Entrepreneurship Innovation – Food Image Quality Testing

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Analyzing Food Quality and Safety using Images

Introduction

Determining food quality and safety has been a global issue, especially in urban areas. Although these two terms can be so confusing at times. Food quality refers to any factor that can contribute to affecting the value of a product. Whereas, food safety includes any hazard that may make edible products cause a risk to the health of an individual. Some of the factors that contribute to interference with food safety and quality include spoilage, loss of the original color, flavor, smell, and texture. Hazards that are likely to affect food quality include pesticide residues, adulteration, and chemical contamination such as biological toxins, microbiological hazards, and misuse of food additives. Most of the time these problems are not caused by the retailer but most of them originate from the farm where production begins. Some farmers tend to use strong chemicals to deal with pests and diseases, weeds, and also in the effort to try and increase their yield. From the farm, some manufacturing companies also interfere with the food quality and safety in the process of value addition. Some of these manufacturers use excess food additives and preservatives so that the product can stay for long without going bad and in the end, these ingredients destroy the original flavor, texture, and color.

Different images can be used to analyze the food quality and safety of diverse food products. Various food products require several images depending on their thickness, state, color, and texture. To come up with these images a chemical technique is incorporated with technology so that when images are taken on any food substances, there are sensors to identify the presence of any contaminants that may interfere with the food quality and safety. The chemical technique

known as spectroscopy requires only a picture of the food substance then all the nutritional content, the level of moisture, and freshness are detected.

Review of Literature

Khan et al published a journal on food quality in 2021 where the suggestion was that producers should ensure they satisfy their customers with food that is safe and of good quality. In the journal, the discussion was mainly based on the use of machine vision to ensure food security most effectively. According to the authors of this journal, there is an increase in the living standards which makes food contamination a major issue. Food is required as an energy source and a source of food, therefore there is a need to ensure quality and safety. The best way to use machine vision is through image recognition. It comprises algorithms and technologies that in the evaluation of data, classification of food, and recognition of any contaminants. Some of the techniques involved in image recognition include deep learning in food safety and machine learning in food safety. In deep learning techniques food is different in terms of thickness, form, quantity, flavor, and content. All these factors make the identification of contaminants a complex process for natural food and processed foods (Khan et al.., 2021).

In this technique, there is the universal manipulation of a convolutional neural network. The network helps in the identification of the nutritional content of the food in question. The architectural network takes images concerning the convolutional neural network which comprises several image processing units to ensure safety. The other technique is machine learning in food safety. In this strategy, there is a range of novel data stream sources which can be manipulated to conduct tests on food safety and quality. Different types of data are collected on the food to be tested. The data include raw data, transactional data, and trade data. Raw data is

that which relates to the original state of the food. Transactional data is used to test for foodborne contamination while trade data helps in the evaluation of food hazards (Siche et al.., 2016). After that, the machine helps in image segmentation, feature extraction, and classification before identifying any contaminants.

Research has shown that there is an increase in the level of living standards, advancements in technology, and an increase in population. These advancements have increased the need for assurance of food quality and safety. Since there are advancements in technology, consumers expect more from manufacturers in terms of releasing agricultural products that are of high quality and safe for human consumption. A computer image processing system appears to be one of the best methods which can assure consumers of safety and quality. Through the use of computers food quality and safety can be analyzed using a range of internal and external parameters concerning the food characteristics. Although manufacturers can still use sensors and safety scores. For the process of identification of contaminants to be made easier. The external qualities can be monitored by employees since they are visible and tangible (Turgut, Karacabey & Küçüköner, 2014). On the other hand, internal factors such as the Ph value, firmness, amount of additives and preservatives, and presence of any titratable acidity are identified by the computer. Although some traditional methods were previously used to check for any contamination in food products computer imaging processing system is preferred. When using a computer, there is no damage to the food, it is left in the same condition and the method is fast and feasible. A manufacturer using the computer system has an opportunity to carry out objective inspections, automated processes, rapid, and hygienic tests. According to the authors of this article, some basic steps should be followed strictly during image processing and analysis of food safety and quality. The vision and the algorithm present in the computer system help in the

gathering of information from the food substance (Turgut, Karacabey & Küçüköner, 2014). The information gathered helps in food classification, quality sorting, and recognition of internal and external features of the type of food under the test. The steps involved in the image recognition process include image acquisition, pre-processing, division, representation and description, identification, and interpretation of the results.

According to Eissa et al, there is imaging technology about monitoring and analyzing the quality and safety of food. The quality and safety of food are becoming a serious issue in developed and developing countries which need to be debated upon. Image analysis which is commonly used in engineering and computer science departments is now becoming common and of great help in the agricultural sector. The process helps in the quantification of the image characteristics in terms of the location and the fillings. The application of image analysis in the food sector has several advantages. There is objectivity, consistency, and a quicker decision-making process. The authors agree that in the agricultural sector, analyzing internal and external food quality and safety is turning out to be among the most important issues in the sector. Through imaging technology, consumers can be assured of safety from diseases and contamination. It is required that the imaging technology should meet the good manufacturing practices, hazard analysis, and critical control points to achieve food safety and quality results. According to this technology, the image produced should be digital to ensure there is intensity in terms of reflection and representation. The cameras used should be sensitive to ensure the internal food characteristics are identified (Eissa et al.., 2021). An excellent example used by the authors is the image of potatoes or apples. The thickness of these two food products is almost the same, and therefore the reading of each food will depend on the variations in terms of distance from the source of light during imaging and segmentation of the same. For the manufacturers to

ensure good and correct results the distance from the source of light should be equal for all the food samples to be tested. The first step is to cut the sample into a sub-sample that the camera's sensor can read through the photograph. The authors recommend hyperspectral imaging technology which is capable of analyzing the physical and morphological features of the food product in question. The technology also can identify the chemical and molecular characteristics to ensure the assessment and analysis of food quality and safety (Eissa et al.., 2021). The method ensures that the inspection of quality and safety is done at a high level. The technology has the following advantages, especially for manufacturers whose products have been receiving some complaints from consumers. It can detect foreign objects such as metals, glass, and plastics that might have made their way during food processing. The method also identifies any holes in the packaging that might have occurred during the sealing process since a lot of heat is engaged during this activity. Hyperspectral is cost-effective since the sensors used are sold at affordable prices which seem to be decreasing rapidly. There is no destruction caused to the food product since it does not come into contact with the sensors. The sensors used are also versatile since they can be applied for other purposes such as detecting the moisture content in the food substance (Eissa et al.., 2021).

Several pieces of research have been done regarding the advancements in imaging technology to ensure food safety and quality. Deng et al published an article in 2020 suggesting that issues to do with food quality and safety are concerns of several stakeholders such as the government, consumers, and the food processing industries at large. Biochemical and instrumental analysis methods are some of the traditional methods that were used to detect any contaminants that could interfere with food quality and safety. Instrumental analysis methods include chromatography and chromatography-mass spectrometry. Although the manufacturers

realized that these methods are time-consuming and it is not easy to get a spatial distribution of the analytes in the food product. The drawbacks of the traditional methods in the analysis of food safety and quality are what led to the development of other visual detection technologies that are fast, real-time, and non-destructive on the food sample being assessed. The development of visual detection has become the focal point of the food research institutes and other non-governmental organizations concerned with food safety and quality (Deng et al.., 2020). The authors of this article suggested the use of hyperspectral imaging which is comprised of imaging and spectral technology. The method appears to be slowly taking over all the other methods that are available in the food industry.

Manufacturers using the Raman technique can be able to determine the geometrical characteristics of the food product as well as the chemical composition of the food sample. The meat processing industry is well known for the application of this technique for detecting adulteration, evaluating meat quality, and meat classification. The technique is used in combination with Raman imaging which helps in the detection of any illegal additives and preservatives present in the food product (Yaseen, Sun & Cheng, 2017). The strategy is also affordable. Furthermore, the application of this technology makes it easier to get spatial and spectral information about the food sample. There is no need to prepare complex samples through labeling and staining when using this method. The distribution of nutrients and the number of harmful substances can also be detected. Food research institutes prefer mass spectrometry imaging due to its unique merits which include its ability to be used in the detection of molecular levels in the sample. It also helps in the correct positioning of the substances present in the product. The method is governed by principles that include detailed application in

quality detection, source identification, and the level of microbial pollution in the sample (Yaseen, Sun & Cheng, 2017).

Xiao et al suggested that to ensure success in food detection for quality and safety purposes, the machine vision system is the best. There is a lot of competition in the food processing industry due to the emergence of companies. This has made the industry to be more dynamic as consumer increases their knowledge of the need to know the composition of what they are consuming. The functions of food have also increased over the past years. This is a result of new demands for safety and quality and the body's nutritional needs. The need to enhance efficiency in food production and processing has hastened the need to develop methods that will help in the detection of any contaminants. The development of the machine vision system is a result of computer and technology advancements (Xiao et al.., 2022). The application of the machine vision system helps in stimulating video and graphic images that cannot be seen through the human eye. It also helps in monitoring and processing the existing data through image information capture and image information. The machine must consist of image acquisition and image information gadgets to help in the collection of information from the food to be tested. The image acquisition instrument comprises x-rays, thermal imaging, and remote sensing imaging in conjunction with a camera that is highly defined. On the other hand image, information instruments help in the analysis of the obtained food information (Xiao et al.., 2022). The machine vision is also capable of detecting food defects and performing a ripening analysis. An excellent example used by the authors of this article for defect detection is the use of the mango sorting process. Monochrome cameras are used for automatic mango sorting and 98% of the mangoes set aside had defects. The use these monochromes cameras work best when used in combination with deep learning. With the presence of deep learning, tracking devices are

developed to detect adulteration. The method works best in manufacturing companies of black pepper which they use to detect papaya seeds in the pepper. The machine vision system is also capable of classifying food products in terms of their color depending on the results from the digital images (Xiao et al.., 2022). Deep learning is required for the analysis of food safety and quality by collecting several building data sets, training the network model using the datasets, and then using the training model to detect and recognize food images which are further used to identify the presence of any contaminants.

From the journal of food quality Hemamalini et al 2022, quality and safety assurance is one of the most critical aspects in the effort to try and satisfy customers. Customers prefer quality products rather than quantity. The application of machine vision to analyze food safety and quality in the food industry is becoming significant day after the other, especially for fruits and other food products. The reason why this method is embraced and implemented in the food industry is that it works best, especially in situations where the human eye cannot be able to evaluate further on food safety and quality. However, the authors focused more on how to evaluate the quality and safety of food products using picture segmentation and machine learning. These two methods have the ability of grouping fruits and recognize whether a certain portion of the fruit is rotten (.Hemamalini et al.., 2022) some issues are connected to the automated inspection of agricultural products. They include the diverse flavors and textures of the food in its natural state. Foods such as fruits and vegetables display a wide range of exterior qualities, fruits differ in terms of size, color, and the form in which they are originally harvested from the farm from the same tree. The color and texture of fruits are likely to change depending on the nature of storage, the duration of storage, humidity and temperatures prevailing in the storage section, presence of fungal infections, and other substances which could be volatile. The

authors of the journal conducted research by examining the Hass avocadoes, mangoes, and the maize tortilla. After harvest, the produce of each was sorted using a machine vision algorithm (Hemamalini et al.., 2022). Then a horizontal and vertical grading system was used with the help of automatic cameras to separate produce with internal defections that the workers cannot detect. Digital images at times contain defects such as noise due to poor capture which requires to be eliminated. Annoyances and Gaussian filtering is used to ensure the digital images are smooth for better results during the analysis of food quality and safety.

Connection of the problem and innovation to classwork

There is a positive and direct connection between the problem and the innovation selected to solve the problem and classwork. Based on what was covered in the entrepreneurship class, there are seven major principles that an entrepreneur should follow when choosing an innovation. Entrepreneurs are businesspersons who are entitled to come up with possible solutions to challenges or issues affecting the field of business. Problem identification and innovation are based on the seven principles which include the following. The first one is to do something vital. Identifying that food quality and safety require a lot of attention and looking for a possible solution through imaging technology is obeying the first principle. The second principle is to always respect your customers. Some of the manufacturing companies as clearly indicated in the review of the literature have been receiving complaints from their customers (Mandrup & Jensen, 2017). The complaints are about the contamination of food products evident in the change of color and flavor. By obeying this principle several food processing companies have adopted the new technology the use of imaging technology to analyze food quality and safety to ensure it is fit for human consumption.

The third principle is to always respect employees. Employers should understand that some activities are beyond human capabilities. An excellent example is shown in the review of the literature where so many processing companies understand that employees can only see the external features of a food product. These companies have acquired imaging technology such as machine vision to analyze the internal features and identify whether they are at risk of interfering with the food quality and safety. The fourth principle is to always respect investors' capital. Most of these food processing companies are public limited companies where investors own part of the shares. Investing is done to get some benefits in return (Mandrup & Jensen, 2017). Companies that have failed to adhere to the complaints' of their customer ignore the importance of analyzing food quality and safety through imaging technology. For such companies, they end up losing their customers and investors get no profit in the long run. Many companies have adhered to this principle by ensuring investors will not regret having invested their capital in the company.

The fifth principle requires that every entrepreneur should be ready to grow their business. Adopting advanced technology is one method that can lead to the growth and expansion of the business. From the various articles and journals analyzed in the review of the literature, it is clear that the traditional methods that were used in the analysis of food quality and safety were time-consuming and expensive implying that companies were not making a lot of profit. Recently most companies have adopted imaging technology which is fast and less costly, therefore there is an increase in profit margin due to the increased sales since customers have gained trust again in the companies (Mandrup & Jensen, 2017). The sixth principle is always to strive to be the leader in your space. Due to technological advancements and the increase in the standards of living, there is an increase in competition as more companies are being established to satisfy the needs of the growing population. Food processing is striving to be the best by

adopting some imaging techniques such as hyperspectral imaging to ensure they attract customers and gain a competitive advantage over their competitors in the industry. The last principle is to never give up. Analyzing food quality and safety is always a complex task but companies have been doing their best to ensure they meet the needs of their consumers by producing products that are safe for human consumption. Apart from the problem and the innovation being connected to the seven principles of entrepreneurship, they are also connected to the fact that entrepreneurs are supposed to ensure their product is unique and the customers are aware of the original products (Mandrup & Jensen, 2017). Food processing companies have ensured they indicate the color, flavor, texture, and content of their product so that customers can differentiate it from the counterfeit which could be contaminated with foodborne bacteria and other pathogens.

How to determine the effectiveness of the innovation

The effectiveness of the imaging technology in analyzing food quality and safety can be determined through various metrics. The first measure is to determine employees' and customers' perceptions concerning the company's innovativeness. This can only be done by surveying the employees and customers so that they can air their views and suggestions regarding the innovation. The other measure would be to analyze the general performance of the company in terms of the revenue generated (Nechaev, Ognev & Antipina, 2017). The measure will determine the effectiveness when the company has to compare previous profits when the company was using traditional methods of analyzing food quality and safety and the current profits after adopting the new imaging technology. If the current profits exceed the previous revenue then the innovation is effective.

The other way would be to determine the number of new customers acquired after the implementation of the new technology. This will also involve checking the exact number of loyal customers that the company has. If the number of customers has increased after the adoption of the innovation, then it is effective and if the number of customers has reduced then the innovation is not effective. A comparison of the previous and current market share should also be evaluated (Nechaev, Ognev & Antipina, 2017). Research has shown that companies that have adopted the imaging techniques are likely to increase their market share as they are going to gain a competitive advantage over their competitors who have not adopted the profitable new technology. Financial stability can also be evaluated based on how timely the company can pay its suppliers and employees and the amount of return on investment received by investors.

Requirements to turn the innovation into reality

The project is viable and hence it requires to be put into reality. Putting innovation to reality requires several steps which should be followed for implementation to be a success. Innovation implementation requires customization and rationalization. Before starting the implementation process it is crucial to ensure that as the management, you have built a culture of innovation in the organization. Most of the time employees and customers are likely to show resistance to an innovation that is being introduced since the company was established (Rogan, 2017). But once innovation becomes the culture of the organization, employees and customers expect the implementation of innovation at any time since it has become a norm.

The first step is strategic direction. Employees should be in a position where they clearly understand the strategic direction of the company before proposing any ideas. Innovative strategy is one of the most important elements of strategic direction which acts as a guide for

creativity efforts by the management. The second step is an inspiration to offer solutions and innovative services to the issue of food quality and safety. Most of the time companies are inspired by their competitors, employees, and customers. When customers air their grievances about the presence of contaminants in the food products the company is inspired to adopt the imaging technology to help solve the issue (Rogan, 2017). When employees interact with the customers during sales and delivery services, they become inspired to share some of the ideas with the company which will help in increasing profit and attaining the largest market share in the food processing industry.

The third step is ideation. Ideas can come from employees or customers. Employees get ideas from companies they have previously worked for and are willing to share their experience with the current employer. For example, maybe an employee was previously working in a company where the imaging technology was fully implemented and was the major factor that led to the success of the business. The employee might share some of the activities that the previous company was involved in so that the current employer can take in the ideas. Customers get ideas from other companies with whom they have interacted with their goods (Rogan, 2017). An excellent example includes companies that indicate on the packaging the condition of their product to prevent customers from purchasing counterfeit products.

The fourth step is proof of the concept. Although research has shown that food quality and safety are increasingly becoming a major issue it would be best for the company to first confirm the concept by conducting research in most of its target market and analyzing the data collected. Collaboration in the workplace helps in fostering proof of the concept since employees are made of different experts (Rogan, 2017). The fifth step is pilot which involves testing the concept under a limited run to check and monitor the progress. Piloting helps the company get an

idea of how the customers are likely to respond to the innovation once it is fully implemented. It also helps the company to learn from previous mistakes that might have contributed to the failure of implementation. The last step is measurement and feedback which requires that all the above-mentioned steps be evaluated and analyzed. This involves clear communication to the employees on what the imaging technology entails (Rogan, 2017).

Summary of the next steps

In conclusion, imaging technology is the major cause of success for many food processing companies. Although some companies have not yet adopted the new technology and are still using the traditional methods which are not effective. Since imaging technology such as machine vision has high levels of accuracy, it would be essential to develop devices that are of high resolution. Doing this will ensure accuracy and an improvement in the inspection process. In computer vision, image processing seems to be the core activity; therefore technological companies should ensure they develop advanced processing software to help in improvement in the processing efficiency. Through a partnership between food processing companies and technological experts, it would be easier to establish algorithms that are more efficient to make the machine vision more appropriate for the analysis process.

Inspecting food quality and safety has remained to be the most vital issue for many food processing companies. For those companies that have not adopted the imaging technology, they should start taking the customers' complaints seriously. The government should start taking action against those companies that are not serious about the analysis of food quality and safety. Such companies are putting the lives of their customers at risk including the capital invested by some investors. Since customers tend to lose faith in food products due to some ignorant

companies, technology experts should strive to ensure they develop an application that can be installed on smartphones. With this application, customers can be able to scan the product to ensure there is no contamination. Scanning any food product before they consume it, customers can feel confident when buying products produced by some companies since they are assured of the quality and safety of the product. Farmers should also adopt imaging technology to ensure they do not buy contaminated seeds from the stores.

Self-reflection

To the Director of the Advanced Technology Center

Dear Sir/Madam

Ref: Analyzing Food Quality and Safety through Imaging Technology

Although some companies have not yet adopted the new technology and are still using the traditional methods which are not effective. Since imaging technology such as machine vision has high levels of accuracy, it would be essential to develop devices that are of high resolution. Doing this will ensure accuracy and an improvement in the inspection process. In computer vision, image processing seems to be the core activity; therefore technological companies should ensure they develop advanced processing software to help in improvement in the processing efficiency. Through a partnership between food processing companies and technological experts, it would be easier to establish algorithms that are more efficient to make the machine vision more appropriate for the analysis process.

From the project, I have learned that issues of contamination are not supposed to be the main challenge facing small companies. Most of these imaging technologies are not expensive

and therefore even upcoming companies can be able to afford them. The other fact learned is that whenever one is planning to venture into any business it is vital to ensure that they fulfill all the principles of entrepreneurship to prosper. Students who come across my project can use it as an opportunity to conduct more research on the benefit of imaging technology. These students can also be hired by food processing companies to conduct research on their behalf and come up with the best imaging technology whose benefits outweigh the weaknesses. If the director seeks me out in the future as a consultant I would recommend that imaging technology be a requirement before any food processing company can start its production to ensure customers' safety.

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