperspace." The principal component analysis is a technique for extracting and visualizing relevant data from a multivariate data table. PCA condenses this data into a few new variables known as principal components. These new variables are the result of a linear combination of the old ones. The number of original variables is less than or equal to the number of primary components. The overall variance or inertia included in a dataset corresponds to the information contained in it. The goal of PCA is to find the directions (i.e., principal axes or principal components) where the data has the most variation. To put it another way, PCA lowers the dimensions of multivariate data to two or three main components that may be graphically represented while preserving as much information as feasible (Granato et al., 2018; Lever et al., 2017; Naik, 2017). Experience has shown that feature conversion in the form of the PCA method often leads to increased learning model accuracy. But this method also has limitations. The limitations of the PCA method include the following (Stewart et al., 2014):

- The data set is assumed to be a linear combination of specific bases;
- Assume that variance is the main characteristic;
- Assume that mean and covariance are probabilistically reliable;
- The resulting principal components have conceptually nothing to do with the primary features that have replaced them.

The latter limitation prevents the use of PCA in some data mining models, such as the decision tree, which can also lead to analyzable rules. Because the main components extracted from the data set are, in fact, extracts and summaries of all the features of the original data set, it is not possible to say which feature of the data each one is conceptually related to.

The basic component analysis is a method of extracting relevant variables out of a wide range of variables in a collected data. Baseline component analysis takes a high-dimensional collection of characteristics and pulls a low-dimensional feature set to help capture more data using fewer variables (Eriksson et al., 2006; Gündoğdu et al., 2019; Malla & Brewin, 2020; Corches et al., 2020; Schroeder et al., 2020; Kumar et al., 2020; Anil & Bhat, 2020). In this way, data visualization also becomes more meaningful. The essential component analysis is more useful when dealing with data with three or more dimensions. The essential component analysis is always applied to the covariance or correlation matrix. This means that the data must be numerical and standardized. It was due to the fact that the major estimates could have varying scales. A data collection with variables in light-years, kilometers, gallons, and other sorts of units is an example. This is obvious that the variance of such parameters would be significant. When PCA is performed on non-normalized data, excessively significant loads are generated for widely varying variables, which might lead to the underlying component's dependency on widely varying variables, which is incredibly problematic.

Choosing a selection of predictions that include the most information about the data could be a good technique. This makes it possible to plot the data scatter diagram in smaller dimensions. The principal component analysis approach is used to map high-dimensional (3-dimensional) data to lower-dimensional (2-dimensional) data, as seen in Figure 2. Each dimension in the new space is a linear combination of the number of predictions (predictor variables) key features.

3 Results and discussion

Sensory evaluation and consumer research have played an important role in the development of food science and industry. This is important to understand the relationship between food characteristics on the one hand and consumer acceptance and

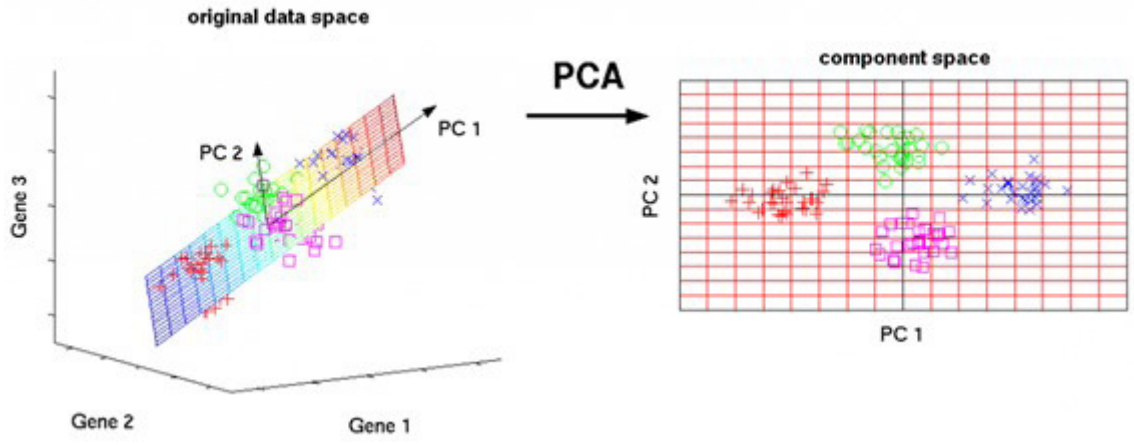

Figure 2. Reduce data dimensions using the basic component analysis method.

buyer behavior on the other. Sensory evaluation studies generate extensive data. Therefore, without using data analysis methods, it is not possible to fully understand these studies and achieve practical results. Therefore, the analysis and interpretation of the results of sensory evaluation of food with the help of statistical software have become one of the most important topics in recent years in the food industry and food industry research. Scientific and technical support is needed to analyze and interpret sensory data performed by experts, sensory evaluators, or consumers, and this is important because of achieving reliable and repeatable results. In sensory evaluation laboratories, in addition to training sensory evaluators and monitoring and supervising their activities (sensory judgments), training in the use of computer skills should also be considered.

Over the past two decades, statistics and math experts have developed a number of software tools for easier use by users. For this purpose, statistical software has been used to ensure product quality control and analysis and interpretation of sensory evaluation results. The main advantage of this software is that the outputs of different statistical calculations can be displayed graphically. The principal component analysis (PCA) method is one of the models studied in statistical software used to analyze multiple indicators, measurement, and recognition of complex structures, and data reduction. This method, especially when the dimensions of the data and the composition of their structure The purpose of this article is to introduce the principal component analysis method as the most important statistical method used in the analysis of sensory data and the basic criteria for interpreting this data based on the author's expertise and scientific research published by him and with An in-depth look at the authoritative scientific sources for the use of students and researchers has been written. Providing practical examples, the criteria for interpreting these diagrams are discussed in detail.

The correct interpretation of sensory data is the most important challenge for the food industry and research sector. Sensory data sets of their kind have tens/hundreds of columns and rows that require statistically valid methods to interpret them. These methods should be able to extract the most important information and present the results in a way that the user easily understands. The principal component analysis is the most important of these methods. Multiple data analysis plays an essential role in information analysis. Multiple datasets contain many states or variables for each observation. If there are *n* variables in each dataset, each variable can have several dimensions. Due to the fact that multidimensional space is often difficult to understand and visualize, the principal component analysis (PCA) method reduces the dimensions of all observations based on similar indicators and classifications. It is used in all analytical forms, from neural network science to computer diagrams. It is an easy and non-parametric method for extracting relevant information from a complex data set. The obtained non-correlated components are called principal components (PC), which are obtained from special vectors of the covariance matrix or correlation matrix of the main variables. For a better understanding of this issue, see Figure 3. This diagram shows points on the two coordinate axes X1 and X2. To determine the general direction of the points, an ellipse is drawn to determine the correlation between the variables.

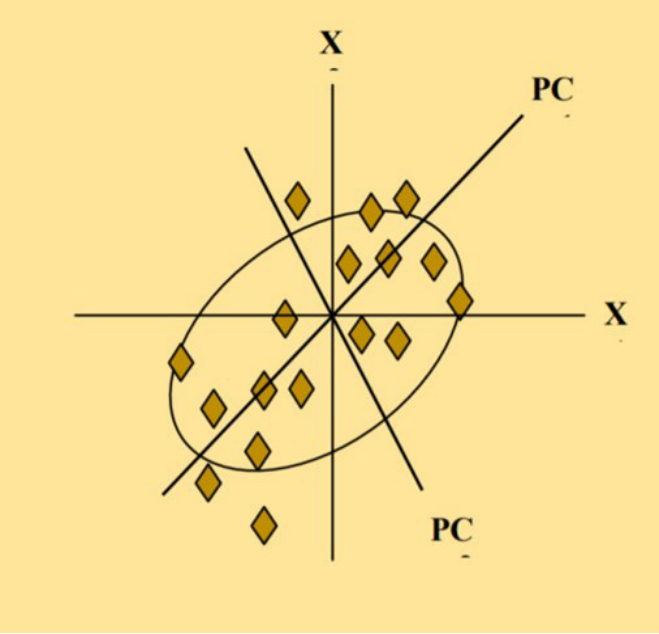

Figure 3. Dimension of data in Principal Components.

Of course, the accumulation of a large number of them can be seen on the main diameter of the ellipse. X1 and X2. The second component (PC2) is an ellipse along the sub-diameter that is exactly perpendicular to PC1 and describes the rest of the changes in X1 and X2. PC1 and PC2 are two new axes to describe X1 and X2. It can be said that X1 and X2 are linear combinations of PC1 and PC2. The principal components can be calculated using the main data set, the covariance matrix, or the correlation matrix. In general, the main application of the principal component analysis method is to reduce the number of variables and find the structure of communication between variables, which is, in fact, the classification of variables.

In the sensory evaluation of food, PCA provides a way to visualize the relationship between the product/sample and its sensory characteristics/traits. In fact, PCA is used to create a simplified view of a multidimensional data set. The data set becomes smaller data due to the correlation of the main variables, and as a result, the main components are formed. Each principal component is a linear combination of principal variables. The maximum amount of variance of the data is in the principal component 1 (PC1) and then in PC2 and PC3, respectively. The principal components are not correlated. For a better understanding of the subject, see Figure 4.

If we want to convert the left diagram drawn from certain data such as product and taste to PCA; The diagram on the right is a new graph that correlates with each point, and each point has a new size/coordinate. Axes have no physical meaning in PCA. They are a combination of indicators/variables (such as product × taste), which, as mentioned, are called the main components.

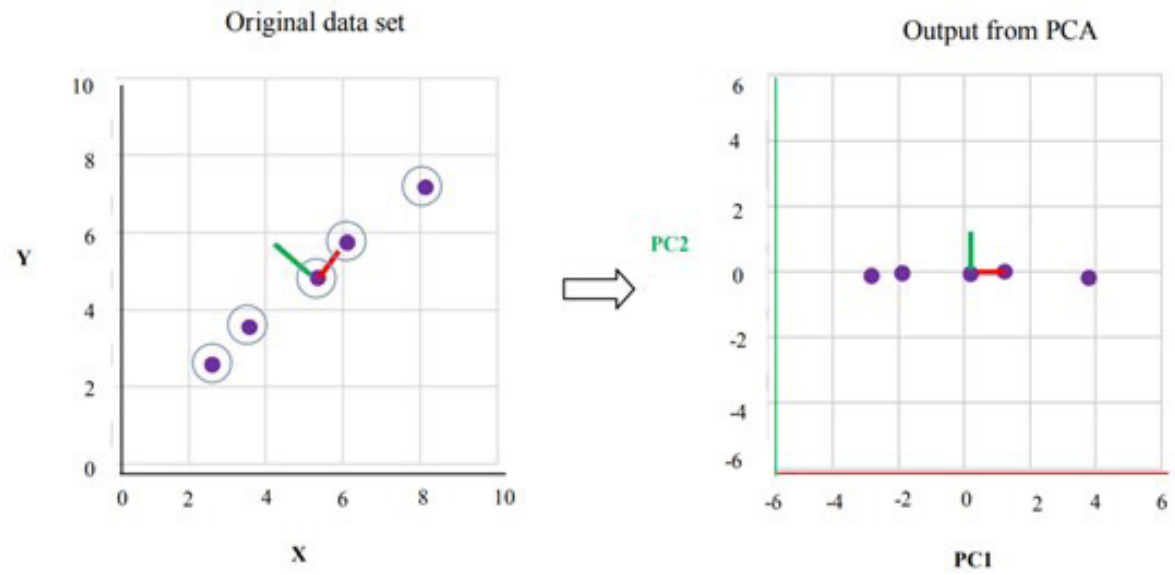

Figure 4. Changing data to PCA plot.

4 Conclusion

Food insecurity in a country or society has no clear explanation. Political, economic, social, and environmental factors are all factors that contribute to the problem. Poverty, conflicts, corruption, national policies, environmental degradation, trade barriers, insufficient agricultural development, population growth, low levels of education, social and gender inequalities, insalubrity, cultural insensitivity, and natural disasters are all factors that can contribute to food insecurity in a country. More recently, a global increase in the price of grains has pushed numerous towns into this predicament, which was caused by a shortage of finances to purchase essential meals rather than a fall in overall food production. Food safety refers to the study, preparation, and storage of food that has the least risk of diseases caused by microbial, physical, and chemical contamination. The main goal of food safety is to prevent food contamination and poisoning. Food safety is a global concern that covers various areas of daily life. Unsafe foods contain harmful bacteria, viruses, parasites, or chemicals that cause more than 200 diseases, including cancers. According to the World Health Organization (WHO) statistics in 2017, about 600 million people (approximately one in ten people worldwide) die after eating contaminated food. Diarrhoea is the most common disease caused by the consumption of contaminated food, with 230,000 people dying from the disease each year. At any stage of production, packaging, transportation, distribution, and even food consumption, there is a possibility of contamination. One of the major and most common of these contaminants is chemicals and pesticides, and herbicides used on farms when crops are grown to control agricultural pests and diseases. The most common contaminants that threaten food safety are Pathogens such as bacteria, viruses, and parasites, Fungal toxins such as aflatoxins, ochratoxins, etc. Heavy metals such as lead, mercury, cadmium chemical pesticides used in agriculture, organic residues in the environment, use of antibiotics, hormones, and additives in food preparation.

4.1 Food safety and security challenges

The FAO said in a report that with a population increase to 9.7 billion by 2050, we need 70% more food available to ensure global food security. Challenges facing food safety include:

- Agricultural land restrictions;
- Weather changes;
- Lack of water resources;
- Rising energy prices;
- Increasing the volume of food waste;

Challenges facing food safety include:

- Contamination of food with heavy metals;
- The emergence of new pathogens and toxins;
- Prevalence of hormones and chemical preservatives;
- The effect of pesticides on food;
- Lack of a healthy diet and related diseases (such as obesity, diabetes, heart disease, infertility, and cancer).

4.2 Solutions

Organic farming

Organic farming is one of the most important and optimal answers to health, safety, and food security challenges.

Organic farming is a type of agricultural system in which, without the use of chemical fertilizers, pesticides, chemical pesticides, growth hormones, and environmental damage, agricultural products are produced that are healthy and free from pollution and common diseases.

In addition, organic farming maintains the balance of the ecosystem and provides food security by creating sustainability and protecting natural resources.

Megatrends

Megatrends are products, technologies, and services that will change the atmosphere of communities and businesses in the future.

Here is a brief overview of some of the cloud trends:

Digital food and internet food

3D food printers are among the technological advances in the food industry that will revolutionize the industry.

With these printers, anyone can be a food producer.

Also, online food sales, which are increasing in many countries, will solve some of the problems related to food access.

Personalized regimes

In addition to paying attention to nutrients, it is programmed based on each individual's personal microbiome (each person's unique intestinal microbial flora) and allows it to be manipulated to prevent or cure related diseases.

Use of nanotechnology

New food packaging methods that rid them of any bacterial contaminants and toxins, viruses, and chemicals.

Application of whole-genome sequencing technology

In this method, reading the specific genetic information of each creature leads to accurate identification and diagnosis of pathogens and reduce and prevents food safety problems.

Advances in food chemical analysis tests

For example, using tests such as mass spectrometry, specifically and with high sensitivity, can be accurately identified in terms of quality and quantity, known and unknown toxins or metabolites in food.

Big data development

Collect and analyze large data on food safety and quality comprehensively. Everyone in the community can access real-time information about disease outbreaks at any time and consumer safety measures online. Also, the analysis of this data provides good information to large companies active in the field of food and its safety and security. Given the correlation between the two concepts of food safety and security, we cannot have food security and sustainable access to food without food safety. The issue of food safety and security is a global challenge that is increasingly affecting developing countries. It should be noted that this area can provide a good opportunity for innovation potential of young people and start-ups with the future research of technologies and development of ideas in the fields of the production process, quality control, maintenance, packaging, and ease of processes. Food access can be effective in solving most of these challenges in our country.

References

Anil, M. A., & Bhat, J. S. (2020). Transitional changes in cognitive-communicative abilities in adolescents: a literature review. *Journal of Natural Science, Biology, and Medicine*, 11(2), 85.

Birawida, A. B., Selomo, M., & Mallongi, A. (2018). Potential hazards from hygiene, sanitation and bacterium of refill drinking water at Barrang Lompo island (water and food safety perspective). In I. F. Mujahidin (Ed.), *IOP Conference Series: Earth and Environmental Science* (Vol. 157). Indonesia: IC-FSSAT. http://dx.doi.org/10.1088/1755-1315/157/1/012034.

Bomba, M. Y., & Susol, N. Y. (2020). Main requirements for food safety management systems under international standards: BRC, IFS, FSSC 22000, ISO 22000, Global GAP, SQF. *Food Technology*, 22(93), 18-25.

Bouzembrak, Y., & Marvin, H. J. (2019). Impact of drivers of change, including climatic factors, on the occurrence of chemical food safety hazards in fruits and vegetables: a Bayesian Network approach. *Food Control*, 97, 67-76. http://dx.doi.org/10.1016/j.foodcont.2018.10.021.

Corches, C. L., McBride, A. C., Robles, M. C., Rehman, N., Bailey, S., Oliver, A., & Skolarus, L. E. (2020). Development, adaptation and scale-up of a community-wide, health behavior theory-based stroke preparedness intervention. *American Journal of Health Behavior*, 44(6), 744-755. http://dx.doi.org/10.5993/AJHB.44.6.1. PMid:33081873.

Elsheikh, M. A. A. (2020). Degradation kinetics of carbofuran insecticide in tomato fruits. *European Chemical Bulletin*, 9(10-12), 355-359. http://dx.doi.org/10.17628/ecb.2020.9.355-359.

Eriksson, L., Andersson, P. L., Johansson, E., & Tysklind, M. (2006). Megavariate analysis of environmental QSAR data. Part I–A basic framework founded on principal component analysis (PCA), partial least squares (PLS), and statistical molecular design (SMD). *Molecular Diversity*, 10(2), 169-186. http://dx.doi.org/10.1007/s11030-006-9024-6. PMid:16770514.

Fayaz, H., Kumar, A., Kousar, F., Sharma, S., & Kumar, S. (2020). Application of total quality management to ensure food quality in food industry. *Journal of Animal Research*, 10(3), 329-338. http://dx.doi.org/10.30954/2277-940X.03.2020.1.

Flynn, K., Villarreal, B. P., Barranco, A., Belc, N., Björnsdóttir, B., Fusco, V., Rainieri, S., Smaradóttir, S. E., Smeu, I., Teixeira, P., & Jörundsdóttir, H. Ó. (2019). An introduction to current food safety needs. *Trends in Food Science & Technology*, 84, 1-3. http://dx.doi.org/10.1016/j.tifs.2018.09.012.

Fritsche, J. (2018). Recent developments and digital perspectives in food safety and authenticity. *Journal of Agricultural and Food Chemistry*, 66(29), 7562-7567. http://dx.doi.org/10.1021/acs.jafc.8b00843. PMid:29920081.

Granato, D., Santos, J. S., Escher, G. B., Ferreira, B. L., & Maggio, R. M. (2018). Use of principal component analysis (PCA) and hierarchical cluster analysis (HCA) for multivariate association between bioactive compounds and functional properties in foods: a critical perspective. *Trends in Food Science & Technology*, 72, 83-90. http://dx.doi.org/10.1016/j.tifs.2017.12.006.

Gündoğdu, Y., Karabağlı, P., Alptekin, H., Şahin, M., & Kılıç, H. Ş. (2019). Comparison of performances of Principal Component Analysis (PCA) and Factor Analysis (FA) methods on the identification of cancerous and healthy colon tissues. *International Journal of Mass Spectrometry*, 445, 116204. http://dx.doi.org/10.1016/j.ijms.2019.116204.

Jaffee, S., Henson, S., Unnevehr, L., Grace, D., & Cassou, E. (2018). *The safe food imperative: accelerating progress in low-and middle-income countries*. Washington: World Bank Publications.

Kohl, H. (2020). Industry-specific standards for management systems. In *Standards for management systems* (pp. 251-334). Cham: Springer. http://dx.doi.org/10.1007/978-3-030-35832-7_3.

Kumar, V., Bhatia, M., & Kumar, A. (2020). Microbes from mouth to gut impacting probiotics to antibiotics. *Journal of Natural Science, Biology, and Medicine*, 11(2), 83.

Lehel, J., Yaucat-Guendi, R., Darnay, L., Palotás, P., & Laczay, P. (2021). Possible food safety hazards of ready-to-eat raw fish containing product (sushi, sashimi). *Critical Reviews in Food Science and Nutrition*, 61(5), 1-22. PMid:32270692.

Lever, J., Krzywinski, M., & Altman, N. (2017). Points of significance: principal component analysis. *Nature Publishing Group*, 14(7), 641-642

Liu, F., Rhim, H., Park, K., Xu, J., & Lo, C. K. (2021). HACCP certification in food industry: trade-offs in product safety and firm performance. *International Journal of Production Economics*, 231, 107838. http://dx.doi.org/10.1016/j.ijpe.2020.107838.

Malla, S., & Brewin, D. G. (2020). An economic account of innovation policy in Canada: a comparison of canola. *Wheat, and Pulses*, 53(2), 83-107

Molajou, A., Afshar, A., Khosravi, M., Soleimanian, E., Vahabzadeh, M., & Variani, H. A. (2021). A new paradigm of water, food, and energy nexus. *Environmental Science and Pollution Research International*. http://dx.doi.org/10.1007/s11356-021-13034-1. PMid:33634401.

Naik, G. R. (2017). *Advances in principal component analysis: research and development*. Cham: Springer.

National Advisory Committee on Microbiological Criteria for Foods. (1999). Microbiological safety evaluations and recommendations on sprouted seeds. *International Journal of Food Microbiology*, 52(3), 123-153. http://dx.doi.org/10.1016/S0168-1605(99)00135-X. PMid:10733245.

Omari, R., Frempong, G. K., & Arthur, W. (2018). Public perceptions and worry about food safety hazards and risks in Ghana. *Food Control*, 93, 76-82. http://dx.doi.org/10.1016/j.foodcont.2018.05.026.

Panghal, A., Chhikara, N., Sindhu, N., & Jaglan, S. (2018). Role of food safety management systems in safe food production: a review. *Journal of Food Safety*, 38(4), e12464. http://dx.doi.org/10.1111/jfs.12464.

Pouladi, P., Afshar, A., Molajou, A., & Afshar, M. H. (2020). Socio-hydrological framework for investigating farmers' activities affecting the shrinkage of Urmia Lake; hybrid data mining and agent-based modelling. *Hydrological Sciences Journal*, 65(8), 1249-1261. http://dx.doi.org/10.1080/02626667.2020.1749763.

Reilly, A., & Käferstein, F. (1997). Food safety hazards and the application of the principles of the hazard analysis and critical control point (HACCP) system for their control in aquaculture production. *Aquaculture Research*, 28(10), 735-752. http://dx.doi.org/10.1111/j.1365-2109.1997.tb00999.x.

Sansawat, S., & Muliyil, V. (2011). *Comparing Global Food Safety Initiative (GFSI) Recognised Standards.* Rouen: SGS.

Schroeder, K., Kubik, M. Y., Sirard, J. R., Lee, J., & Fulkerson, J. A. (2020). Sleep is inversely associated with sedentary time among youth with obesity. *American Journal of Health Behavior*, 44(6), 756-764. http://dx.doi.org/10.5993/AJHB.44.6.2. PMid:33081874.

Silva, M. M., Fonseca, L. M., & Sousa, S. D. (2016). The impact of ISO 9001: 2015 on ISO 22000 and food safety management systems (FSMS). *Calitatea*, 17(152), 81.

Singh, S., Singh, N. P., & Rani, R. (2020). Hazardous elements in aqueous leachates of coal fly ash around thermal power plants disposal area. *European Chemical Bulletin*, 9(10-12), 360-365. http://dx.doi.org/10.17628/ecb.2020.9.360-365.

Soares, N. F., Vicente, A. A., & Martins, C. M. (2015). *Food safety in the seafood industry: a practical guide for ISO 22000 and FSSC 22000 Implementation*. Hoboken: John Wiley & Sons.

Stewart, S., Ivy, M. A., & Anslyn, E. V. (2014). The use of principal component analysis and discriminant analysis in differential sensing routines. *Chemical Society Reviews*, 43(1), 70-84. http://dx.doi.org/10.1039/C3CS60183H. PMid:23995750.

Trafialek, J., & Kolanowski, W. (2017). Implementation and functioning of HACCP principles in certified and non-certified food businesses. *British Food Journal*, 119(4), 710-728. http://dx.doi.org/10.1108/BFJ-07-2016-0313.

van der Fels-Klerx, H. J., Camenzuli, L., Belluco, S., Meijer, N., & Ricci, A. (2018). Food safety issues related to uses of insects for feeds and foods. *Comprehensive Reviews in Food Science and Food Safety*, 17(5), 1172-1183. http://dx.doi.org/10.1111/1541-4337.12385. PMid:33350154.

Weinroth, M. D., Belk, A. D., & Belk, K. E. (2018). History, development, and current status of food safety systems worldwide. *Animal Frontiers*, 8(4), 9-15. http://dx.doi.org/10.1093/af/vfy016. PMid:32002225.

World Health Organization – WHO. (2019). *Preventing disease through healthy environments: exposure to highly hazardous pesticides: a major public health concern.* Geneva: WHO.

Zimon, D., Madzik, P., & Domingues, P. (2020). Development of key processes along the supply chain by implementing the ISO 22000 standard. *Sustainability*, 12(15), 6176. http://dx.doi.org/10.3390/su12156176.