Research Paper

Dhofar Municipality solutions for food inspection through the Internet of Things

Rack App

Fatma ALSHAHRI, Dhofar Municipality,
Oman Mariam JAIME, Dhofar Municipality,
Oman Muna TABOOK, Dhofar Municipality,
Oman

Abstract

The applications of artificial intelligence (AI) provide sustainable solutions for vital issues all over the world. Food safety and quality control assurance are one of the important issues that related to the human health rights. In The sultanate of Oman a smart application has been developed by the Dhofar municipality in order to facilitate food inspection. (Rack app) is a food inspection system that provides a roadmap for sustainable initial health care. It relieves the burden on the food supply and catering services that dramatically increases simultaneously with the exponential domestic growth.The rack app connects the regulatory authority with the consumer and the owner of the facility. The owner of the facility holds a card with a special barcode that connect to rack up. The implementation of a Rack app inspects with accurate records through the Internet of things.The customer can download the app for the direct communicate with the municipality. The Rack app customer space creates an area of giving notes and ranking the facility in a transparent manner. The Rack app consists of a communication system between the facility and the community for preserving the food and achieving the food security and social justice for everyone.

Keywords

Dhofar Municipality, food safety, inspection, donation, IoT.

1. Introduction

1.1. Overview

According to the Royal Decree No. 101/2020 which promulgating the governors and municipal affairs system in Oman, Dhofar municipality is responsible of food monitoring and inspection to ensure its validity and safety. It has the authority to monitor factories, restaurants, shops and their employees, and take the necessary measures thereon in accordance with the provisions of the relevant lesson addition, it is monitoring and inspecting food imported and exported across the border ports, ensuring the food safety and its suitability for human consumption. Food control is an important way to address the negative effects of food pollution and food spoilage. According to the World Health Organization (WHO), Anestimated 600 million – almost 1 in 10 people in the world – fall ill after eating contaminated food and 420 000 die every year (Mehlhorn, 2015).Economically, total productivity loss associated with foodborne

disease in low- and middle-income countries was estimated at US$ 95 billion per year, and the annual cost of treating foodborne illnesses was estimated at US$ 15 billion (Ecology, 2012). As illustrated by united nations industrial development organization (UNIDO), food safety is a key determinant of human health. Having safe product is a fundamental requirement in food trade. For this reason, its far-reaching impacts elevates food safety to a common denominator and connector of health, agriculture and trade, by contributing to economic and human development (Businesses, no date).Failure to address food safety impacts the growth and modernization of domestic food markets, thus diminishing income and employment opportunities. Dhofar Governorate is a regionally tourist destination and the economic vision of the Sultanates of Oman goes toward improving the tourism sector. For countries wishing to develop tourism, confidence in the safety and quality of food can reinforce tourism attraction, while uncertainty around food quality and safety could impede economic growth (Tanceva and Petrevska, 2012).Recently, artificial intelligence (AI) has been proposed for its potential to advance and transform food safety practices and outcomes (Friedlander and Zoellner, 2020).This article aims to introduce the vision of Dhofar municipality to apply different tools of (AI) in the food inspection system. It is a , mobile Application (Rack app) for food inspection and excess food donation. The system will improve the Hazard Analysis and Critical Control Point (HACCP) in the food establishments.Food safety inspection involves assessment of food handling practices and the condition of food production environments. The traditional inspection work requires a physical visit to the several food establishments such as food stores, food industries, restaurants, hotels, etc. The existent process consumes more time and need more inspectors and more inspection tools. Moreover, the more funds have to be paid to cover the periodic inspection visits requirements.The application could introduce an addition value by organizing the food donation and make it more systematic.

Figure 1. Food safety is the connector between the Health, Agriculture and Trade policy agendas. Source: Businesses, R. (no date) 'Food Safety Approach'

1.2. Objectives

This paper aims to find the importance of the collaboration between the government, the food business holders (clients), the consumers and the non-governmental organizations (NGO). The collaboration is to move toward the AI in order to provide safe food for all of the society in Dhofar governorate.

1.3. Literature review

The use of IoT in food safety is a new trend that is growing exponentially. A journal of Trends in Food Science & Technology shows that IoT in food safety was first reported in 2011 and since then the number of articles published has increased. It also found that the Chinese universities published the mostnumber of articles in this topic(Bouzembrak et al., 2019)The Journal of Electrical and Computer Engineering Give a deep understanding of the taxonomy of the IoT(Sethi and Sarangi, 2017)The building blocks of the IoT and the interactions between its components are illustrated in details(Kumar and Mallick, 2018).the previous article give a useful information about IoT Architecture Layers which can be more complicated depending on the complexity of the system. Part of this study depending in the understanding of the sensors. The most available types of sensors are categorized in three types: environmental, motion and position (Sikder et al., 2018)sensors are used to transmit data via the internet through IoT ex, temperature and humidity sensor (DHT 11 sensor), light sensor, contamination sensor (MQ-135 gas sensor)(S et al., 2021).For food safety, the applications of AI presented by (Friedlander and Zoellner, 2020)are categorized as vision, text, interactive, analytical, or functional-based solutions.Tajkarimi,Mdemonstrated a successful application of AI for food safety and quality control in the Chicago Department of Public Health(Tajkarimi, 2020).Montclair State Universit, Department of Computer Science design a simple prototype app called SeVa to assist food donation (Varghese, Pathak and Varde, 2021). Department of Computer Science and Engineering of the SVKM's Institute of Technology in India published an ideal smart application (Zero Hunger) for food donation system. As this paper is a proposal introduced by Dhofar municipality, the research focused to find the papers that published by the Arabian Gulf countries that cover the same topic. Searching using the AI or it in food safety gave no published results within the nearest countries (UAE, Qatar, KSA, Bahrain and Kuwait)

2. Methodology

2.1 The smart application

This system provides an application that allows access for four different types of users. The users that are able to log in the applications are the followings:

- Inspection officer
- Client (represent the establishment)
- The consumers
- NGO

Inspection officer has the ability to log as an admin and assess the establishment distantly. The inspection officer will check the quality assurance using an IoT devices ex, CCTV and notifications received through the sensors. He sends a voice or text notes to each establishment in particular, receiving complaintand fining offenders and report writing. The client is able to receive the notifications to repair any malfunction in any equipment such as refrigerators and assess the food safety control in his establishment via the CCTV. Moreover, the client is able to send an information about availability of any excess food. The consumer: after a successful registration in the rack app the consumer can log in and benefit from the knowledge and advices posted on the application. The consumer has the ability to do several actions:

- Send notes of feedback
- Upload files in terms of media
- Act as a donor if excess food is available.
- Rate the food establishments.

NGO they receive the notifications about the locations and the quantities of the excess food. They can check quality assurance using an IoT device. Finally, they distribute the food according to the data that they have families and individuals in need. The proposed application fulfil requirements that guarantee consistent follow up of food safety and reduce food wastage.
The following chart shows the application architecture:

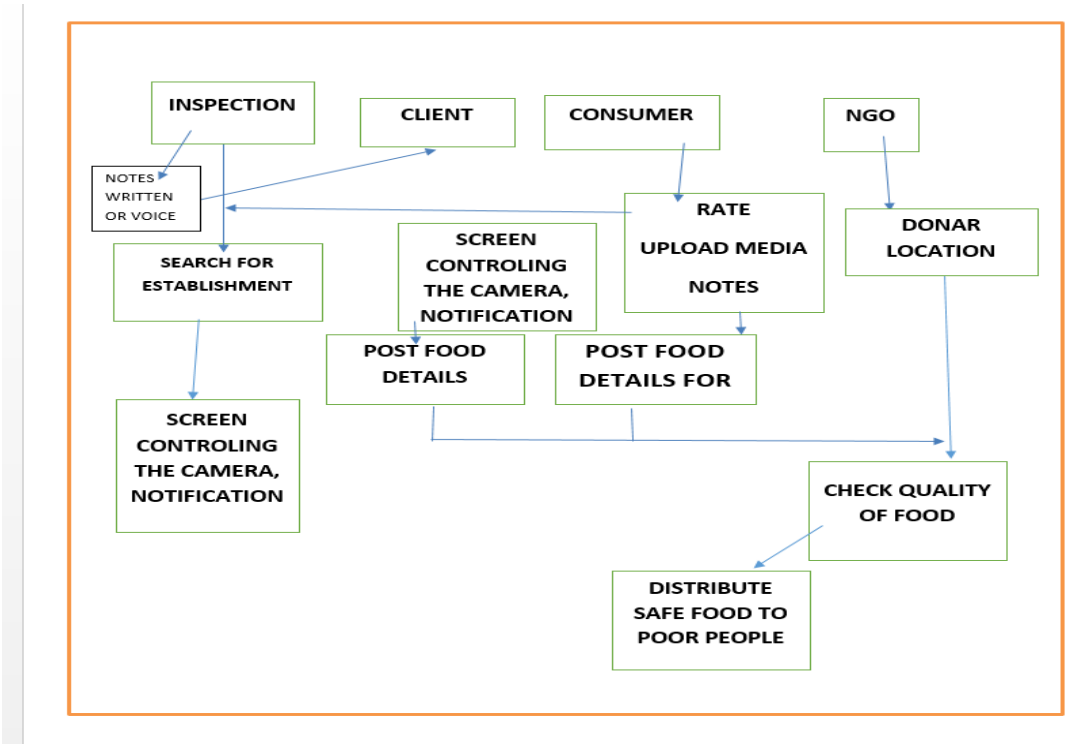

Figure 2. Rack app architecture.

2.2 sensors

The sensors are divided according to their uses in this project into two categories:
For the inspection system
Surveillance cameras (CCTV)
Temperature and humidity transmitter
For the food donation quality assurance

Figure 3. WIRELESS AMBIENT TEMPERATURE AND HUMIDITYSENSOR

(SS3-101) sources: Swift sensor

Swift Sensors Wireless Ambient Temperature and Humidity Sensor described as the following:

- Measures ambient temperature and relative humidity (Temp: -40°C to - +60°C (-40°F to +140°F); Humidity: 0% – 95%).
- This sensor is ideal for buildings, museums, restaurants, factories, and greenhouses.
- The sensor enclosure is water-resistant and dustproof with a rating of IP66.
- Users can set the inspection rate and thresholds for notifications via SMS text, email, and phone call.

Figure 4. WIRELESS TEMPERATURE SENSOR W/ RING LUG PROBE

(SS3-103) sources: Swift sensor

Swift Sensors Wireless Temperature Sensor with Ring Lug Probe includes a 1m (3 ft.). It is described as the following:

- NTC temperature probe with a metal ring lug termination and can measure temperatures between -40°C to +125°C (-40°F to +257°F)
- This sensor is ideal for refrigerated enclosures, wet environments, factories, and greenhouses. Users can set the inspection rate and thresholds for notifications via SMS text, email, and phone call.

Figure 5. The CCTV Camera sources: solink

The description:
A 360 camera is a good choice because it covers a lot of space at once, for example the dining area or kitchen. The price of these cameras (up to $600). The advantage is it to replace roughly four to six regular dome cameras

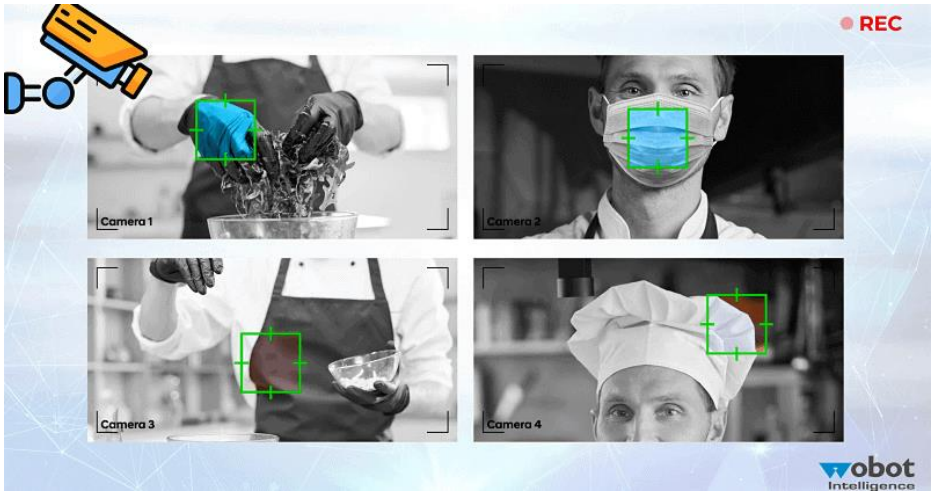

Figure 6. Wobot intelligence sources: wobot intelligence

Description of WOBOT intelligent software:

- Choose What You Wish to See
- Align the cameras with what you intend to watch.

- Set the standard for A. I. - Powered video intelligence by creating a technology that can be paired with existing CCTV equipment.

3. Results:

The final proposed view of the application will be as the following illustrations:

Figure 7. Home page

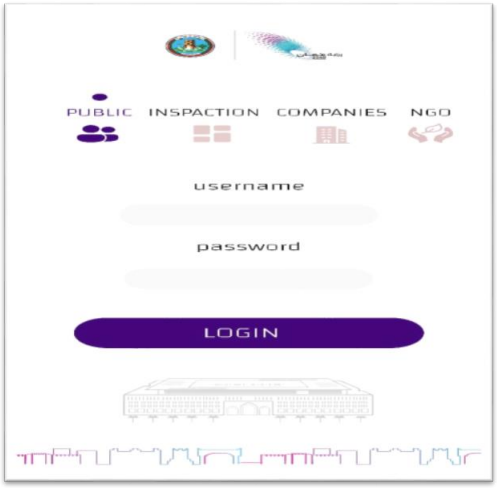

Figure 8. Consumer log in

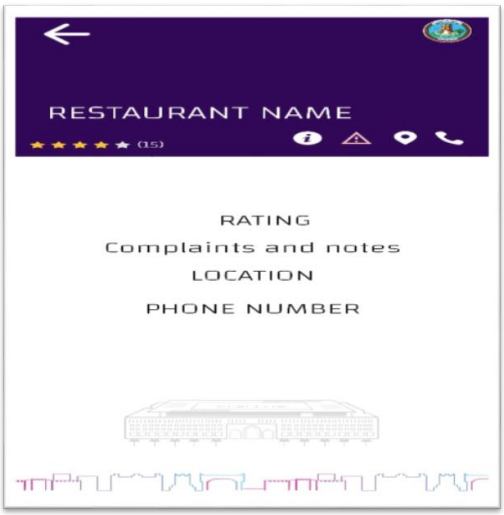

Figure 9.Consumer page

Figure 10.Client log in

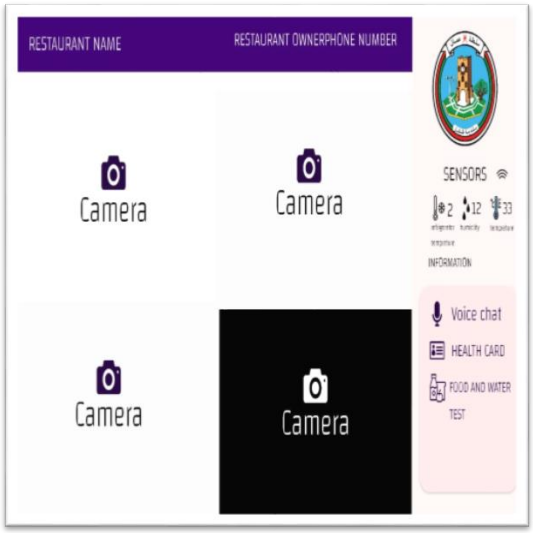

Figure 11. Client page

Figure 12. Establishment log in

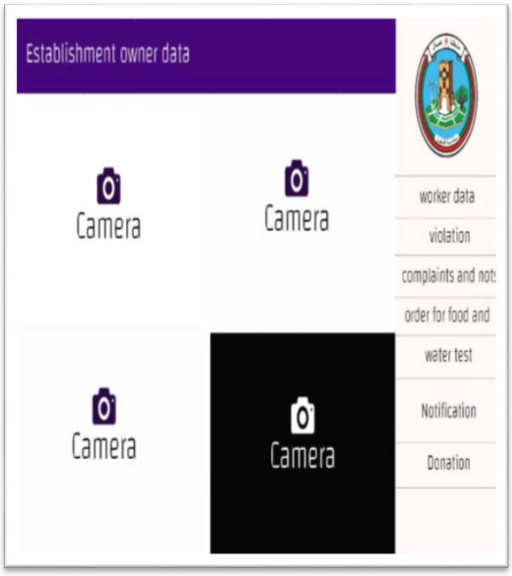

Figure 13. Establishment page

The previous figures illustrated the first step which have been requested to design by the administration further design are almost to be ready.

4. Discussion

Assessment services play an important role in confirming that consumers, suppliers and other food business holders have assurance in the safety and conformity of the products For Traditional and usual ways of inspection use on-site audits, however, during the COVID-19 pandemic, remote 'audits' became the 'new reality'(Castka *et al.*, 2021).Effective and consistent implementation of food safety regulations is a cornerstone in protecting public health and preventing misleading competition between food business companies (clients). As a routine work food control authorities in this case (Dhofar municipality) must provide the food with advice and requests to ensure that the clients modify any actions that are incompatible with health requirements(Kettunen, 2018).In terms of food safety assessment , variation in meanings were found between consumers, food business associates and food safety inspectors. Each group have its own point of view which is due to the influence of sociological factors in defining food safety inspection(Barnes *et al.*, 2022). A cooperation between the government authority and the private organization gives the first priority that keep the supply chain energetic and guarantee protection of each point of food supply chains (Uddin *et al.*, 2020). Individuals are the best judges of their own actions. Therefore, every person is the best regulator of food safety. Everybody can participate in food safety regulation anytime, anywhere, and in various ways (Wu *et al.*, 2018). As the issue of food safety became one of the important public trends, consumer concern for food safety became the general public concern in the developed countries (Kim, 2009). Shifting the community in Dhofar governorate toward this global agenda, is a cornerstone in creating a healthy life for healthy citizens. According to the recent situation, automated systems become urgent in the food industry to carry out food production to maintain the required quality control of the product (Arachchige *et al.*, 2022). The smart inspection system consists of several devices scattered within the establishment that are linked together using a wired or wireless network. A computer system acts as a server in a node which controls all the information exchange through the network(Rajabzadeh, Manashty and Jahromi, 2010). By working with food safety professionals, capitalizing on developing AI solutions that focus on improving food safety assurance will result in finding new applications and developing novel algorithms for specific food safety problems (Friedlander and Zoellner, 2020). The IoT has the proficiency of improving the automated monitoring and real-time control for food safety. The legal basis is the most significant aspect affecting public-public collaboration (Zhang *et al.*, 2022). Dhofar municipality has the authority to legislate, regulate and achieve compliance. In 2019,Oman has introduced a tougher food safety law, where CCTV will need to be installed in food establishments and violations for penalties are raised (Tingmin koe, 2019). More regulations should be issued for the installation the required sensors within the refrigerators and the stores. Food contamination leads to huge economic losses related to production. Therefore, of extreme importance that the food establishments and food business holders assure that only safe food is handled and placed on the market (Focker and van der Fels-Klerx, 2020). An instantaneous way of inspecting food using the IoT will ensure consistency, accuracy and sustainability. In addition to food inspection, IoT brought smart solutions for food donation. Huge amount of edible food are wasting every day in Dhofar. Although there is no recorded figures, an excess food is a noticeable habits in the Dhofar society. In the other hand, different NGOs that work in charity have list of poor people who are suffering from starvation. Excess food wastage is measured as global problem due to the number of people who are suffering from starvation in the world (Mallya *et al.*, 2020).Dhofar municipality manages the Rack app program to assist emergency responders in making decisions. The Rack app conducts assessments and validations on food establishments and systems. The on-site detection analysis of the donated food ensures its safety and quality. In this research, we tried to focus on the application of the Internet of Things (IOT) in the field of food safety by linking all food establishments to the supervisory authority. This program helps to create cooperation between these authorities and also encourages the owners of the facilities to feel responsible and raise the level of quality of their products. We have also added a choice that

encourages establishment owners to donate excess food by adding charitable organizations to participate in this aspect, and we will work to provide ways to ensure the safety of the donated food. The researchers could benefit from the big data and information that will be saved within the system. Moreover the Sultanate of Oman would use the outcome datacenter to make developmental decisions.

5. Challenges

Lack of societal awareness in the field of food safety creates a gap that must be closed in order to achieve a shift in the application of modern systems. Because the awareness of society makes it easier for us to apply modern technology. Moreover, there is a shortage of companies that provide equipment related to work in this field. As a Gulf country, there is no realistic experience found in the region as the common factors facilitate going through the experience and apply it. The requirements of artificial intelligence force us to have specialists in the technical field that work together with the food safety professionals.

6. Conclusion

This study mentioned the use of IoT in the food safety. Several studies were found in the related field and we can benefit from the chines studies as it published the major number of articles. As there is no published paper was found in the neighbor countries, Oman experience can lead for further studies and applications. Therefore, more innovations in IoT related to food safety could be enhanced in the region. This paper focuses on the design implementation of a smart application called (Rack app) to assist food safety in the food establishments and organize the donation of safe food. Addressing the issues of hunger as well as food waste, thus targeting the UN SDGs related to poverty, hunger, health and the economy. Smart application educates the society and bring it to live in a smart sustainable city.

Acknowledgments
The authors thank the Dhofar Municipality leaders for their support and appreciated fund to the novel ideas of food safety that support Oman vision 2040 which align with SDGs.

7. Reference:

Arachchige, U. *et al.* (2022) 'Development of automated systems for the implementation of food processing', *J. Res. Technol. Eng*, 3(1), pp. 2022–2030. Available at: https://www.researchgate.net/publication/357732780.

Barnes, J. *et al.* (2022) 'Defining Food Safety Inspection', *International Journal of Environmental Research and Public Health*, 19(2). Available at: https://doi.org/10.3390/ijerph19020789.

Bouzembrak, Y. *et al.* (2019) 'Internet of Things in food safety: Literature review and a bibliometric analysis', *Trends in Food Science and Technology*, 94(April), pp. 54–64. Available at: https://doi.org/10.1016/j.tifs.2019.11.002.

Businesses, R. (no date) 'Food Safety Approach'.

Castka, P. *et al.* (2021) 'Executive Summary', (July).

Ecology, S. of W.D. of (2012) 'Https://Www.Who.Int/Publications/M/Item/Draft-Who-Global-Strategy-for-Food-Safety-2022-2030', *European University Institute*, (2), pp. 2–5. Available at: https://eur-lex.europa.eu/legal-content/PT/TXT/PDF/?uri=CELEX:32016R0679&from=PT%0Ahttp://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:52012PC0011:pt:NOT.

Focker, M. and van der Fels-Klerx, H.J. (2020) 'Economics applied to food safety', *Current Opinion in Food Science*, 36, pp. 18–23. Available at: https://doi.org/10.1016/j.cofs.2020.10.018.

Friedlander, A. and Zoellner, C. (2020) 'Artificial intelligence opportunities to improve food safety at retail', *Food Protection Trends*, 40(4), pp. 272–278.

Kettunen, K. (2018) *Food safety enforcement at the local level in Finland: risk-basis, efficacy and consistency*. Available at: https://core.ac.uk/download/pdf/157588366.pdf.

Kim, R.B. (2009) 'Meeting consumer concerns for food safety in South Korea: the importance of food safety and ethics in a globalizing market', *Journal of agricultural and environmental ethics*, 22(2), pp. 141–152.

Kumar, N.M. and Mallick, P.K. (2018) 'The Internet of Things: Insights into the building blocks, component interactions, and architecture layers', *Procedia Computer Science*, 132, pp. 109–117. Available at: https://doi.org/10.1016/j.procs.2018.05.170.

Mehlhorn, H. (2015) 'Food-Borne Disease Burden Epidemiology Reference Group', *Encyclopedia of Parasitology*, pp. 1–1. Available at: https://doi.org/10.1007/978-3-642-27769-6_3884-1.

Rajabzadeh, A., Manashty, A.R. and Jahromi, Z.F. (2010) 'A Mobile Application for Smart House Remote Control System', (May 2014). Available at: http://arxiv.org/abs/1009.5557.

S, M. *et al.* (2021) 'IoT Based Monitoring and Control System using Sensors', *Journal of ISMAC*, 2(2), pp. 111–120. Available at: https://doi.org/10.36548/jismac.2021.2.004.

Sethi, P. and Sarangi, S.R. (2017) 'Internet of Things: Architectures, Protocols, and Applications', *Journal of Electrical and Computer Engineering*, 2017. Available at: https://doi.org/10.1155/2017/9324035.

Sikder, A.K. *et al.* (2018) 'A Survey on Sensor-based Threats to Internet-of-Things (IoT) Devices and Applications', (February). Available at: http://arxiv.org/abs/1802.02041.

Tajkarimi, M. (2020) 'Food safety and quality data management using artificial intelligence', *Food Protection Trends*, 40(6), pp. 464–467. Available at: https://doi.org/10.4315/1541-9576-40.6.464.

Tanceva, V. and Petrevska, B. (2012) 'Enhancing the food safety in the tourism sector - the case of Macedonia.', *Journal of Hygienic Engineering and Design*, 1, pp. 182–186. Available at: http://www.jhed.mk/filemanager/Food Quality and Safety/24 Vesna Tanceva.pdf.

Tingmin koe (2019) 'Tougher-food-safety-rules-in-Oman-Higher-fines-and-CCTV'.

Uddin, M.N. *et al.* (2020) 'Impact of COVID-19 on food safety and security in low and middle income countries',

Asian Journal of Medical and Biological Research, 6(2), pp. 130–137. Available at: https://doi.org/10.3329/ajmbr.v6i2.48043.

Varghese, C., Pathak, D. and Varde, A.S. (2021) 'SeVa: A Food Donation App for Smart Living', *2021 IEEE 11th Annual Computing and Communication Workshop and Conference, CCWC 2021*, (March), pp. 408–413. Available at: https://doi.org/10.1109/CCWC51732.2021.9375945.

Wu, L. *et al.* (2018) 'Social co-governance for food safety risks', *Sustainability (Switzerland)*, 10(11), pp. 1–14. Available at: https://doi.org/10.3390/su10114246.

Zhang, L. *et al.* (2022) 'Public-Public Collaboration for Food Safety Risk Management : Essence , Modes , and Identification of Key Influencing Factors Using DANP', 10(July), pp. 1–16. Available at: https://doi.org/10.3389/fpubh.2022.944090.

Figure 1. Businesses, R. (no date) 'Food Safety Approach'.

Figure 3. Swift sensor, *wireless ambient temperature and humidity sensor (online).*Available at: www.swiftsensors.com/product/wireless-ambient-temperature-and-humidity-sensor-ss3-101/ (Accessed: 21 Jule 2022).

Figure 4. Swift sensor, *wireless ambient temperature and humidity sensor (online).*Available at: https://www.swiftsensors.com/product/wireless-temperature-sensor-ring-lug-probe-ss3-103/ (Accessed: 21 Jule 2022).

Figure[5]: A 360 camera,*solink(online)*.Available at :https://www.solink.com/ (19 Jule 2022).

Figure[6]: Wobat.ai, *wobot intelligence(online)*. Available at: https://wobot.ai/ (Accessed: 20 Jule 2022).