



(RESEARCH ARTICLE)



INVESTIGATING THE PROXIMATE COMPOSITION AND LEVELS OF MICROBIAL CONTAMINATION OF DIFFERENT BRANDS OF YOGHURT SOLD IN ELELE MARKET, RIVERS STATE

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International Journal of Science and Research Archive, 2026, 21(01), 050–061

Publication history: Received on 11 August 2026; revised on 24 September 2026; accepted on 26 September 2026

Article DOI: <https://doi.org/10.30574/ijrsra.2026.21.1.1800>

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ABSTRACT

Yoghurt is a fermented dairy product widely consumed because of its nutritional value and health benefits. However, poor hygiene during production, storage, transportation, and marketing can lead to microbial contamination, posing a risk to consumers. This study investigated the proximate composition and levels of microbial contamination of different brands of yoghurts sold in Elele Market, Rivers State, Nigeria. Five yoghurt brands were sampled, with three samples collected from each brand, giving a total of fifteen samples. Proximate composition was determined using standard analytical procedures, standard microbiological methods were used in the enumeration and characterization of microorganism. While pH was measured using a digital pH meter. The proximate analysis indicated that disparity in the nutritional content of the yoghurt brands, with moisture content ranging from 82.90 to 87.58%, protein from 1.89 to 3.20%, ash from 0.52 to 0.75%, all yoghurt had similar fibre content of 0.00%, lipid from 1.40 to 2.30 and carbohydrate from 6.40 to 11.25. Differences were observed in the nutritional components across the brands. Microbiological analysis showed disparity in bacterial and fungal load across samples. The microbial counts ranged as follows. Total heterotrophic bacterial count ranged from 0.3×10^5 to 1.1×10^5 CFU/mL; Coliform count 0.1×10^3 to 0.4×10^3 CFU/mL; *Staphylococcus aureus* count 0.2×10^3 to 0.3×10^3 CFU/mL; and fungi count 0.2×10^3 to 0.4×10^3 cfu/ml. The microorganisms isolated and their percentage occurrence were; *Lactobacillus* spp. (58.5%), *Staphylococcus aureus* (14.1%), *Escherichia coli* (8.2%), *Bacillus* spp. (14.0%), *Salmonella* spp. (5.2%) for bacteria while the fungi species include: *Aspergillus* spp. (25%), *Penicillium* spp. (50%), *Mucor* spp. (25%). The pH values were within the normal acidic range for yoghurt (4.64–4.73). The study concludes that although some yoghurt brands were microbiological safe, improved hygienic practices, effective quality control, and regular monitoring are necessary to ensure the safety of yoghurt sold in Elele Market.

Keywords: Microbial Contamination, Yogurt, Pathogenic Bacteria, Food Safety, Microbial load, Elele Market.

1 INTRODUCTION

Yoghurt is a fermented dairy product produced through the controlled fermentation of milk by lactic acid bacteria, primarily *Lactobacillus spp* and *Streptococcus thermophilus*. It is widely consumed because of its nutritional value, pleasant taste, digestibility, and health-promoting properties. Yoghurt is rich in proteins, calcium, vitamins, minerals, and beneficial microorganisms that contribute to improved gut health and enhanced immune function (Akinyemi et al., 2022). The increasing demand for yoghurt in Nigeria has led to the production and marketing of numerous local and commercial brands.

Despite the acidic nature of yoghurt, which inhibits the growth of many harmful microorganisms, contamination may occur during production, packaging, transportation, storage, or retail distribution. Poor hygienic practices, contaminated raw materials, inadequate pasteurization, improper refrigeration, poor handling by vendors, and environmental exposure may introduce pathogenic bacteria and fungi into yoghurt. Such contamination reduces product quality and may expose consumers to food borne illnesses (Akpan et al., 2022).

Microbial contamination of dairy products remains a significant public health concern worldwide. Organisms frequently isolated from contaminated yoghurt include *Escherichia coli*, *Staphylococcus aureus*, *Salmonella spp.*, *Bacillus spp.*, *Klebsiella spp.*, *Pseudomonas spp.*, and fungi such as *Aspergillus*, *Penicillium*, *Candida*, *Rhizopus*, and *Mucor* species. The presence of these organisms may indicate poor sanitation, post-processing contamination, or inadequate storage conditions. Some of these microorganisms produce toxins capable of causing severe illness in humans.

International bodies such as the World Health Organization (WHO, 2023) and the Food and Agriculture Organization (FAO) provide microbiological criteria for dairy products, which specify acceptable limits for total viable counts, coliforms, and absence of pathogens like *Salmonella*. National regulatory agencies like the National Agency for Food and Drug Administration and Control (NAFDAC) in Nigeria enforce standards to protect consumers. However, compliance varies widely in informal market settings.

International food safety organizations recommend that yoghurt should be manufactured under strict hygienic conditions using Good Manufacturing Practices (GMP) and Hazard Analysis and Critical Control Point (HACCP) principles. According to the Codex Standard for Fermented Milks (CXS 243-2003, amended 2024),

yoghurt should contain viable starter cultures inadequate numbers at the time of sale, while pathogenic microorganisms such as *Salmonella spp.* should be absent. Coliforms and *Staphylococcus aureus* should be absent or present only within acceptable microbiological limits. Proper pasteurization, refrigerated storage ($\leq 4^{\circ}\text{C}$), hygienic packaging, and routine microbiological monitoring are essential for maintaining yoghurt safety and quality

Research in Nigerian markets has frequently reported microbial contamination of yoghurt:

Studies in urban markets such as Lagos and Port Harcourt have documented the presence of high total viable counts and coliforms in locally sold yoghurt, often exceeding recommended safety limits. These findings were attributed to poor hygiene, inadequate refrigeration, and unsafe handling practices. Some studies demonstrated the presence of *E. coli* and other enteric bacteria, indicating faecal contamination and high health risk, this study highlight ongoing concerns about the microbiological safety of market-sold yoghurt in Nigeria, but few focus specifically on Elele Market, leaving a geographic and comparative research gap.

Elele Market in Rivers State serves as a major commercial center where various locally produced and commercially manufactured yoghurt brands are sold daily. Although many yoghurt products carry quality certification labels, improper storage, handling during transportation and retail marketing may compromise their microbiological quality before it reaches the consumers. Regular microbiological assessment of yoghurt sold in such markets is therefore necessary to ensure consumer safety and compliance with food safety standards.

This study seeks to investigate the level of microbial contamination of different brands of yoghurt sold in Elele Market, Rivers State, Nigeria, by determining their total viable bacterial count, Coliform count, fungal count, pH level and identifying microorganisms isolated using Nutrient Agar, MacConkey Agar, and Sabouraud Dextrose Agar.

2 MATERIAL AND METHODS

2.1 Study Area

Rivers State, Nigeria. Elele is located along the East–West Road and serves as one of the major commercial centres in Rivers State. The choice of Elele Market for this study was based on its high patronage, availability of multiple yoghurt

brands, and its importance as a major food distribution center in the study area. The findings from this study will provide useful information on the microbiological quality and safety of yoghurts sold to consumers in the market and contribute to public health protection (Wang et al., 2024).

2.2 Sample Collection

A total of five (5) different brands of yoghurt was randomly purchased from different vendors within Elele Market. The yoghurt samples were collected based on availability and popularity among consumers. Three (3) samples per brand was collected from different sellers to increase reliability, at least 100-200 ml per sample (factory sealed, unopened). Before buying each yoghurt brand, the following was checked; expiry date, manufacturing date, packaging condition (swollen, leaking or damaged) and storage condition (refrigerated or not). Laboratory analysis commenced within 24 hours of sample collection to minimize changes in microbial population before examination. Until analysis, the samples were stored under refrigeration at 4°C to preserve their microbiological quality and prevent additional microbial growth (Food and Agriculture Organization & World Health Organization (FAO/WHO,2024).

2.3 Study Population

The study population consisted of all commercially packaged yoghurt brands available for sale in Elele Market, Rivers State. These products included locally produced and nationally distributed yoghurt brands sold by wholesalers, supermarkets, kiosks, and open market retailers. The study focused on yoghurt products that were within their expiry dates and intended for human consumption, only sealed yoghurt containers that met the inclusion criteria were considered for microbiological analysis.

2.4 Sample Size

A total of fifteen (15) yoghurt samples were analyzed during this study. Five (5) different brands of commercially available yoghurt were selected, and three (3) samples were purchased from each brand, the samples were coded as follows:

- Brand Sample Codes
- Brand A; A1, A2, A3
- Brand B; B1, B2, B3
- Brand C; C1, C2, C3
- Brand D; D1, D2, D3
- Brand E; E1, E2, E3

This sample size was considered adequate for comparing the microbiological quality of the selected yoghurt brands and has been adopted in similar microbiological studies on fermented dairy products (Wang et al., 2024).

2.5 Experimental design

This study adopted a cross-sectional descriptive study design to assess the level of microbial contamination in different brands of yoghurt sold in Elele Market, Rivers State. Samples of various yoghurt brands were randomly purchased from different vendors within the market. Laboratory analysis was conducted to determine total viable bacterial count, coliform count, and fungi count using standard microbiological methods and pH determination. The isolated microorganisms were identified using colony morphology, Gram staining, and biochemical tests. This design enabled comparison of the microbial quality of different yoghurt brands available to consumers at the time of the study (Marco et al., 2022).

2.6 Microbiological Analysis of Yoghurt Samples

The total viable count of the flour samples was determined using the pour plate technique as described by Giwa et al., (2012). Briefly, 1g of each yoghurt sample was homogenized in 9ml of sterile peptone water in a sterile 500ml gas jar cylinder. The solution was agitated vigorously for a few minutes to ensure even mixing and then allowed to settle. A ten-fold dilution series was performed to obtain a colony count of 10^4 (CF/ml), A fresh sterile pipette tip was used for each transfer to prevent cross-contamination. Furthermore, one ml of the diluted sample was poured into an empty sterile 9ml Petri dish. Potato dextrose agar (PDA) was poured into the prepared plates for fungi counts, nutrient agar (NA) was poured into the prepared plates for bacterial counts, and MacConkey agar (MA) was poured into the prepared plates for enteric bacteria counts. MRS base agar (Merck Ltd.) was used for the enumeration of Lactobacilli counts, while Mannitol Salt Agar (MSA) for the enumeration of Staphylococcus and was incubated at 37°C for 24hours for bacteria and 72hours for fungi (Spencer and Ragout de Spencer, 2001). All plates were prepared in duplicate. Colonies were counted and recorded after incubation period. The different colonies on each plate were isolated, purified and stored on nutrient agar slants (for bacteria) and Potato Dextrose Agar slants (for fungi) for further characterization and identifications.

2.7 Characterization and Identification of isolated bacteria and fungi

The bacteria isolates obtained were identified based on a combination of colonial morphology, motility tests and gram staining; these tests were conducted to determine the cultural characteristics of the isolates. The biochemical tests conducted was described by Wang, (2024) and include; catalase test, oxidase test, glucose test, glucose fermentation tests and hydrolysis of arginine. Purified selected fungal isolates were identified using their cultural and morphological characteristics as described by James and Natalie (2001).

2.8 Analyses of Proximate Properties of Yoghurt Samples

The proximate composition of the yoghurt sample was determined using the standard methods of the Association of Official Analytical Chemists (AOAC, (2019). Moisture content was determined by drying a known weight of each yoghurt sample in a hot air oven at 105⁰ C to a fixed weight. Ash content was determined by incineration of the dried sample in a muffle furnace at approximately 550⁰ C until a constant weight was obtained. Crude protein was determined using the Kjeldahl method while crude fat was determined by Soxhlet extraction using an appropriate organic solvent. Crude fibre was determined using by sequential acid and alkali digestion of defatted sample. Carbohydrate content was calculated by difference, as 100 minus the sum of the percentages of moisture, ash, protein, lipid and fibre. All determinations were carried out in triplicate, and the results were expressed as percentage composition.

2.9 Determination of the pH of the Yoghurt Samples

The method as described by Zhang et al., (2025) was used in determining the pH of the yoghurt samples. “Twenty milliliters of each yoghurt sample was poured into a sterile beaker, and the electrode of the pH meter was immersed directly into the sample. The pH was standardized using freshly prepared pH buffer solutions of pH 4.0 and 7.0. The standardization of the metre rule was performed by dipping the electrode into each of the buffer solutions. The electrode was rinsed with distilled water, cleaned with an absorbent cotton wool and dipped in the solution of the sample contained in a test tube of unknown ph. The pH of the sample was read on the display panel, the value was recorded. After each determination, the electrode was rinsed with distilled water and gently dried with tissue paper before testing the next sample to avoid contamination, each sample was analyzed in triplicate, and the mean pH value was calculated.

2.10 Statistical Analyses

Mean and standard deviations were calculated to analyze sample attributes. The data obtained were subjected to analysis using a one-way analysis of variance (ANOVA)

2.11 Ethical consideration

No human or animal subjects were involved in this study. All laboratory procedures were conducted following standard microbiological safety guidelines.

3 RESULTS

3.1 Proximate Composition

Table 1: Proximate Composition of selected brands of Yoghurt Purchased from Elele Market (%)

Yoghurt brands	Moisture (%)	Protein (%)	Ash (%)	Fibre (%)	Lipid (%)	CHO (%)
Viju yoghurt	86.20±0.11	3.09±0.07	0.57+0.04	0.00+0.01	2.09+0.06	9.02+0.15
Nutri yoghurt	85.75+0.14	3.20±0.06	0.52+0.03	0.00+0.01	2.30+0.45	10.15+0.17
Hollandia yoghurt	82.90±0.10	3.15±0.05	0.59+0.04	0.00+0.01	2.00+0.95	11.25+0.13
Fresh yoghurt	83.50±0.12	2.85±0.07	0.54±0.02	0.00±0.01	2.07±0.06	8.75±0.16
Peak yoghurt	87.58±0.09	1.89±0.04	0.75±0.04	0.00±0.01	1.40±0.06	6.40±0.11

Values are presented as mean standard deviation

Table 1 shows the result of proximate analysis of the different brands of yoghurt purchased from Elele market. The moisture content was high in all the yoghurt samples, with Peak yoghurt having the highest (87.58%) while Hollandia yoghurt recorded the least moisture content (82.90%) in the same order, Nutri yoghurt had the highest protein content (3.20%) while Peak yoghurt had the least (1.89%). Fresh and Nutri yoghurt had almost the same and least ash content (0.52%) while Hollandia yoghurt had the utmost ash content (0.59%). For the fibre parameter, all the yoghurt samples had the same fibre content across (0.00%). For lipid and carbohydrate, peak yoghurt recorded the lowest content

(1.40%) and (6.40%) while Nutri yoghurt recorded the lightest for lipid (2.30%) while the Hollandia recorded high for carbohydrates (11.25%) respectively.

Table 2: shows the pH of the different samples of yoghurt purchased from Elele market. The pH ranged from 4.65 - 4.73. The sample with the least pH value is Hollandia yoghurt with pH value of 4.65 while the sample with the highest pH value is the Nutri-yoghurt, and its recorded 4.73 pH.

Table 2: pH values of the different yoghurt sample

BRAND	pH 1	pH 2	pH 3	Mean $\pm$ SD
FYO	4.66	4.64	4.67	4.66 $\pm$ 0.02
HDA	4.65	4.66	4.65	4.65 $\pm$ 0.01
NYO	4.74	4.71	4.73	4.73 $\pm$ 0.02
PEAK	4.69	4.65	4.65	4.66 $\pm$ 0.02
VIJU	4.71	4.69	4.71	4.70 $\pm$ 0.01

Key: FYO = Fresh-yoghurt; HDA= Hollandia-yoghurt; NYO = Nutri-yoghurt; PKYO= Peak-yoghurt; VIYO= Viju-yoghurt

Table 3: shows the results of the microbial load, the Total Heterotrophic Bacteria Count ranged from 1.1×10^5 to 0.3×10^5 . The sample with the least Total Heterotrophic Bacteria Count (THBC) is the Nutri-yoghurt with a count of 0.3×10^5 CFU/ml. The sample with the highest count is the Hollandia-yogurt with a count of 1.1×10^5 CFU/ml. The coliform count ranged from 0 to 0.4×10^3 CFU/ml. The result obtained showed that Fresh, Hollandia and Peak yoghurts recorded the same coliform count, with the value of 0, while Nutri-yoghurt recorded the heaviest coliform count with the value of 0.4×10^3 CFU/ml. The *Staphylococcus aureus* ranged from 0 to 0.3×10^3 CFU/ml. Fresh-yoghurt, Hollandia and Peak recorded a *Staphylococcus aureus* count of 0 while Nutri-yoghurt recorded the highest *Staphylococcus aureus* count 0.3×10^3 . The fungi count ranged from 0 to 0.4×10^3 . Hollandia yoghurt recorded the highest fungi count of 0.4×10^3 CFU/ml, While Peak yoghurt recorded the lowest fungi count of 0

Table 3: Microbial counts of Different Brands Yoghurt Samples Purchased from Elele Market

Sample	THBC ($\times 10^4$ CFU/mL)	Coliform count ($\times 10^2$ CFU/mL)	<i>S. aureus</i> count ($\times 10^2$ CFU/mL)	Fungi count ($\times 10^2$ CFU/mL)
FYO	0.4×10^5	0	0	0.3×10^3
HDA	1.1×10^5	0	0	0
NYO	0.3×10^5	0.4×10^3	0.3×10^3	0.4×10^3
PEAK	0.8×10^5	0	0	0.2×10^3
VIJU	0.8×10^5	0.1×10^3	0.2×10^3	0.4×10^3

Key: FYO = Fresh-yoghurt; HDA= Hollandia-yoghurt; NYO = Nutri-yoghurt; PKYO= Peak-yoghurt; VIYO = Viju-yoghurt; THBC = Total Viable Bacteria

3.2 Biochemical and Morphological Characteristics of Bacterial Isolates obtained from Different Brands of yoghurt Purchased from Elele Market

Table 4: shows biochemical and morphology characteristics of the bacterial isolates obtained from different brands of yoghurt purchased from Elele market respectively. The bacteria were presumptively identified as *Bacillus spp.*, *Staphylococcus spp.*, *Lactobacillus spp.*, *Escherichia coli* and *Salmonella spp.* These bacteria isolated exhibited two basic shapes which include the rod and spherical shapes.

Table 4: Bacterial Isolated and their percentage occurrence

Bacteria	Isolate Frequency (n)	Percentage (%)
<i>Lactobacillus spp.</i>	8	58.5
<i>Staphylococcus aureus</i>	3	14.1
<i>Escherichia coli</i>	2	8.2
<i>Bacillus spp.</i>	5	14.0
<i>Salmonella spp.</i>	3	5.2
TOTAL	13	100%

3.3 Characterization and Identification of Fungal isolates obtained from Different Brands of yoghurt Purchased from Elele Market

Tables 5: Shows the characterization and identification of the fungal isolates obtained from different brands of yoghurt purchased from Elele market respectively. The characteristics of the isolates showed that different fungi were obtained from the samples. The cultures were incubated for five days with visible growth beginning from the third day. The results showed that *Penicillium spp.*, *Aspergillus spp.*, and *Mucor spp.* Were isolated from the various brands of yoghurt analyzed. *Aspergillus spp.* had irregular colonies. It changed colour on continuous incubation, at first it was white, then turned yellow and finally to green. Branched mycelium terminating into conidia was observed.

Table 5: Morphological and Biochemical Characteristics bacterial of isolates obtained from Different Brands of Yoghurt Purchased from Elele Market

Gram rxn	Shape	Catalase	Coagulase	Motility	Starch hyd.			Citrate	Urease	MR	VP	Spore and hyphae	Dnase	Lip	Gala	Glucose	Malt	Xylose	Lactose	Fructose	Sucrose	Manitol	Galactose	Dextrose	Probable organisms
+ve	Cocci in cluster	+	+	-	-	+	-	-	-	+	A	+	-	-	A	A	-	-	AG	-	AG	A	AG	<i>Staphylococcus aureus</i>	
+ve	Rods	-	-	-	-	-	+	+	+	-	-	-	-	-	-	A	-	A	A	A	-	AG	A	<i>Lactobacillus spp.</i>	
+ve	Rods	-	-	+	+	-	-	-	-	+	+	-	-	-	AG	A	-	-	A	A	-	A	A	<i>Bacillus spp.</i>	
+ve	Rods	+	-	+	+	+	-	-	-	+	+	+	-	-	AG	A	A	-	A	-	-	AG	-	<i>Escherichia coli</i>	
+ve	Rods	+	-	-	-	+	-	+	+	-	+	-	-	-	AG	AG	A	-	A	AG	-	A	A	<i>Salmonella spp.</i>	

Key: A/G = Acid/Gas positive, + = Positive, - = Negative, VP = Voges Proskauer, MR = Methyl red,

3.4 Percentage Occurrence of Microbial Isolates in Different brands of yoghurt

Table 6: The percentage occurrence of bacterial isolates. The result of the percentage occurrence is in the order of thus; *Lactobacillus spp.* (45.4%) > *Bacillus spp.* (16.1) > *Escherichia coli* (15.2%) > *Staphylococcus spp.* (14.1%) > *Salmonella spp.* (9.2%).

Macroscopy	Microscopy	Parable organism
White powdery surface, bluish-green with white border. Reverse is white and non-crack	Separate hyphane with branched conidiospores that have secondary branches known as metulae	<i>Penicillium spp.</i>
Brown/black powdery surface with a velvet whitish surrounding, the reverse is cream and crack colony	Non-septate Non—branched sporangiophores no stalons and rhizoids	<i>Mucor spp.</i>
Irregular, at first white, then turn to yellow and finally to green	Branched mycelium, condiophores are enlarged at the tip forming a rounded vesicle.	<i>Aspergillus spp.</i>

Table 7: shows the percentage occurrence of fungal isolates. From the result of the percentage occurrence *Penicillium spp.* had the highest percentage (50%), while *Aspergillus spp.* and *Mucor spp.* had the same and the least percentage occurrence (25%).

Table 7: Fungal isolates obtained from Different Brands of Yoghurt Purchased from Elele Market and their percentage occurrence

Fungal	Isolate	Frequency (n)	Percentage (%)
<i>Aspergillus spp.</i>	2		25
<i>Penicillium spp.</i>	4		50
<i>Mucor spp.</i>	2		25
TOTAL	8		100%

4 DISCUSSION

This present study investigated the proximate composition and microbiological quality of five different brands of yoghurt namely: Viju Yoghurt, Nutri Yoghurt, Fresh Yoghurt, Hollandia Yoghurt, and Peak Yoghurt purchased from Elele Market, Rivers State. The parameters evaluated included moisture, protein, fat, crude fibre, crude fat and carbohydrate contents, pH, total heterotrophic bacterial count (THBC), total coliform count (TCC), *Staphylococcus aureus* count, total fungal count (TFC), and the identification the bacterial and fungal isolates recovered from the samples. The disparity observed among the different brands of yoghurt shows a major difference in their nutritional and microbiological quality, which may be as a result of difference in their sources, production, fermentation conditions, hygiene during the manufacturing, sterility of packaging materials, post-handling and the storage temperature.

Moisture content is meant to be the major composition of the yoghurt samples because yoghurt comprises of a substantial proportion of water arising basically from the milk. The moisture content of the yoghurt samples in this recent study ranged from (82.90 – 87.58%). This result aligns with the result obtained from the work of Abdulrahman et al., (2021), who reported moisture content of 77.76 – 80.06% in yoghurt samples collected in Kaduna. The moisture content of this recent research shows that the analyzed brands of yoghurt contained comparatively reduced total solids and the disparity in moisture content across yoghurt brands could result from variation in composition of the milk, addition of water or other ingredients, processing conditions and differences between producers.

Ash indicates the inorganic mineral fraction of the product and it is influenced to a large extent by the mineral composition of milk and other ingredients utilized during production, from the present study the ash content of the analyzed yoghurt brands ranged from 0.52 – 0.59%, this finding corroborated with the work of Leeward et al, (2023), who reported ash values of 0.525 – 0.635% in yoghurt incorporated with unripe false horn plantain. The observed ash in this study indicates the presences of mineral constituents in the yoghurt. The variation in ash content across the different brands of yoghurt may arise from difference in milk composition, formulation, processing condition and added ingredients.

The protein content obtained ranged from 1.89 – 3.20%, this is in agreement with the finding of Abdulrahman et al, (2021) who reported a crude protein of 3.40 - 3.45% in yoghurt samples from Kaduna municipal. The disparity observed between brands could be as a result of difference in milk composition, milk-solid concentration and production formulation. Protein is the major nutritional component of yoghurt; this is because it basically originates from milk proteins and contributes to the nutritional value and structural features of yoghurt.

For the crude fibre, the same value was obtained across all brands of yoghurt analyzed, (0.00%), the results from this finding were consistent with the investigations of Mbaeyi – Nwaoha et al, (2025), who reported 0.00% fibre content in plain yoghurt and it encourages the expectation that conventional dairy products contain little or no dietary fibre because naturally milk does not contain an appreciable amount of fibre.

Furthermore, the crude lipid content of the yoghurt samples ranged from 1.40 – 2.30%, the results obtained from this present finding agrees with the result obtained from the work of Abdulrahman et al, (2021) who reported crude lipid values of 1.76 – 1.79% for yoghurt samples obtained from Kaduna. The values obtained for lipid in this work can be attributed to the use of whole milk or increase milk fat.

The pH recorded for the yoghurt samples in this present research ranged from 4.64 - 4.74, it falls within the normal pH range of fermented yoghurt (approximately 4.0–4.8), indicating that the products underwent adequate lactic acid fermentation. The acidic environment produced by lactic acid bacteria is important because it suppresses the growth of many spoilages and pathogenic microorganisms while improving the shelf life, characteristic flavor, texture and microbiological stability of yoghurt (Codex Alimentarius Commission, 2023). The little differences in pH observed among the brands may be attributed to difference in fermentation time, starter culture activity, storage conditions and manufacturing processes. Similar pH values were reported by Chiwendu et al., (2015) who worked on commercial yoghurt in Owerri and reported a narrower pH between 4.29 -4.46; whereas Taiwo et al., (2019), reported pH values between 4.05 and 5.50 among commercial yoghurt products sold at Ota, Ogun State Nigeria. Therefore, the result of the present study agrees with report of Chiwendu et al., (2015); Taiwo et al., (2019), The findings therefore; suggest that all the yoghurt brands were properly fermented and maintained acceptable acidity.

The result obtained from the Total heterotrophic bacterial count (THBC) in the present study ranged from 0.4×10^5 – 1.1×10^5 CFU/mL. Fresh Yo had the least count of 0.4×10^5 CFU/mL while Hollandia Yo had the higher microbial load of 1.1×10^5 CFU/mL. The disparity in THBC among the brands of yoghurt can be in connection to the efficiency of pasteurization, fermentation process, hygiene during the manufacturing process, packaging and post-handling. This present result aligns with the findings of Chikwendu et.al., (2019), who reported THBC values between 2.00×10^5 - 2.04×10^6 CFU/mL in brands of yoghurt sold in Owerri.

The *Staphylococcus aureus* count obtained in this present study ranged from 0.2×10^3 - 0.3×10^3 CFU/mL. Viju Yo had the least count of 0.2×10^3 CFU/mL while Hollandia Yo had the higher Staphylococcal count of 0.3×10^3 CFU/mL. This result is consistent with the findings of Ekeleme et al., (2024), who detected Staphylococcal organisms in all the brands of yoghurt investigated in Uturu, with total of Staphylococcal count ranging from 1.1×10^1 – 1.8×10^2 CFU/mL. The occurrence *Staphylococcus spp* in the two brands of yoghurt out of the five brands analyzed may be associated with poor personal hygiene of handlers, utilization of contaminated utensils and water, inadequate control during and distribution packaging.

Total Coliform Count (TCC) The results showed that fresh-yo and hollandia and peak had no detectable coliform bacteria, whereas Nutri-yo and Viju contained Coliform. The absence of Coliform organisms in most samples indicates good manufacturing practices, effective pasteurization and satisfactory sanitary conditions during processing. However, the results of the total coliform count in the present study ranged from 0.1×10^3 – 0.4×10^3 CFU/mL. Viju Yo had the least count of 0.1×10^3 CFU/mL while Nutri Yoghurt had the highest coliform count 0.4×10^3 CFU/mL. detection of coliforms in Nutri-yo and Viju suggests post-pasteurization contamination, poor hygiene during processing, contaminated water or improper handling during transportation and marketing. According to the International Commission on Microbiological Specifications for Foods (ICMSF, 2022), coliform bacteria are recognized as indicator organisms that reflect the sanitary quality of food products. Similar findings were reported by Okeke et al., (2023), who isolated coliform organisms from a few commercial yoghurt samples and attributed their occurrence to inadequate hygiene during processing and packaging. The presence of *Escherichia coli* among the isolates in this study further supports the likelihood of faecal or environmental contamination.

Furthermore, the three fungal genera that were isolated from the yoghurt samples, include; *Penicillium* specie, *Aspergillus* specie and *Mucor* specie. The predominance of *Penicillium* species agrees with the findings of Aw ah et al., (2016); Keta et al., (2019), Kumar et al. (2022), who reported that *Penicillium* species are among the most common mould contaminants of fermented dairy products. Similarly, *Aspergillus* and *Mucor* species have frequently been isolated from improperly stored dairy products, because their spores are widespread in the environment. The presence of these fungi suggests contamination during packaging, storage or marketing and may reduce the shelf life of yoghurt. This

therefore, indicates the need for an un-compromise hygienic practices and storage conditions during the production and distribution of yoghurt knowing that some species of *Aspergillus* and *Penicillium* may also produce mycotoxins under favourable environmental conditions, thereby posing potential health risks to consumers (EFSA, 2023).

The bacteria species isolated from the yoghurt samples were *Lactobacillus* spp., *Staphylococcus aureus*, *Escherichia coli*, *Salmonella* spp., and *Bacillus* spp. From the result of the percentage occurrence presented on Table 5, *Lactobacillus specie* had the highest percentage occurrence at 58.5%, while *Salmonella specie* had the least percentage occurrence of 5.2%. The predominance of *Lactobacillus* spp. was expected because these organisms are the principal starter cultures used in yoghurt production. Their dominance demonstrates successful fermentation and contributes to the nutritional and probiotic quality of the yoghurt products. Similar findings were reported by Ranadheera et al. (2021), who identified *Lactobacillus* species as the dominant bacteria in fermented dairy products. The isolation of *Escherichia coli*, *Salmonella specie*, *Bacillus specie* and *Staphylococcus aureus* is undesirable, because these organisms are noted as indicators of poor hygiene and contamination during processing packaging or marketing. Their occurrence suggests that although fermentation was successful, certain brands experienced contamination after production. From an overall microbiological quality perspective, the following brands of yoghurt; fresh-yoghurt, Hollandia yoghurt and peak yoghurt exhibited better microbiological quality when compared to nutria-yoghurt and viju-yoghurt because they showed no detectable coliforms, *Salmonella specie* or *Staphylococcus aureus*. Hollandia demonstrated the best microbiological quality since neither fungal nor indicator bacterial contaminants were detected despite having a relatively high heterotrophic bacterial count attributable to beneficial lactic acid bacteria. In contrast, Nutri-yo and Viju showed comparatively poorer microbiological quality because both contained coliform bacteria, *Staphylococcus aureus* and fungal contaminants. Although the level contamination was relatively low, the detection of these microorganisms indicates shortcomings in hygiene, storage or post-production handling. The findings therefore suggest that while most yoghurt brands marketed in Elele are microbiologically acceptable, stricter adherence to Good Manufacturing Practices (GMP), Good Hygienic Practices (GHP).

5 CONCLUSION

This study showed that the yoghurt brands examined differed in both nutritional and microbial quality. The disparity noticed in moisture, ash, protein, lipid, fibre and carbohydrate contents shows disparity in the nutritional composition and production of the yoghurt. The microbial evaluation also indicated disparity in both bacterial and fungal load, with isolation of *Staphylococcus aureus* in some samples and *Penicillium*, *Mucor* and *Aspergillus* among fungal contaminants. These investigations indicates that, even though the yoghurt samples contributed significantly in terms of nutritional values, some products may be susceptible to microbial contamination, majorly via improper production hygiene, post-production handling storage. This study therefore, highlights the necessity for strict compliance to proper manufacturing and sanitary conditions, effective quality control measures, appropriate cold-chain control during manufacturing, distribution and storage of the yoghurt product to protect the health of consumer and maintenance of product quality.

STATEMENTS ON COMPLIANCE WITH ETHICAL STANDARDS

Acknowledgments

The authors are highly grateful to the management and staff of Madonna University and the department of Microbiology in particular, for making their laboratories available for this research work. We are indeed grateful.

Funding Source

All the authors jointly funded the research, by taking care of all the expenses that had to do with the study, including sample collection, laboratory analysis and manuscript preparation, the support was made available through individual contribution of authors.

Disclosure of conflict of interest

Authors have declared that no competing interest exist.

Statement of ethical approval

The authors highly appreciate the management and staff of Madonna University and the department of Microbiology in particular, for making their laboratories available for this research work. We are really grateful.

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