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Comparative Analysis of Microbial Populations in Organic and Inorganic Foods from Benin City, Nigeria

[1,2*]Aghemwenhio, I.S., [1]Iduwe, S., [3]Odekunle, O.D., & [2]Imoobe, G.
[1]Department of Microbiology, University of Benin, Benin City, Nigeria.
[2]Edo State College of Agriculture and Natural Resources, Iguoriakhi, Edo State, Nigeria
[3]Royal Rangers Academy, Jos North, Plateau State

***Corresponding author email:** itohan.aghemwenhio@uniben.edu

Abstract
Consumers consider food safety and quality very important. Microbiological population in food is one factor affecting its quality. Microorganisms can affect the taste, texture and overall safety of food in both positive and negative ways. Food produced without artificial fertilizers, pesticides and GMOs is known as organic, and interest in it has increased recently. The interest in learning about possible differences in microbial growth between these two foods is inspired by the contrast between organic and non-organic food. Compared to conventionally grown non-organic foods, organic foods claim to have a lower microbial load. The purpose of this study was to examine microbial populations found in both organic and non-organic foods to gain insight into how agricultural practices affect microbial growth. A comprehensive study was conducted to assess the microbial composition and diversity in various organic and inorganic food samples. Our results showed that there was little or no difference in microbial growth between organic and non-organic foods. These findings suggest that food and its organic or inorganic content may not have a significant effect on microbial communities. However, it is important to consider the specific circumstances and factors of each sample, and also to study the limitations. These findings provide insightful information for consumers, farmers and policy makers.

Keywords: Organic Food, Inorganic, Microbial Population, Bacteria, Fungi.

Introduction

Global demand for organic food has grown steadily over the past few decades. Increasing concern exists regarding the possible health and environmental impacts of traditional agricultural practices, leading them to choose organic alternatives (Walmsley et al., 2017). Organic food production uses agricultural practices that prioritize the use of biological control pests, crop rotation and natural fertilizers, while non-organic food production uses traditional agricultural methods that may include synthetic fertilizers, pesticides, and organisms modified through genetic engineering. One area of interest in organic food research is the microbial populations present in these foods. Organic food versus non-organic food has attracted interest and debate among consumers, scientists and agricultural experts. One aspect of this ongoing debate is the potential impact of these agricultural practices on microbial growth in food.

Current studies have shown conflicting results, with some showing significant differences in the microbial composition of the two foods, while others have found little or none. Microbes, including bacteria, fungi and other microorganisms, are found in a various environments. They play a vital role in nutrition, fermentation and even human health. The rising demand of the organic market may be partly due to the weakening of consumer confidence in the traditionally prepared food that dominates the market (Lee et al., 2016). The production of these inorganic foods often uses intensive methods, synthetic fertilizers, chemical pesticides, growth regulators and preservatives, and synthetic flavors and aromas during processing. A number of studies have been conducted on consumer attitudes and preferences to understand the reasons behind the rising demand in the consumption of organic food . The preference for organic food is often linked to factors which includes environmental protection, animal welfare and personal health. (Harper et al., 2002; Magnusson et al., 2001; Davies et al., 1995; Tregear et al., 1994).Health concerns play a key role in organic food choices, and perceptions of food safety play a key role in purchasing decisions (Harper et al., 2002). However, it is worth noting that historically there have been unverified assertions about the properties of organic products. For

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example, one of the most prominent claim by proponents of the organic movement is that organic food may help in treatment of cancer (Bishop, 1988). In an earlier study, J.I. Rodale about the complete recovery of four cancer patients after the introduction of a fully organic diet (Jukes, 1974). Presumably, the medical community has expressed doubts about the validity and veracity of these claims. Despite this, quite a handful of supportive care centers "now offer patients and their families fresh organic fruits and vegetables to promote cancer nutrition" (Cabaret, 2002). Despite the fact that we do not have solid evidence to recommend eating organic food to reduce the risk of cancer, many people strongly believe that organic food is better. Considering the expectations of consumers, paying attention to the safety of organic products is crucial. Despite the common perception among consumers that organic foods are "healthier" than conventional foods, it can be difficult to find concrete evidence to support the superiority of organic foods. The microbiological safety and quality of organic agricultural products are still contested and disputed (Magkos et al., 2006). This concern surfaced due to insufficient research to accurately depict the situation . The belief that fresh organic produce is safer and superior to conventionally grown foods stems from the notion that organic fruits and vegetables are grown without synthetic fertilizers or chemical based pesticides. This perception drives consumer preference for organic foods, as they are concerned about the potential health risks associated with chemical residues (Devcich et al., 2007). However some studies have indicated that application of manure which is an organic farming practice, can elevate the risk of microbial contamination. Manure can carry harmful pathogens that cause foodborne illnesses like *Salmonella* spp., *L. E. coli* O157:H7 and *monocytogenes* (McMahon et al., 2001). Although manure can introduce pathogenic microorganisms that persist in the soil (Pell, 1997). It is challenging to definitively state that consuming fresh organic products poses a higher microbiological risk compared to conventional produce. Microbial contamination can occur at various stages, including harvest, postharvest treatment and throughout the food chain (Parra et al., 2014).

Microorganisms can affect food, spoilage and safety (Holban et al., 2018). Ensuring food safety is a global concern, and people around the world appreciate it more and more. Safe food production practices are critical to maximizing public health and environmental benefits. It is important to prioritize food safety to ensure the well-being of all. Organic food is food that has been grown or grown without using antibiotics, artificial chemicals, genetically modified organisms and hormones. To receive the organic label, food must not contain artificial food additives such as colorings, preservatives, artificial sweeteners, monosodium glutamate and flavoring. In organic farming, natural fertilizers such as manure are often used to promote plant growth. Organic livestock for meat, eggs and dairy products must be bred in conditions that allow their natural behavior, such as grazing. They must also be fed organic fodder and fodder and are prohibited from receiving antibiotics, growth hormones or animal by-products (Średnicka-Tober et al., 2016). Some of the most frequently purchased organic products are grains, vegetables, fruits, meat and dairy products. Processed organic products such as soft drinks and baked goods are also available. In addition, organic food is also usually found in ecological dishes or packages, which reduces the human impact on the planet and the CO2 emissions associated with their production. Several older studies have shown that organic food contains more certain trace elements such as zinc, iron, vitamin C and antioxidants. (Brandt et al., 2011; Hunter et al., 2011).Organic plants do not rely on chemical pesticides, but have a natural defense mechanism by producing more of their own defense compounds such as antioxidants reduces the need for chemical pesticides. Instead, they produce more compounds that protect themselves, such as antioxidants. Antioxidant levels can be up to 69% higher in these foods (Brandt et al., 2011).In contrast, synthetic substances such as chemical fertilizers and pesticides are used to produce inorganic foods. In addition, producers have the ability to modify non-organic foods at the molecular or genetic level, allowing the development of stronger and higher-yielding varieties through cross-breeding .The biggest disadvantages of inorganic foods are:Long-term research on the safety of many synthetic substances used in inorganic foods is limited. Therefore long-term effects of these substances are not fully understood (Leonardo et al., 2021).Non-organic foods generally contain fewer nutrients than organic foods. There is also evidence that synthetics used in inorganic agriculture can have long-term negative effects on soil, potentially making it less fertile or infertile. The widespread use of aerosols, pesticides and other methods in large-scale cultivation of crops can have adverse effects on the environment. These practices can contribute to the depletion of the ozone layer and development of climate change (Leonardo et al., 2021)

Regular use of pesticides can be harmful to health. The liver is sensitive to pesticides because it is responsible for detoxifying these compounds. Regular consumption of foods containing pesticides can increase the workload of the liver, which can lead to inefficiency. Although there is conflicting research on the extent of the health risks, some experts strongly believe that these residues have long-term effects on human health, although the degree of harm can vary depending on the particular pesticide. Many pesticides are water soluble, so washing food before use can help remove a significant portion of it. However, lipid-soluble pesticides can

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be more difficult to remove, leading to higher consumption of these compounds (Plimmer, 2001). The specific objectives of this research were to investigate the microbial status of organic and inorganic food samples, compare the microbial population present in organic and inorganic food samples and assess the overall microbial load.

Materials and methods

Collection of samples

A total of 20 organic and inorganic foods with 10 organic samples (certified by professional authorities and trusted farmers) and 10 inorganic foods purchased from different vendors in Benin City, Edo State, Nigeria. Samples included: Ogbono seed (Irvingia gabonensis), melon (Cucumeropsis mannii), peanut (Arachis hypogaea), cucumber (Cucumis sativus), tomato (Lycopersicon esculentum) apple (Malus domestica). The samples were aseptically transported for microbiological analysis to the microbiological laboratory of the University of Benin, Benin City.

Preparation and sterilization of culture media

All media are prepared according to the manufacturer's instructions. Sterilization is at 121ºC at 15 psi for 15 minutes unless otherwise specified by the manufacturer.

Nutrient agar

Twenty-eight grams of nutrient agar was dissolved in 1000 ml of distilled water in Erlenmeyer flask covered with foil and cotton wool and the flask was placed in an autoclave and the medium sterilized 121°C for 15 minutes. The flask was allowed to cool after sterilization

Preparation of Potato Dextrose Agar (PDA)

Thirty-nine grams (39 g) of PDA was dissolved in 1000 mL of distilled water in Erlenmeyer flask covered with foil and cotton wool and the flask was placed in an autoclave , the medium was sterilized at 121°C for 15 minutes

Total heterotrophic bacterial enumeration and isolation

Hundredfold serial dilutions of the samples were aseptically prepared in sterile physiological saline. An aliquot of 0.1 ml was inoculated using the plating method. Nutrient agar (supplemented with fluconazole) and potato dextrose agar (supplemented with chloramphenicol) were used for enumeration. Plates were incubated at 37 ± 2 °C for 24 h for bacterial and 48 h for fungal growth. The number of colony-forming units per milliliter (p/ml) was calculated using the following formula:

$$\frac{cfu}{ml} = \frac{number\ of\ colonies\ x\ dilution\ fold/series}{volume\ of\ inoculum}$$

(Willey *et al.*, 2008)

Phenotypic identification of bacteria from samples.

Several tests such as Gram reaction, catalase, urease, indole, oxidase, sugar fermentation, citrate utilization, a corresponding reaction was performed with triple sugar-iron agar tests to presumably identify bacterial isolates (Holt et al., 1994).

Morphological identification

***Gram stain*:**

This test was carried out to confirm the cell type of the bacteria used. Gram-staining techniques were used to distinguish between Gram-negative and Gram-positive bacteria. Organisms that retain the primary stain are called gram-positive, while those that do not retain the primary stain are called gram-negative. The stain's non retention is due to the composition of the cell. The Gram stain procedure is as follows: A bacterial isolate was smeared on a grease-free slide and heat-fixed by passing it over a flame. The cartridge was stained with crystal violet primary stain for 1 minute, then washed with distilled water. The slides were then flooded with Lugol's iodine solution for 30 seconds and then washed with distilled water. For decolorization, 95% alcohol was used for 10 seconds and immediately washed with distilled water. Finally, the smear was stained with safranin for 1 minute and washed away. The slides were allowed to dry before being viewed under a microscope using a 100x oil immersion objective to view the slides.

Biochemical Identification

A biochemical test was performed to facilitate the identification of bacterial isolates for phenotypic (cultivation) characteristics. The various biochemical tests performed are given below;

Oxidase test

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It is mainly used to distinguish Pseudomonas from other Gram negative rods. The oxidase test was carried out to identify the bacterial species producing the cytosome oxidase enzyme. and *Staphylococcus aureus* and *Escherichia coli* which are Gram-positive and gram negative, were used as controls. Using a piece of filter paper, 2-3 drops of freshly prepared oxidase reagent (1% tetramethyl-3-phenylenediamine dichloride aqueous solution) was added to the sterilized wire loop. A positive oxidase test is indicated by a purple color within 10 seconds..

Urease test

Urease test was employed to identify organisms that produce enzyme urease, which catalyzes the conversion of urea into ammonia. The test is particularly useful for distinguishing organisms like Proteus mirabilis from other non-urease positive organisms. Sterilized medium was aseptically distributed into test tubes and the isolated test bacteria were inoculated into the medium and incubated at 37°C for 24 hours. A color change from yellow to reddish pink indicated the presence of urease.

Indole Production Test

This test was employed to test for isolates that can separate tryptophan from indole in peptone water. The test is used to distinguish gram-negative bacilli, especially enterobacteria. Five grams of peptone broth was dissolved in 1 liter of distilled water. Sterilization of the medium was carried out in an autoclave for 15 minutes at 121 degrees Celsius. 4 ml of medium was poured into a sterile test tube and each bacterial isolate was inoculated into peptone broth. The inoculated medium was incubated at 37°C for 24h, and a few drops of KOVAC reagent were added. KOVAC reagents consist of 150 ml of amyl alcohol, 10 g of dimethylaminobenzaldehyde, and 150 ml of concentrated hydrochloric acid. A positive test was indicated by a red color that appeared immediately at the top of the test tube.

Citrate Utilization Test

This test was employed to determine which isolates can use citrate as their sole source of metabolic carbon. The medium used was Simon's citrate agar. 22 g of commercially available Simon's citrate agar was dissolved in 1 liter of distilled water and sterilized at 15 minutes for 121 °C in an autoclave . The medium is supplied in test tubes and the test organism was inoculated by stabilizing the medium on the top of the tubes using a sterile straight inoculation thread containing the culture. The test tubes were incubated at 37°C for approximately 24 hours. A positive result is indicated by a color change from green to light blue.

Catalase Test

This was employed to detect for the presence of the enzyme catalase. The enzyme catalase catalyzes hydrogen peroxide breakdown, releasing free oxygen and forming water. A few drops of 3% hydrogen peroxide that was freshly prepared were added to the bacterial isolates spread on the plate. The formation of gas bubbles indicated that the catalase enzyme was positive.$2\ H2O2 \rightarrow 2\ H2O + O2$

Sugar Fermentation and Gas Production with Triple Sugar Iron Agar (TSI)

The manufacturer's instructions was followed to prepare TSI and the prepared medium was placed in a test tube and held at an angle to solidify . The oblique and posterior part of the medium was inoculated with test bacteria using a sterile loop and incubated for 18-24 hours. The results were read based on the production of acid or alkali on the bevel or back side of the pipe, and gas production was confirmed by the presence of cracks or air bubbles in the bend area. As the environment darkened, more hydrogen sulfide production was confirmed. A prepared laboratory interview was used to interpret the results according to the microbiological standard protocol and to confirm or confirm their identity in other biochemical tests performed on the isolates.

Antibiotic Susceptibility Test

Bacterial isolates were subjected to antibiotics that are commonly used in Nigeria through the Kirby Bauer agar disc diffusion technique as outlined by and Akinyemi et al. (2005) and Aromolaran and Badejo (2014). Pure colonies of bacterial isolates were plated on sterile Muller Hinton agar (MHA) plates and incubated at 37°C for 24 hours. The cells were then suspended collected in sterile normal saline and standardized to 0.5 McFarland standard. These standardized cells were spread on the surface of sterile MHA using sterile cotton swabs, and antibiotics from various plates were aseptically placed onto the medium. The plates were incubated again at 37°C for 24 hours. The antibiotic discs used included colistin (30 µg), erythromycin (30 µg), ciprofloxacin (5 µg), metronidazole (5 µg), tetracycline (300 µg), clindamycin (10 µg), gentamicin (10 µg). The diameter of the z inhibition zones around each disc were measured and recorded after the incubation period . All data represent the averages of triplicate measurements.

Data Analysis

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The mean, range and standard deviation of each parameter were calculated. Means were separated using Duncan's multiple range test (SPSS, 2010).

Results

Microbial colonies from organic and inorganic food samples were identified based on their morphological and cultural characteristics. The morphological and cultural characteristics of the bacterial and fungal isolates are shown in Tables 1 and 2, respectively. The pages following display a more thorough result.For the bacteria, normal culture, morphological, and biochemical methods were used to determine the isolates' potential identities. The dimensions, color, margin, elevation, and shape are examples of cultural characteristics. Cell type and arrangement are examples of morphological characteristics, whereas citrate, indole, oxidase, sugar fermentation catalase, and urease are examples of biochemical tests. As shown in Table 3, Test for antibiotic sensitivity was performed in order to determine which antibiotic was most suited to hinder the growth of the isolated pathogens as well as to determine whether the isolates were resistant to more than one antibiotic. Following the incubation time, the diameter of inhibition zones surrounding each disc was measured and recorded. The isolates showed varying degrees of susceptibility or resistance to the drugs. The investigation revealed the following antibiotics: colistin, methronidazole, erythromycin, tetracyclin, and clindamycin were the least effective isolates, while ciprofloxacin, gentamicin, and augmentin were the most effective.

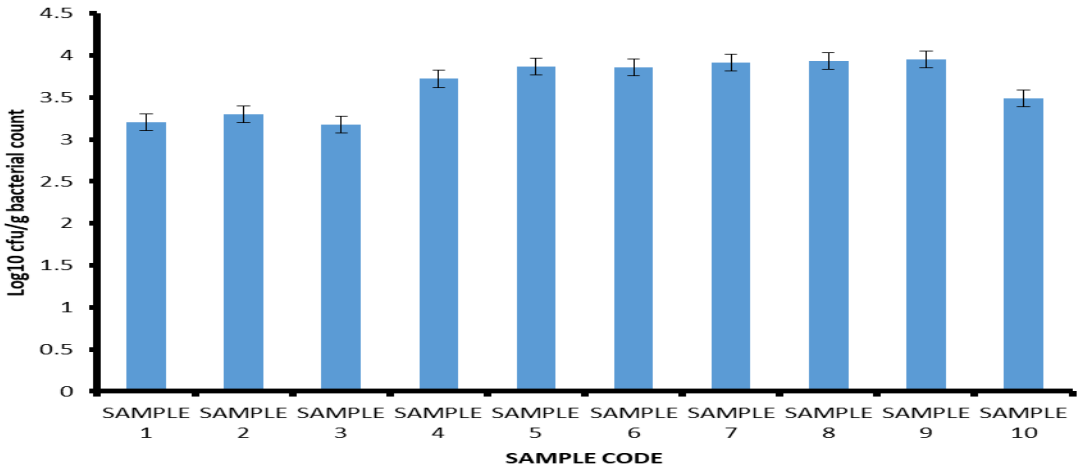

Figure 1: Total heterotrophic bacterial count of the organic food sample

The total heterotrophic bacteria count for the different organic food samples is shown in Figure 1

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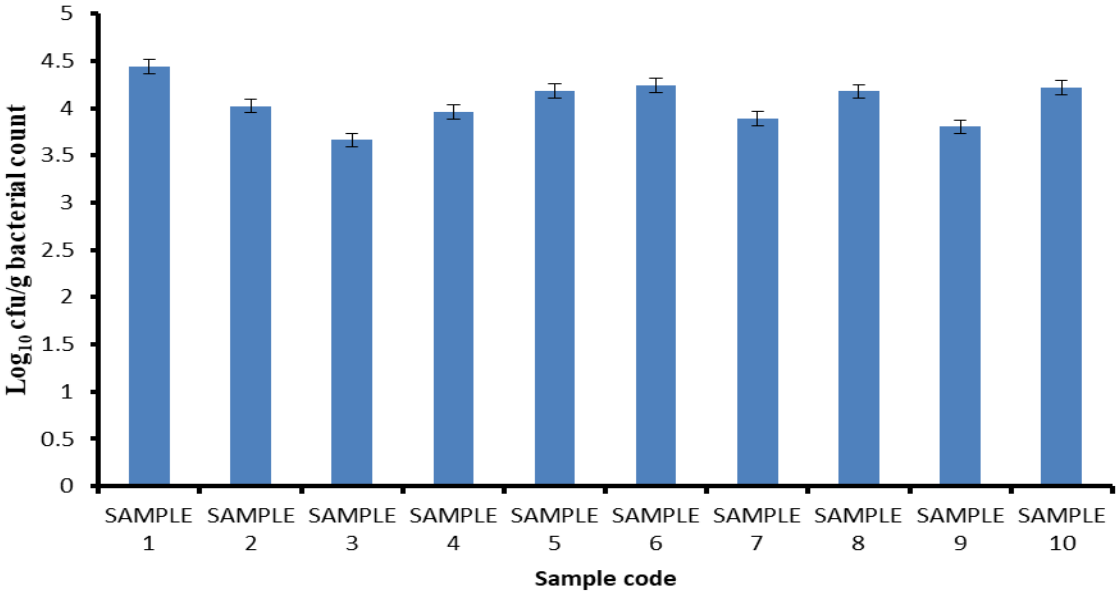

Figure 2: Total heterotrophic bacterial count of inorganic food sample

The total heterotrophic bacteria count for the different inorganic food samples is shown in Figure 2

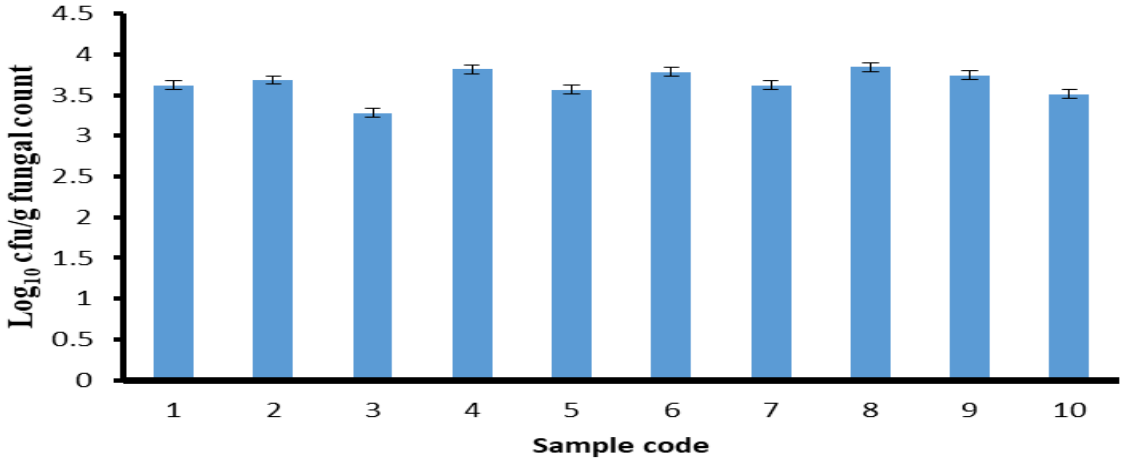

Figure 3: Total fungal count for organic food samples (log_{10} cfu/g)
The total fungal count for the different organic food samples are shown in Figure 1

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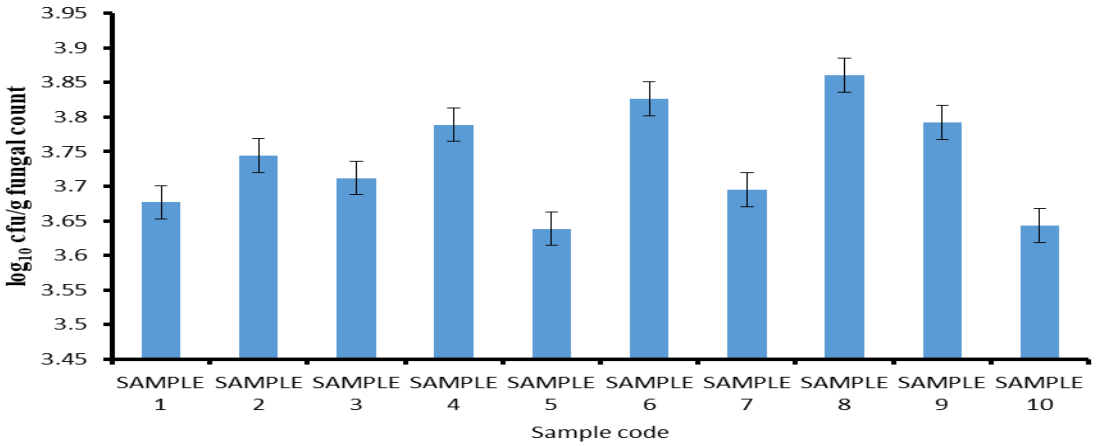

Figure 4: Total fungal count of inorganic samples (log_{10} cfu/g)
The total fungal count for the different inorganic food samples are shown in Figure 1

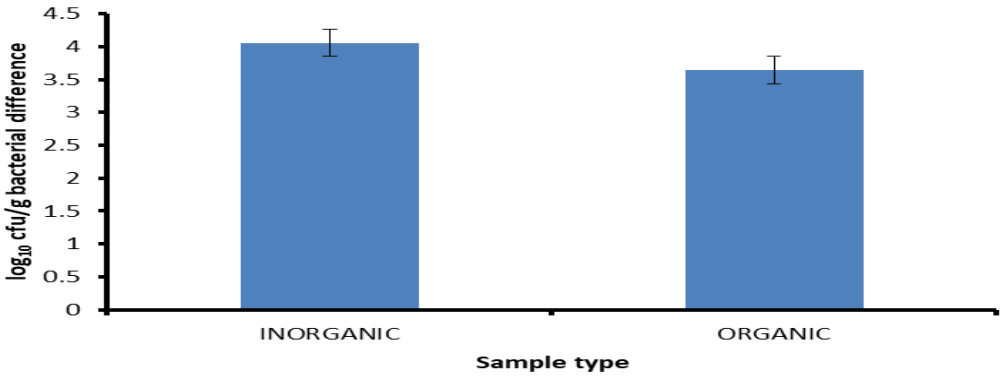

Figure 5: log_{10} cfu/g bacterial difference between organic and inorganic food

Figure 5 shows the comparison of bacteria count between organic and inorganic foods.

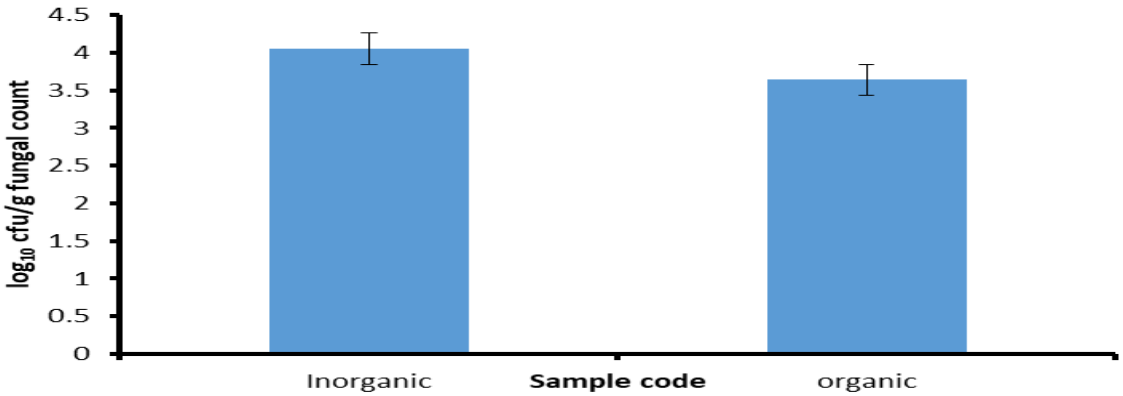

Figure 6: log_{10} cfu/g fungal difference between organic and inorganic food
Figure 6 shows the comparison of fungal count between organic and inorganic foods.

Table 1: cultural, morphological and biochemical characteristics of bacterial isolates

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Cultural characteristics	1	2	3	4	5
Colour	Cream	Cream	Golden yellow	Cream	Yellow
Shape	Circular	Circular	Circular	Circular	Circular
Elevation	Convex	Convex	Convex	Convex	Convex
Margin	Entire	Entire	Entire	Entire	Entire
Size	Small	Small	Small	Small	Small
Morphological characteristics					
KOH	+	+	-	-	-
Gram stain	-	-	+	+	-
Cell morphology	Rod	Rod	Cocci	Rod	Rod
Cell arrangement	Single	Single	Clusters	Single	Clusters
Biochemical characteristics					
Catalase	+	+	+	+	+
Coagulase	-	-	+	-	-
Indole	+	-	-	-	-
Oxidase	-	-	-	-	-
Citrate	-	-	+	+	-
Urease	-	-	+	-	-
H2S production	-	+	-	-	-
Glucose	+	+	+	+	+
Lactose	+	-	+	-	-
Sucrose	-	-	+	+	-
Mannitol	+	+	+	+	-
Gram. Diff.	Green metallic Sheen (EMB)	Black (SSA)	Yellow (MSA)	Straw (BCA)	Cream (SSA)
Identity	*E. coli*	*Salmonella* sp.	*S. aureus*	*Bacillus* sp.	*Shigella* sp

Key: SSA = Salmonella-Shigella Agar. EMB = Eosin Methylene Blue

Table 2: Cultural and morphological characteristics of fungal isolates

Cultural characteristics of fungi isolates	Fluffy black colony with reverse yellow side	Texture of cotton candy, white with pale yellowish brown reverse color	Velvety, whitish to grayish-orange, reverse is pale yellow to white
Number of hyphae	septate	septate	septate
Color of spore	brownish	whitish	grey
Type of spore	conidiospore	conidiospore	conidiospore
Possible isolate	*Aspergillus niger*	*Mucor sp.*	*Penicillium sp*

Table 3: Antibiotic sensitivity test of bacterial isolates

ISOLATES	CS	CIP	GEN	E	TE	M	CD	AG
E.coli	0(R)	16(S)	14(S)	0(R)	0(R)	0(R)	9(R)	12(I)
Staphylococcus sp	0(R)	14(S)	15(S)	8(R)	0(R)	7(R)	11(I)	14(S)
Bacillus sp	0(R)	22(S)	15(S)	10(I)	17(S)	7(R)	0(R)	9(R)
Shigella sp	0(R)	24(S)	19(S)	10(I)	10(R)	0(R)	10(R)	15(S)

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Salmonella sp	0(R)	16(S)	16(S)	0(R)	0(R)	0(R)	0(R)	14(S)
***Pseudomonas* sp**	4(R)	14(S)	17(S)	2(R)	0(R)	0(R)	4(R)	17(S)

Key
R: Resistance, S: Susceptible, CS: Colistin, CIP: Ciprofloxacin, E: Erythromycin, TE: Tetracyclin, M: Metronidazole, CD: Clindamycin, AG: Silver

Discussion

In the past few years, more attention has been directed to healthy eating habits, leading to increased public demand for vegetables and fresh fruits (Holley et al., 2012). Fresh produce offers many health benefits, but the potential for microbiological contamination of vegetables is a concern, as it can occur at various stages of food chain. During the last decade, there have been many cases of foodborne illness caused by Salmonella spp, Escherichia coli O157:H7 and Listeria monocytogenes . were associated with eating of contaminated vegetables (Maffei et al., 2013). The rising awareness of health, environmental sustainability and organic agriculture among the public has sparked controversial debates in recent years. This is mainly due to their ability to expose the disadvantages of chemical-intensive conventional agriculture and offer an alternative approach. Organic food is widely regarded as a safer and healthier alternative to conventionally produced foods, as it is produced using chemical-free farming techniques. (Somasundram et al., 2016). Even though many consumers consider organic foods to be a safer and healthier choice than non-organic foods, the evidence supporting this is not easy to determine, leaving behind much debate and controversy (Magkos et al., 2006). In this study, we investigated the microbial populations present in organic and non-organic foods and compared their abundance and diversity. It is important to note that our study has some limitations. The sample size of the food samples was relatively small and the study focused on a specific geographic area. In the future, to confirm and generalize these results, it is necessary to carry out further studies on a larger scale and in various fields. In addition, research on the long-term effects of organic and non-organic food consumption on human health would provide valuable information. The result of this study showed that the bacterial population found in organic food varies from log10 cfu/g 3.176091±1.00 to log10 cfu/g 3.95424±2.00, while the bacterial population in inorganic food varies from log10 cfu/g 3, 6621757. 10.00 to log10 cfu/g 4.43616±3.00. The population mean bacterial difference for all organic and inorganic foods was log10 cfu/g 3.641632±1.00 and log10 cfu/g 4.058675±1.00. This result corresponded with (Mishra et al., 2017) who conducted a study on microbial contamination of organic and inorganic foods. The resulting fungal load for organic ranged from log10 cfu/g 3.27875 ± 1.50 to log10 cfu/g 3.84509 ± 1.33, while inorganic ranged from log10 cfu/g 3.63848 ± 2.5 to 3.86033 ± 3.86033. the mean fungal difference between organic and inorganic foods was log10 cfu/g 3.64745±3.00 and log10 cfu/g 3.73770±1.00. These figures align with Kuan et al (2017), who compared the microbial quality of organic and non-organic foods. The bacterial isolates identified in this study included *Escherichia coli, Salmonella, Staphylococcus aureus, Bacillus sp and Shigella sp*. Which were also reported by Kuan et al. (2017) in their study on organic and non-organic food. Escherichia coli is often used as an indicator of food healthiness or to monitor potential contamination with pathogenic microorganisms (Kornacki and Johnson, 2001). In this study, the presence of coliform bacteria indicated a decline in food quality due to fecal contamination. This contamination can originate from multiple points along the supply chain, including the use of polluted irrigation water, harvest and post-harvest handling, transportation, suboptimal storage conditions, and unsanitary handling practices (National Advisory Committee on Microbiological Criteria for Foods, 1999). While most coliform bacteria are not inherently pathogenic, certain strains, such as *Escherichia coli* O157:H7 pose a significant risk to human health and have been associated with numerous foodborne illness outbreaks (Chang et al., 2013).

Although surface contamination is the most common route of microbial transmission in fresh produce, bacteria may also infiltrate internal plant tissues. Entry points include natural openings like stomata, lenticels, and trichomes, as well as lesions created by stem scars or infections from plant pathogens (Montville & Matthews, 2008). Numerous studies have documented the presence of *Salmonella* spp. and *E. coli* O157:H7 in fresh produce (Bordini et al., 2007). In the present investigation, *Salmonella* sp. was detected, underscoring the need to explore the underlying causes of contamination events.Epidemiological evidence indicates that *Salmonella enterica* serovars Typhimurium and Enteritidis are among the most commonly implicated in foodborne disease outbreaks (Thung et al., 2016). Interestingly, Ryu et al. (2014) found no detection of *E. coli* O157:H7 or *Salmonella* spp. in either conventional or organic fresh produce. Similarly, Mukherjee et al. (2004) reported that both organic and conventional vegetables collected in Minnesota, USA, tested negative for *Salmonella* but yielded positive results for *E. coli* O157:H7. Although not prevalent across all samples, one regular lacquer

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sample showed contamination by Shiga toxin-producing *E. coli* (STEC), a group of pathogens known for their role in foodborne outbreaks linked to raw vegetable consumption (Loo et al., 2013). STEC strains produce Shiga toxins, which are potent virulence factors responsible for severe gastrointestinal illness, including bloody diarrhea and potentially life-threatening complications such as hemolytic uremic syndrome (HUS) (Mead & Griffin, 1998).

This study found no statistically significant differences in the microbiological safety and quality of organic versus non-organic produce. Irrespective of the farming system employed, fresh produce can be exposed to microbial contamination during the harvest stage. Contributing factors include the application of raw or insufficiently composted animal manure, contaminated irrigation water, and contact with wild animals, insects, or pests (Mandrell, 2009; Talley et al., 2009; Mishra et al., 2017). Moreover, post-harvest practices such as pre-sorting, washing, pre-cooling, packaging, and transportation can introduce or amplify microbial risks if not properly managed (Mandrell, 2009; Buchholz et al., 2012; Maffei et al., 2013). Environmental and agronomic factors, such as geographic location, climate variability, and the crop type (including leafy greens, root vegetables, bulb and stem plants, flower buds, seeds, and fruit-bearing species) also influence the degree and likelihood of contamination (Ryu et al., 2014). In this study, *Aspergillus niger, Mucor sp* and *Penicillium* sp. Were identified. This result aligns with Buyukunal et al., (2015) who studied microbial contamination of organic and conventional food. It is Important to note that some species of *Asperigillus* are known to produce powerful mycotoxins harmful to human, making their presence in food undesirable. Most of these fungi are surface contaminant of agricultural products that induces decay, and many of the fungi isolates can grow inside the food (Amaike and Keller, 2011). Aspergillus niger can also be a human pathogen with many strains is capable of generating large amounts of aflatoxin, a highly toxic and carcinogenic substance. *Aspergillus niger* is a common species of the genus *Aspergillus* and is the main cause of many crop diseases. Certain *Aspergillus niger* strains have been identified as producers of ochratoxins, highly potent mycotoxins known for their toxicological significance. Penicillium infections can cause clinical manifestations of keratitis, endophthalmitis, pneumonia, endocarditis, otomycosis, necrotizing esophagitis, , peritonitis, urinary tract infections, skin mucosa, urogenital, gastrointestinal, lung and disseminated infections (Kontogiorgi et al., 2007). Fungal infections can be prevented by avoiding contact with contaminated items and the practice of good hygiene . A chemical approach can also be used to control the appearance of etiological factors of these fungi . The various molds found can cause various diseases in humans and are favored by exposure to moisture in baked goods. *Aspergillus flavus* produces toxins, also known as aflatoxin, which cause mycotoxicosis, which can also cause liver cancer, cirrhosis, and algotosis/hepatitis in humans. Antibiotic susceptibility tests showed that all isolates found in this study (*staphylococcus aureus, Pseudomonas sp Bacillus sp, Escherichia coli, Shigella sp and Salmonella sp* were all sensitive to gentamicin and ciprofloxacin but on the other hand were resistant to metronidazole and colistin. This result was again closely related to Nutanbalani et al., 2011).

Conclusion

This study found that food can contain pathogens regardless of whether it is produced using organic or inorganic methods. While the use of composted manure in organic farming is often scrutinized for potential microbial risks, our findings reveal it has minimal impact on the microbiological status of fresh produce. Instead, environmental conditions, postharvest handling, and supply chain management play more influential roles in microbial contamination. Farmers should prioritize good agricultural practices (GAP) such as proper composting techniques, water quality management, and field hygiene over farming method labels. Investing in postharvest sanitation measures like clean packaging materials and temperature control is critical. Policymakers should develop regulations that emphasize safety standards across both farming systems rather than promoting one over the other. Encourage training programs that support hygiene and monitoring protocols throughout the production and distribution chain. Future research directions includes Investigating the microbial risks associated with specific postharvest practices such as washing, storage, and transport methods. Exploring the role of environmental variables (e.g., humidity, soil type, wildlife exposure) in pathogen proliferation across different farming regions and to examine consumer-level handling and storage to better understand contamination risks at the final stage of the food chain.

Recommendations

1. Based on the research findings, enhanced monitoring and surveillance is recommended. Implementing regular monitoring of both organic and non-organic foods for pathogens will help in early detection and prevention of foodborne illnesses.
2. Also developing and enforcing strict guidelines for post-harvest processing operations including selection, sorting, pre-cooling, washing, packing , storage and transportation is recommended. Public awareness about the dangers of mycotoxins produced by fungi like *Aspergillus* and *Penicillium*,

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educating farmers, food handlers , consumers about the risk of foodborne pathogens is highly recommended.

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