Multi-Knowledge Electronic Comprehensive Journal For Education And Science Publications(MECSJ)
Issues 70 (2024)
ISSN: 2616-9185

Statistical Analysis of Foodborne Pathogens in Jeddah Region

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Abstract

Foodborne pathogens are becoming a globally challenging health problem and are perceived as a major health concern in the Kingdom of Saudi Arabia (KSA). Contamination resulted from unclean raw food materials and particles, the use of polluted water, unhygienic preparation processes, and the use of contaminated containers. As a result, this research aims to identify the extent of the prevalence of foodborne pathogens in food outlets such as restaurants, cafeterias, and cafes in the Jeddah region of Saudi Arabia and analyze the collected data by health inspectors to

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withdraw useful statistics. These data will help us study the number of foodborne pathogens outbreaks in Jeddah region, and this includes causative organisms, diseases, symptoms, and case numbers. In this study, the prevalence of foodborne pathogens in food places such as restaurants, cafeterias, and coffee shops in Jeddah Region of Saudi Arabia was studied. The collected food samples from the 235 places included, Meat products, Dairy products, potatoes, sauces, vegetables (Salads), and sweets. The isolates were detected using biochemical tests, and API 20E. The results confirmed the presence of two types of foodborne pathogens in the food samples, namely (E-coli bacteria and Salmonella bacteria). The results of inspection and sample processing reports indicate that the largest percentage of food samples cause infection with E. coli bacteria, at a rate of 84.7%. The results of the sample testing and processing reports also indicated that the remaining percentage of food samples, represented in the sample of (15.3%), were found to cause (Salmonella bacterium).

KEYEORDS: Statistical Analysis, Foodborne Pathogens, Jeddah Region.

1.1 Introduction

A food product has an inherent microbiota that includes pathogenic and/or bacteria that can cause deterioration (Böhme, Barros-Velázquez & Cañas, 2012). It is crucial to identify pathogens in food and drink before they reach the body and cause serious infections (Chattaway et al., 2011). Worthy here to differentiate between food spoilage and foodborne pathogens. Food spoilage is the term used to describe food that has gone bad (i.e., fungi, grown mould, or yeast) Okanlawon, Adeyemo & Agbaje, 2023, and foodborne pathogens are biological agents that can spread disease or illness (Hubert Company, 2022). Foodborne pathogens are responsible for a wide range of illnesses with serious consequences for both human health and the economy. In addition to some significant outbreaks, the most prevalent pathogenic organisms include bacteria (Salmonella spp., Clostridium botulinum, Bacillus cereus, Staphylococccus aureus, Campylobacter jejuni, Listeria monocytogenes, Clostridium perfringens, Cronobacter sakazakii, Esherichia coli, Yersinia enterocolitica, Shigella spp., and Vibrio spp.), parasites (Trichinella spiralis, Cyclospora cayetanensis, and Toxoplasma gondii) and viruses (Hepatitis A and Noroviruses) (Bintsis, 2017).

Many strategies have been suggested to increase the shelf-life of food and illuminate foodborne pathogens, these strategies include pasteurisation, canning, cooling, freezing, drying, and adding preservatives (Popa, Miteluț & Popa, 2019). Furthermore, monitoring and testing activities can play critical roles in that process. Food manufacturers and health inspectors should test and monitor the microbial load in products to ensure compliance with safety standards (Nielsen, 2010). Several countries nowadays have decided to centralize their food control systems. Establishing a primary authority to manage the entire food chain from farm to fork has become increasingly popular to improve the country's administrative structure for food control (Al-Kandari & Jukes, 2012).

National control agencies around the world set food laws and regulations to ensure food safety (World Health Organization, 2019). Most countries nowadays try to improve food quality and enhance their microbial control through the introduction of different regulations and the adoption of specified systems such as The Hazard Analysis Critical Control Point (HACCP). The HACCP system is a proactive approach to food safety that identifies and controls potential hazards, including microbial contamination, in the food production process. It is widely used in the food industry to prevent and reduce the risk of contamination (Chaturvedi et al., 2013; Wiedmann et al., 2019). Food safety initiatives often concentrate on physical inspection of the finished product and laboratory testing, while programmes to increase awareness of the factors that lead to foodborne illness have gotten less attention, this indicates a lack of consumer education regarding the issue to be discussed (AL-Mohaithef, 2021). In summary, monitoring and controlling the microbial load in food is essential for ensuring food safety and quality. It involves a combination of good manufacturing practices, regulatory standards,

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ISSN: 2616-9185

testing, and preservation techniques to reduce the risk of foodborne illnesses and spoilage.

1.2 Statement of the Problem

FBD cause significant economic loss, a decline in quality of life, and decreased productivity (Scharff RL, *et al.*, 2012). Moreover, there are no accurate projections of the global impact of FBD currently. However, 1.9 million children die worldwide each year from diarrheal infections, which make up a sizable component of FBD. Despite developments in food laws and food management that are helping to lower the occurrence of contamination in foods, food-borne infections remain a major concern for people all over the world (Bhunia *et al*., 2018). In Saudi Arabia, Foodborne disease is a common public health problem (Drudge *et al*, 2019). It is also known as "food poisoning" and is primarily brought on by eating contaminated food that contains parasites, bacteria, viruses, chemicals, and toxins. The World Health Organization (WHO) estimated that there were 600 million cases of foodborne illnesses and 420,000 fatalities globally in 2010. The WHO classified the Eastern Mediterranean Region (EMR) as the third worst region (World Health Organization. 2015). Public health is significantly impacted by foodborne illness through direct and indirect healthcare costs, which can include lost productivity (Hoffmann *et al*, 2014), 3081 periodic occurrences of foodborne illness were reported in the Saudi Arabian Ministry of Health's Statistical Yearbook for 2020 with 1258 of those cases occurring in people between the ages of 15 and 45 years old (McLinden *et al*., 2014). Alhadlaq, Mujallad & Alajel (2023) have confirmed the presence of E. coli O157:H7 in samples of imported raw meat in food samples taken from the Kingdom of Saudi Arabia. In a recent study conducted by Ashgar et al. (2023), the results revealed that most of the food samples (crushed and sliced green salad) were contaminated with pathogenic bacteria in the Kingdom of Saudi Arabia. Alsayeqh (2020) has confirmed that reported rates of foodborne diseases in the Kingdom of Saudi Arabia are underestimated in comparison with regional and global rates. To monitor food safety procedures, stop contamination from spreading, protect the public's health, and guarantee the security of the food supply chain, it is crucial to undertake a thorough examination and analysis of the microorganisms that cause foodborne illness (Melebari, 2023). The current study has tried to bridge this gap by identifying the extent of the prevalence of foodborne pathogens in food outlets and analyzing the collected data by health inspectors.

1.3 Objectives of the Study

Microbes can contaminate food resulting in foodborne illnesses. Investigating microbial hazards in foods at the point of sale with rapid tools required to avoid foodborne illness outbreaks. This research aims to identify the extent of the prevalence of foodborne pathogens in food outlets such as restaurants, cafeterias, and cafes in the Jeddah region of Saudi Arabia and analyze the collected data by health inspectors to obtain useful statistics. The data is obtained from the Jeddah Plat City Council after analyzing several samples of food in the marketplace to detect the target bacteria using the microbiological tests method.

1.4 Significance of the Study

Foodborne diseases are critical public health issues discussed at the international level in general and in the Kingdom of Saudi Arabia in particular. It has been demonstrated that the frequency of foodborne infections is rising daily. Foodborne infections continue to be a major cause of concern for people's health globally and are harmful to people, communities, and the food business. It has become of critical significance to analyze the prevalence of food-borne pathogens in different regions within the Kingdom of Saudi Arabia.

2. Literature Review

2.1 Microbial load

The study of microorganisms that colonize, alter, and process food as well as those that contaminate and spoil is referred to as food microbiology. It contains a diverse range of microorganisms such as pathogenic, probiotic, fermentative, and

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ISSN: 2616-9185

spoilage bacteria, as well as moulds, yeasts, viruses, and prions. It deals with various meals and beverages that combine a wide range of environmental conditions that may affect microbial survival, growth, and load (Laranjo et al., 2019; Adams & Moss, 2008). Thus, it has become of utmost importance to measure the microbial load in food. The microbial load in food can vary widely depending on factors such as the type of food, its processing and handling activities, and storage conditions. Some foods naturally contain a higher microbial load, while others are more susceptible to contamination during processing. Hosein et al. (2008) have confirmed that the manufacturing procedures used have significant impacts on microbial loads, which vary according to different work conditions. This variance has led to the emergence of microbial load variability. Microbial food variability is a result of different food bacteria, which come in a wide range of sizes, varieties, and characteristics (Bacon et al., 2003).

2.2 Foodborne Pathogens

The human body contains harmless microorganisms, primarily bacteria, as part of the regular microbiota in the gut and on the skin. These microorganisms aid in many vital bodily processes. However, several microorganisms are pathogenic. Pathogens can enter the body through the digestive tract and cause a variety of foodborne illnesses. These illnesses can cause by food and water that has not been properly prepared or was contaminated (Leach et al., 2010). Pathogen may include Acinetobacter spp., Bacillus cereus, Bacillus subtilis, Citrobacter koseri, Campylobacter jejuni, Clostridium freundii, Clostridium perfringens, Clostridium difficile, Enterobacteriaceae cloacae. Enterobacter sakazakii, Klebsiella oxytoca, Escherichia coli O157:H7, Klebsiella pneumoniae, Salmonella Enteritidis, Listeria monocytogenes, Shigella sonnei, Salmonella Typhimurium, Staphylococcus aureus, Yersinia pestis and Vibrio cholerae (He et al., 2013). The most common types can be reviewed as follows:

2.2.1 Escherichia coli

The bacteria Escherichia coli is Gram-negative and does not produce spores. In addition to being mobile, some rods are flagellated, while others are not (Schau,

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1985). There are many strains of E. coli, which is a large and diverse group of bacteria. Most strains of E. coli are harmless; some strains, however, have acquired pathogenic characteristics, such as the ability to produce toxins (Schau, 1985). These pathotypes are a major public health concern since they have low infectious doses and are spread through ubiquitous routes, including food and water (Croxen et al., 2013). Enterohemorrhagic E. coli (EHEC, also known as shigatoxin—producing E. coli [STEC] is one example. STEC strain O157:H7 is estimated to cause 63,000 illnesses, 2,100 hospitalizations, and 20 deaths each year (Scallan et al., 2011a). In 1982, investigators linked undercooked ground meat consumption with outbreaks of O157:H7 that emerged as a significant public health threat (Scallan et al., 2011a). A wide variety of foods, including fresh produce, have since served as vehicles for E. coli O157:H7 outbreaks. Food producers must report the presence of E. coli O157:H7 to health authorities (Scallan et al., 2011). E. coli is transmitted through food or water contaminated with the faeces of infected humans or animals. During the slaughter and processing of animal products, contamination occurs frequently (Croxen et al., 2013). Animal manure used as fertilizer for crops can contaminate produce and irrigation water (Croxen et al., 2013). E. coli can survive for long periods in the environment and can proliferate in vegetables and other foods (Scallan et al., 2011).

2.2.2. Salmonella spp.

A group of Enterobacteriaceae known as Enterobacteriaceae have pathogenic characteristics and are a common cause of enteric infections (food poisoning) worldwide. Depending on growing conditions, Salmonella species are Gram-Negative rod-shaped bacteria (bacillus) and range in size from 0.7 to 1.5 mm in diameter and 2 to 6 mm in length. With peritrichous flagella, these species do not form spores and are predominantly motile (Ehuwa et al., 2021). Known as a Chemoorganotroph bacterium, Salmonella is an aerobic and facultative anaerobe microorganism, which means it can grow with oxygen and survive without it through anaerobic respiration through fermentation. The genus Salmonella is divided into two species that can cause illness in humans: S. enterica and S. bongori (Schmidt & Rodrick, 2010).

Several other species of Salmonella can cause enteric infectious diseases, including Salmonella enterica subsp. Direct contact with faecal matter, along with cross-contamination during food processing, is the main route of transmission (Wu et al., 2016). Ingestion of contaminated food or water is the most common way for this pathogen to spread, followed by contact with domestic animals or livestock, as well as contamination of surfaces, in addition to transmission by faeces and saliva. Different types of infections can appear, such as gastroenteritis, bacteremia, typhoid fever or, in the case of asymptomatic carriers. As Forsythe (2003) and Chaves et al. (2016) noted, this depends on the infected person's age, state of health, and infectious dose.

2.2.3 Salmonella spp.

Salmonellosis is another foodborne illness caused by these bacteria. This is one of the most common diarrheal illnesses in the world. Consequences of food contamination include abdominal pain, vomiting, and diarrhoea. After consuming a large infectious dose, these symptoms appear after a 12-72 hour incubation period and last for 4-7 days. People with weakened immune systems, such as those immunocompromised, over 60, and young children under 5, may die from it due to severe dehydration (Wang and Hammack, 2014; Cohn et al., 2021).

According to recent estimates issued by the World Health Organization, food contamination by biological or chemical agents accounts for more than 70% of the roughly 1.5 billion episodes of diarrhoea that happen worldwide each year. The severity of the issue is indicated by the high frequency of diarrheal infections, particularly among youngsters in the area, which is estimated at 3.3 to 4.1 episodes per child per year (World Health Organization, 2023). Generally, these diseases are caused by eating raw or ready-to-eat foods that have not been heat treated sufficiently effectively to inactivate this microorganism, resulting in these diseases. This is especially true for raw fruit and vegetable products that might be contaminated by soil or polluted irrigation

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water, including unpasteurized dairy products, meats, eggs, and their derivatives (Ricke, 2021). Diseases caused by foodborne pathogens can be shown in the following table:

Disease or Clinical Symptoms	**Pathogens/Toxins Involved**
Vomiting, diarrhoea, dysentery	Staphylococcus, Bacillus, Cronobacter, Salmonella, Shigella, Vibrio, Norovirus, Rotavirus, Entamoeba; Cryptosporidium; Cyclospora; Giardia; Cystoisospora; Taenia
Arthritis (reactive arthritis, Reiter's syndrome, rheumatoid arthritis)	Campylobacter, Salmonella, Shigella, Yersinia
Hemorrhagic uremic syndrome (HUS), kidney disease	Shiga-toxin-producing Esc. coli (STEC); Shigella spp.
Hepatitis and jaundice	Hepatitis A virus (HAV), Hepatitis E virus (HEV)
Guillain-Barre syndrome (GBS)	Campylobacter
CNS/meningitis/encephalitis	Listeria, bovine spongiform encephalopathy (BSE)
Miscarriage, stillbirth, neonatal infection	Listeria, Toxoplasma
Paralysis	Clostridium botulinum, fish and shellfish toxins, Campylobacter
Malignancies and autoimmune diseases	Mycotoxin
Allergic response	Fish and shellfish toxins

Table (1): Diseases caused by foodborne pathogens

Ray & Bhunia (2014, p. 306)

The Middle East and North Africa (MENA) region is especially concerning; it includes the Eastern Mediterranean countries, which according to the World Health Organization have the third-highest estimated burden of FBDs per population, after the

African and Southeast Asian regions (Havelaar et al., 2015). In this region, 32 million children under the age of five are thought to be infected by FBD. Also, 70% of FBD cases in this region are accounted for by Escherichia coli (E. coli), non-typhoidal Salmonella, Campylobacter, and norovirus. In general, Shigella species Salmonella species, and other pathogens including the hepatitis A virus and parasites are to blame for the majority of the region's common gastrointestinal infections. (World Health Organization, 2017). In FBDs recorded in Algeria, Kuwait, Jordan, Saudi Arabia, Oman, Lebanon, Syria and the Palestinian Authority, unpasteurized dairy products were a contributing factor (World Health Organization, 2018).

2.3 Testing and Monitoring Food Pathogens

Consuming contaminated food and other products results in food-borne disease (Noor et al., 2019). The term "foodborne diseases" (FBD) refers to a broad range of disorders caused by consuming food contaminated with microorganisms (Byrd-Bredbenner et al., 2013). Monitoring can help ensure that identified risks are maintained under control. For instance, it is possible to examine staff behaviours to determine whether food safety protocols are being followed. To prove that the identified hazard has been controlled or that corrective action has been taken when a hazard is determined to not be under control, monitoring and testing activities must be documented (Australia New Zealand Food Standards Code, 2007). The food processor can maintain a high level of hygienic food production by using microbiological monitoring to identify the presence of microorganisms, particularly harmful ones. It aids in the production of safe food items that adhere to international standards and regulations and aids in preventing the release of potentially contaminated products onto the market (Manju & Mishra, 2021). The final product, such as a bottled beverage or a prepared food item, cannot be the only thing that is subject to quality assurance examination. In contrast, it is necessary to undertake in-process quality control tests as well as ongoing monitoring of incoming raw materials throughout the production process. A big part of this kind of quality control is microbiological and aseptic testing (Sartorius AG., 2014).

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2.4 Preservation Techniques

To control microbial load and extend the shelf-life of food products, various preservation techniques are used. These include pasteurization, canning, refrigeration, freezing, drying, and the use of preservatives. The main goal of food preservation is to stop or slow down the growth of microorganisms such as mould, yeast, and bacteria because their growth leads to food spoilage. It also aims to slow down enzymatic reactions that happen during the raw material's post-harvest, post-slaughter, or shelf-life (Popa, Miteluț & Popa, 2019). The main techniques for food preservation can be reviewed as follows:

→ **Pasteurization:** It is the name given to heat treatments normally applied for up to a few minutes at temperatures between 60 and 80 C, and has two goals to remove a particular infection or pathogens connected to a product (Adams & Moss, 2008).

→ **Canning:** The technique of placing food in a container and putting it through a heat procedure to extend its shelf life is known as canning. An ideal thermal procedure will eliminate potentially harmful bacteria, reduce or eradicate existing spoilage organisms, and have a positive impact on the food's nutritional and physical qualities (Rajput et al., 2022).

→ **Preservatives:** They are substances that are added to a variety of food products, pharmaceutical dosage forms, and cosmetic preparations to maintain product consistency and quality, extend the shelf-life of food, improve or maintain nutritional value, preserve palatability and wholesomeness, provide leavening (yeast), control pH, enhance flavour, or add colour by keeping them from spoiling (Dwivedi et al., 2017).

→ **Dehydration**: or drying of food is used to cut losses while increasing the food's commercial worth. Sun drying and solar drying, which may require the use of solar dryers, are natural drying processes. Radiation, freeze drying, osmotic drying, dielectric drying, and other artificial drying techniques are available.

Food drying now uses more cutting-edge technologies like microencapsulation and nanotechnology (Adeyeye, Ashaolu & Babu, 2022).

→ **Refrigeration:** The food chain now requires refrigeration as a necessary component. It is utilized throughout the entire value chain, from farm and food production to distribution, retail, and home consumption. To halt the physical, microbiological, and chemical processes that could lead to food deterioration, the food industry uses both chilling and freezing operations, in which the food is cooled from ambient to temperatures above 0°C in the former and between -18°C and -35°C in the latter (Popa et al., 2019).

→ **Freezing**: The shelf life of many goods can be successfully extended by freezing, which offers a large increase. Despite the development of numerous new technologies, including high pressure, infrared radiation, pulsed electric field, and ultrasound freezing, the freezing method is still one of the most popular ways to preserve food. When energy is lost from a substance by chilling below the freezing point, water is transformed into ice, changing the substance's physical state. The temperature is typically further lowered to a storage level such as -18°C (Rahman & Velez-Ruiz, 2020).

2.5 Hazard Analysis and Critical Control Points (HACCP)

To meet consumer demands for food that is fresh, safe, healthy and free of hazardous bacteria and chemical preservatives, variety of procedures are currently available. These procedures allow the food to maintain its nutritional value and organoleptic qualities while extending its shelf life (Habibat & Fapohunda, 2023). The food sector relies heavily on microbiological control to ensure healthy food that is free from hazardous bacteria and chemical preservatives (Chaturvedi et al., 2013). Many strategies have been developed among them is the use of microbial control systems such as Hazard Analysis and Critical Control Points (HACCP). HACCP is a scientifically based method for avoiding cross-contamination and ensuring food safety during food processing. The food processing industry has been focusing on prevention since the HACCP system gained popularity, and any deviations are promptly fixed to address issues with food safety (Manju & Mishra, 2021). The significance of the HACCP system lies in its capacity to ensure food safety and enhance quality control, with a focus on identifying a specific targeted critical control point (CCP) for each hazard identified as reassuringly likely to occur (Wiedmann et al., 2019).

2.6 Laws and Regulations for Food Safety

The food legislation often includes a section or clauses that specify the various topics that might be addressed through regulations to fulfil the law's objectives. The majority of legal systems agree that there should be at least two avenues for legislation to be adopted; primary laws and secondary laws. The Primary law establishes important violations as well as the fundamental rules of a legal power. The complete legislative process—including extensive debate and consideration in the parliament—is typically used to approve this kind of legislation. It is expected that the primary legislation would include a clause allowing for a streamlined process for adopting secondary legislation (sometimes referred to as regulations or decrees). Making changes to this secondary law is consequently simpler (World Health Organization, 2023). In addition to existing regulatory guidelines for the use of food additives, microbiological poisoning, food safety, and instructions for food handlers, the Saudi municipality recently released particular regulatory guides for sanitarian and HACCP implementation. Additionally, the Ministry of Health reviews market food inspection through the Public Administration of Environmental Health (Alsubaie & Berekaa, 2020). The Saudi Food and Drug Authority (SFDA) has been established as the Saudi government organization in charge of developing rules and guidelines for food, unprocessed animal feed products, and processed animal feed products (Hallman & Mousa, 2019).

2.7 Consumer Education

It is important to maintain hygienic food preparation practices to prevent foodborne pathogens from growing or surviving (Scallan et al., 2011). Moreover, the expansion of fast-food businesses operated by poorly educated personnel from some

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developing countries, who do not possess adequate food safety training, has further aggravated this situation (Cetinkaya et al., 2008). The development of ongoing consumer education on several facets of food safety (storing, preparation, and handling) is necessary. Early childhood should be the starting point for this education. The target audience for food safety education includes not just food handlers but also all consumers, particularly males, of all age groups, as the majority of food safety-related morbidities are caused by household unsafe food behaviours and are easily avoidable (Boulos & Abouelezz, 2020). Grujić et al. (2013) have confirmed that consumers must be better informed and educated about food quality and safety, labels and labelling, as well as how to use and interpret label material.

3. Methodology of the Study

First: The research methodology:

The researcher adopted the descriptive analytical approach as the research method, as it suited the nature and objectives of the study. This approach was defined by Delah (2018, pp. 140-141), as the approach that focuses on studying the relationship between entities, existence, events, and circumstances.

Second: The research delimitations (Region):

The research was conducted within the boundaries of Jeddah, a Saudi Arabian city located along the eastern coast of the Red Sea. Jeddah is a commercial centre and tourist destination, with a population of (3.4) million people, which makes it the second-largest city after Riyadh. The research data was collected between the months of (January and September) in the year (2022). Three different food outlets, including restaurants, buffets, and cafes, affiliated with the Jeddah Municipality in the Kingdom of Saudi Arabia, were selected for food sampling by the Jeddah Council Data Center. These settings were chosen because they are highly popular among buyers, employees, and students.

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Third: the study sample:

The research sample included several commonly consumed food samples that are highly favoured by the residents of Jeddah. The total number of samples collected was (8393), which were collected from (19) districts within the Jeddah region. The following table illustrates this:

Table (2) Distribution of research samples according to region

Municipalities	Samples numbers	percentage
Obour	620	7.4%
North Obour	256	3.1%
Abraq Alraghama	143	1.7%
Um Alselm	184	2.2%
Al-balad	740	8.8%
Al-jamah	732	8.7%
South	503	6.0%
Al-Sharfiah	597	7.1%
Al-safaa	274	3.3%
Al-Aziziah	799	9.5%
Al-Matar	991	11.8%
Al-Malysa	226	2.7%
Bryman	408	4.9%
Thwal	112	1.3%
Jeddah Historical	95	1.1%
Jeddah Al-Jadedah	914	10.9%
Guzam	184	2.2%
Thahban	203	2.4%
Taiba	412	4.9%
Total	**8393**	**100.0%**

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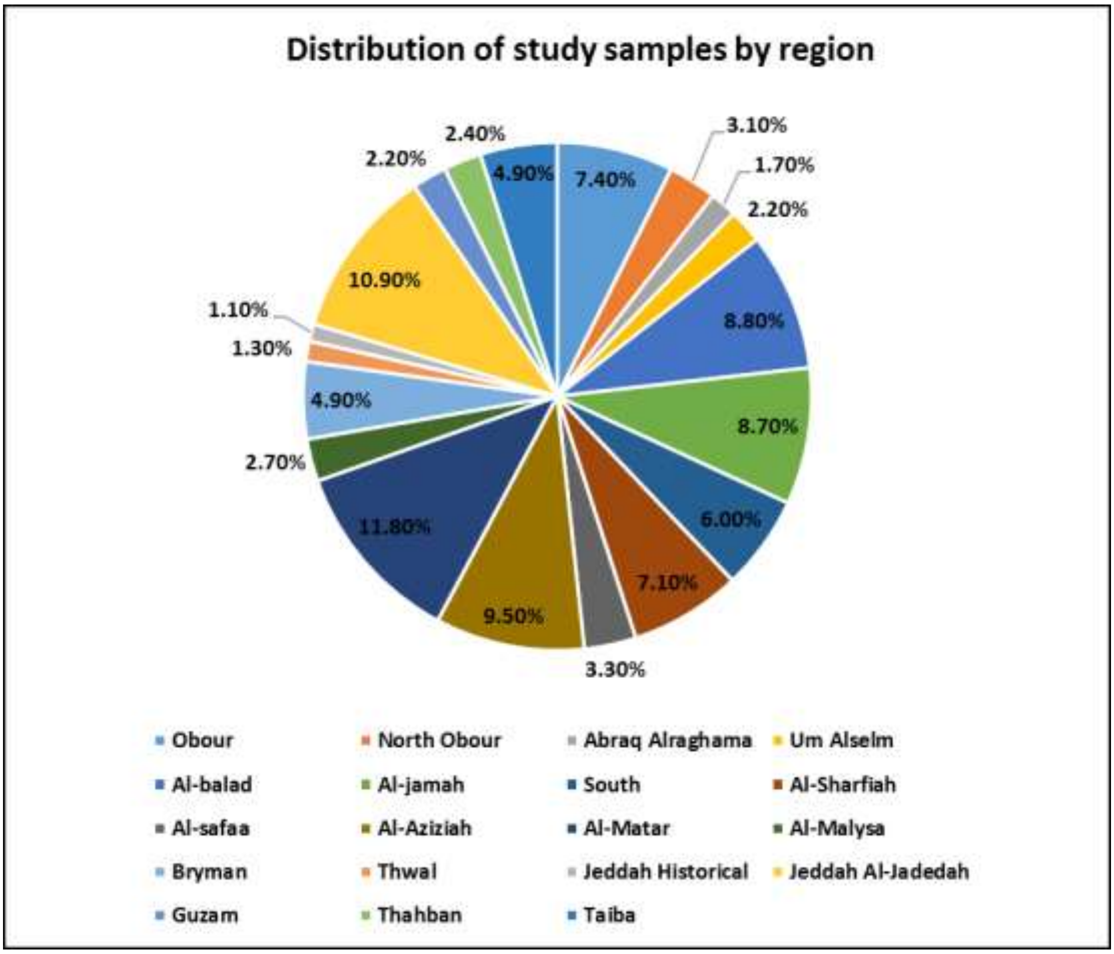

Figure (1) Distribution of research samples according to region

Figure (1) shows that the total number of the collected samples was (8,393), and it was distributed across (19) municipalities. The highest percentage of food samples obtained was from the "Al-Matar" municipality, with a number of (991) samples, represented by a percentage of (11.8%). It was followed by the "Jeddah Al-Jadedah" municipality, with a number of (914) samples, represented by a percentage of (10.9%) of the total sample. It was followed by a percentage of (9.5%) and it was gathered from "Al-Aziziah" municipality represented by (799) samples, It was followed by a percentage of (8.8%) of the food samples obtained from the (Al-balad) municipality, with a number of (740) samples, followed by a percentage of (8.7%) of the food samples

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obtained from the (Al-jamah) municipality, with a number of (732) samples, followed by a percentage of (7.4%) of the food samples obtained from the (Obour) municipality, with a number of (620) samples, followed by a percentage of (7.1%) of the food samples obtained from the (Al-Sharfiah) municipality, with a number of (597) samples. It was followed by a percentage of (6.0%) of the food samples obtained from the (South) municipality, with a number of (503) samples, followed by a percentage of (4.9%) of the food samples obtained from the (Bryman and Taiba) region, with a number of (408) samples. This was followed by a percentage of (3.3%) of the food samples obtained from the (Al-safaa) municipality, with a number of (274) samples, followed by a percentage of (3.1%) of the food samples obtained from the (North Obour) municipality, with a number of (256) samples, followed by a percentage of (2.7%) of the food samples obtained from the (Al-Malysa) municipality, with a number of (226) samples, followed by a percentage of (2.4%) of the food samples obtained from the (thahban) municipality, with a number of (203) sample, followed by a percentage of (2.2%) of the food samples obtained from the (Um Alselam and guzam) municipality, with a number of (184) samples, followed by a percentage of (1.7%) of the food samples obtained from (Abraq Alraghama) municipality, with a number of (143) samples, followed by a percentage of (1.3%) of the food samples obtained from the (Thwal) municipality, with a number of (95) samples.

Fourth: Procedures for collecting the research sample (food samples):

- **First procedure:** Obtaining a certified letter from the Jeddah Municipality.
- **The second procedure**: Collecting data on (8,393) food samples representing (11) different food kinds, including meat, dairy, potatoes, sauces, salads, and desserts, all of which are dishes that are frequently ordered from restaurants in the research municipalities, and will be presented in detail as follows:

Table (3) food types samples

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Percentage	Food Kinds	
20.9%	meat	**Food Samples (8393)**
9.80%	fruits	
3.40%	Taameya	
15.30%	Vegetables	
7.70%	Egg	
7.70%	Legumes	
3.80%	Potatos	
10.60%	Starches	
6.40%	Appetizer	
8.90%	Drinks	
5.50%	Dairy	
100%		

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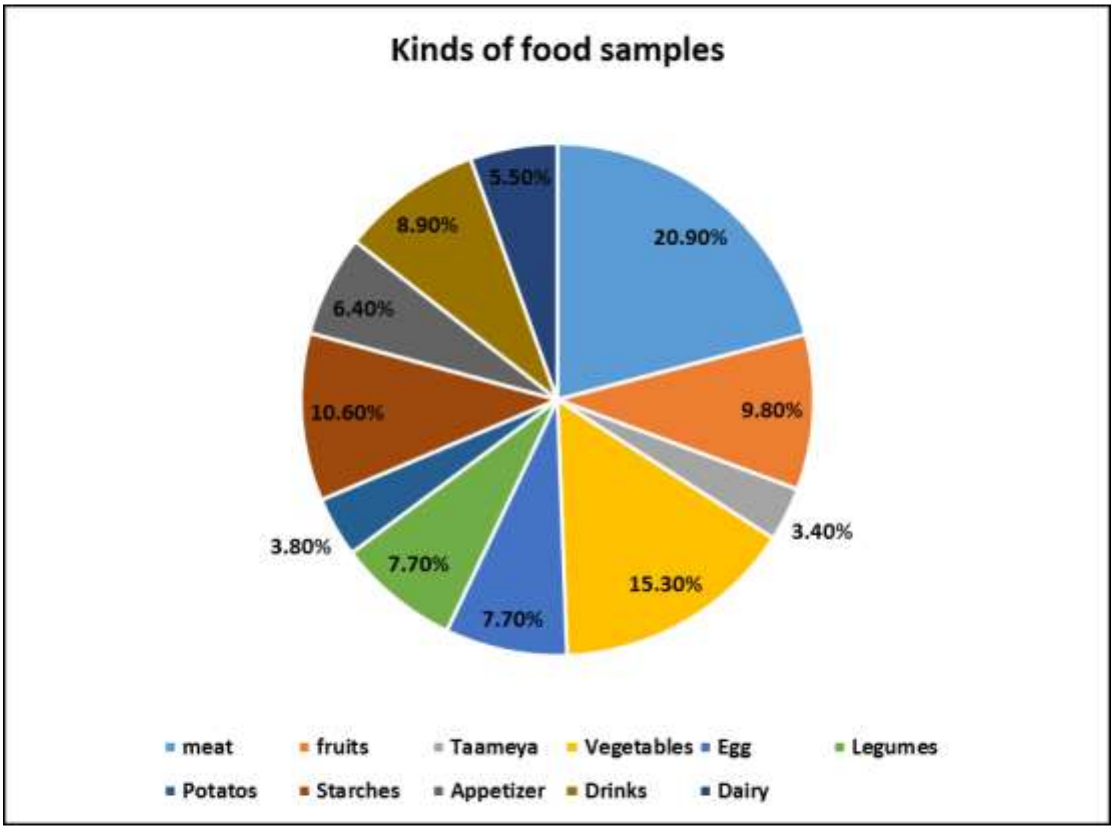

Figure (2) Types of food samples

Figure (2) shows that the food samples collected from the previously mentioned areas of Jeddah, with a number of (8393) samples, were classified into (11) kinds of food, where the highest percentage of the food kinds collected was (20.9%) allocated to (Meat), while the lowest percentage was represented by a percentage of (3.40%) allocated to (Taameya).

- **Third procedure**: Samples are filled by concolic employee into (500 ml) bottles and stored in ice boxes in accordance with the requirements of the microbiological research laboratory of the Jeddah Municipality for Analysis.
- **Fourth procedure:** assigning sequential identification numbers to the store names to ensure confidentiality.
- **Fifth procedure**: carrying out this work in accordance with the ethical standards of Al Baha University.

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Fifth: Procedures for testing and processing research samples (Food Samples):

The samples were processed and tested at the microbiological research laboratory of Jeddah Municipality, by following these steps:

- **Procedure 1:** Enrichment broths were incubated on Bird-Parker agar (Oxoid, England), XLD agar (Oxoid, England), Eosin Methylene Blue (EMB) agar (HIMEDIA, India), Blood agar (HIMEDIA, India), and Blood agar supplemented with 5% sheep blood**.**
- **Procedure 2:** The plates were then incubated for bacterial growth in an aerobic environment for 24-48 hours at 37 degrees Celsius.
- **Procedure 3:** Gram staining features and colony staining were used to examine the bacterial colonies.
- **Procedure 4:** A portion of the isolated colony was streaked on nutrient agar and incubated aerobically for 24 hours at 37 degrees Celsius to obtain pure cultures. A MASTASTAPH TM kit was used, and catalase activity and coagulase tests were performed on isolates.
- **Procedure 5:** The isolates were biochemically characterized using API 20E strips (BioMerieux- France).

Sixth: Statistical Methods:

Based on the nature and primary objective of the research, which is to assess the prevalence of foodborne pathogens in food outlets such as restaurants, cafeterias, and cafes in the Jeddah region of Saudi Arabia, the researcher relied upon the Statistical Package for the Social Sciences (SPSS) for data analysis. The results were then extracted using various statistical methods, including frequencies, percentages, and the chi-square test.

4. Results

This chapter includes a presentation of the results reached after collecting data using the aforementioned statistical methods and achieving the primary goal of the research.

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First: Distributing the foods collected from cafeterias in the specified research municipality in the Jeddah region.

Frequencies, percentages, and chi-square tests were calculated, and are shown in the following table:

Table (4) Distribution of Foods collected from Cafetieres in the study area

Municipality	Cafetieres		Chi-Square	Sig
	Samples numbers	percentage		
Obour	190	7.4%	1186.261[a]	.000
North Obour	50	1.95%		
Abraq Alraghama	20	0.78%		
Um Alselm	50	1.95%		
Al-balad	300	11.68%		
Al-jamah	230	8.96%		
South	153	5.96%		
Al-Sharfiah	125	4.87%		
Al-safaa	80	3.12%		
Al-Aziziah	100	3.89%		
Al-Matar	256	9.97%		
Al-Malysa	121	4.71%		
Bryman	135	5.26%		
Thwal	50	1.95%		
Jeddah Historical	38	1.48%		
Jeddah Al-Jadedah	353	13.75%		
Guzam	95	3.7%		
Thahban	52	2.02%		

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Taiba	170	6.62%		
Total	**2568**	**100**		

a. 0 cells (0.0%) have expected frequencies less than 5. The minimum expected cell frequency is 135.2.

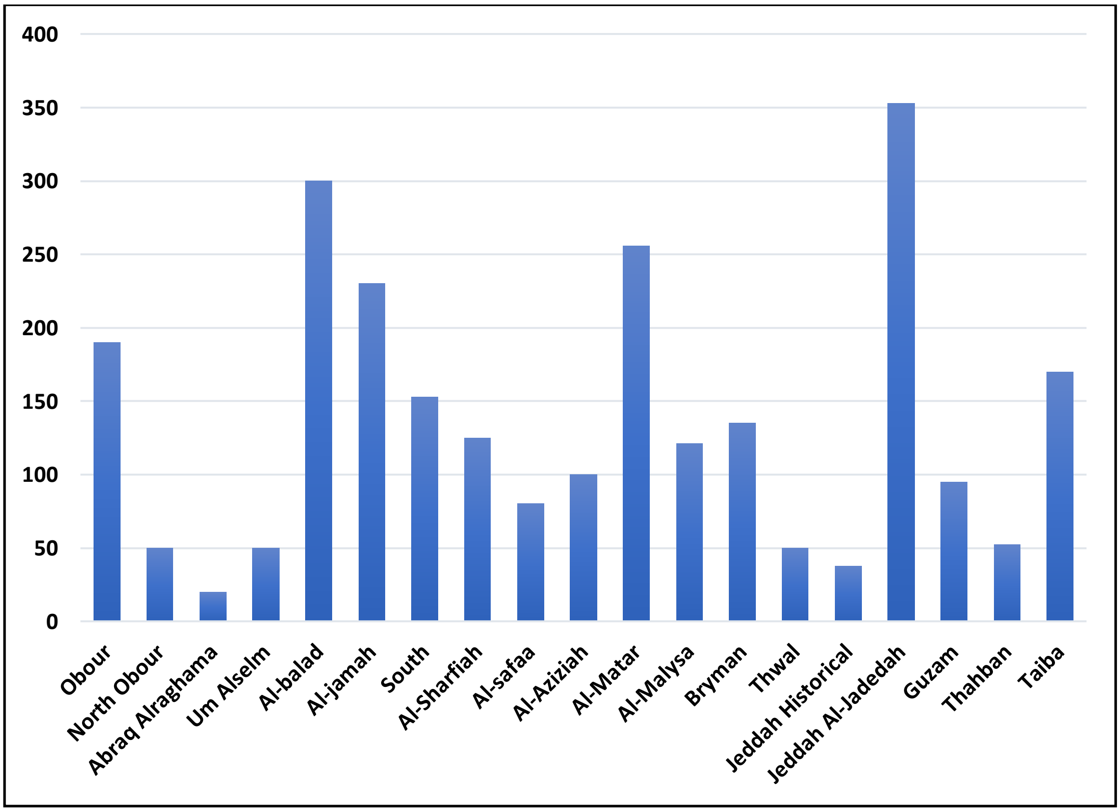

Figure (3) Distribution of Foods collected from Cafetieres in the study area

Figure (3) illustrates the number of food samples collected from various cafeterias located in different municipalities of Jeddah, with a total of (2568) samples. The highest percentage of collected food samples was (13.75%) with a number of (353) samples, and it was from the "Jeddah Al-Jadedah" municipality. This was followed by a percentage of (11.68%) with a number of (300 samples) from the "Al-balad" municipality, where the lowest percentage of food samples was (0.78%) with a number of (20 samples), and obtained from the "Abraq Alraghama" municipality.

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The previous result is consistent with what the statistical indicators demonstrate in Table No. (1.4) regarding the significant correlation between the distribution of foods collected from cafeterias and the study areas in the Jeddah municipalities, where the value of chi-square reached (1186.261[a]) at a significance level of (.000).

Second: Distributing the foods collected from coffee shops in the specified research municipalities in the Jeddah region.

Frequencies, percentages, and chi-square tests were calculated, and are shown in the following table:

Table (5) Distribution of Foods collected from Coffee shops in the study area.

Municipality	Coffee shops		Chi-Square	Sig
	Samples numbers	percentage		
Obour	100	5.37%	897.956[a]	.000
North Obour	75	4.03%		
Abraq Alraghama	10	0.54%		
Um Alselm	50	2.68%		
Al-balad	150	8.05%		
Al-jamah	110	5.9%		
South	121	6.49%		
Al-Sharfiah	200	10.74%		
Al-safaa	53	2.84%		
Al-Aziziah	217	11.65%		
Al-Matar	230	12.35%		
Al-Malysa	37	1.99%		
Bryman	130	6.98%		
Thwal	15	0.81%		
Jeddah Historical	25	1.34%		

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Jeddah Al-Jadedah	158	8.48%		
Guzam	36	1.93%		
Thahban	26	1.4%		
Taiba	120	6.44%		
Total	1863	100%		

a. 0 cells (0.0%) have expected frequencies less than 5. The minimum expected cell frequency is 98.1.

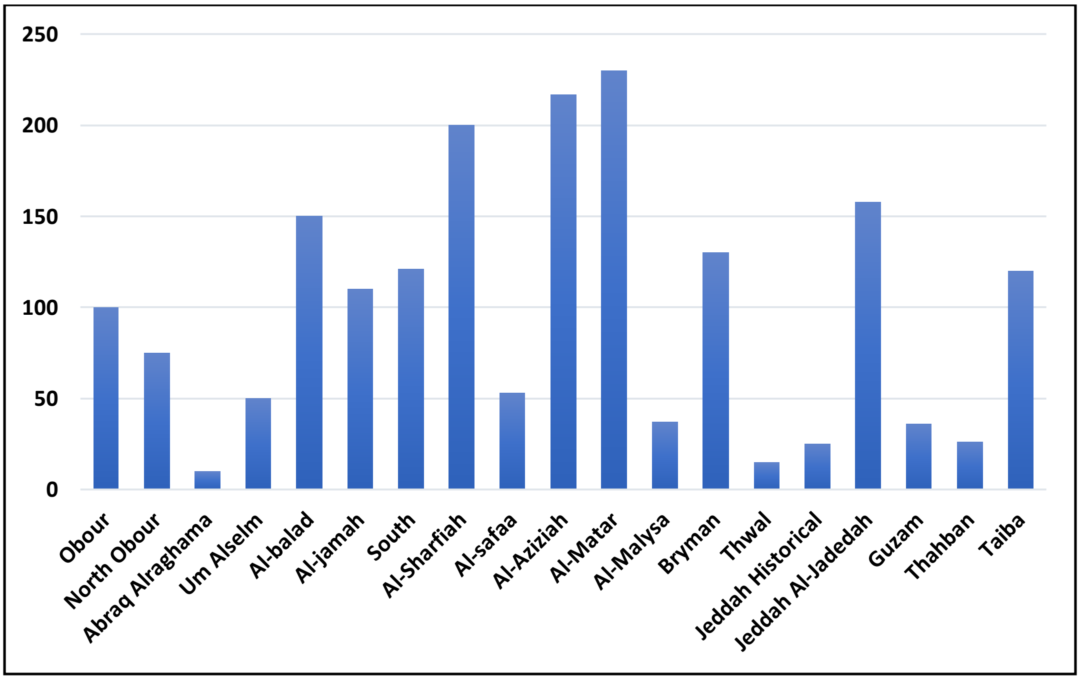

Figure (4) Distribution of Foods collected from Coffee shops in the study area.

Figure No. (4) shows the number of food samples collected from all coffee shops in the various areas of Jeddah, with a number of (1863) samples. The highest percentage of food samples collected was (12.35%) with a number of (230) samples belonging to (Al-Matar), followed by a percentage of (11.65%) with a number of (217) samples and it belonged to the (Al-Aziziah) region, while the lowest percentage of food samples was (0.54%) with number of (10) samples, and it belonged to the (Abraq Alraghama) municipality .

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The previous result was consistent with what the statistical indicators demonstrated in table no. (4) regarding the significant correlation between the distribution of foods collected from coffee shops and the study areas in the Jeddah region, where the value of chi reached (897.956[a]) at a significance level (.000).

Third: Distributing the foods collected from restaurants in the specified research areas in the Jeddah region.

Frequencies, percentages, and chi-square tests were calculated, and are shown in the following table:

Table (5) Distribution of Foods collected from Restaurants in the study area.

Municipality	Restaurants		Chi-Square	Sig
	Samples numbers	percentage		
Obour	330	8.33%	1990.908[a]	.000
North Obour	131	3.31%		
Abraq Alraghama	113	2.85%		
Um Alselm	84	2.12%		
Al-balad	290	7.32%		
Al-jamah	392	9.89%		
South	229	5.78%		
Al-Sharfiah	272	6.87%		
Al-safaa	141	3.56%		
Al-Aziziah	482	12.17%		
Al-Matar	505	12.75%		
Al-Malysa	68	1.72%		
Bryman	143	3.61%		
Thwal	47	1.19%		
Jeddah Historical	32	0.81%		

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Jeddah Al-Jadedah	403	10.17%		
Guzam	53	1.34%		
Thahban	125	3.15%		
Taiba	122	3.08%		
Total	**3962**	**100%**		

a. 0 cells (0.0%) have expected frequencies less than 5. The minimum expected cell frequency is 208.5.

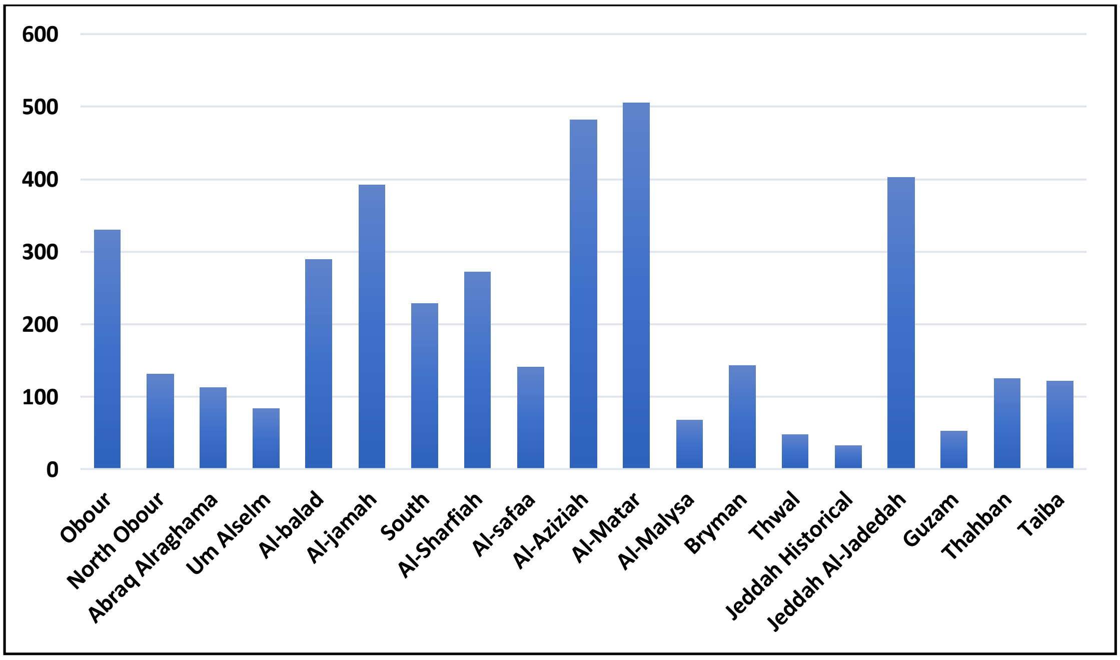

Figure (5) Distribution of Foods collected from Restaurants in the study area

Figure 3.4 illustrates the number of food samples collected from various restaurants in different municipalities of Jeddah, totaling (3,962) samples. The highest percentage of collected food samples was represented by a percentage of (12.75%) with a number of (505) samples, and was from the "Al-Matar" municipality. It was followed by the "Al-Aziziah" municipality, with a percentage of (12.17%) with a number of (482) samples. The lowest percentage of food samples was represented by a percentage of (0.81%) with a number of (32 samples), and it belonged to "Jeddah Historical" region.

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The above result was consistent with the statistical indicators presented in table (3.4) regarding the significant correlation between the distribution of collected food items from restaurants and the study areas in Jeddah. The calculated chi-square value was (1990.908[a]) with a significant level of (.000).

Fourthly: the presentation and analysis of the main research objective, which focuses on identifying the "prevalence of foodborne pathogens in food settings such as restaurants, cafeterias, and cafes in the Jeddah region of Saudi Arabia".

To achieve the primary goal of the research, frequencies and percentages were calculated and the types of foodborne pathogens were identified in food settings such as restaurants, cafeterias, and cafes in the Jeddah region in the Kingdom of Saudi Arabia. This is shown in the following table:

Table (6) Types of Foodborne pathogens in the collected food samples (N = 235)

Isolates bacteria	Sample number (n)	percentage
E- coli	199	84.7%
Salmonella	36	15.3%
Total	235	100%

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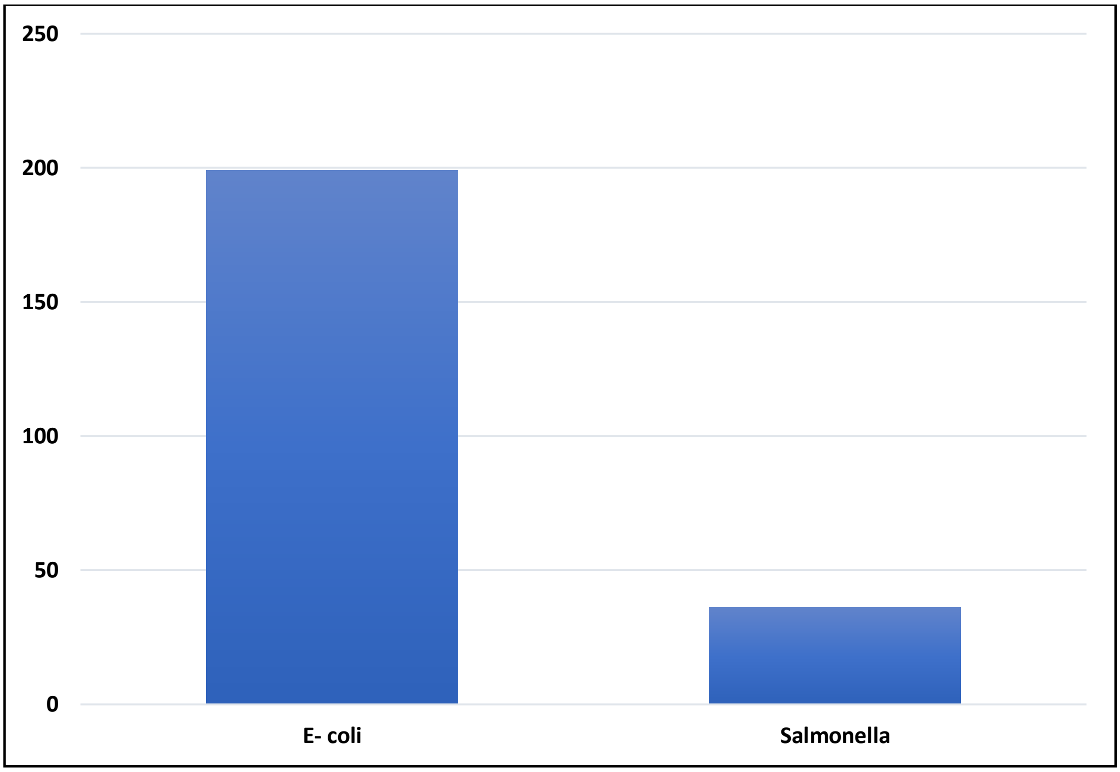

Figure (6) Types of Foodborne pathogens in the collected food samples (N =235)

Figure 6 demonstrates that based on the results of examining and processing the food samples collected from the specified municipalities in Jeddah, as conducted by the microbiological research laboratory of Jeddah Municipality, which is responsible for the examination and processing of food, accurate reports have been issued. It was found that there were (235) food samples out of the collected samples that were deemed unfit for consumption, as the results confirmed the presence of two types of foodborne pathogens in the food samples, namely (E. coli bacteria and Salmonella bacteria). It was found that out of the samples tested and proven to be unfit, a number of (199) samples were found to be responsible for causing E. coli bacterial infection with a percentage of (84.7%), while the remaining unfit samples, totaling (36) samples, were found to potentially cause (Salmonella bacterial infection) with a percentage of (15.3%).

5. Discussion

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The main objective of the current research is to identify the extent of the prevalence of foodborne pathogens in food outlets such as restaurants, cafeterias, and cafes in the Jeddah region of Saudi Arabia. To achieve this goal, a number of food samples were collected from various food outlets in a number of municipalities in the Jeddah region. These samples were examined and processed in the microbiological research laboratory affiliated with Jeddah Municipality, and it was found that there were a number of (235) food samples out of the collected samples that were deemed unfit for consumption. The results confirmed the presence of two types of foodborne pathogens in the food samples, namely (E-coli bacteria and Salmonella bacteria), which indicates that these samples are contaminated with the two types of harmful bacteria mentioned above, and this may be attributed to non-compliance with health standards during food during preparation, storage, and distributed which leads to contamination with germs and bacteria. The previous results can be due to, food being exposed to improper and unhealthy use of chemicals such as pesticides and preservatives, which results in food contamination. Also, Food is exposed to environmental pollutants such as lead, and airborne pollution such as dust or smoke affects the safety and quality of food because of air, water, and soil pollution, in addition to the fact that animals getting sick and becoming infected with bacterial infections and various viruses is considered one of the most important causes of contamination of meat and dairy products. This was consisted with the study of Bharathirajan *et al.* (2013), pathogens such *E. coli*, *Salmonella spp*., *Campylobacter*, and *Listeria* were found in home freezers when samples were isolated from stores and counted to evaluate the prevalence of harmful microorganisms. This obviously shows very poor consumer refrigerator management and cleanliness standards, endangering consumer health, and also the study of Iyer et al. (2013) which reported the presence of pathogenic *Salmonella* and *E. coli* contaminants in meat from various outlets in Jeddah, Saudi Arabia. They studied a total of 60 meat samples from different branches such as supermarkets, groceries and local butcheries. They found that local butcheries in open market harbored *Salmonella* as well as *E. coli* to a greater

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percentage in comparison with groceries and large hypermarkets, clearly indicating that proper handling and food storage conditions are major factors that are involved in the dissemination of the food-borne pathogens.

The results of inspection and sample processing reports indicate that the largest percentage of food samples cause infection with E. coli bacteria, at a rate of 84.7%. This may be due to the presence of some types of food that cause infection with this type of bacteria, such as eating a hamburger that is not cooked well, or swallowing a small amount of contaminated swimming pool water, even if it is consumed in small quantities. There are a few strains of E. coli that cause diarrhea. E. coli strain O157:H7 belongs to a group of E. coli strains that secrete a type of strong toxin that destroys the lining of the small intestine, and may result in bloody diarrhea. E. coli infection can occur when this strain of bacteria is ingested. Eating contaminated food is also one of the most important and common causes of E. coli infection, such as meat. E. coli bacteria present in the small intestine of the carcass can spread to its meat when it is slaughtered. Ground meat, which combines the meat of many carcasses, increases the likelihood of contamination and infection with bacteria. Animal milk is also more prone to contamination with E. coli bacteria that spread in the animals' udders or in the milking machines used. In addition to fresh agricultural products, including vegetables and fruits, which can be contaminated from the fields in which they are grown, certain types of vegetables are particularly exposed to this type of contamination, such as spinach and lettuce. This is consistent with what was indicated by Altalhi et al.(2010), as they collect meat samples from different establishments in Taif, Saudi Arabia. Those meat samples were found to be significantly contaminated with several E. coli strains that were extremely resistant to a variety of antibiotics, this also aligns with the study of AL-Dughaym & Altabari, (2010) chicken meat from Saudi Arabia's Al-Ahsa markets revealed a significant prevalence of E. coli, and the study of Ali et al. (2010) ،conducted a similar investigation on the microbial contamination of raw meat and its surroundings in retail stores in Pakistan. Their findings revealed a significant frequency of a variety of food-borne diseases, including E. coli O157:H7, the study by Christison et al. (2008) found that filled baguettes and salads had the highest bacterial frequency. Furthermore, E. coli-related diarrhea is quite common in both travellers and young children in underdeveloped nations. However, none of the food samples that were gathered had the E. coli 0157.H7 strain. This result is inconsistent with Alhadlaq, Mujallad & Alajel (2023) who confirmed the presence of E. coli O157:H7 in samples of imported raw meat in food samples taken from the Kingdom of Saudi Arabia.

The results of the sample testing and processing reports also indicated that the remaining percentage of food samples, represented in the sample of (15.3%), were found to cause (Salmonella bacterium). This highlights that salmonella species are among the most significant causes of foodborne illnesses, which is a critical health issue both internationally and in the Kingdom of Saudi Arabia. Salmonella infection, also known as salmonellosis, is a common bacterial disease that affects the intestines. Salmonella bacteria typically reside in the intestines of both animals and humans. Infection with these bacteria can occur because of the consumption of contaminated water or food. Certain types of food can facilitate the transmission of bacterial infections, including meats, fish, and various seafood, where faeces can contaminate raw meat and poultry during the cutting process. Seafood can also become contaminated when harvested from polluted waters, and raw or undercooked eggs can be sources of infection. Even though eggshells seem to be an ideal barrier against contaminants, some infected poultry may lay eggs containing Salmonella before the eggshell is formed. Moreover, raw eggs are used in the preparation of various sauces such as mayonnaise and Toumeya (Arabic Garlic Aioli). Fresh fruits and vegetables are susceptible to contamination if irrigated with water contaminated with Salmonella. Failure to adhere to food safety standards during food preparation can also contribute to the spread of Salmonella.

Additionally, Salmonella infections can be transmitted from infected animals, especially pets that carry Salmonella bacteria on their feathers or skin. This aligns with

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the information provided in the study by CDC, (2012) Although eggs, pork, and poultry are frequently linked to *salmonella* outbreaks, other foods including fruits and vegetables can also get contaminated. More recently, the CDC announced that a total of 258 people from 24 states and the District of Columbia had contracted the epidemic strains of *Salmonella Bareilly* (247 people) or *Salmonella Nchanga* (11 people), this also agrees with the study of (Al-Mazrou, 2004) ،had reported *Salmonella* food poisoning in Saudi Arabia. He found a steady increase in food poisoning incidents in KSA, especially during the summer months and Hajj season, with meat and chicken being the main sources associated with these outbreaks. Recent reports of meat contamination with *Salmonella* in KSA are increasing ،Another study by Al-Dughaym and Altabari (AL-Dughaym & Altabari, 2010) reported a significant presence of *Salmonella* in meat samples from AlAhsa markets in Saudi Arabia. Serotypes are *Typhimurium* and *Enteritidis* which are the most two widespread serotypes that cause human salmonellosis .

In light of the research findings, the researcher recommended the importance of the food that is manufactured and presented to customers being prepared healthily and safely for human consumption, and therefore it is recommended that all food outlets follow food safety standards and microbial quality control rules in the Kingdom of Saudi Arabia in the Jeddah region.

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