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Research Article

Bacteriological and Mycological Quality Assessments of Selected Soaps Sold in North-West, Nigeria

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ABSTRACT

This study examines the microbial quality of forty soaps sold in Katsina, Kano, Kaduna, and Jigawa States markets by evaluating the presence and load of bacteria and fungi in various soap brands. Samples were collected from various vendors in these markets and analysed using standard microbiological techniques, including total viable counts and total bacterial and fungal counts. Inadequate manufacturing processes, contamination during handling, and improper storage can compromise the microbial quality of soap, posing potential health risks. According to the results, there were different degrees of microbial contamination along with possible pathogens such *Candida albicans, Escherichia coli, and Staphylococcus aureus*. Among the several brands, laundry soap was the least effective, and the most common microorganisms found were *Staphylococcus aureus and Candida albicans*. Multipurpose and medicated soaps showed a strong positive connection ($r=0.710$, $P<0.01$). The microbial load may have been influenced by elements like subpar raw materials and inadequate packing. The results show that in order to guarantee the safety of soap products in these markets, stronger quality control procedures and regulatory enforcement are required.

Keywords: Bacteria; Brands; Fungi; Quality; Soaps

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INTRODUCTION

In North-western Nigeria, the quality of commercial soaps varies greatly, with a significant percentage falling short of established standards. Therefore, strict enforcement of regulatory standards, consumer education regarding the importance of buying products from reliable sources, and support for local manufacturers who are dedicated to quality are all necessary to address the soap quality disparity (Mohammed and Usman, 2018).

Vegetable and/or animal fats are reacted with either potassium hydroxide (KOH) or sodium hydroxide (NaOH) to create soap. Triglycerides are hydrolysed using a base (NaOH or KOH) in the "saponification" process, which yields three molecules of salt (soap) and glycerol. The choice of base affects how the molecules crystallize. Potassium hydroxide (KOH) is more commonly used for liquid or soft soaps, but NaOH yields a tougher bar (Mohammed and Usman, 2018). The reaction equation is thus:

Oil + 3NaOH = Glycerol + 3 Soap

A fatty acid molecule dissolved in salt is called soap. The carboxylic acid group on one end of a soap molecule's lengthy hydrocarbon chain forms an ionic bond with a metal ion, typically potassium or sodium. While the hydrocarbon end is non-polar and highly soluble in non-polar substances, the ionic end is soluble in water. Soaps have the ability to clean because they can emulsify or disperse substances that are insoluble in water and hold them in a water suspension (Mohammed and Usman, 2018).

From a chemical perspective, soap is a cleaning agent that is an alkali metal salt of long-chain monocarboxylic

acids. On the other hand, soap is represented by the formula CH_3COONa, in which R-is the hydrocarbon chain and R-COONa is the polar group that is hydrophobic. A hydrophilic carbon chain of 12 to 18 is seen in useful soaps. Abubakar and Anih (2012) stated that soap cannot remove oil if its hydrophobic fraction has fewer than 12 carbon atoms; if it contains more than 18 carbon atoms, the soap is effectively a detergent, even if the word "detergent" is only used to describe manufactured detergent.

Microbial screening is the process of testing and analyzing samples for microorganisms, such as bacteria, yeast, and mold to determine their presence, type, and quantity. The goal of microbial screening is to ensure the safety and quality of various products such as cosmetics and personal care products, food and beverages, pharmaceuticals and medication, environmental and water samples, and soil and agricultural products (Kumar *et al.,* 2018). Therefore, the current study focuses on microbial analysis of soaps sold in some states in northwest geopolitical zone in Nigeria.

MATERIALS AND METHODS

Study Area

In the sampling states (Katsina, Kano, Kaduna, and Jigawa), all of the soap samples were collected randomly from different vendors. The 29,938 square kilometre territory of Katsina State is located between latitudes 1107'N and 13032'N and longitudes 6052' and 9002". In contrast, Kaduna State is located between latitudes 10026'N and 10040'N and longitudes 7019'E and 7033'E. Kano State, which has an elevated plane of 472 meters above sea level, is located between latitudes 11055'N and 1203'N and longitudes 8027'E and 8036'E. With coordinates of 100N and 120N and longitudes of 70E and 100E, Jigawa State occupies an area of roughly 22,410 km². Figure 1 below shows a map of the study vicinity (Kano State Ministry of Land).

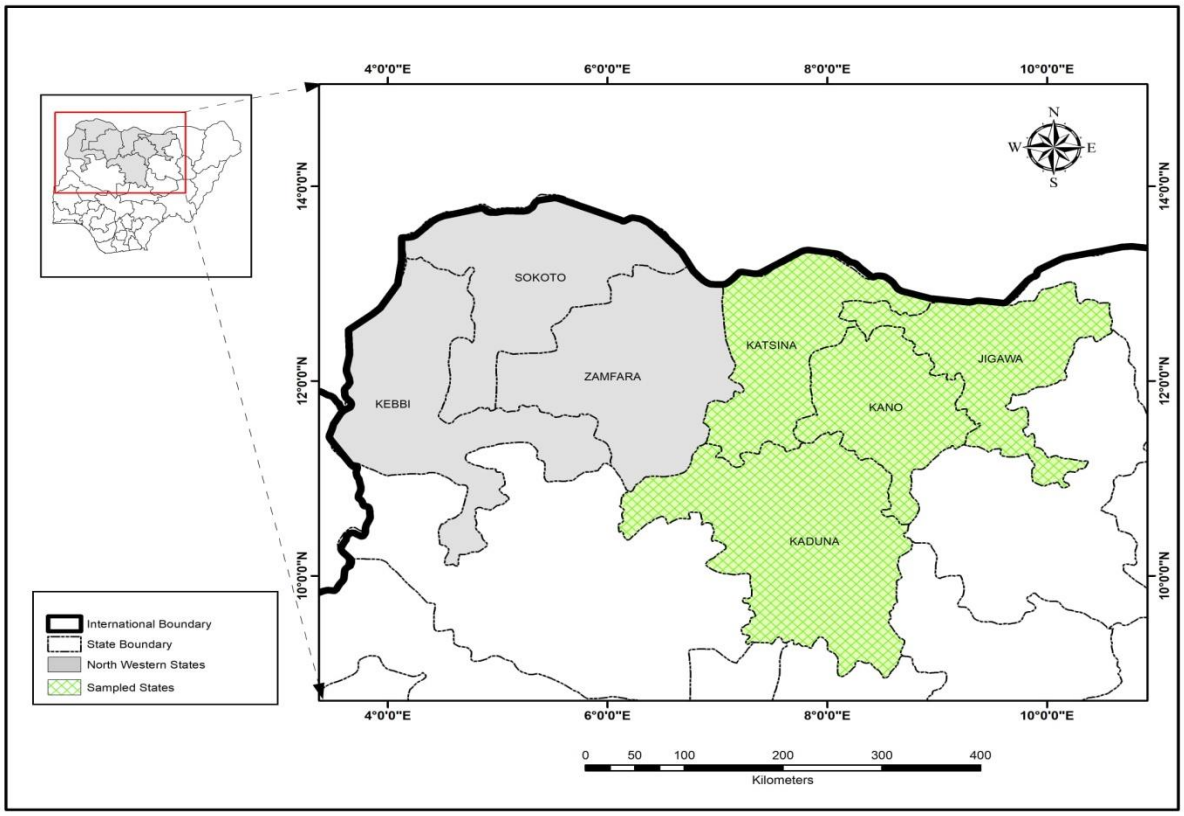

Figure 1. Map of the sampling States

Collection Samples and Processing

In the northwest geopolitical zone of Nigeria, the central markets of Katsina, Kano, Kaduna, and Jigawa were the sources of the medicinal, laundry, multipurpose, and toilet soaps. According to Ogunsuyi and Akinnawo (2012). All 40 soap samples were bought at random and aseptically delivered to the Central Laboratory of Umar Musa Yar'adua University, Katsina for analysis. A sterile grater was used to finely grind each soap sample, which was then stored in a sterile plastic container until it was needed again (Mohammed and Usman, 2018).

Preparation of Soap Extracts for microbial analysis

A sterile grater was used to finely grind each soap sample. To get a 10% soap extract, 10 g of the grated

soap was weighed and dissolved in 90 mL of sterile distilled water. After giving the mixture, a good shake to guarantee adequate dissolution, it was left to settle for half an hour. After that, the supernatant was filtered through sterile Whatman No. 1 filter paper and utilised as stock for the microbiological analysis (Cheesbrough, 2020). *Staphylococcus aureus, Escherichia coli,* and *Candida albicans* were isolated from the soap extracts using selective media:

Isolation of *Staphylococcus aureus*

Staphylococcus aureus was isolated using Mannitol Salt Agar (MSA). After inoculating into separate sterile Petri dishes, one millilitre of each soap extract, followed by addition of 20 millilitres of molten MSA that had been cooled to 45°C. After gently swirling the plates, they were left to set. All the inoculated plates were incubated at 37°C for 48 hours. Colonies that grew and appeared pale yellow due to fermentation of mannitol were taken as presumptive *Staphylococcus aureus* (Harrigan and McCance, 2021).

Isolation of *Escherichia coli*

Eosin Methylene Blue (EMB) Agar was employed to isolate Escherichia coli in a selective manner. Twenty millilitre (20 mL) of molten EMB agar (cooled to 45°C) was poured to sterile Petri dishes after one millilitre of each soap extract had been added and the inoculum was mixed by gently swirling the plates, and then allowed to set. The plates were incubated at 37^{o}C for 48 hours. Presumptive *Escherichia coli* was identified from colonies that showed a metallic green sheen, which is a hallmark of *E. coli* on EMB agar (Jawetz *et al.*, 2021).

Isolation of *Candida albicans*

To isolate *Candida albicans*, Sabouraud Dextrose Agar (SDA) was added with chloramphenicol. After adding one millilitre of each soap extract to sterile Petri dishes, 20 millilitres of molten SDA that had been cooled to 45°C was swirled and allowed to set. The inoculated plates were incubated at 25°C. *Candida albicans* was assumed to be the cause of the creamy white colonies (Samson *et al.*, 2021).

Total Viable Count (TVC)

The pour plate method was used to calculate the overall viable count. Sterile physiological saline (0.85% NaCl) was used to serially dilute 1 mL of each soap extract up to 10^{-6}. Aliquot of 1 mL of each dilution was aseptically transferred from 10^{-1} to sterile Petri plates, and each dish was filled with 20 mL of molten nutrient agar that had been cooled to 45°C. To guarantee that the inoculum was distributed evenly, the plates were gently swirled before being left to set. Every plate was incubated at 37°C. Colony-forming units per gramme (CFU/g) of each sample was determined (Cheesbrough, 2020).

Microbial Identification

To purify, representative colonies from the yeast, mould, and total viable count plates were subcultured onto new media. Gram staining and biochemical assays (catalase, coagulase, oxidase, and indole tests) were used to identify the bacterial isolates. According to conventional identification protocols, fungal isolates were identified by their microscopic and macroscopic features (Samson *et al.*, 2021).

Gram Staining

Gram-positive and Gram-negative bacteria were distinguished using Gram staining. A thin smear of bacterial isolate was made on a clean, grease-free glass slide, air-dried and heat-fixed. Crystal violet was used to stain the smear for one minute, and then it was rinsed with water. After a minute of flooding with Gram's iodine, the slide was rinsed once more. In order to achieve decolourisation, 95% ethanol was added for 20 seconds and then immediately rinsed with gentle running. Thereafter, safranin was used to counterstain for a minute, and rinsed with water then allowed to air dry. Oil immersion (100 × objectives) was used to examine the stained slide under a microscope in order to detect the Gram reaction and morphology. According to Cheesbrough (2020), bacteria that were Gram-positive were purple, while those that were Gram-negative were pink.

Biochemical Test

Different biochemical tests were carried out as described by (Cheesbrough, 2020).

Catalase Test

The catalase test was done to find out if the organism produces the enzyme, which converts hydrogen peroxide to oxygen and water. A sterile wire-loop was used to move a pinch of the bacterial colony unto a sterile glass slide. The pinch of bacterial colony was exposed to a drop of 3% hydrogen peroxide, and the reaction was monitored. Bubbles suggested that the bacteria produced catalase, indicating a positive catalase test. A negative result was indicated by a lack of bubbling.

Coagulase Test

The purpose of the coagulase test was to find out if the organism produces the coagulase enzyme. The slide procedure, which involves emulsifying a colony of the bacterial isolate in distilled water to produce a smooth suspension, was applied. The drop was placed on a sterile glass slide. After adding a drop of rabbit plasma, the suspension was mixed by gently rocking the slide. When the cells clustered within 10–20 seconds, the coagulase test was positive, indicating that the organism was coagulase positive. It was a negative test if there was no clumping.

Oxidase Test

The oxidase test was used to find out whether bacteria have cytochrome c oxidase. After being soaked in a few drops of oxidase reagent (1% tetramethyl-p-phenylenediamine dihydrochloride), a piece of filter paper was set aside on a spotless surface. A section of the bacterial colony was rubbed onto the wet filter paper using a sterile wire-loop. The presence of cytochrome c oxidase was suggested by a positive oxidase test, which developed a dark purple colour in 10–30 seconds. A bad outcome was indicated by the lack of colour change.

Indole Test

To find out if bacteria could make indole from the amino acid tryptophan, the indole test was conducted. After being inoculated into a test tube with 1% tryptone broth, the bacterial isolate was incubated at 37°C. Thereafter, 0.5 mL of Kovac's reagent was added to the broth culture. The creation of indole was confirmed by the development of a crimson coating on the medium's surface, which signified a positive indole test. A layer of yellow signified a negative outcome.

Yeast and Mold Count

Chloramphenicol (used to suppress bacteria) and Sabouraud Dextrose Agar (SDA) were used to measure the number of mould and yeast. After transferring one millilitre of each serially diluted soap extract unto sterile Petri dishes, 20 millilitres of molten SDA (cooled to 45°C) was added. To ensure that the inoculum was distributed evenly, the plates were gently swirled before being left to set. For five to seven days, the plates were incubated at room temperature (25°C). Colonies of mould and yeast were enumerated and reported as CFU/g of soap following the incubation period (Saxena et al., 2020).

Data Analysis

The data obtained from the study was analyzed using statistical package for social sciences (SPSS, Version 20). Descriptive statistic was use to describe the data. Correlation analysis was used to assess the relationships among the parameters. Analysis of variance (ANOVA) also was used to evaluate the significant differences of the soap's quality among the states in the geopolitical zone.

RESULTS

Staphylococcus aureus (SA), *Escherichia coli* (EC), and *Candida albicans* (CA) were found in four types of soaps: multipurpose, medicinal, laundry, and toilet. The results are shown in Table 1. Overall, different soap kinds and sample IDs had different levels of microbiological contamination. While EC and CA were mostly absent from multipurpose soaps, SA was found in three samples (S3, S8, S9). Only samples S6 and S10 exhibited EC detection, indicating that the medicated soaps were not heavily contaminated. Sporadic microbiological presence was found in laundry soaps; samples S7 and S5 contained CA, samples S6, S9, and S10 contained EC, and all samples lacked SA. SA was found in samples S2, S3, S5, and S9, EC in samples S5 and S8, and CA in samples S5 and S8, indicating a higher microbiological presence in toilet soaps. Notably, some soaps, especially medicated soaps, remained free from all tested microorganisms, and *Candida albicans* was the least common germ found.

Table 2 shows the mean and standard deviation values for the bacterial count in different soap samples (S_1–S_{10}). The microbial parameters measured are Mesophilic Plate Count (MP), Mould (M), Lactobacillus (L), and Total Count (T) in colony-forming units per gram (CFU/g). These values reflect the hygiene level and microbial safety of the soap products. MP values range from 23.5±1.5 CFU/g (S_8) to 140±1.0 CFU/g (S_4). Elevated MP levels in S_4 and S_5 may indicate contamination during manufacturing or poor storage conditions. In S1, the mould count was 2.5±1.5 CFU/g; in S4, it was 17.5±1.5 CFU/g. Low mould counts, as those found in S1 and S2, indicate that good manufacturing practices are being followed. From 57±0.0 CFU/g (S7) to 198.5±2.5 CFU/g (S5), lactobacillus counts vary. Although Lactobacillus is usually linked to probiotics, excessive concentrations in soap (such as S5 and S6) could be a sign of microbial contamination, which could change the product's safety and quality. The total number of bacteria varies between 23.5±2.5 CFU/g (S1) to 151±1.0 CFU/g (S9). Significant microbiological presence is indicated by high total counts in S9, S4, and S5, which could make the soap unfit for hygienic use.

Table 1. Detection of *E. coli, Staphylococcus aureus* and *Candida* species

Samples ID	Multipurpose			Medicated			Laundry			Toilet		
	SA	EC	CA	SA	EC	CA	SA	EC	CA	SA	EC	CA
S_1	-ve	-ve	-ve	-ve	-ve	-ve	-ve	-ve	-ve	-ve	-ve	-ve
S_2	-ve	-ve	-ve	-ve	-ve	-ve	-ve	-ve	-ve	+ve	-ve	-ve
S_3	+ve	+ve	-ve	-ve	-ve	-ve	-ve	-ve	-ve	+ve	-ve	-ve
S_4	-ve	-ve	-ve	-ve	-ve	-ve	-ve	-ve	-ve	-ve	-ve	-ve
S_5	-ve	-ve	-ve	-ve	-ve	-ve	-ve	-ve	-ve	+ve	+ve	-ve
S_6	-ve	-ve	-ve	-ve	-ve	-ve	-ve	+ve	-ve	-ve	-ve	-ve
S_7	-ve	-ve	-ve	-ve	-ve	-ve	-ve	-ve	+ve	+ve	-ve	-ve
S_8	+ve	-ve	-ve	-ve	-ve	-ve	-ve	-ve	-ve	-ve	+ve	-ve
S_9	+ve	-ve	-ve	-ve	-ve	-ve	-ve	+ve	-ve	+ve	-ve	-ve
S_{10}	-ve	-ve	-ve	-ve	-ve	-ve	-ve	+ve	-ve	-ve	-ve	-ve

Key: SA=*Staphylococcus aureus*, **EC**= *Escherichia coli* and **CA**= *Candida albicans* **+ve**= detected in the soap, -**ve** = not detected in the soap

Table 2. Mean and standard deviation values for soap bacterial count

Samples	MP ($X10^{-6}$) CFU/g	M ($X10^{-6}$) CFU/g	L ($X10^{-6}$) CFU/g	T ($X10^{-6}$) CFU/g
S_1	25.0±1.0	2.5.0±1.5	108.5±2.5	23.5±2.5
S_2	39.0±2.0	6.0±1.0	79.0±1.0	108±3.0
S_3	56.5±0.5	16.5±1.5	82.0±3.0	59.5±1.5
S_4	140.0±1.0	17.5±1.5	64.0±3.0	84.0±1.0
S_5	86.0±2.0	9.0±0.0	198.5±2.5	43.5±0.5
S_6	57.0±2.0	12.0±1.0	172.5±4.5	87.0±1.0
S_7	75.5±0.0	7.0±0.0	57.0±0.0	30.5±0.0
S_8	23.5±1.5	12.5±0.5	148.5±4.5	74.0±0.0
S_9	82.5±6.5	6.5±0.5	88.5±0.5	151.0±1.0
S_{10}	49.5±1.5	11.0±0.0	129.5±1.5	67.0±0.0

Key: **MP**=Multipurpose, **M**=Medicated, **L**= Laundry and **T**= Toilet soap

The mean and standard deviation of the yeast and mould counts in colony-forming units per gramme (CFU/g) for the different types of soap (multipurpose, medicated, laundry, and toilet soaps) are shown in Table 3. Microbial contamination levels, a crucial component of soap product quality and safety, are reflected in the data. 4.0±1.0 CFU/g (S3) to 46±1.0 CFU/g (S9) are the range of MP values. High levels of mould and yeast in MP samples like S9 and S8 point to possible contamination hazards during storage or production. From 0.5±0.5 CFU/g (S1) to 10.0±1.0 CFU/g (S8), mould levels vary.

Although medicated soaps contain antimicrobial ingredients, it is typically believed that their bacteria loads will be reduced. Although some samples (like S1) fit this description, others (like S8 and S10) have high numbers, which may lessen the effectiveness of the samples. Among the samples, laundry soap has the greatest levels of mould and yeast, with counts ranging from 10.0±1.0 CFU/g (S3) to 49±2.0 CFU/g (S6). The use of inferior raw materials or inadequate sterilisation procedures may be the cause of the increased numbers. Microbial counts in toilet soap samples range from 4.5±0.5 CFU/g (S3) to 39.5±3.15 CFU/g (S6). Increased counts in samples such as S6 and S10 suggest the possibility of contamination, which could compromise the soap's efficacy as a sanitary product.

Based on viable microbiological counts, Table 4 displays the findings of the ANOVA for microbial study of various soap brands (toilet, laundry, medicinal, and multipurpose). Toilet soap (54.86 CFU/g), laundry soap (85.53 CFU/g), medicated soap (7.73 CFU/g), and multipurpose soap (48.04 CFU/g) were the brands with the highest mean microbiological counts. These products' comparatively high standard deviations (SD)—44.60 for toilet soap, 64.42 for laundry soap, 5.74 for medicinal soap, and 39.61 for multipurpose soap—reflected variations in the levels of microbiological contamination. For every brand, the sample size (N) remained constant at 40.

P-values for microbiological characteristics were found to be 0.49 for toilet soap, 1.00 for laundry soap, 1.00 for medicated soap, and 0.49 for multifunctional soap, according to the analysis. At the traditional significance level ($P < 0.05$), these P-values show no statistically

significant difference in viable microbial counts between the various soap brands.

Table 3. Mean and standard deviation values for soap yeast and mould count

Samples ID	MP ($X10^{-6}$) CFU/g	M ($X10^{-6}$) CFU/g	L ($X10^{-6}$) CFU/g	T ($X10^{-6}$) CFU/g
S1	10.5±1.5	0.5±0.5	11.0±0.0	13.5±0.5
S2	7.0±0.0	3.0±1.0	16.5±0.5	8.0±1.0
S3	4.0±1.0	2.0±0.0	10.0±1.0	4.5±0.5
S4	7.0±1.0	2.0±0.0	24.5±0.5	15.0±1.0
S5	11.0±0.0	7.5±1.5	29.0±2.0	18.5±0.5
S6	23.5±1.5	6.5±1.5	49±2.0	39.5±3.1.5
S7	12.0±2.0	2.0±1.0	14.0±1.0	29.0±3.0
S8	28.5±2.5	10.0±1.0	44.5±2.5	27.5±1.5
S9	46±1.0	5.5±0.5	14.5±2.5	39.5±1.5
S10	21.5±1.0	9.5±2.5	40.0±0.0	38.0±1.0

Key: **MP**=Multipurpose, **M**=Medicated, **L**= Laundry and **T**= Toilet soap

Table 4. ANOVA for Microbial analysis of soaps

Brand	Mean	SD	P-value	Microbial parameter
Toilet	54.86	44.60	0.49	
Laundry	85.53	64.42	1.00	Viable count
Medicated	7.73	5.74	1.00	
M/Purpose	48.04	39.61	0.49	

The findings of a Pearson correlation study between microbiological counts and various soap brands (multipurpose, medicinal, laundry, and toilet soaps) are shown in Table 5. Several soap types showed significant relationships with one another, as shown by P-values less than 0.01. A strong positive connection (r=0.710, P<0.01) is seen between multipurpose soap and medicated soap, a moderate positive correlation (r=0.410, P<0.01) with laundry soap, and a strong positive correlation (r=0.579, P<0.01) with toilet soap. There was a somewhat positive connection between laundry soap and multifunctional soap (r=0.410, P<0.01), medicinal soap (r=0.547, P<0.01), and toilet soap (r=0.479, P<0.01).

A moderate positive association with medicinal soap (r=0.540, P<0.01), a strong positive correlation with multifunctional soap (r=0.579, P<0.01), and a moderate positive correlation with laundry soap (r=0.479, P<0.01) are all shown by toilet soap.

The dendrogram shown illustrates a hierarchical clustering analysis of microbial activities across four soap types: multipurpose, medicated, toilet, and laundry soaps. The analysis uses single-linkage clustering based on the correlation coefficient distance to group the soaps based on their microbial activity profiles. The vertical axis represents the similarity level, with a higher percentage indicating greater similarity between clusters. Key observations include: Cluster 1: Multipurpose and medicated soaps are grouped at a similarity level of approximately 92.46%, suggesting a high level of similarity in their microbial activity patterns. Cluster 2: Toilet soap is closely linked to the multipurpose-medicated cluster, forming a second-tier cluster at a similarity level of 84.92%. Cluster 3: Laundry soap is the most distinct, joining the other groups at a lower similarity level of 77.37%.

Table 5 Correlations analysis between microbial count and different soap brands

Multipurpose	Pearson Correlation	--			
	N	40			
Medicated	Pearson Correlation	.710**	--		
	Sig. (2-tailed)	.000			
	N	40	40		
Laundry soap	Pearson Correlation	.410**	.547**	--	
	Sig. (2-tailed)	.009	.000		
	N	40	40	40	
Toilet soap	Pearson Correlation	.579**	.540**	.479**	--
	Sig. (2-tailed)	.000	.000	.002	
	N	40	40	40	40

**. Correlation is significant at the 0.01 level (2-tailed).

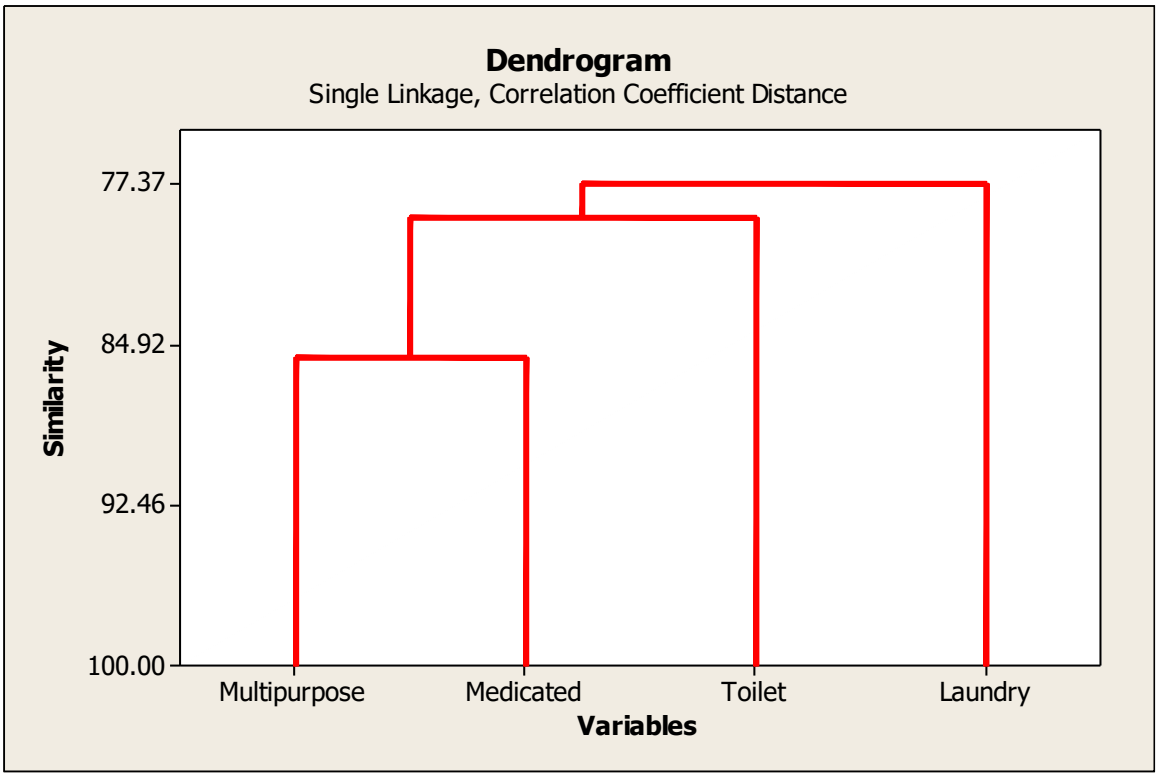

Fig. 2. Dendrogram showing relationship between the soap brands

DISCUSSION

The detection of *Staphylococcus aureus* in multiple soap types is concerning as SA is a pathogenic bacterium that can cause skin infections or other health complications (WHO, 2018). *Escherichia coli*, indicative of fecal contamination, was less commonly detected but raises significant safety issues when present, as observed in S3 and S5 (ISO 21149:2017). The absence of *Candida albicans* in most samples is a positive finding, suggesting that fungal contamination is less prevalent than bacterial contamination. Medicated soaps performed the best, with no microbial contaminants detected, likely due to their antimicrobial formulations.

However, the contamination found in toilet, laundry, and multipurpose soaps points to either poor post-production handling or manufacturing errors. Poor raw material quality, insufficient sterilisation during production, and storage in less-than-ideal environmental conditions are some of the factors that might lead to contamination. The existence of harmful bacteria in soap undermines its purported hygienic properties and may actually spread illness rather than prevent it (Chukwu *et al.*, 2020).

Microbial contamination across soap samples revealed variable microbial count. Elevated microbial counts, as observed in S_4, S_5, and S_9, could result from improper

handling, inadequate sterilization, or poor packaging, leading to potential health risks (Akpan *et al.*, 2021). Samples with low bacterial counts (e.g., S_1, S_8) indicate better compliance with hygienic standards during manufacturing and storage (Chukwu *et al*., 2020).

Elevated microbiological counts, as shown in S4, S5, and S9, may be the result of improper handling, inadequate sterilisation, or inappropriate packaging, and they may present health risks (Akpan *et al.*, 2021). Samples with low bacterial counts (like S1, S8) exhibit better adherence to hygienic norms during production and storage, claim Chukwu *et al.* (2020).

Yeast and mould counts (Table 3) varied significantly throughout soap varieties, indicating irregular production and storage methods. Due to improved quality assurance procedures, such as adherence to sterilisation requirements, low counts in S1 (Medicated soap) and S3 (Multipurpose soap) show successful microbiological control (Akpan *et al.*, 2021). High levels of S6, S8, and S9 in different kinds of soap, however, are alarming since they could jeopardise product safety and cause spoiling while being used or stored (Okoro *et al.*, 2019).

Due to their antibacterial qualities, medicated soaps should have the lowest microbial counts (WHO, 2018). But samples like S8 and S10 show notable variations, which raise concerns regarding possible post-production contamination or the sufficiency of the active components. Conversely, laundry soaps exhibit consistently high microbiological counts, which are probably caused by the use of raw materials that are not of cosmetic quality or by lax quality control procedures (Chukwu *et al.*, 2020).

Important information about the degrees of contamination in various soap kinds can be found through the microbiological analysis of soaps. The lowest mean microbial count (7.73 CFU/g) and smallest standard deviation (5.74) were found in medicated soaps, indicating superior antibacterial qualities and consistency in quality. This result is consistent with other research highlighting the antimicrobial effectiveness of medicated soaps, which generally include active ingredients intended to prevent the growth of microorganisms (Smith *et al.,* 2020).

With a high standard deviation (64.42) and the highest mean microbial count (85.53 CFU/g), laundry soaps demonstrated a notable degree of variability in microbial contamination. The lack of antimicrobial ingredients in the majority of laundry soaps and differing manufacturing standards may be the cause of this outcome (Jones *et al.,* 2019). With similar P-values of 0.49, toilet and multipurpose soaps showed intermediate levels of microbial counts (54.86 CFU/g and 48.04 CFU/g, respectively). These soap varieties' significant standard deviations point to a lack of consistency in microbial contamination, which may be caused by variations in the raw materials or manufacturing techniques (Brown and Green, 2018).

Overall contamination levels among soap types appear to be rather stable, as indicated by the non-significant P-values for all brands, which show that the observed variances in microbial contamination are not statistically significant. However, some brands, particularly laundry soaps, have high microbe counts that may be harmful to health, especially for people with weakened immune systems (WHO, 2021).

The correlation study (Table 4) demonstrates how microbial contamination in various soap brands is interconnected. Multipurpose and medicinal soaps had a substantial positive association ($r=0.710$, $P<0.01$), which implies that the two categories may have comparable production or storage conditions that lead to microbial contamination. This result is consistent with earlier studies that highlighted how shared resources and facilities contribute to the cross-contamination of personal hygiene items (Jesumirhewe and Timothy, 2024).

The fact that laundry soaps exhibit moderate relationships with other soap kinds (e.g., $r=0.547$, $P<0.01$) suggests that, despite their distinct qualities, laundry soaps might still be impacted by comparable manufacturing or environmental conditions. Despite being designed for cleaning, the existence of microbiological contamination in laundry soap raises questions regarding production facilities' hygienic standards (Jones and Brown, 2018). Systemic variables influencing microbial contamination are suggested by the consistent connections found across all soap brands. These elements could include the source of raw materials, the settings in which they are manufactured, or the methods used for packaging. For example, identical microbiological profiles across products may result from poor storage conditions or insufficient sterilisation during production (WHO, 2021).

The strong positive correlations also show that there is a chance that microbial contamination can spread from one product to another, especially in shared-use environments like homes or marketplaces. In order to reduce health hazards, this emphasises the necessity of more stringent quality control and microbiological monitoring throughout the production and distribution processes.

The dendrogram reveals significant relationships and differences in microbial activities among the four soap types, reflecting shared and distinct characteristics influenced by their formulations and intended

purposes. The close clustering of multipurpose and medicated soaps indicates that these two types share similar microbial activity levels. This could be attributed to overlapping production processes or comparable formulations, including the potential presence of antimicrobial agents. Medicated soaps are designed for antimicrobial efficacy, while multipurpose soaps may incorporate mild antimicrobial properties for versatile use. This similarity aligns with findings by Smith *et al.* (2020), which highlighted comparable microbial profiles in soaps with overlapping ingredient compositions. Toilet soap joins the multipurpose-medicated cluster at a slightly lower similarity level, suggesting that while it shares some characteristics, it also exhibits distinct microbial activity patterns. This difference may stem from variations in raw materials, antimicrobial additives, or manufacturing hygiene (Brown and Green, 2019). Toilet soaps are primarily intended for personal hygiene but often lack the stringent antimicrobial formulations found in medicated soaps. Laundry soap is the most dissimilar from the other types, clustering at the lowest similarity level of 77.37%. This result highlights the unique microbial activity patterns of laundry soap, likely due to its specific formulation, which prioritizes stain removal and cleaning over microbial inhibition (Jones and Green, 2018). The distinct clustering also reflects the variability in microbial contamination levels observed in laundry soaps, as shown in previous studies. The clustering patterns suggest systemic factors influencing microbial activities in soaps, such as production environment or storage conditions. The distinct position of laundry soap underscores the need for stricter quality control measures for this product category to address microbial risks, particularly since its primary use involves fabric cleaning rather than direct skin contact (WHO, 2021). The clustering of multipurpose, medicated, and toilet soaps may point to shared contamination risks in manufacturing or supply chains. Addressing these risks requires targeted interventions, such as enhanced sterilization protocols, ingredient quality assessments, and improved storage conditions (Brown *et al.*, 2019).

CONCLUSION

Based on the microorganisms recovered, the microbial analysis of this study revealed that the laundry, toilet, medicinal, and multifunctional soaps sold in the North-west geographical region in Nigeria are subpar and have high microbial contamination. This suggests that inferior soaps are sold in the Northwest, which could have a detrimental effect on customers.

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