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Determination of pH and Microbiological Quality of Commonly Used Tomato Pastes in Katsina Metropolis, Katsina State, Nigeria

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Abstract:
Tomato products are of considerable importance worldwide and the demand for tomato paste is increasing rapidly both in domestic and international market. Tomato samples of six different local and international brands were purchased from various retail outlets and analysed for pH values and microbiological quality. The pH values of all the tomato paste samples analysed were lower than the critical level of 4.6, with Mamia (a local brand) having the highestpH value of 4.15. Substantially higher bacterial count was observed in De Rica (an imported brand) and the least viable count was observed in Gino (an imported brand) with no bacterialisolate detected. Five different bacterial species (Staphylococcus aureus, Staphylococcus epidermidis, Bacillus spp, Streptococcus spp and Lactobacillus) were isolated fromthe different brands with Bacillus spp having the highest percentage occurrence. Higherfungal count was observed in De Rica and least was observed in Mamia with no fungi detected.Four different fungal species were detected (Penicilium spp., Mucor spp., Aspergillus niger and Rhizopus spp) in the tested samples, withMucor spp having the highest percentage occurrence. All samples of tomato pastes examined show acceptable pH values but poor microbiological quality, which poses significant public health hazard. This necessitates the need for further studies to investigate the extent of microbial contamination of canned and sachet products used in the preparation of routine cuisines, imposition of strict HACCP principles on processing plants to ensure safety of products and prevention of food-associated diseases and poisoning as well as public enlightenments on sterilization of such products at high cooking temperatures prior to consumption.

Keywords: *pH, microbiological quality, tomato pastes, Katsina, Nigeria*

1. Introduction

Tomatoes have been shown to be important sources of vitamin A and C (Gould, 1983). However, nutritional composition of tomatoes varies with species, stages of ripeness, year of growth, climatic conditions, light, temperature, soil fertilization, irrigation and other conditions of cultivation, handling and storage. They are highly perishable and large quantity of tomatoes is wasted due to poor handling/storage facilities. The great majority of plant diseases are caused by pathogenic microorganisms, which cause losses by attacking the tomato fruit directly, rendering them unfit for consumption or sufficiently detracting from the appearance to reduce consumer preference, result in reduced yield and monetary losses. The pathogens attacking tomato can be classified into three major groups: fungi and fungal-like microbes (hereafter referred to as fungi), bacteria and viruses (Pernezny and Purdy, 2003).

Fruits and vegetables usually show high rates of transpiration and respiration during periods of high temperatures and therefore need shade from the sun's heat (Harvey and Harris, 1986; D'sousa and Ingle, 1989; Eckert and Eaks, 1989; Robbins and Moore, 1992). For this reason, it is recommended that tomatoes are harvested in the morning to ensure the coolest possible temperature during delay period between harvest and initial cooling. In addition to perishability, tomatoes are highly susceptible to mechanical damage with poor handling and transportation (Bani *et al*. 2006). Most often also, losses of fresh vegetables occur along the long chain of supply from the producer to the consumer.

Losses occur at the stages of sorting, packaging, storage, transport and marketing stages of fresh horticultural produce (Kitinoja, 2008). As a remedy, Kitinoja and Gorny (2009) recommended that when handling fresh produce at its market destination, it is important to avoid rough handing, minimize the number of handling steps and strictly follow a temperature and relative humidity management. Stacking of non-uniform containers should also be done with care to prevent collapse of weaker packages and heavier cartons should always be placed at the bottom of a stack (Kitinoja and Gorny, 2009). Tomatoes should be transported to processing plants at the shortest possible time and processed immediately on arrival, or subjected to proper storage procedures (Gould, 1992). Though adequate heat processing is given to tomato paste to achieve commercial sterility (Speck, 1984), subsequent abusive post process handling/storage may lead to undesirable microbiological changes (Anon, 1980).

Tomato spoilage is the alteration of the quality characteristics (such as appearance, taste, texture, and odour) due to enzymatic and microbial attacks, thereby making the tomato unacceptable. These changes are not always microbiological in origin, because physical (e.g.chilling) damage can predispose the tomato to microbial spoilage (Efiuvwevwere and Thorne, 1988; Jay, 1996). Abusive storage conditions (including hoarding of foods in ware houses) are reminiscent of the era of 'essential commodities' in the 1980s. The microbial hazards associated with both imported and locally canned tomato products showing defective appearance as well as those with normal appearance have been reported and they are of serious health concerns due to the prevalence of *Clostridium botulinum* and mycotoxigenic moulds (Efiuvwevwere and Atirike, 1998; Pawsey, 2002; Peck, 2005). Consumption of contaminated tomatoes may result in microbial poisoning (Jay, 1996), resulting in microbial reproduction to attain infective load and establish infections (Jay 1996). For example, *Salmonella spp., Campylobacter jenuni, Listeria monocytogens, Shigella spp., Vibrio parahaemolyticus* and Norwalk viruses have been implicated in tomato-associated diseases.

Among factors that contribute to spoilage of tomatoes, Kitinoja and Gorny (2009) noted that adequate storage facilities (on farm, at whole sale or retail markets) as well as ventilation and cooling systems are mostly lacking in developing countries. Others include over loading of cold stores (where available) including placing warm produce into cold room, stacking produce too high (beyond container strength) and the practice of mixing produce with others with different temperature and relative humidity requirements (Kitinoja and Gorny, 2009). Insect pests can cause a considerable deterioration and spoilage of fresh vegetables by damaging the integrity of the food. According to Hurst *et al*. (1993), insects do not destroy tomatoes by consuming large quantities of it, but once they damage the product, further deterioration results from microbial invasion. FAO (2008) reported that at 10^0C and optimum humidity of about 80%, green tomatoes can be stored for 16-24 weeks. In another report, Ashby (2000) recommend 13-21^0C and relative humidity of between 90-95% as the best transport conditions for green mature tomatoes.

Utilization of tomato paste for household meal preparation is quite ubiquitous in Katsina, which suggests that microbial contamination of this product constitutes a grave public health threat. This study assessed the microbial qualities of commonly used brands of tomato pastes, paying special attention to their pHs, viable counts and identities of observed bacteria and fungi. The results were compared against stipulated standards to ascertain the safety of the studied brands for human consumption.

2. Materials and Methods

2.1. Materials and Reagents

Tomato samples, petri dishes, test tubes, conical flasks, beakers, syringes, spatula, glass rod, autoclave, incubator, weighing balance, vortex mixer, colony counter, hotplate, wire loop, pipette, microscope, glass slides, coverslips, cotton, hand gloves, foil paper, tissue, masking tape, razor blade, detergent, normal saline, crystal violet, Lugo's iodine, acetone, safranin solution, ethanol, methylated spirit, immersion oil, lactophenol, sterile distilled water, plate count agar (PCA), malt extract agar (MEA), nutrient agar (NA), mannitol salt agar (MSA), and Macconkey agar.

2.2. Procurement of Samples

Six local (Mamia, Vitali, Sonia, Tasty Tom) and imported (Gino and De Rica) brands oftomato pastes were purchased from various retail outlets in Katsina metropolis.

2.3. Sterilization of Glass Wares

The wares used for this study were washed, air dried and sterilized in an autoclave at 120^0C for 15 minutes.

2.4. Preparation and Opening of Samples

The top of each sample was swabbed with 70% ethanol to avoid contamination prior too pening (Harrigan and McCance, 1976).

2.5. Preparation of Media

The media for bacteriological and mycological analysis were prepared according to the manufacturers' instructions.

2.5.1. Preparation of Plate Count Agar (PCA)

Plate Count Agar (PCA) was used for bacterial count/enumeration.2.87g of the powdered medium was dissolved in 140ml of sterile distilled water for each of the tomato paste samples. The mixture was then swirled to ensure the even

dissolution of the powdered medium in water. The opening of the conical flask was covered with cotton and then Aluminium foil and placed in an autoclave for sterilization. Sterilization was attained at 121°C for 15 minutes. The conical flask was then removed and placed in a water bath to cool its content. When the media cools, 20ml of the medium was dispensed into each of the 6 sterilized petri dishes which is then closed after wards and allowed to solidify.

2.5.2. Preparation of Malt Extract Agar (MEA)

Malt Extract Agar (MEA) was used for fungal count/enumeration. 7g of the powdered medium was dissolved in 140ml of sterile distilled water for each of the tomato paste samples. The mixture was then swirled to ensure the even dissolution of the powdered medium in water. The opening of the conical flask was covered with cotton and then Aluminium foil and then heated to completely dissolve the powdered medium in water on a hot plate. Sterilization was attained at 121°C for 15 minutes. The conical flask was then removed and placed in a water bath to cool its content. When the media cools, 20ml of the medium was dispensed into each of the 6 sterilized petri dishes which is then closed after wards and allowed to solidify.

2.5.3. Preparation of Nutrient Agar (NA)

3.36g of the powdered medium was dissolved in 120ml of water for each of the tomato paste samples. The mixture was then swirled to ensure the even dissolution of the powdered medium in water. The opening of the conical flask was covered with cotton and then Aluminium foil and then heated to completely dissolve the powdered medium in water on a hot plate. It was then placed in an autoclave for sterilization. Sterilization was attained at 121°C for 15 minutes. The conical flask was then removed and placed in a water bath to cool its content. When the medium cools, 20ml of the medium was dispensed into each of the 6 sterilized petri dishes which is then closed after wards and allowed to solidify.

2.5.4. Preparation of Mannitol Salt Agar (MSA)

13.32g of the powdered medium was dissolved in 120ml of water for each of the tomato paste samples. The mixture was then swirled to ensure the even dissolution of the powdered medium in water. The opening of the conical flask was covered with cotton and then Aluminium foil and then heated to completely dissolve the powdered medium in water on a hot plate. It was then placed in an autoclave for sterilization. Sterilization was achieved at 121°C for 15 minutes. The conical flask was then removed and placed in a water bath to cool its content. When the media cools, 20ml of the medium was dispensed into each of the 6 sterilized petri dishes which is then closed after wards and allowed to solidify.

2.5.5. Preparation of Macconkey Agar

6.19g of the powdered medium was dissolved in 120ml of water for each of the tomato paste samples. The mixture was then swirled to ensure the even dissolution of the powdered medium in water. The opening of the conical flask was covered with cotton and then Aluminium foil and then heated to completely dissolve the powdered medium in water on a hot plate. Sterilization was achieved at 121°C for 15 minutes. The conical flask was then removed and placed in a water bath to cool its content. After cooling, 20ml of the medium was dispensed into each of the 6 sterilized petri dishes which is then closed after wards and allowed to solidify.

2.6. Serial Dilution and Inoculation

For each of the samples, 4ml of distilled water was measured into sterilized test tube for the preparation of stock solution. 4g of the tomato paste sample was weighed and transferred into the test tube. It was then mixed thoroughly using vortex mixer. 9ml of distilled water was measured and transferred into each 6 sterilized test tubes and labelled 10^{-1}, 10^{-2}, 10^{-3}, 10^{-4}, 10^{-5} and 10^{-6}. 1ml of the stock solution was measured and transferred into the first test tube labelled 10^{-1}. Another 1ml was measured from 10^{-1} and transferred into the second test tube labelled 10^{-2}. The process was repeated until 10^{-6}. 1ml was measured from each test tube (10^{-1} – 10^{-6}) and transferred into petri dish each labelled A^{-1}-A^{-6} respectively for bacterial analysis. 20ml of PCA was then dispensed into each petri dish and allowed to solidify and later incubated at 37°C for 24 hours for enumeration of total viable count (cfu/g). Another 1ml was measured from each test tube (10^{-1} – 10^{-6}) and transferred to petri dish each labelled B^{-1}-B^{-6} respectively for mycological analysis. 20ml of MEA was then dispensed into each petri dish and allowed to solidify and later incubated at about 24°C for 5-7 days (Booth, 2006).

2.7. pH Determination

For each of the samples, 10gram was weighed and dispensed into 10ml of sterilized distilled water in a beaker. A digital pH meter was deepened into the solution for direct measurement of the pH.

2.8. Microbiological Analysis

2.8.1. Counting of Colonies

The colonies of bacteria from PCA plates of each brand were counted using colony counter. The plates were placed on the colony counter and the colonies were counted. Some discrete colonies were then selected at random and sub-cultured on differential/selective media (NA, MEA and Macconkey Agar). Fungal isolates were also counted.

2.8.2. Characterization and Identification of Bacterial Isolates

Identification of the bacterial isolates was carried out based on morphological characteristics, Gram reaction and biochemical (catalase and coagulase) tests (Cowon and Steel, 2002).

2.8.3. Gram Staining

A small amount of normal saline was dropped on clean glass slide, a sterilized wire loop was used to pick a small portion of the bacterial isolate and gently smeared on the glass slide. It was then allowed to dry and then passed over gentle flame to fix the smear. A drop of crystal violet was added to cover the fixed smear and allowed for 60 seconds. It was then rinsed with distilled water using wash bottle. A drop of Lugo's iodine was then added and allowed for 60 seconds. It was then washed with distilled water. Acetone was added for few seconds to decolourize it. It was then washed immediately with distilled water. Drop of safranin solution was added to cover the smear and allowed for 2 minutes. It was then rinsed with distilled water, dried with cotton and then placed on draining rack to air dry completely. It was then observed under oil immersion lens (Bergey, 1994).

2.8.4. Biochemical Tests (Catalase and Coagulase)

2.8.4.1. Catalase Test

Using a dropper, 1 drop of 3% H_2O_2 was placed on a clean glass slide. A small portion of the bacterial isolate was collected using a sterilized glass rod and placed on the glass slide. It was then observed for immediate bubble formation (Cheesbrough, 2000).

2.8.4.2. Coagulase Test

Using a dropper, 1 drop of distilled water was placed on a clean glass slide. A small portion of the bacterial isolate was collected using a sterilized inoculating loop and smeared on the glass slide. A drop of human plasma was then placed on the smear using a dropper. It was then observed for clumping of the bacterial cells (Cheesbrough, 2000).

2.9. Identification of Fungal Isolates

Using a dropper, 1 drop of Lactophenol was placed on a clean glass slide. A small portion of the fungal isolate was picked using a sterilized needle and placed on the glass slide. It was then covered with a cover slip and observed under microscope. The fungal isolates were identified based on the morphological characteristics and microscopy. It was then compared with Atlas (Food Microbiology).

3. Results

Analysis of the samples revealed poor microbiological quality of the tomato pastes, though pH values of all samples fall below the critical limit. pH values of the analyzed samples are shown in table 1, whereas tables 2 to 7 reflect the microbiological quality and microbial compositions of the tested samples. A number of bacterial species have been observed (plates I to V), of which *Bacillus spp* (Figure 2) dominate the microbial populations. Of the fungal species detected in these samples (plates VI to IX), however, *Mucor spp* (plate VII) has been seen to dominate. Bacterial counts, isolates as well as their percentage occurrences are presented in tables 2, 3 and 4 respectively, whereas counts, isolates and percentage occurrences of fungi are presented in tables5, 6 and 7 respectively.

S/N	Brands	pH values
1	Mamia	4.15
2	Vitali	3.95
3	Sonia	4.08
4	Gino	3.76
5	Tasty Tom	3.54
6	De Rica	3.73

Table 1: pH Values for the Tested Brands of Tomato Pastes

S/N	Brands	Dilution Factor/ No. of Colonies Obtained					
		10^{-1}	10^{-2}	10^{-3}	10^{-4}	10^{-5}	10^{-6}
1	Mamia	6.4×10^{2}	TFTC	TFTC	TFTC	TFTC	3.6×10^{7}
2	Vitali	6.7×10^{2}	TFTC	TFTC	TFTC	TFTC	TFTC
3	Sonia	TNTC	TNTC	TFTC	--	--	--
4	Gino	--	--	--	--	--	--
5	Tasty Tor.	TFTC	TFTC	TFTC	TFTC	--	--
6	De Rica	TNTC	TNTC	TNTC	TNTC	TFTC	--

Table 2: Bacterial Enumeration (Cfu/Ml)
**TFTC = Too Few to Count (< 30); TNTC = Too Numerous To Count (> 200); -- = Nil*

S/N	Brands	Bacterial isolates
1	Mamia	*Staphylococcus aureus, Staphylococcus epidermis, Streptococcus spp, Bacillus spp.*
2	Vitali	*Staphylococcus epidermis, Bacillus spp.*
3	Soria	*Staphylococcus epidermis.*
4	Tasty Tom	*Bacillus spp, Lactobacillus, Streptococcus spp.*
5	De Rica	*Staphylococcus aureus, Streptococcus spp, Bacillus spp.*

Table 3: Bacterial Isolates Detected in the Tomato Pastes

S/N	Bacterial isolates	Percentage occurrence
1	*Staphylococcus aureus*	2 (15.4%)
2	*Staphylococcus epidermis*	3 (23.1%)
3	*Bacillus spp*	4 (30.8%)
4	*Streptococcus spp*	3 (23.1%)
5	*Lactobacillus*	1 (7.7%)

Table 4: Percentage Occurrence of Bacterial Isolates in the Samples

S/N	Brands	Dilution Factor/ No. of Colonies Obtained					
		10^{-1}	10^{-2}	10^{-3}	10^{-4}	10^{-5}	10^{-6}
1	Mamia	--	--	--	--	--	--
2	Vitali	2×10^{-1}	--	1×10^{-3}	2×10^{-4}	1×10^{-5}	--
3	Sonia	3×10^{-1}	--	--	1×10^{-4}	--	--
4	Gino	8×10^{-1}	2×10^{-2}	1×10^{-3}	--	--	--
5	Tasty Tom	12×10^{-1}	1×10^{-2}	--	--	--	--
6	De Rica	2×10^{-1}	1×10^{-2}	4×10^{-3}	6×10^{-4}	7×10^{-5}	--

Table 5: Howard Mould Count in the Tested Samples

**-- = Nil*

S/N	Brands	Fungal isolates
1	Vitali	*Penicilium spp, Mucor spp.*
2	Sonia	*Penicilium spp, Aspergillus niger.*
3	Gino	*Mucor spp, Rhizopus spp.*
4	Tasty Tom	*Mucor spp, Rhizopus spp.*
5	De Rica	*Mucor spp.*

Table 6: Fungal Isolates Detected in the tomato pastes

S/N	Fungal isolates	Percentage occurrence
1	*Penicilium spp*	2 (22.2%)
2	*Mucor spp*	4 (44.4%)
3	*Aspergillus niger*	1 (11.1%)
4	*Rhizopus spp*	2 (22.2%)

Table 7: Percentage Occurrence of Fungal Isolates in the Samples

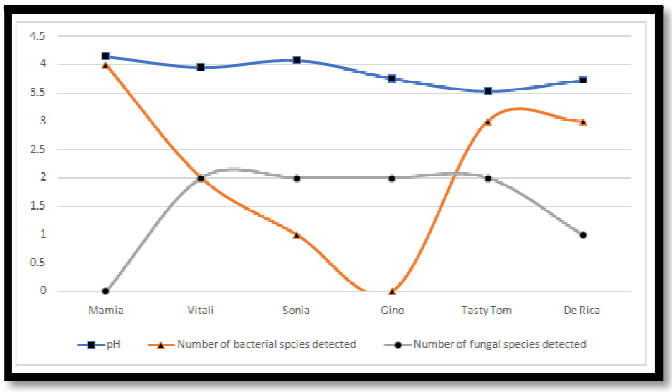

Figure 1: Summary of pH and Microbiological Quality of Studied Samples

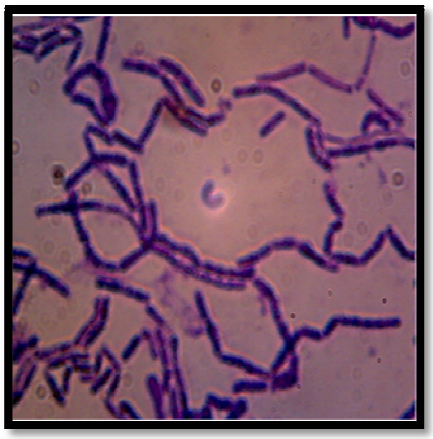

Figure 2: Bacillus Spp under Light Microscope

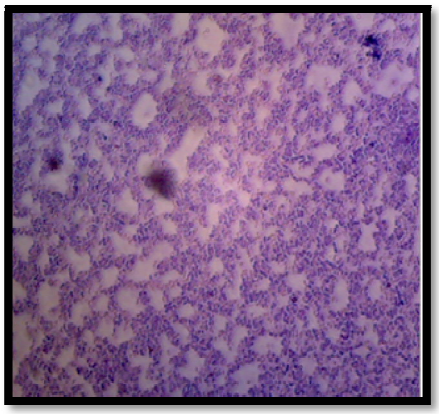

Figure 3: Lactobacillus under Light Microscope

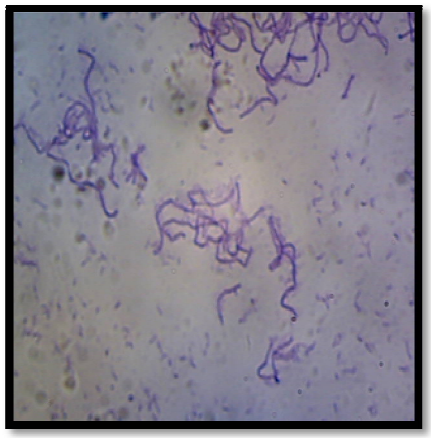

Figure 4: Staphylococcus Aureus under Light Microscope

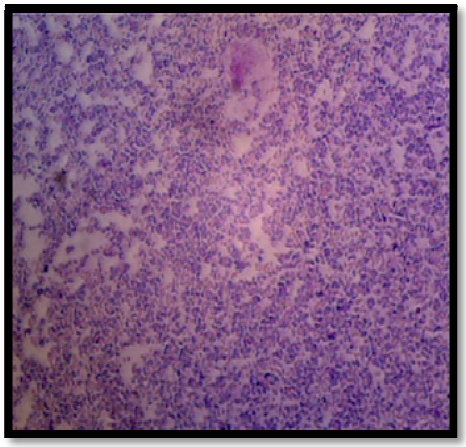

Figure 5: Staphylococcus Epidermis under Light Microscope

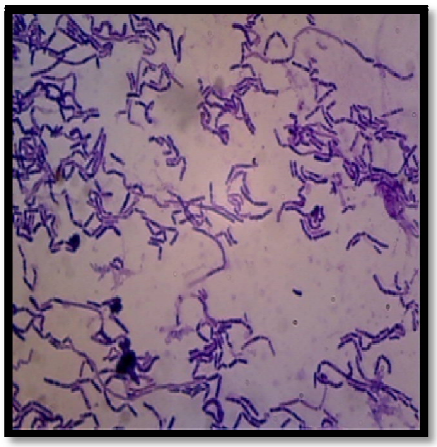

Figure 6: Streptococcus Spp under Light Microscope

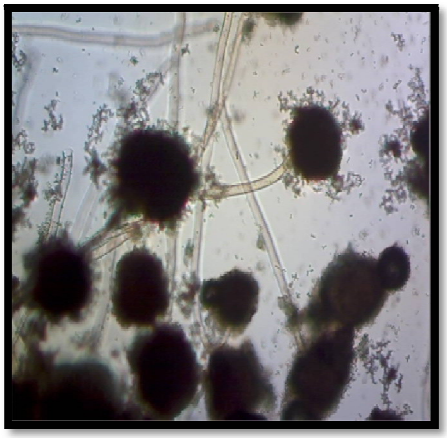

Figure7: Aspergillus Niger under Light Microscope

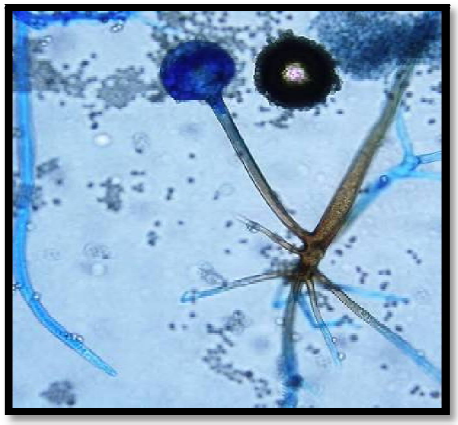

Figure 8: Mucor Spp under Light Microscope

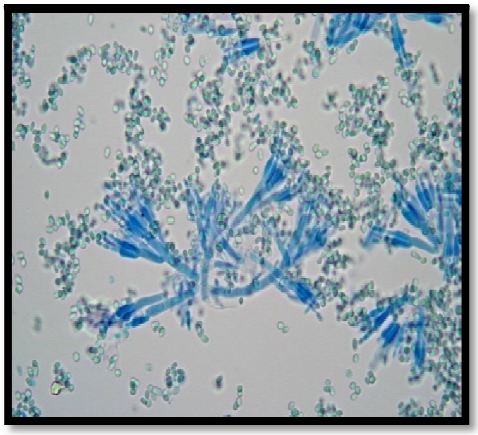

Figure 9: Penicilium Spp under Light Microscope

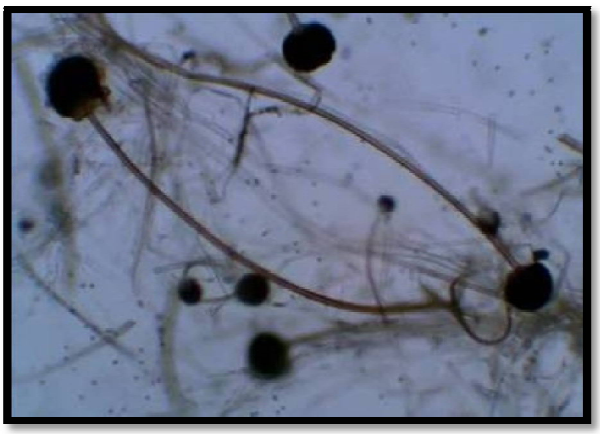

Figure 10: Rhizopus spp under light Microscope

4. Discussion

Among the tomato paste samples examined for pH values and microbial quality, higher pH was observed in Mamia brand, with 4.15, which is followed by Sonia, Vitali, Gino, De Rica and Tasty Tom, having 4.08, 3.95, 3.76, 3.73 and 3.54 respectively (Table 1). Since the pH values are below the critical limit of 4.6, these products might be considered safe for consumption.

Higher bacterial viable count was observed in brand De Rica (Table 2). This can suggest alteration of the hermetic condition normally associated with canned products. Consequently, favourable growth conditions not usually encountered must have occurred within the can, thereby enhancing the growth of diverse microflora and increased population. The least bacterial viable count was observed in brand Gino with no bacterial isolate detected. A total number of 5 bacteria were isolated from the different brands. These bacterial isolates include: *Staphylococcus aureus, Staphylococcus epidermis, Bacillus spp, Streptococcus spp and Lactobacillus*. Among these bacterial isolates, *Bacillus spp* shows higher percentage occurrence (30.8%) occurring in 4 of the brands (Mamia, Vitali, Tasty Tom and De Rica) (Tables 3 and 4).

Bacillus species are known to have extreme wide growth temperature of 20-50^{0}C and can cause infection and food poisoning. The presence of *Bacillus* in canned food, even in very small amounts, calls for concern as temperature abuse and poor storage conditions prevalent in kiosks and stores from where these products were purchased could encourage proliferation of these organisms to unacceptable level. *Bacillus spp* has been reported as spoilage organism in tomatoes, causing flat sour spoilage, putrefaction, rancidity and off flavour. Its presence in canned food portends possible spoilage if storage conditions become favourable due to abuse. *Staphylococcus epidermis and Streptococcus spp* shows high percentage occurrence after Bacillus spp (23.1% each) occurring in 3 of the brands. *Staphylococcus epidermis* occurred in brands Mamia, Vitali and Sonia while *Streptococcus spp* occurred in brands Mamia, Tasty Tom and De Rica. *Staphylococcus epidermis* is not usually pathogenic but patients with compromised immune systems are at risk of developing infection. Some *Streptococcal* species are not pathogenic and form part of the commensal human microbiota of the mouth, skin and upper respiratory tract where as some species are pathogenic, responsible for many infections like meningitis and bacterial pneumonia. Their presence in canned food products could be through producers or handlers. *Staphylococcus aureus* has the next high percentage occurrence (15.4%) occurring in 2 brands (Mamia and De Rica). Staphylococcus aureus is of human flora, it is a known opportunistic pathogen. Contamination of canned foods could be via food producers/handlers and equipment. They are facultative and hardy organisms, thus their survival in canned foods could be explained. Toxigenic strains of *Staphylococcus aureus* have been implicated in food borne illness and are known to proliferate in conditions of temperature abuse. *Lactobacillus* shows the least percentage occurrence (7.7%) occurring in one brand (Tasty Tom). *Lactobacillus* is aciduric in nature (Sneath *et al*., 1986), and this may have favoured its proliferation in the product (Tasty Tom) with favourably low pH range (Table 1). The apparently high levels of *Bacillus spp* and other bacterial isolates suggests that these products are potential health hazards. The occurrence of such hazards is highly probable, especially in developing countries where 'commercially sterile' products are often assumed to be actually sterile and are therefore consumed without adequate precaution.

Higher fungal count was seen in brand De Rica while the least fungal count was seen in brand Mamia with no fungi detected (Table 5). Different fungal species were isolated from the different brands which include *Penicilium spp, Mucor spp, Aspergillus niger and Rhizopus spp.* Among the fungi isolated, *Mucor spp* showed higher percentage occurrence (44.4%), isolated from 4 brands (Vitali, Gino, Tasty Tom and De Rica). This is followed by *Penicilium spp* and *Rhizopus spp* (22.2% each), isolated from 2 brands. *Penicilium spp* was isolated from brands Vitali and Sonia while *Rhizopus spp* was isolated from brands Gino and Tasty Tom. *Aspergillus niger* showed the least percentage occurrence (11.1%) isolated from 1 brand (Sonia) (Tables 6 and 7).

These microbial profiles may be related to several interactive behaviours influenced by temperature and oxygen content. In this connection, temperature seems to be the major factor as the growth of these microorganisms is particularly favoured by high temperatures ranging between 30-55^{0}C (Samson and van Reenen-Hoesktra, 1988). The influence of mould growth on acidic foods is of health significance because of metabiotic phenomena (Robinson et al. 1994), thereby altering the safety margin commonly associated with such acidic products. Among the variables that affect

the microbial profile and shelf stability of canned tomato products is the initial contamination of the raw materials (Robinson *et al.* 1994), the temperature-time process regime (Jay, 1996), and post process handling such as transportation and storage conditions.

Generally, low counts ($<10^4$ cfu/g) are found in canned foods, including tomato paste subjected to 'commercial sterility'; but the number could increase if the conditions of the microenvironment of the food become favourable. Tomato paste is an acidic product and is therefore processed by relatively mild heat treatment to achieve 'commercial sterility' (Gould, 1983). This process is assumed to be adequate to inhibit *Clostridium botulinum*, cocci and non-sporing rods as well as fungi. It is generally acknowledged that thermophilic organisms and other highly heat resistant types are often present in canned foods. However, the isolation of mixed cultures of relatively non-heat-resistant organisms such as non-sporing rods, cocci and fungi from canned tomato paste is not uncommon (Speck, 1984). The present result therefore corroborates these earlier findings. Nevertheless, their presence in canned products is considered by most investigators as an indication of post process contamination or under-processing (Banwart, 1981).

5. Conclusion

It has been demonstrated from this work that all the brands of tomato pastes examined have pH values which are within the tolerable limit (being lower than critical level of 4.6) and therefore can be associated with some degree of safety for consumption. However, these products may be regarded hazardous (health hazard) due to the fact that they contain one or more species of bacteria and fungi (such as *Bacillus spp and Staphylococcus aureus*), which are associated with food poisoning and infection and are therefore not safe for consumption. This necessitates the need for further studies to investigate the extent of microbial contamination of canned and sachet products used in the preparation of routine cuisines, imposition of strict HACCP principles on processing plantsto ensure safety of products and prevention of food-associated diseases and poisoning as well as public enlightenments on sterilization of such products at high cooking temperatures prior to consumption.

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