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CONSUMERS' SAFETY OF SOME SELECTED READY TO EAT AND STREET VENDED FOODS IN WUDIL, KANO STATE AS DETERMINED BY MICROBIAL CONTENT

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Abstract

Because of their cost, affordability, availability and simplicity to prepare, ready-to-eat foods are highly consumed in all over Nigeria, therefore critical to Nigerians' health. This research aimed at ascertaining the consumers' safety in terms of microbial load in ready-to-eat sell on the street *Awara* (Steamed Cowpea Beans Slurry) and *Moin-moin* (Bean pie) sold in three different vending locations retailed to the students of Aliko Dangote University of Science and Technology Wudil, Kano state Nigeria. Total of 24 samples consisting of equal quantity of *Awara* (Bean pie) and *Moin-moin* (Steamed Cowpea Bean Slurry) were collected from three different location in Wudil town and analyzed for total aerobic bacteria, fungi and *Staphyococcus* count. Seven different species of microorganism of health concern were identified to include *Micrococcus spp, Staphylococcus aureous, Bacillus spp., Klebsiella spp., Mucor, Rhizophus stoonifer and Aspergillus flavus.* The total mean of the aerobic bacteria, fungi and Staphylococcus count across all the location in all the samples were found to be withing the tolerable range with the standard set by the International Commission for Microbial Specification for Foods (ICMSF) and Food and Environmental Hygiene Standard (FEHD) as well as the South Wales Food Authority Standards for ready-to-eat foods. Higher microbial counts were founds on *Moin-moin* sample and this may be attributed to its high moisture content which is found to range from 64.2 to 70.0 %. The comparison of this research findings with international standard justified the safety of consumers and conclude the acceptability of these foods as safe to eat even though the presence of microorganisms such as *Aspergilus spp.* has been found to pose serious public health issue such as aflatoxin intoxication.

Keywords: street foods, ready-to-eat, health, microorganism, food safety, contamination, traditional foods, consumers.

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1. Introduction

Lack of sufficient protein in most of African diet has been a great setback to nutrition and human development in the region [1], several campaigns were launch in the region to curtail the rise of Protein Energy Malnutrition (PEM) this includes promotion for utilization of indigenous protein rich crops such as cowpea and soybean. Though, even before that Cowpea and soybean are widely utilized alone or in combination with other food crops in African dishes, *Awara* and *Moin-moin* are the most common products and had been of acceptance across many communities in Africa, this is maybe due to their ease of preparation, nutrition, accessibility and affordability, they are mostly produce in almost all food restaurant and or street vended as ready to eat foods.

Awara is produced from dehulled, wet milled soybean paste. The paste is produce by milling of a dehulled soybean seed water soaked overnight, the paste is filtered first to obtain a soy milk which is cooked with coagulum to coagulate the milk casein and then dewatered to obtain a coagulated solid mass, the mass is then diced to a smaller sizes, fried in oil and eaten with pepper or sauce. *Moin-moin* on the other hand is a gel produced by heating slurry containing cowpea beans solid of 15 % to above. The procedure for production involves the dehulling of the cowpea beans followed by wet milling into a paste. The hard paste is then mixed with water, vegetable oil, pepper, seasoning and other ingredients (based on preference) to form a homogenous mixed, the slurry mix is then packed into a shaped container (usually a one side open tin of canned milk) or into a transparent nylon, cooked in a boiling water or steam to solidify it into irreversible gel at 73 to 87 °C for 30 minutes to 1 hour. Due to the nature of their production process retailing (usually open in public places) and handling, *Awara* and *Moin-moin* are prone to easy microbial contamination either from the ingredients, water source, the retail process or the retailer, and the retailing environment. The

high moisture content in *Awara* (64 %) and *Moin-moin* (73 %) is also a great concern because, high water activity has been linked to increase food spoilage due to increase in microbial growth, providing good media for the proliferation of different bacteria species [2].

However, despite their economic, social and nutritional advantage, ready-to-eat street vended foods such as *Awara* and *Moin-moin* has been found to inflict potential foodborne hazard/disease [3–6] because the nature of their point of sell (the street) these foods are easily contaminated from different factors including the surrounding air, the water source and the food handlers [6]. Although street food vending is critical to food security in low-income countries [7] such as Nigeria, however there is no standard procedure for determining the risk of microbial, chemical and or toxicological hazard of the foods [8]. According to Katase [9] for a production of highly quality safe foods for mass consumption, there should a well plan advocacy/sensitization program focusing on controlling to reduce the microorganism contamination in foods during and after processing. Fortunately, production of ready to eat street vended foods are not well planned, and the advocacy for the adoption of safety food production practice is poor in Nigeria. In Nigeria these foods are produced and retailed around crowded and intense traffic centers of the street this is maybe to attract more customers, these street also are located beside dumping sites, dusty roads, heavy gutters which could encourage deposition of bio aerosols. Also, from the handling perspective, Most of street food sellers are unhygienic, serving the foods with uncontrolled hand handling using bare hands making them becoming vehicle for microorganisms contamination through their hands, mouth, skin among others because they most at time did not practice proper personal hygiene or correct food preparation, [10, 11]. Studies in Nigeria have linked street foods to frequent contamination with hazardous microorganisms, Oyet et al., [6] reported heavy contamination of street foods vended in Porthacourt streets with *E. coli, Bacillus spp., Salmonella, S. aureous,* and *Mould.* [5] reported contamination of meat pie, beef sausage roll, egg roll, peeled orange, walnut and apple on Onitsha-Warri with *E. coli, Shigella spp. Enteroccci, Aspergillus niger Bacilus spp., Salmonella, S. aureous, Pseudomonas* and *Mould* other reports can be found in [12–18]. Presence of these organisms is of serious consumer health concern. Recently, research has shown that over 200,000 people die every year in Nigeria due to food poisoning caused by food contamination [19] this troll include 60 cases and 3 death due to foodborne outbreak among people that ate during a funeral service as reported by [20].

Street foods in Nigeria, despite their potential risks are part of the catering business especially in the urban and semi urban areas such as Wudil and are utilized by all classes, in Wudil town these foods are consumed mostly by students and staffs of the Aliko Dangote University of Science and Technology may be due to their always availability, closeness to study center, lack of standard and affordable eateries in the schools and or busy of the consumers, as such very critical to the university safety. Thus this study is carried out to investigate the safety of the university community based on their preference on the most common utilized ready to eat foods around the school environs.

2. Material and Methods

2. 1. Sample Collection

Total of 24 samples comprising of twelve each of *Awara* and *Moin-moin* were collected three retailing locations Yan-kwaya, KUST cafeteria and Kofar Fada over one week period in October 2022 at point of sale in a fresh and sterile containers and taken covered in cod packs aseptically to the food analysis (formerly physiochemical) laboratory of the Aliko Dangote University of Science and Technology Wudil for microbial analysis within one hour of collection.

2. 2. Sample Preparation

The *Awara* and *Moin-moin* were chopped into very small pieces (less than 10 mm) with a sterilized knife. 11g of each sample was transferred into a sterilized dilution bottle containing 99 ml of 0.1 % peptone water, and were blended and mixed thoroughly into a homogenate this labelled 10^{-1} for subsequent dilution procedure.

All media were prepared according to manufacturer's instruction written on the packs.

2. 2. 1. Study Location

This study was conducted in a semi-urban location in Kano state. Wudil town in Wudil local government Kano state Nigeria. Wudil is one of the semi-urban and heavily populated towns in Kano state, it is located in the southern zone of Kano along A237 highway of Kano-maiduguri road on 11°49'N and 8°51' coordinates (**Fig. 1**). It has a population of 185,189 people as of 2006 census with a land are of 362 km^2.

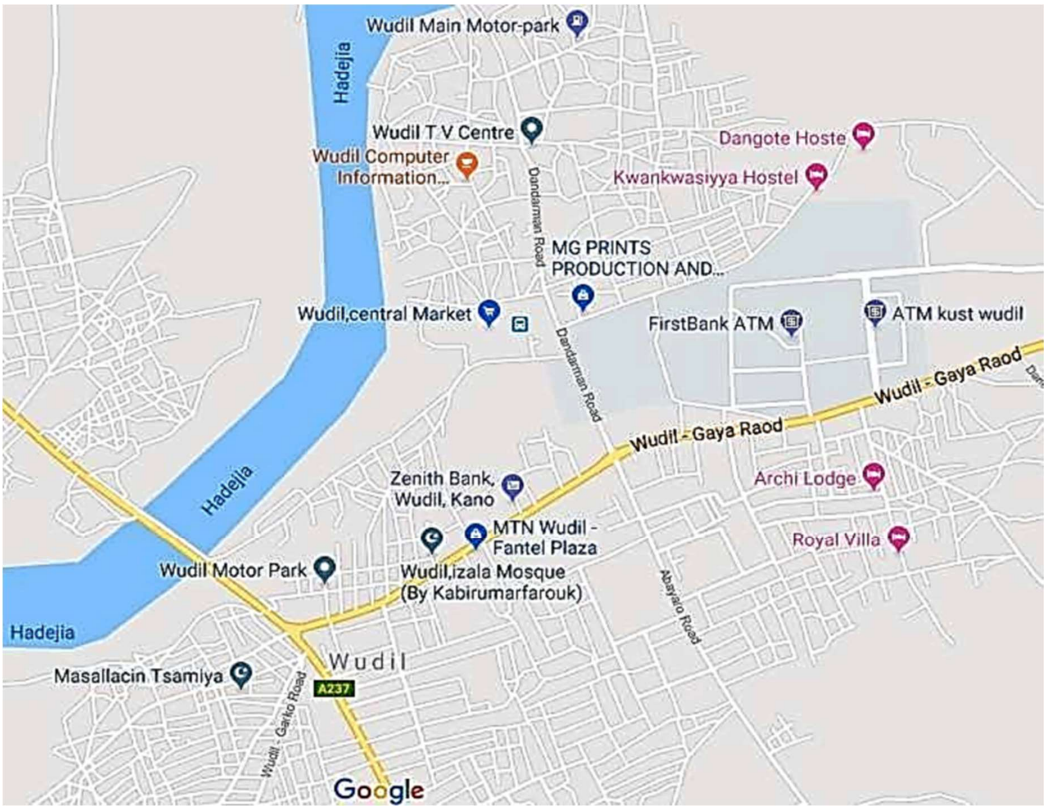


Fig. 1. Google map showing Wudil

2. 3. Microbiological Analysis

The serial dilution procedure of the American Public Health Association [21] were adopted for the determination of the total bacteria, fungi and staphylococcus count in a Nutrient Agar, Potatoes Dextrose and Baird Packer Media while Three Tube MPN technique was adopted for the determination of Coliform count in a MacConkey broth.

2. 3. 1. Enumeration of aerobic mesophilic bacteria

From 10^{-1} diluent, 1m was transferred to another dilution bottle containing 9m of 0.1 % peptone water and this give 10^{-2}, another 1m was pipetted to next dilution bottle labelled 10^{-3} and the procedure continues to 10^{-5} dilution, all the dilution bottles were shake vigorously to conform even distribution of the diluent solution.

1 ml from each dilution bottle was pipetted into a corresponding duplicate petri dishes labelled according to the dilution. About 15 ml of Nutrient Agar (supplemented with Antibiotic) that was cooled to 45 °C was then poured on to the dish containing the homogenate. The dish containing the media and the homogenate were then mixed by rotating the plate on a plat surface and allowed to solidify at room temperature before incubation in an inverted form at 35 °C for 48 hours in a controlled oven incubator.

After the incubation, plates that show growth were counted using a colony counter, plates with 30–300 colonies were selected and the count obtained was multiplied by the dilution factor

for the corresponding dish and this gave the number of the colony forming unit per gram (CFU/g) of the sample.

2. 3. 2. Enumeration of aerobic mesophilic fungi

From 10^{-1} diluent, 1m was transferred to another dilution bottle containing 9 m of 0.1 % peptone water and this give 10^{-2}, another 1m was pipetted to next dilution bottle labelled 10^{-3} and the procedure continues to 10^{-5} dilution, all the dilution bottles were shake vigorously to conform even distribution of the diluent solution.

1 ml from each dilution bottle was pipetted into a corresponding duplicate petri dishes labelled according to the dilution. About 15 ml of Potatoes Dextrose Agar (PDA) that was cooled to 45 °C was then poured on to the dish containing the homogenate. The dish containing the media and the homogenate were then mixed by rotating the plate on a plat surface and allowed to solidify at room temperature before incubation in an inverted form at 35 °C for 48 hours in a controlled oven incubator.

After the incubation, plates that show growth were counted using a colony counter, plates with 30–300 colonies were selected and the count obtained was multiplied by the dilution factor for the corresponding dish and this gave the number of the colony forming unit per gram (CFU/g) of the sample.

2. 3. 3. Test for coliform bacteria

Three tubes Most Probable Number (MPN) technique was used for enumeration of coliform: Aseptically, 11 g of the *Awara* and *Moin-moin* samples were transferred in to a sterile blender jar, and 11 ml of 0.1 % peptone water was added to the blender jar and blend for 2 minutes.

From the homogenate mixture, 1 ml was transferred to a 9 ml dilution bottle containing MacConkey broth to make $1{:}10^{-1}$, this dilution is repeated up to 10^{-3} dilution in triplicate. The dilution was shaken vigorously 25 times in 7 seconds. They were all labelled according to their dilution before incubation for 24–48 hours at 35 °C. After incubation positive tubes were observed for acid production (detected by change in color to yellow) and gas formation in either inverted vial or through effervescence when shaken. The number of positive bottles were counted and referred to MPN table for three tube technique.

2. 3. 4. Confirmatory test for coliform

Small portion from the positive coliform bottles was inoculated using 3 mm loop into a fresh tubes containing Brilliant Green Lactose Broth (BGLB) and incubated at 35 °C for 48 hours. Tubes that shows gas formation were physically studied and counted, the count was the referred to MPN table for 3 tubes dilution and the value recorded as coliform count per gram of the food sample.

2. 4. Isolation and identification

2. 4 .1. Isolation and identification of bacteria associated with street foods

From the positive plates that shows growth of bacteria. The color, shape and microscopy of the bacteria was studied. Representative colonies were selected from plates that shows identical characteristics and re-cultured on a fresh NA dish at 35 °C for 24 hour for a pure culture growth [22].

The gram staining technique as described in [23] was employed for bacteria identification. A portion of the bacteria colony from the pure culture plate was transferred on to surface of a cleaned glass slide using wire loop. A drop of distilled water was added and about 17 mm thick smear was made by gentle mixing of the colony drop with distilled water on the surface of the glass slide, it was then allowed to air dry before passed over a Bunsen flame. The smear was then flooded with crystal violet (30 seconds), rinsed with clean water and then covered with gram's iodine and allowed to react for ½ a minute. Acetone alcohol was then added (allowed for 20 seconds) and the mixture was then washed on with a clean water before air dried on drying rag after covering with Saffranin for 20 seconds. The dried stained smear was then observed under microscope in oil immersion.

Purple appearance and reddish appearance under microscopic view was used to different gram positive and gram negative bacteria respectively.

2. 4. 2. Isolation and identification of fungi

Pure culture was prepared from positive plates by transferring portion of the fungi on to a fresh potatoes dextrose agar plate.

Cotton blue in lactophenol stain technique as described in [24] was used for identification of unknown fungi isolate. Small part from the fungi mycelium was transferred on to a surface of a clean slide containing lactophenol stain using mounting needle. The mycelium was spread, covered with coverslip with little pressure and then observed under ×10 and ×40 objective lenses. The unknown fungi species was identified in accordance with [25].

2. 5. Biochemical tests

Biochemical tests are series of analysis carried for specie identification of bacteria and they include; catalase, coagulase, motility, methyl red test, voges proskers test, indole test, citrate, starch hydrolysis were employed to identify different bacterial species.

2. 5. 1. Catalase test

Small portion of the pure colony is transferred into 2–3 ml of hydrogen peroxide in a test tube. Formation of immediate bubble indicate positive test. Catalase test is used to differentiate staphylococcus (positive) and streptococcus (negative catalase) species.

2. 5. 2. Coagulase test

A thick suspension was made by emulsifying the test organism in a distilled water on a glass slide. A loop full plasma was added to the suspension, immediate clumping within 10 second indicate positive test. Coagulase test is used to separate pathogenic staphylococcus aureous from any bacteria species.

2. 5. 3. Indole test

To a grown isolate grown in a 5 ml peptone water and incubated at 35 °C for 24 hours, add 3 drops of Kovac's indole reagent and shake gently. Red color formation indicate positive result [26].

2. 5. 4. Carbohydrate Fermentation

Involves stabbing of the pure culture into a media slant containing lactose, fructose, glucose, sucrose, maltose and raffinose followed by incubation at 28 °C. Positive result is detected by acid production.

2. 5. 5. Methyl red test

Inoculate a small quantity of the pure isolate into a sterile glucose phosphate peptone medium and incubate for 48 hours at 37 °C. After incubation, add five drops of methyl reagent, positive test is read by the formation of red color.

2. 5. 6. Voges-Proskauer test

Incubate 2ml glucose phosphate peptone water together with a portion of the pure culture at 37 °C for 48 hours. Add 1 ml of 40 % potassium hydroxide and 3 m of 5 % alphanapthal and shake at interval. Formation of pink color after 2 to 5 minute indicate positive.

2. 5. 7. Citrate utilization test

Inoculate the pure isolate into simmon's citrate agar slant and incubate for 24–72 hour. Development of deep blue color indicate positive result [25, 26].

2. 5. 8. Motility Test

Inoculate the pure isolate into a motility medium by fine stabbing with a needle (1–2 cm deep) and incubate for 24–48 hours at 35 °C. Formation of cloudiness along the sharp line indicate positive result

2. 6. Determination of moisture content

5 g of the sample was placed in a clean dish. The dish containing the sample was then transferred to and oven and dried at 105 °C to a constant weight. After 5 hours the sample is removed and cooled in a desiccator for 30 minutes and weigh again [27]. The moisture content is determine as below:

$$\text{Moisture content}(\%) = \frac{\text{Loss in sample weight}}{\text{Original sample weight}} \times 100.$$

2. 7. Data analysis

All analysis were conducted in duplicate and result were recorded in an excel sheet. Data analysis was carried out using Statistical Package for Social Science (SPSS) using analysis of variance (ANOVA) software and presented as mean of the duplicate±standard deviation.

3. Result

3. 1. Result of moisture content of *Awara* and *Moin-moin*

Table 1 below shows the result of moisture analysis. The result shows that all the sample contains significantly high amount of moisture with exist significant difference at $p>0.05$ across the samples. *Awara* sample from Yan-kwaya has the highest moisture value of 72.97 % and *Moin-moin* sample from Yan-kwaya has the lowest moisture of 64.2 %.

Table 1

Moisture contents of the Food sample

S/N	Location	Moisture content (%)	
		Awara	***Moin-moin***
1	Kust	68.93 ± 1.092^{ab}	70.4 ± 0.85^{b}
2	Wudil	67.97 ± 1.12^{c}	66.34 ± 0.35^{b}
3	Yan-kwaya	71.78 ± 1.26^{b}	65.72 ± 1.11^{a}

Note: result are presented as mean of n=24±standard deviation. All values on the same column with the same superscript did not differ at p>0.05.

3. 2. Microbial load on *Awara* and *Moin-moin*

Table 2 shows the microbial load on *Moin-moin* cross the locations. The bacteria count ranges from 45.8×10^3CFU/g in *Moin-moin* from Yan-kwaya to 36.5×10^3 CFU/g on *Moin-moin* from Kofar Fada, fungi count were found to ranges from 1.17×10^3 CFU/g on KUST sample to 1.7×10^3 CFU/g on sample from Kofar Fada and there exist no significant difference in bacteria and fungi count, *Staphylococcal* count ranges from 8.83×10^3 CFU/g on Kofar Fada samples and equal of 13.33×10^3 CFU/g in all the remaining samples, with a significant difference between the sample with highest count with the sample with the lowest count.

Table 2

Microbial load on *Moin-moin* samples across the locations

S/N	Location	Bacteri count (CFU/g)	Fungi count (CFU/g)	Staphylococcus count (CFU/g)
1	Kofar Fada ($\times10^3$)	36.50 ± 1.8^{a}	1.70 ± 0.58^{a}	8.83 ± 1.61^{b}
2	KUST Campus ($\times10^3$)	44.17 ± 7.9^{a}	1.17 ± 0.76^{a}	13.33 ± 4.7^{a}
3	Yan-kwaya ($\times10^3$)	45.8 ± 13.3^{a}	1.50 ± 0.15^{a}	13.33 ± 5.1^{a}

Note: result are presented as mean of n=24±standard deviation. All values on the same column with the same superscript did not differ at p>0.05.

Table 3 contains the result of microbial analysis across *Awara* sample. There is no significant difference in the Bacteria count, highest value of 50.56×10^3 was found in sample from Yan-kwaya and the least value in sample from KUST with 34.7×10^3 CFU/g. the fungi count show a significant difference with the highest count found in Wudil sample (2.5×10^3 CFU/g) and the least

count in Yan-kwaya samples 1.0×10^3 CFU/g. Least *Staphylococcal* count was found in KUST sample (11.3×10^3 CFU/g) and the highest in Yan-kwaya sample with 22.0×10^3 CFU/g.

Table 3

Microbial load on *Awara* samples across the locations

S/N	Location	Bacteri count (CFU/g)	Fungi count (CFU/g)	Staphylococcus count (CFU/g)
1	Kofar Fada ($\times10^3$)	44 ± 10.1^a	$2.5\pm0.8.66^b$	15.2 ± 0.76^a
2	KUST Campus ($\times10^3$)	34.7 ± 5.9^a	1.8 ± 1.0^a	11.3 ± 5.2^b
3	Yan-kwaya ($\times10^3$)	50.67 ± 6.5^a	1.0 ± 8.66^a	22.0 ± 10.6^a

Note: result are presented as mean of n=24±standard deviation. All values on the same column with the same superscript did not differ at p>0.05.

Table 4 shows the result of microbial count across the sample the samples shows no significant difference in their microbial load with the highest bacteria count found on *Awara* (42.89×10^3) and the least on *Moin-moin*, highest *Staphylococcal* count was found on *Awara* (13.9×10^3) and lowest fungi count on *Awara*.

Table 4

Mean of microbial count across the sample

S/N	Sample	Bacteria count (CFU/g)	Staphylococcal count (CFU/g)	Fungi count (CFU/g)
1	*Awara* (10^3)	42.89 ± 9.8^a	13.9 ± 4.61^a	1.8 ± 1.038^a
2	*Moin-moin* (10^3)	42.11 ± 8.9^a	11.83 ± 4.19^a	1.44 ± 0.92^a

Note: result are presented as mean of n=24±standard deviation. All values on the same column with the same superscript did not differ at p>0.05.

3. 3. Result of biochemical analysis

The result of biochemical characteristics of bacterial isolates identified across all the locations in *Awara* and *Moin-moin* was presented on **Table 5.** The isolate were identified to be *Staphylococcus aureous, Micrococcus spp., Klebsiella spp.,* and *Bacillus spp.*

Table 5

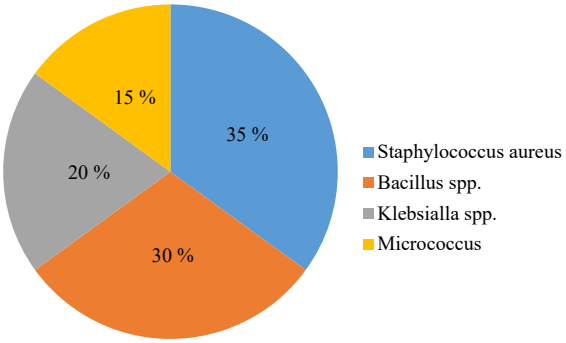
Biochemical characteristics of bacterial isolates

Colonial morphology	Gram reaction	OXI	CAT	COA	IND	MOT	CITR	MR	VP	ACID	Organism
Cream, big round colonies grow on N.A.	Gram positive cocci in cluster and in chain	+	+	–	–	–	–	–	–	–	*Micrococcus spp.*
Golden yellow cream grow on NA and B.P.A	Gram positive cocci in cluster and in chains	–	+	+	–	+	–	+	+	–	*Staphylococcus aureus*
Shiny mucoid/viscous colonies grow on N.A	Gram positive long rods	+	+	–	–	+	–	–	–	–	*Bacillus spp.*
Flat, white opaque colonies grow on N.A.	Gram positive short rod	–	+	–	+	+	–	+	+	–	*Klebsiella spp*

Note: N.A. – nutrient agar; MR – methyl red test; VP – voges proskaeurtest; OXI – oxidase; CAT – catalase; COA – coagulase; MOT – motility; IND – indole

3. 4. Occurrences of bacteria isolates across the samples

The result for the occurrence of bacteria isolates across the samples was presented on **Fig. 2**, the figure shows the occurrence of four bacteria isolate (*Staphylococcus aureus, Micrococcus spp., Klebsiella spp. and Bacillus spp.*) for both *Awara* and *Moin-moin* sample from all the three location. *Staphylococcus aureus* appear more frequently across the samples with 35 % percentage of occurrences appearing in 14 samples followed by *Bacillus spp.* with 30 % of occurrence appearing in 12 samples and *Klebsiella spp.* with 20 % appearing in 8 samples, *Micrococcus spp* has the least percentage of occurrence appear in 6 samples with 15 % of occurrence only six samples across the samples. No *Micrococcus spp.* Was detected in all *Moin-moin* samples analyzed.



ISOLATES	FREQUENCY
Staphylococcus aureous	14(35) %
Micrococcus spp.	12(30) %
Klebsiella spp.	8(20) %
Bacillus spp.	6(15) %

Fig. 2. Occurrence of bacterial isolate across the samples

3. 5. Morphological characteristics of fungi isolates

The morphology and microscopy of the fungal isolates were presented on **Table 6**, the fungi isolates were identified to be: *Mucor, Rhizopus stolonifer* and *Aspergillus flavus* according to their microscopic and morphological appearance.

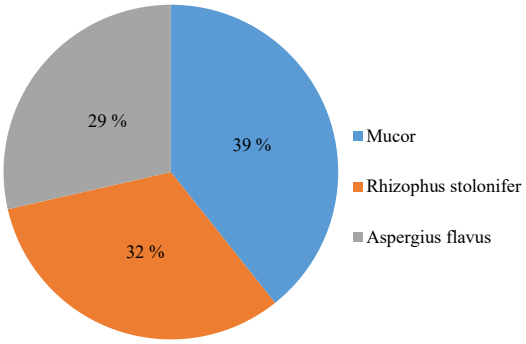
Table 6

Morphology and microscopy of fungal Isolates

S/N	Isolates	Morphological description	Microscopy	Organism
1	A	Appear white at young then grey as it age.	Single sporangiophore rising from mycelium with all branches terminating with sporangia	*Mucor*
2	B	Appear dusty, black and spongy.	Sporangiosphore rises from long stolon opposite rhizoids	*Rhizopus stolonifer*
3	C	Appear with yellowish green surface with reddish brown underneath	Bottle shaped cell formed from vesicle shaped conidiophores at apex. Have sterigmata with chained globes conidiophores	*Aspergillus flavus.*

3. 6. Occurrences of fungal isolates across the samples

Fig. 3 below shows the occurrences of fungi isolates across the sample the result shows that; *Mucor*appear more frequently with 30.6 % of appearance appearing in 11 samples followed by *Rhizopus stolonifer* and *Aspergillus flavus* with 25 % and 22.4 % frequency appear in 9 and 8 samples respectively.



ISOLATES	FREQUENCY %
Mucor	11 (39.29) %
Rhizopus stolonifer	9(32.14) %
Aspergillus flavus	8(28.57) %
TOTAL	28 (100 %)

Fig. 3. Occurrence of fungal Isolates across the *Awara* and *Moin-moin* samples

4. Discussion

The total Bacterial count ranged from 2.7×10^4 CFU/g as the minimum count observed in *Awara* sample from Kofar Fada to 5.9×10^4 CFU/gas the highest count observed in *Moin-moin* sample from Yan-kwaya. The bacteria count in this research were generally low and did not differ ($p<0.05$) among themselves, this shows that there is a significant food safety practice in the production and retailing of these food sample in the selected location. From the review, *Awara* and *Moin-moin* production involves heat treatment such as boiling and frying, it is not surprising if some of the bacteria are said to be killed by these operation. Higher bacterial load in most *Awara* sample maybe attributed to its mode of handling and process of sale. *Awara* is usually fried and cooled before retailing and the retailing involves packing the *Awara* in a cleaned bucket, it was observed that the mode at which *Awara* is served to consumer exposes it to a possible contamination from the handlers because it is usually served with bare hands and also without proper packaging. This agrees to the fact that microbiological contamination is linked to post processing handling [28, 29], therefore microbial load has been confirmed to be an excellent index for sanitary condition during and after processing as well as the food safety practice of the producers [30, 31] including their personal hygiene.

The *Staphylococcus* count generally falls below the maximum limit of 1×10^5 CFU/g recommended by the World Health Organization, [32]. The result shows Bacteria count, fungi count and *Staphylococcal* count did not differ significantly in all the location. Samples of *Moin-moin* from Wudil were found to contain significantly highest amount of the Bacteria count (36.7×10^3 CFU/g) and the lowest count found in *Moin-moin* was from Yan-kwaya samples (4.0×10^4 CFU/g), highest fungi was found in Wudil with 1.7×10^3 CFU/g to 1.17×10^3 from the lowest in KUST, the lowest *Staphylococcal* count is founded in samples from Yan-kwaya with 1.1×10^4 CFU/g to 3.73×10^4 CFU/g in Wudil sample.

Table 6 reveals the results of the Physiological and Biochemical properties of Bacteria isolated from *Awara* and *Moin-moin* samples. The isolates were identified to the genera with the exception of *Staphylococcus aureus* because of lack of some few reagents that are necessary for identification to specie level. Four Bacteria isolates were identified to be *Staphylococcus aureus, Bacillus spp., Klebsiella spp. and Micrococcus spp.* across the eighteen samples analyzed. The findings agree in some terms with the report of [10–16, 18, 20, 30, 31] which reporting *Staphylococcus aureus, Bacillus cereus, Klebsiella pnuemoniae Micrococcus spp*, as some of these microorganisms that contaminate Food. And also it is in agreement with the work [4–6, 20, 29] reporting *Bacillus spp, Klebsiella, Shigellia and E. coli* as the major food contaminants.

The occurences of bacteria isolatets in *Moin-moin* and *Awara* is presented on table 5. above. *Staphylococcus aureous* appear more frequently among all the bacteria isolated, appearing in 14 (35 %) of the 24 samples. This high occurrence of *S. aureous* agrees with the finding of [33] who reported high prevalence of *s. aureous* in street vended chicken in Nairobi. Presence of *S. aureous* indicate poor personnel hygiene because *s. aureous* is found only on the skin surfaces and nasal passage of human beings. So it is introduced into the food during processing or vending and can lead to a serious food poisoning, gastroentrities characterized by the inflammation of gastro intestinal track including the stomach and the small intestine leading to acute or sub-chronic diarrhea, vomiting, abdominal cramping and severe abdominal pain [34]. Prevalence of *s. aureous* has been reported in many foods around the word as in [35] who reported high prevalence of *s. aureous* in meat on a survey conducted at Trinidad and Tobago. Because of their susceptibility to heating and cleaning, *staph* contamination usually occur after production either through direct human contact through fingers or indirectly through contaminated utensils or food ingredients that have been handled previously with bare hands. *S. aureous* have been inflicted with endotoxin characterized by short incubation period (1–8 hours) which can cause immediate poisoning characterized by violent nausea, diarrhea and vomiting. On the other hands [36, 37] reported no *Staphylococcus* in ready to eat street vended foods in Thohoyandou in South Africa. Lack of *Staphylococcus* in food is an indication of good hygiene practices among producers and the handlers [35]. *S. aureous* has been found to be major infectious bacteria in sexually active women that can cause endocarditis and other system infection [38]. The second most prevalent bacteria isolated from *Awara and Moin-moin* is *Bacillus cereus* (**Table 5**). *Bacillus cereus* is a heat resistant spore forming bacteria found

mostly in dust, soil and raw foods, therefore their presence in foods indicate poor food preparation (even though they can survive normal cooking temperature), contamination from the surrounding usually passerby. It may also be said that this organism may have gotten into the foods from the shoe surfaces or the surface of car tires that are on a continuous move in the areas were these foods are retailed. *Bacillus cereus* found to be associated with *diarrhea* and emetic food poisoning due to toxin. They are also found to be associated with processed soy foods such as *Topu* (*Awara)* [39, 40]. *Bacillus cereus* usually appear in colonies with large, extensive and irregular shape [40] therefore hard to count.

Micrococcus specie appears in 12 samples (30 %) and is commonly isolated from soy food such as *Awara* and they often produce acidity from utilizable carbohydrates. At higher load, *Micrococcus* specie causes bacteraemia, endocarditis and septic shock, characterized by whole body inflammation.

The coliform index per 100 g of the samples ranged from <3 found in 5 of the samples to 460 as the highest found in *Awara* from Wudil sample, confirmatory test for the coliform group revealed negative result for all the samples. The result disagree with the report of [41, 42] which reported that food are contaminated with coliform most importantly *E. coli*. Presence of coliform bacteria indicates faecal contamination as these organisms are found only in the intestinal track of living organisms. Coiform such as *E. coi, Shigella dysenteriae, Streptococcus spp and Enterobacter* are of serious health concern, *E. coli* can produce toxin 0157:H7 that have been associated with haemorrhagic colitics, haemolytic uraemic syndrome and thrombotic thrombocytopenic purpura that can cause immediate death within short period of infection [43].

Low fungal count was obtained relatively in all the samples and no fungi were detected in two of the eighteen samples, maximum count was obtained in *Awara* from Yan-kwaya sample with 2.5×10^3 CFU/g. Three fungal isolates were identified from the *Awara* and *Moin-moin* (**Table 4**), these are *Mucor*, *Aspergillus flavus* and *Rhizopus stolonifer*. *Mucor* has the highest rate of occurrence appearing in 11 (30.6 %) samples, followed by *Rhizopus stolonifer* which appeared in 9 (25 %) of the samples, *Aspergillus flavus* has the least rate of occurrence, appearing only in 8 (22.4 %) of the samples. Presence of these organisms agrees with the report of [44] who reported *Aspergillus flavus, Aspergillus niger, Penicilium spp, Fusarrium, Mucor, Rhizophus stolonifer* as major contaminating fungi in foods. *Aspergillus flavus* has been reported to be associated with aflatoxin formation in foods especially grains [45] thus there presence in these food sample indicate poor preparation and possible aflatoxin food poisoning. Presence of *Mucor* and *Rhizophus stolonifer* in some of the food sample is not surprising as they are found to be associated in formation of spores that can be disperse in the surrounding air therefore can be introduced into the food through dust and soil. They are also found to be associated with myotoxin production in food which can cause serious public health issue [44, 45].

5. Conclusions

According to the specification set by the International Commission for Microbial Specification for Foods (ICMSF) [46] which said all ready-to-eat foods with plate count within the range of $0–10^{-3}$ is acceptable for consumption, between $10^{-4}\leq10^5$ is tolerable and 10^6 and above is unacceptable. Therefore based on this standard *Awara* and *Moin-moin* retailed in Wudil town have a microbial load within the tolerable range (10^4) and due to the fact that no strong toxigenic organisms has been isolated from the food such as *Escherichia coli;* a well-known diseases causing microorganisms. Throughout the analysis it was founded that the *Moin-moin* sample contain significantly more level of the isolated organism and this can be attributed for its high moisture content (64.2 % to 70.0 %) even though that the *Awara* samples are expected to have more microbial count due to its mode of sell (usually open in rubber/plastic containers and counted with bare hand during sell). The bacterial isolates were found to include *Micrococcus, Staphylococcus Bacillus spp* and *Shigellia spp* and the fungal isolates were found to include *Mucor, Aspergillus flavus* and *Rhizophus stolonifer.*

Even though, the contamination level is low compared with the standard used *Awara* and *Moin-moin* sold to the staff and students of Aliko Dangote University of Science and Technology and the people of Wudil town contain significantly some health hazard microorganisms that can

implicate health, and it is observed that majority of the food samples treated are sold by dirty and unhygienic food handlers which can possibly be vehicle for contamination and subsequently impose consumers to Health hazards.

There is need for minimized poor handling and awareness creation on personal hygiene to the retailers to reduce food safety issues and ensure consumer safety. Relevant organization and departments needed to address this urgently by training on hygiene and sanitation, provision of continuous food safety education, screening of food handlers on regular basis for carriers, and establishment of code of practice for the sale of foods in the university. The school authorities needed to improve the establishment of rudimentary water and waste management efficacies within the school mini market to diminish the gap between knowledge and practices of safe street food vending.

Conflict of interest

The author declare no conflict of interest in relation to this research.

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Data availability

Data will be made available on request.

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