Asian Journal of Biology

14(2): 1-11, 2022; Article no.AJOB.82696
ISSN: 2456-7124

Assessment of the Microbiological Status of Yoghurt Sold in Owerri, Imo State, Nigeria

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/AJOB/2022/v14i230206

Open Peer Review History:
This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here: https://www.sdiarticle5.com/review-history/82696

Original Research Article

Received 25 November 2021
Accepted 31 January 2022
Published 05 February 2022

ABSTRACT

The assessment of the microbiological status of samples of yoghurt sold in Owerri, Imo state, Nigeria, was carried out to ascertain the microbiological fitness of the yoghurt samples for consumption. The yoghurt samples were collected from areas spanning three local governments in Owerri. Ten samples of commercial brands of yoghurt drinks was collected and analyzed bacteriologically by pour plate method using Nutrient Agar for heterotrophic bacteria, MacConkey Agar for total coliform and MacConkey Broth for fecal and thermo-tolerant coliform bacteria by Most Probable Number (MPN) technique and mycologically on Sabouraud dextrose Agar for fungi. Data from analysis were analyzed using ANOVA. Determination of the pH of the yoghurt samples was done and the results showed that the pH values ranged from 4.28 to 4.79. the results of the total heterotrophic bacteria count were from 5.0 ± 7.1^{bc} to $9.0\pm7.1^{a}\times10^{5}$CFU/ml, while the total coliform bacteria ranged from 1.7 ± 0.5^{ab} to $3.6\pm1.2^{ab}\times10^{4}$CFU/ml and the thermo-tolerant coliform bacteria ranged from 11 to 120(MPN) 100^{-1}. The total fungal count ranged from 2.9 ± 1.6^{b} to $10.3\pm3.6^{a}\times10^{4}$CFU/ml. The pH determination revealed that the isolates are acidophile because the pH of the yoghurt samples were in the acidic range. There was a significant difference at P >0.05 and the difference were separated using the least significant difference (LSD). Five bacterial

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isolates were identified included: *Staphylococcus aureus, Escherichia coli, Streptococcus* spp., *Lactobacillus bulgaricus* and *Serratia marcesecens.* The fungal genera identified were *Candida albicans, Aspergillus niger, Mucor spp.* and *Saccharomyces cerevisiae.* The isolation of both fungal and bacterial organisms known to be enteric pathogens is suggestive of faecal contamination and by implication a serious public health problem due to the health hazards they pose to consumers. The result of this study therefore indicated poor Microbiological qualities of commercial yoghurts sold in Owerri at the time of this research. Therefore, the attention of the appropriate government agencies is needed to ensure that adequate hygiene is maintained during preparation, processing, storage and distribution of high quality yoghurt products to avert public health challenges.

Keywords: Yoghurt; milk; Streptococcus thermophilus; Aspergillus niger; MPN; Saccharomyces cerevisiae.

1. INTRODUCTION

Yoghurt is a cultured dairy product that can be made from whole low fat or skim milk, including reconstituted non fatty dried milk powder. The Food and Drug Administration (FDA) describes yoghurt as a food produced by culturing one or more of the basic ingredients (cream, milk, partially skimmed milk, skim milk, or the reconstituted versions of these ingredients may be used along or in combination) and any of the optional dairy ingredients with a characterizing bacteria (live and active) culture that contain the lactic acid-producing bacteria (*Streptococcus thermophilus* and *Lactobacillus bulgaricus*).

Yoghurt is a suitable product for most delicacies and events [1]. It is a product of milk fermentation [2]. It has a world-wide usage owing to its attractiveness [3]. *Lactobacillus bulgaricus and Streptococcus thermophilus* play key roles in the production of yoghurts and the end product looks like custard-like food with a tartflavor and usually, it is sweetened [4]. Following the production of amino acids by *L*. *bulgaricus*, *S*. *thermophilus* is stimulated to produce formic acid. This is essential for the survival and growth of the *L. bulgaricus*. The sour nature of the yoghurt is caused by *S*. *thermophilus* while the aroma is produced by *L*. *bulgaricus*. Goat, cow, ewe and buffalo milks can be sources of yoghurt. The combination of these milks can too [5].

Yoghurt is rich in proteins, vitamins, potassium, calcium, phosphorus, and other minerals but has low concentration of low in saturated fat and cholesterol [6]. High blood pressure may be prevented by yoghurt. It helps in flushing sodium out of the system due to its high potassium content. It also high higher quantity of vitamins, carbohydrate and protein when compared with milk [7,8]. Milk and yoghurt differ in energy content. Although, milk has lesser energy content than sweetened yoghurt [9].

Antibacterial property of yoghurt has been reported and the lactic acid which it contains has been said to have a protective effect in both the gum and the intestines [10]. The nutritional benefits of yoghurt outweigh that of milk and this is because of the tolerance of yoghurt by lactose intolerant persons compared to milk and other dairy products. Lactose enzymes are usually being produced by the starter cultures and these aid in digestion [11]. Yoghurt contains a whole lot of probiotics that inhibit the habitation of harmful microorganisms [12]. Fermented milk, like the fresh milk from which they are produced, is liable to contamination. Proper storage of yoghurt is very important because changes in some of its characteristics due to inadequate storage, affects its shelf life [13,14]. The pH value of yoghurt immediately after production ranges between 4.5 and 4.2 [15]. The microbiological quality assessment of yoghurt is mainly concerned with protection of the consumers against exposure to any health hazard and ensuring that the material is not suffering microbiological deterioration during its anticipated shelf-life [16]. In addition to deterioration in sensory quality, microbiological counts have been used as indices for the end of shelf life of dairy products [17]. Coliform detection or enumeration is often used as parameters for evaluating the yoghurt quality indifferent countries [18]. Presence of coliforms in dairy products is an indication of fecal contamination when the hygiene is poor [19]. The inferior quality of milk and milk products is usually caused by taints produced by some members of coliforms [20]. *Escherichia coli* (*E. coli*) is usually taken to be a good indicator of faecal contamination and its isolation from milk products suggest contamination by enteropathogenic organisms [21]. When it comes to poor sanitation in factory, *Enterococci* are

good indicators. This is because of their high resistance to detergents and adverse temperatures. In addition, they are associated with cases of food poisoning [20]. *Enterococci* organisms are recommended for inspections of the hygiene of fermented products [22].

The presence of *enterococci* in dairy products has long been considered an indication of inadequate sanitary conditions during the production and processing of milk [23]. *Staphylococcus aureus* is used as an indicator for personnel contamination of food products. Moreover, enterotoxigenic strains of *Staphylococcus aureus* can multiply and cause food poisoning [24]. Low pH provides a conducive environment for the growth of yeasts making them the lead cause of yoghurt spoilage [25]. Yeasts and moulds are the major contaminants in yoghurt. Even at refrigeration temperatures, micotoxigenic fungi and pathogenic bacteria still to numbers and this can cause infection [26]. Even in few numbers, yeasts and moulds can render milk products inferior due to the changes they cause. Moulds and yeasts growing in yoghurt utilize some of the acid and produce a corresponding decrease in the acidity, which may favour the growth of putrefactive bacteria [27].

The conditions at which yoghurts are sold in some parts of Nigeria are actually not conducive. Vendors carry the products from manufacturers without making provisions for maintenance of appropriate storage temperature and sanitary control. This predisposes the yoghurt to post-production contamination. This post-production contamination leads to food poisoning like diarrhea which poses health risk to the public or consumers. Hence, the relevance of this study in assessing the wholesomeness of yoghurt drink and use the information obtained in educating stakeholders on necessary precautions to safeguard public health.

2. MATERIALS AND METHODS

2.1 Collection of Yoghurt Samples

Ten samples of different brands of yoghurt drink in Owerri, Imo State, for the current study. The yoghurt samples were purchased from different yoghurt vendors, supermarkets and open markets at different locations in Owerri. The samples were immediately taken to the laboratory in ice containers, under aseptic conditions, where analysis was carried out immediately. These samples were labelled A to J.

2.2 Determination of Physical Parameters

The Jenway pH meter was used in the determination of the pH of the yoghurt samples. The yoghurt samples were thawed after mixing, poured into a terile beaker, and the pH rod inserted, and the reading recorded. This was after the standardization of the pH rod using sterile water in a beaker. Each of the yoghurt samples was subjected to this process. In addition, the packaging information like volume, expiry dates, colour of the contents, were also taken.

2.3 Cultivation and Enumeration of Total Heterotrophic Bacteria and Fungi

The pour plate method was used in the estimation of the total viable count of bacteria and fungi in the yoghurt samples. This was done using the Serial dilution technique and with 10^5 as the dilution factor for the isolation of bacteria while 10^2 was for fungi. With this, discrete colonies were obtained on the plated medium. into 9.0ml of normal saline (diluent), 1.0ml of each yoghurt sample was added and further dilution was made up to 10^5 and 10^2. From these diluted samples, an aliquot (0.1ml) was taken taken aseptically and plated on nutrient agar (NA) adopting the pour plate method. Also, these aliquots were plated on Sabouraud dextrose agar for fungi isolation. These were done in duplicates. SDA plates were incubated at 22^oC for 5 days while Nutrient agar plates were incubated at 37^oC for 24 hours. The total heterotrophic counts of bacteria were taken to be the discrete colonies produced after the overnight incubation. For bacteria purification, the discrete colonies were streaked onto nutrient agar plates and incubated at 37^oC for 24 hours. MacCartney bottles containing nutrient agar slants were used to store the pure colonies in a fridge. From these, biochemical tests were done. In total, eleven (11) pure bacterial cultures were obtained. The total viable fungi count was taken to be the average of the colonies produced by the duplicate plates after the five days incubation period. Morphological characteristics were also documented and discrete colonies sub-cultured on fresh SDA to obtain pure cultures.

2.4 Estimation of Coliforms

The most probable number technique (MPN technique) was employed in the estimation of coliforms. In this, double strength MacConkey broth was used for 10ml of sample while single

strength MacConkey broth for 0.1ml and 1ml of the sample. With this, MPN index 100ml of each yoghurt sample was obtained. The Verma et al., [28] method was employed in the prsesumptive, confirmatory and completed test steps. This involved the observation of the broth as lactose sugar fermentation change the medium color from pink to yellow & for gas production, bubbles collected in the invertid Durhum tubes inside the broth medium.

2.5 Enumeration of Fecal Coliform Test

After the presumptive test, the contents of the test tubes that produced gas were plated onto MacConkey agar and incubated at 37^0C for 24 hours.

2.6 Isolation, Characterization and Identification of Bacteria in Yoghurt Samples

After pure cultures were obtained by aseptically streaking discrete colonies on nutrient agar plates, incubating at 37^0C for 24 hours, and subsequent sub-culturing on agar slopes/slants and incubated at 37^0C for 24 hours, characterization/biochemical tests were done in duplicates as described by Cappuccino and Macfaddin [29] and Kirk et al., [30]. The pure cultures were identified on the basis of their cultural, morphological and physiological characteristics were used in the identification of pure cultures as described by Cruikshank et al., [31].

2.7 Isolation, Characterization and Identification of Fungi in Yoghurt Samples

Discrete colonies were sub-cultured onto fresh Sabouraud dextrose agar plates and incubated at 28^0C for 7 day to obtain pure cultures. Further sub-culturing of the colonies produced onto agar slopes/slants was done. These were incubated at 28^0C for 7 days. For identification, fungal growth was examined macroscopically and the colony morphology-diameter, texture, colour (pigmentation), and surface appearance observed. Wet mount method was employed in microscopic examination and observation of sexual and asexual reproductive structures.

2.8 Microscopic Examination of Fungi

Following the preparation of the wet mount, the slides were observed under low and high power objectives, and observation recorded according to the recommendations of Barnett and Hunter, [32].

3. RESULTS

A total of ten (10) different brands of yoghurt samples obtained from different markets and vendors within Owerri were used in this study. The result of the microbiological status assessment of the yoghurt samples are shown in the tables below.

Table 1. pH values of the ten samples of yoghurt

Samples	pH Values
A	4.39
B	4.70
C	4.29
D	4.46
E	4.65
F	4.28
G	4.62
H	4.56
I	4.79
J	4.35

Table 1 Shows the pH readings of ten different yoghurt samples which ranged between 4.28 and 4.79. Yoghurt sample F had the lowest pH value of 4.28 whereas yoghurt sample I recorded the highest pH value of 4.79. These pH values portrayed the acidic status of the yoghurt samples.

Table 2 shows the result of the microbial load of the ten samples of yoghurt. Total heterotrophic bacteria count ranges from5.0 ± 7.1^{bc} to 9.0 ± 7.1^{a}x 10^5CFU/ml, Total coliform count ranges from $1.7\pm0.5^{ab}$to $3.6\pm1.2^{ab}\times 10^4$CFU/ml, Total count for fungi ranges from 2.9 ± 1.6^{b} to 10.3 ± 3.6^{a} x 10^4CPFU/ml as shown in Fig.1.

Table 3 Shows the result of most probable number (MPN) of thermotolerant and fecal coliform bacteria which ranged from 11 to 120 (MPN) $100ml^{-1}$of yoghurt sample.

Table 4 shows the different types of microorganisms isolated and identified from different yoghurt samples. Five bacterial genera included *Streptococcus spp, Escherichia coli, Staphylococcus aureus, Lactobacillus bulgaricus* and *Serratia marcescens* were identified. The first three bacteria were contaminants in the yoghurts and therefore undesirable while the last two are desirable microorganisms as they

constitute the starter cultures used in the production of yoghurts by fermentation. Also four fungal genera which included *Aspergillus niger, Candida albicans, Saccharomyces cerevisiae and Mucor spp* were identified.

Colonial, cellular morphological, and biochemical features were used in the characterization and identification of the bacterial isolates. Table 5 shows the colonial morphology (macroscopic observation of colony on plates) and the cellular morphology (microscopic characteristics) of the bacteria isolated from different yoghurt samples. The bacteria were characterized based on their reaction to various biochemical tests. The reactions of the bacterial isolates to the various biochemical tests performed on them were recorded and the probable bacteria were reported as well.

4. DISCUSSION

The present study has revealed the types of heterotrophic bacteria, coliform and fungi in the various samples of yoghurt. The labels on the yoghurt brands provided little information about the products which included only production date, expiry date, batch number and NAFDAC Registration number.

Table 2. Mean± standard deviation of total viablemicrobial counts of the yoghurt samples

Samples	THBC x 10^5(CFU/ml)	TCC ×10^4(CFU/ml)	TFC x 10^4 (CFU/ml)
A	7.5 ± 2.7^{ab}	3.6 ± 1.2^{ab}	8.0 ± 5.7^{b}
B	8.8 ± 5.1^{ab}	2.7 ± 1.7^{a}	5.5 ± 3.5^{ab}
C	6.0 ± 1.4^{b}	2.0 ± 2.2^{b}	2.9 ± 1.6^{b}
D	6.7 ± 0.9^{a}	1.7 ± 0.5^{ab}	10.3 ± 3.6^{a}
E	8.6 ± 0.6^{a}	3.0 ± 1.6^{a}	9.3 ± 6.1^{a}
F	6.0 ± 2.8^{ab}	2.0 ± 0.8^{bc}	6.8 ± 4.6^{a}
G	5.0 ± 7.1^{bc}	3.3 ± 1.7^{a}	10.0 ± 1.4^{bc}
H	8.0 ± 1.4^{a}	2.0 ± 1.6^{bc}	4.8 ± 2.5^{ab}
I	9.0 ± 7.1^{a}	3.3 ± 1.3^{a}	9.5 ± 4.9^{a}
J	7.5 ± 3.5^{ab}	2.3 ± 2.1^{bc}	5.0 ± 7.1^{b}

*Key: THBC: Total heterotrophic bacteria Count; TCC: Total coliform Count,TCF:Total count of fungi. *Means on the row with the same letters (s) are not significant different (at P> 0.05), according to least significant difference (LSD); Source: Field Survey Data, (2017)*

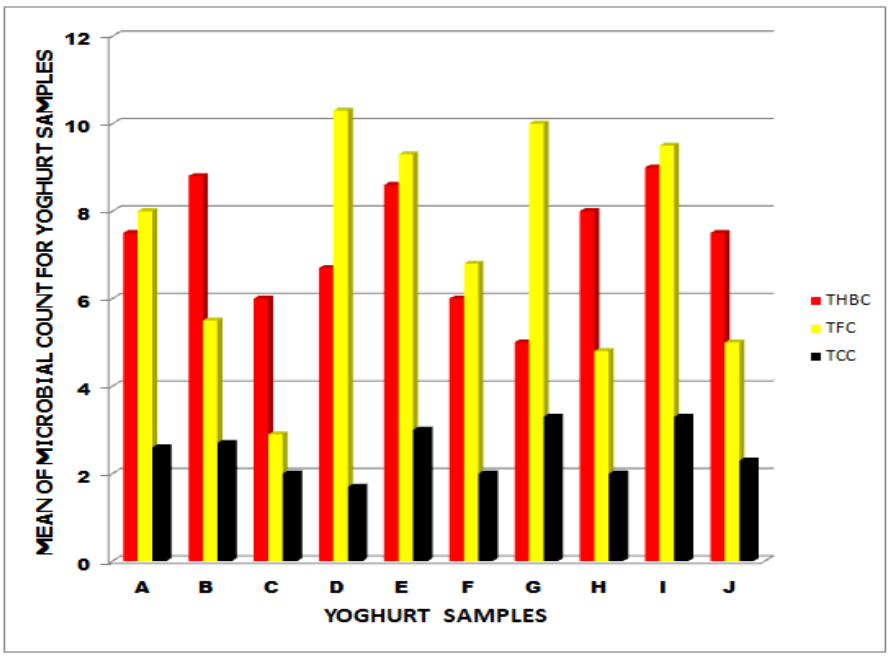

Fig. 1. Bar chart of mean samples of yoghurt

Table 3. Thermotolerant coliform and fecal coliform count of various yoghurt samples

Media	MaCconkey Broth										Number of positive tube			Mpn index/100ml	Confirmation test	Completed test
Strenth	Double strength					Single strength										
Quantity Of Yoghurt Sampls (ml)	10					1	0.1				10	1	0.1			
Number Of Tubes Innoculated	1	2	3	4	5	1	2	3	4	5	5	5	5			
A	+	-	+	-	+	+	-	+	+	-	4	2	5	50	-	+
B	+	-	+	-	-	+	-	+	+	-	5	2	1	70	-	-
C	-	+	+	-	+	+	+	-	-	+	0	1	5	11	+	-
D	+	-	+	-	+	+	-	+	+	+	2	1	2	12	+	+
E	-	-	+	-	+	-	+	+	-	-	5	1	3	84	+	-
F	+	-	+	+	+	+	-	+	-	+	2	1	3	14	-	+
G	-	-	-	+	+	+	+	-	+	-	4	1	5	42	+	-
H	-	+	+	+	+	-	+	+	-	+	0	2	4	11	-	-
I	+	-	+	+	-	+	+	-	+	+	5	2	3	120	-	+
J	+	+	-	+	-	-	+	-	+	+	5	0	2	43	+	+

KEY: +=Positive (Acid and Gas production, Coliform or Fecal Coliform); - = Negative

Table 4. Microorganisms isolated from the different yoghurt samples

Organism	Samples									
	A	B	C	D	E	F	G	H	I	J
E. coli	+	+	+	+	+	+	+	+	+	+
S. aureus	-	-	+	-	+	-	+	-	+	-
L. bulgaricus	+	+	+	-	+	+	+	-	+	+
Streptococcus spp	-	+	+	+	-	+	+	+	-	+
S. marcescens	-	-	+	-	+	+	+	-	+	+
A. niger	-	-	+	+	+	+	+	+	-	-
S. cerevisiae	+	+	+	-	+	+	+	-	-	-
C. albican	-	-	-	-	+	+	+	+	+	+
Mucor spp	-	+	+	+	-	-	-	+	+	+

Key: +, present; -, absent

Table 5. Morphological, cultural and biochemical characterization of isolates from the yogurt samples

Colonial Characteristics	Cell Shape	Gram Reaction	Catalase	Coagulase	Indole	Methyl Red	Urease	Sugar Fermentation	Probable Bacteria
Light pink colonies with smooth edge	Single rod	-	+	-	+	+	-	AG	*E. coli*
Smooth light yellow colonies with raised elevation	Cocci in clusters	+	+	+	-	+	-	A	*S. aureus*
Creamy convex colonies with ciliated edge	Cocci in short chains	+	-	-	-	-	+	A	*Streptococcus Spp.*
White round slight raised colonies	Rod	+	-	-	-	-	+	A	*L. bulgaricus*
Pink smooth irregular flat colonies	Cocci	-	+	-	-	+	-	AG	*S. marcescens*

Key: AG = acid and gas, A= acid, + = positive, - = negative

The pH readings of between 4.28 and 4.79 are somewhat above the high acidity and low pH of between 3.8 and 4.2 expected for yoghurt storage. At this pH yoghurt is not a hospitable medium for pathogens which will not grow in acidic medium and will not survive well either. The bacterial isolates are acidophiles as indicated by the pH values. Yoghurt seems to be a selective medium for moulds and yeasts due to its acidic content that has an acidic content [7].

The total heterotrophic count (THBC) ranged from 5.0 ± 7.1^{bc} to $9.0\pm7.1^{a}\times10^{5}$CFU/ml, average total coliform counts (TCC) ranged from 1.7 ± 0.5^{ab} to $3.6 \pm 1.2^{ab}\times10^{4}$CFU/ml and the thermo-tolerant coliform bacteria and fecal coliform ranged from 11 to 120(MPN) $100ml^{-1}$. The total fungal count (TFC) on the other hand varied between 2.9 ± 1.6^{b} to $10.3 \pm 3.6^{a}\times10^{4}$CFU/ml. Some of the samples showed microbiological parameters not in conformity with the official standards, since their total heterotrophic counts (THC), total coliform counts (TCC) and total fungal counts (TFC) had values far greater than the maximum tolerable limits of 5 x 10^{4}CFU/ml,10 CFU/ml and 1 mould /ml for THC, TCC and TFC respectively [33]. These results are similar with that of Taura et al. [34] whose analysis of 20 yoghurt brands in Kano, Nigeria showed 40%, 55% and 90% of the samples had counts higher than the acceptable standards for THC, TCC and TFC respectively. However, only 1% of his samples passed all three safety limits. Okpala and Jideani [35] also reported poor microbiological standards of commercial yoghurts sold in Bauchi, Nigeria.

Five different bacterial genera were identified. These were *Escherichia coli, Staphylococcus aureus, Lactobacillius bulgaricus, Streptococcus spp* and *Serratia marcesecens.* The presence of *Streptococcus* spp. and *Lactobacillus* spp*.* in the yoghurt samples agrees with the claims of their roles as key species in yoghurt production from milk fermentation [36].

The occurrence of *Streptococci* in this study is in line with the works of Bramley et al. [37], who showed that organisms that contaminate the surface teat and udders of the cow include *Staphylococci,* coliforms, *Streptococci*, spore-formers and gram negative bacteria are organisms that contaminate the udders and surface teats of cow and these can survive pasteurization temperature. Also, *Streptococci* can grow under refrigeration.

The frequent contamination of dairy products by *Staphylococcus aureus,* have been reported by Park et al. [38]. Nasal passage, skin and other mammals are the possible sources of this bacterium. During yoghurt production, transportation, storage and retailing some activities like talking and coughing can produce droplets which will settle on the products. *Staphylococcus aureus* is resistant to radiation, heat and drying. The presence of *Staphylococcus aureus* in yoghurt may causes Staphylococcal food poisoning which is a major type of food intoxication [39].

Poor level of hygiene after processing and Contamination are indicated by the presence of coliforms. Due to high temperature, short time pasteurization, and good hygienic procedures, coliforms are not meant to contaminate yoghurts [40], and as a result, isolation of coliforms from yoghurts suggests negligence of both the vendors, and the producers. This is detrimental to the health of consumers. In yoghurts, the coliform tolerable limit is value less than 10CFU/ml. higher count of 4000 and above is a public health concern [41]. Water or the equipment used in processing might be the source of contamination as reported by Karagul-Yuceer et al. [41]. *Staphylococcus aureus* and *Escherichia coli* have been proved to be potential contaminants of yoghurt [42]. Isolation of *Staphylococcus aureus* from yoghurt samples is of a public health concern and as a result, its presence dairy products should be prevented due to its multiplication rate in these products [43]. Isolation of *E. coli* which is suggestive of fecal contamination and the isolation of *Staphylococcus aureus* indicates that the yoghurt samples were highly contaminated.

Four different fungal genera were identified and included *Aspergillus niger, Candida albicans, Mucor spp and Saccharomyces cerevisiae.* The isolation of fungi such as *Aspergillus and Mucor* species agreed with Oyeleke [27] that moulds are the primary contaminants of yoghurt produced in Nigeria.

According to Adams and Moss [44], yoghurts are spoiled by acidoduric organisms like yeasts and moulds. In fruit containing yoghurts, *S. cerevisiae* has been implicated in spoilage, as well as *Mucor, Rhizopus, Aspergillus, Penicillium and Alternaria*. According to Arnott et al., [45], contamination of yoghurts by yeasts or moulds is generally related to the fruits added for flavour or poor hygienic practices during packaging.

Saccharomyces cerevisiae was also isolated from yoghurt samples in Brazil [46]. Ifeanyi et al., [47] also isolated *E. coli, Aspergillus and Rhizopus* from yoghurt samples sold in Onitsha while De et al., [48] isolated *Staphylococcus* spp. from yoghurt samples sold in Kaduna metropolis.

Yoghurt is not expected to be sterile (free of microorganisms) as the heat treatment of the milk used for production only kills pathogenic microorganisms and substantially reduces the level of spoilage microorganisms. The presence of these contaminants therefore might be caused by inadequate heat treatment (Pasteurization) of milk and poor hygienic standards of processing and packaging that led to recontamination of the product. In addition, the microorganisms could have been introduced into the products from the skin microflora (e.g. *S. aureus* and *Micrococcus*) of personnel employed in the production or from the non-sterile production environment. The detection of fungi and other bacteria probably indicated post-production contamination. Furthermore, the detection of these contaminating microorganisms could also possibly indicate post-production contamination as a result of storage under inappropriate conditions (above 10^0C) during sales in the market environment. Post-production contamination was not impossible, considering the non-sterile environment in which production and sales were carried out.

According to Habibu and Mukhtar [49], many of the home-based local factories of food and drinks undertake the filling of the packs, polythene bags and bottles carelessly without observing any form of sanitation in the production and packaging of the yoghurt drinks. Frazier and Westhoff [50], pointed out that this may be another reason for the high counts of heterotrophic bacteria as well as coliform and fungal counts observed in yoghurt sample drinks.

From the results obtained, it is evident that the yoghurt samples are contaminated with varying microbes including those that are of much public health concern. For these pathogens to be eradicated, proper hygiene should be maintained. If refrigerated at 5°C, the keeping quality of these yoghurts will be maintained and by extension, acid production by lactic acid bacteria used in yoghurt production will be prevented. These yoghurts also be transported in cooling vans so as to maintain the temperature. Good manufacturing practices (GMP) guidelines should be followed at every stage between production and consumption of yoghurts and the relevant agencies must ensure this.

5. CONCLUSION

From the available result, it can be concluded that the microbiological quality of some yoghurt being sold and consumed in Owerri is poor. There is therefore a need for measures to be put in place at various stages between the production and consumption of yoghurts inorder to mitigate bacterial contamination.

Regulatory bodies like NAFDAC should ensure periodical inspection of factories to forestall the meance of poor hygiene. The staff of these factories should be adequately educated on clean and hygienic practices considering the high level of coliform contamination.

NAFDAC registered samples are commonly products of high standard but in this case these products are not safe for people to consume. So there is need fora HACCP (Hazard Analysis Critical Control Points) program for transportation, packaging and storing yogurt in Nigeria.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Isleten M, Karagul-Yuceer Y. Effects of dried dairy ingredients on physical and sensory properties of nonfat yogurt. Journal of Dairy Science. 2006;89:2865-2872.
2. Lucey JA, Munro PA, Singh H. Effect of heat treatment and whey protein addition on the rheological properties and structure of acid skim milk gels. International Dairy Journal. 1999;9: 275–279.
3. Lee SWJ, Lucey JA. Formation and physical properties of yogurt. Asian-Aust. Journal of Animal Science. 2010;23(9):112-1136.
4. American Heritage. Dictionary of English Language (4th Edition). Muffin Houghton; 2000.
5. Alderton R. Milk Products Produced by Lactic Acid Fermentation. Journal of Yoghurt History and Manufacturing Techniques. 2000;6:1 -5.

6. Kolars JC, Aouji M. Yoghurt –an auto digesting source of lactose. New England Journal of Medicine. 2002;310(1):1-3.
7. Porter C, Dryden ME. Lactic fermentation of Diary Foods and their Biological Significance. Journal of Diary Science. 2005;61:7-12.
8. Parnel EM, Kakuda Y, Deman JM. Physical properties of yoghurt. Journal of Diary Science. 2006;69(10):2593.
9. Dryden ME. Lactic fermentation of diary food and their biological significance. Journal of Diary Science. 1999; 6:9 - 12.
10. Schulz ME, Hingst G. The chemistry of yoghurt. In: Acetaldehyde colour reaction for resting yoghurt. Milchwissenschalt. 2000;10:330-336.
11. Shukla FC, Leifson E. Nutritional significance of Probiotics foods. Journal of Science and Technology. 2002;11:1-4.
12. Amanda P. Benefit of yoghurt; 2013. Available:www.Fitnessmagazine/cona/recipes/healthyeating/nutritionalhealth.
13. Salvador A, Fizsman SM. Textural and sensory characteristics of whole and skimmed flavored set-type yoghurt during long storage. Journal of Dairy Science. 2004;87:4033-4041.
14. Sofu A, Ekinci FY. Estimation of storage time of yogurt with artificial neural network modeling. Journal of Dairy Science. 2007;90(7):3118-3125.
15. Holec J. Hygiena, technologic vyroby a vady kysanych mlecnych vyrobku. In Hygienu mbeka umlzern,yh zyrohkoz. Edition, Breierova, Journal. 1990;3:275-283.
16. Caballero B. Encyclopedia of Food Sciences and Nutrition. Academic Press, London, UK; 2003.
17. Muir DD, Banks JM. Milk and milk products. Pages 197– 219 in the Stability and Shelf-life of Food. D. Kilcast and P. Subramanian, edition CRC Press, Boca Raton, FL; 2000.
18. Tamime AY, Robinson RK YOGHURT: Science and Technology Second edition. 2000;3:20.
19. Thatcher and clark. Microorganims in food (2nd Edition), University of Toronto Press; 1978.
20. Yabaya A, Idris A. Bacteriological quality assessment of some yoghurt brands sold in Kadunametropolis Jorind. 2012;10(2): 35-39.
21. Singh P, Prakash A. Isolation of Escherichia coli, Staphylococcus aureus and Listeria monocytogenes from milk products sold under market conditions at Agra Region, Acta agriculturae Slovenica. 2008;92(1):83–88.
22. Vanos V. Boletin IDF 264. Importancia de los estreptococos Del grupo D en productos lacteosfermentados Como indicadores de aseguramiento decalidad en comparacion con coli; 1991.
23. Giraffa G, Carminati D, Neviani E. Enterococci isolated from dairy products: A review of risks and potential technological use. Journal of Food Protection. 1997; 60(6):732- 738.
24. Abdel HKG. Evaluation of chemical and microbiological quality of raw goat milk in Qenaprovince. Assiut Vetinary Medicine Journal. 2011;57 (129):131-144.
25. Fleet GH. Yeasts in dairy products- a review. Journal of Applied Bacteriology. 1990;68:199-211.
26. Potter NF, Hotchkiss JH. Food science 5 Edition, Chapman and Hall (Routledge), Florence,KY. Quality, riboflavin and niacin of plain and fruit yoghurt. Indian Journal of Dairy Science. 1995;39(4):404- 409.
27. Oyeleke SB. Microbial assessment of some commercially prepared yogurt retailed in Minna, Niger state. African Journal of Microbiology. 2009;7:245-248.
28. Verma JK, Greene KD, Relter ME, Trother J, Nowickiki SF. An outbreak of *Escherichia coli* infection following exposure to contaminated food. JANA. 1999;290-2178.
29. Cappuccino J, Macfaddin JF. Biochemical tests for the identification of medical bacteria. (2nd edition). Baltimore, MD., Williams and Wilkins; 2005.
30. Kirk CJC, Peel NR, James KR, Kershaw YK. Basic medical laboratory technology, Pitman medical Pub. Co. Ltd., London; 2005.
31. Cruickshank R, Duguid JP, Marmion BP, Swain RHA. Medical Microbiology, (12th Edition). Church III Livingstone. 1975; 2:137-180.
32. Barnett J, Hunter B. Illustrated Genera of Imperfect Fungi. Aps Press. 1998;1:32-80.
33. FAO. Food and Agriculture Organisation. Manual of food quality control, 4.microbiological Analysis. FAO food and nutrition paper, FAO Italy paper, C3 – C5,D2; 1979.
34. Taura DW, Mukhtar MD, Kawo, AH. Assessment of microbial safety of some Brands of yoghurt sold around old campus

of Bayero University Kano. Nigerian Journal of Microbiology. 2005;19: 1-5.
35. Okpala NN, Jideani IA. Comparative study of microbial quality of commercial and laboratory produced yoghurts. Nigerian Journal of Microbiology. 2006;7:917–926.
36. Perdigon G, Alvarez S, Rachidm M, Agüero G, Gobbato N. Immune System Stimulation by Probiotics. Journal of Dairy Science. 1995;6:1597-1606.
37. Bramley AJ, Mckinnon CW. The Microbiology of Raw milk. In Robinson RK editor, Dairy Microbiology, Volume I, Esevier Science Publisher, London. 2004;163-208.
38. Park C, Albano H, Gibbs P, Teixeira P. Microbiological quality of Portuguese yogurts. Journal of Industrial Microbiology and Biotechnology. 2011;19-21.
39. Willey JM, Sherwood LM, Woolverton CJ. Bacteria assessment of dairy products. In: Prescott Harley and Kleins Microbiology. (7th edition) Mc-Graw Hill, New York. 2008;103.
40. Kawo BC, Srepp T, Bolta JR. Factors leading to the facture of yogurt. Journal of dairy Science Abstract. 2006;7(2):149-150.
41. Karagul Y, Wilson C and White H. Formulation and Processing of Yoghurt. Dairy Science. 2004; 3: 543-550.
42. David M, Carr JG. Incidence of enterobacter in milk. Journal of Food Microbiology. 2003;9:111 – 119.
43. Atanda OO, Ikenebomeh MJ. Microbiology quality of “Nono”. World Journal of Microbiology and Biotechnology. 1991; 7:89–91.
44. Adams MR, Moss MO. Food Microbiology. (4th edition). The Royal Society of Chemistry, Cambridge, UK. 1995;2:263 – 266.
45. Arnott BM, Zentmyer GA, Nishijima WT. Microbial Analysis of Food (3rd edition). Longman Science, Essex, UK. 1997; 6:721–723.
46. Moreira SR, Schaean RF, de Carvalho E P, Wheats AE. Isolation and identification of yeasts and filamentous fungi from yoghurts in Brazil. Brazilian Journal of Microbiology. 2001;10(4):117 – 122.
47. Ifeanyi VO, Ihesiaba EO, Muomaife OM, Ikenga C. Assessment of microbiological quality of Yorghurt sold by street vendors in Onitsha Metropolis, Anambra State, Nigeria. British Microbiology Research Journal. 2013;3(2):198-205.
48. De N, Goodluck TM, Bobai M. Microbiological quality assessment of bottled yogurt of different brands sold in central market Kaduna Metropolis, Kaduna, Nigeria. International Journal of Current Microbiology and Applied Science. 2014;6: 20-27.
49. Habibu UA, Mukhtar MD. Comparative study on microbial contaminants of hand and machine sealed “zobo” drink of hibiscus sabdariffa. Nigerian Journal of Research and Production. 2002; 1(3)127 – 137.
50. Frazier WC, Westhoff DC. Food microbiology. (5th edition). Tata McGraw Hill Publications. Company Ltd, New York, 1978;540.

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