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Evaluation of Storage Control Points and Implicated Pathogens on Fast Moving Consumer Goods in Suburbs of South-western Nigeria

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Authors' contributions

This work was carried out in collaboration among all authors. Author OOA designed the study and wrote the protocol. Authors CCO and MOA wrote the first draft of the manuscript. Author ED performed the statistical analysis. Author RBA managed the literature searches and the analyses of the study. All authors read and approved the final manuscript.

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ABSTRACT

Food borne illness prevention system will depend on the extent of food safety control in place through food production, processing, distribution, keeping food at safe temperature and using safe water and raw materials. These stages of production are some of the important points determining food safety. This suggests the need to implement strict hygienic control measures along the food production chain during manufacturing, handling, storage and commercialization of foods. Ninety samples comprising of fifteen Milo (beverage), fifteen golden Morn (cereal), fifteen Maggi (seasoning), fifteen Lucozade boost (energy drink), fifteen Gala (Sausage) and fifteen Indomie (noodles) were collected from five stores of various shops in Lagos, Agbara and Sango Ogun State, Nigeria. Samples were processed and cultured using pour plate and streak plate techniques. Samples were cultured in five media consisting of four selective media and a basal media; Maconkey agar, Mannitol Salt agar, Salmonella Shigella agar, Eosin Methylene Blue agar and Nutrient agar. Differentiation and isolation of various isolates were based on gram-staining

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technique and biochemical reactions using OXOID MICROBAT ™ identification kits. The *in vitro* assay revealed the presence of five bacteria species namely *Staphylococcus aureus*, *Klebsiellia oxytoca, Proteus mirabilis*, *Yersinia pseudotuberculosis* and *Morganella morganii*. Prevalence of the various isolates in the culture were found to be 67.66%, 11.27%, 9.77%, 7.51% and 3.75% respectively. The highest colony count (140.6) was obtained from samples (Maggi) from Agbara while the lowest colony count (21.0) was obtained from (Milo) Sango. The mean bacteria load of the isolates was $1.0*10^7$CFU/ml. It was concluded that the hygienic quality of the sampled fast moving consumer products in term of microbiological standards compare favourably with international benchmarks as defined by Codex Alimentarius Commission all the observed ranges of aerobic colony count fall well below the upper threshold of microbial levels for class A products.

Keywords: Pathogens; consumer goods; public health; safety control; food production; contamination.

1. INTRODUCTION

Hazard analysis critical control point (HACCP) is a risk management, science based system [1] developed to control food safety. It can be described as an operation-specific, internally managed system of preventative control that identifies, evaluates and controls hazards of significance to food safety [2]. While it has a relatively long history, originating as a mean of assuring the safety of meals produced for the first U.S. manned space program in the 1960s, it is only in the last 10 years that it has emerged as the primary approach to securing the safety of the food supply globally [3]. The HACCP approach can be used in bakeries [4], dairies, cooking oil, hotels, restaurants, meat industry, food storages, supermarkets, juice companies, chocolate company, ice cream company, catering services and agriculture products processing companies [5].

The HACCP program covers the input of the materials, production process, final products, facilities, and personnel at the Critical Control Points (CCPs). It consists of two major components: Hazard analysis and the control measure of the critical limits. Hazard analysis is the process of identifying and evaluating the potential hazard factors that may negatively affect food safety, while the control measure is to prevent or eliminate the hazards to a minimized and acceptable level. The HACCP system has been increasingly and successfully applied by the food industry and by official food control authorities to prevent and control risks associated with potential contamination of food products with pathogenic micro-organisms and chemical toxicants. Food safety programs routinely use information about the factors leading to contamination to establish preventive and control procedures, thus providing the consumer with a safe, wholesome food supply [6].

Death and hospitalization consequent to food poisoning from infectious agents are frequent and represent a serious threat for all countries. A possible solution could give more responsibility to the final consumer, using clear labels [7] which highlights products' safety, similar to the Critical Control Point (CCP) which are part of HACCP. This is extremely important for young, old, pregnant women and immune deficient people which are very sensitive to small contaminations from bacteria [8].

The food industry is only as strong as its weakest link in the food Chain. The food industry in every nation whether developed or not stand to loose if all stages in the food chain are not motivated and strengthened to use food safety approaches. The benefits of reducing hazards in food include reduced morbidity, mortality and demands on healthcare services, a reduction in absences from education or loss of productivity at work and increased consumer confidence in food safety [9]. Food quality is an important food manufacturing requirement, because food consumers are susceptible to any form of contamination that may occur during the manufacturing process. Food quality is the quality characteristics of food that is acceptable to consumers and is the quality characteristics of food that is acceptable to consumers. This includes external factors as appearance (size, shape, color, gloss, and consistency), texture, and flavour. The diseases caused by food, or the food borne diseases are described as the illness with which people are infected by the food they eat and water they drink. These diseases are a widespread public health issue and are expensive to treat. Spoilage pathogen result at any stage from production to consumption produces bacteria, viruses, parasites, chemical agents and toxins, which eventually cause the food borne diseases [10].

Fast-Moving Consumer Goods (FMCG's) or Consumer Packaged Goods (CPG's) are products that are sold quickly and at relatively low cost. Examples include non-durable goods such as soft drinks, toiletries, cereals, snacks, meat, fruits, dairy products and grocery items. Though the profit margin made on FMCG products is relatively small, more so for retailers than the producers/suppliers, they are generally sold in large quantities. FMCG is probably the most classic case of low margin/high volume business. Many of the players on the retailer side such as Walmart, Carrefour are among the largest and most recognized global companies. Global leaders in the FMCG segment include Johnson & Johnson, Colgate-Palmolive, Kellogg's, Heinz, Nestlé, Unilever, Procter & Gamble, L'Oreal, The Coca-Cola Company, General Mills Inc., PepsiCo [11].

The consumer is dependent on quality food manufacturing processes. Contaminating microorganisms may enter and reach the end-product through raw materials, air in the processing plant area, process surfaces, or factory personnel. Spoilage bacteria may also build up in high numbers in processing equipment and develop into biofilm. The sources of spoilage bacteria are numerous, however personnel and the environment being the most prevalent.

In recent years, several developments in society have contributed to changes in the global beverage market. Consumers are increasingly aware of the impact of diet on their health and well-being. Beverages are not only consumed to provide refreshment and hydration, but also to increase well-being and to help in preventing nutrition-related disorders [12]. Moreover, an increasing number of consumers favor minimally processed products from natural ingredients for reducing the intake of chemical additives from food and for obtaining products with improved nutritive and sensory characteristics. For example, studies showing the possible presence of carcinogenic benzene in soft drinks due to the reaction of benzoates (chemical additive) with ascorbic acid and the possible allergenic effects of sulphites and benzoates have naturally contributed to this consumer trend [13]. Manufacturing companies tend to overlook the principles of HACCP which is the critical factor for good manufacturing practices. Therefore, there is a need to carry out field sampling and laboratory analysis with the aim of ascertaining the microbiological quality of fast moving consumer goods at storage critical control point and thus determine the quality and safety of such consumer items and consequently help institute measures to prevent the microbial contamination of such consumable goods in order to minimize the potential health risk they pose.

2. MATERIALS AND METHODS

2.1 Location of Study

This study was carried out in Ogun State and Lagos State, Nigeria. Ogun-State is located at latitude 07°00' N and longitude 03°35'E and at an altitude of 77 m above mean sea level while Lagos-state is located at latitude 6°27'14''N and longitude 3°23'40''E above sea level.

2.2 Sample Collection

Samples were collected at three (3) locations from five shops at 500 metres apart in Agbara, Sango (Ogun state) and Ikeja (Lagos state) respectively.

A total number of 90 samples were collected, 6 samples which including: Sausage (Gala, Superbite and Rite), Milo, Golden Morn, Maggi Seasoning (Star seasoning, Knorr seasoning and Dan Q seasoning), Indomie and Lucozade Boost were collected. The 6 samples were collected in 5 shops at each location of the storage critical control point.

2.3 Preparation of Media

Suitable media were used for the counting and enumeration of microorganisms present in fast moving consumer goods at storage critical control points. The media were prepared according to Manufacturer's instruction.

2.4 Statistical Analysis of Mean Colony

The mean number of colonies for the dilution factor used ranged from 18.3 to 140.6 colonies. The mean colony forming unit per ml (CFU/ml) for all the FMCGs samples were calculated as:

$$\text{Mean} = \sum fx / \sum f = 10379742$$
$$\text{Mean} = 1.0*10^{7}\text{CFU/ml}$$

Where mean was calculated from $\sum fx$ which is the summation of the multiplied values of (f) and (x) and $\sum f$ is the summation of (f).

Table 1. Biochemical test and identification of isolates

	GNB 12A/12E													----------GNB 12B----------											
Isolate	**Lysine**	**Ornithin**	**H_2S**	**Glucose**	**mannitol**	**Xylose**	**ONPG**	**Indole**	**urease**	**V-P**	**Citrate**	**TDA**	**Gelatin**	**Malonate**	**Inositol**	**Sorbitol**	**Rhamnose**	**Sucrose**	**Lactose**	**Arabinose**	**Adonitol**	**Raffinose**	**Salicin**	**Arginine**	**Organism**
GL1	+	-	+	+	+	+	+	+	+	+	+	+	-	+	+	+	+	+	+	+	+	+	+	+	***Klebsiellia oxytoca***
GL2	+	-	+	+	-	+	+	-	+	-	-	+	-	-	-	-	-	-	-	-	-	-	-	+	***Proteus mirabilis***
GL3	-	-	+	+	-	+	+	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	***Yersinia pseudotuberculosis***
GS1	-	-	+	+	-	+	+	-	+	+	-	+	+	-	-	-	-	-	-	-	-	-	-	-	***Yersinia pseudotuberculosis***
GS2	+	-	+	+	+	+	+	+	+	+	+	+	-	+	+	+	+	+	+	+	+	+	+	+	***Klebsiellia oxytoca***
GS3	+	-	+	+	-	+	+	-	+	-	-	+	-	-	-	-	-	-	-	-	-	-	-	+	***Proteus mirabilis***
GA1	-	-	+	+	-	+	+	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	***Yersinia pseudotuberculosis***
GA2	+	-	+	+	+	+	+	+	+	+	+	+	-	+	+	+	+	+	+	+	+	+	+	+	***Klebsiellia oxytoca***
GA3	+	-	+	+	-	+	+	-	+	-	-	+	-	-	-	-	-	-	-	-	-	-	-	+	***Proteus mirabilis***
ML1	+	-	+	+	-	+	+	-	+	-	-	+	-	-	-	-	-	-	-	-	-	-	-	+	***Proteus mirabilis***
ML2	+	-	+	+	+	+	+	+	+	+	+	+	-	+	+	+	+	+	+	+	+	+	+	+	***Klebsiellia oxytoca***
ML3	+	-	+	+	-	+	+	-	+	-	-	+	-	-	-	-	-	-	-	-	-	-	-	+	***Morganella morganii***
MS1	+	-	+	+	+	+	+	+	+	+	+	+	-	+	+	+	+	+	+	+	+	+	+	+	***Klebsiellia oxytoca***
MS2	+	-	+	+	-	+	+	-	+	-	-	+	-	-	-	-	-	-	-	-	-	-	-	+	***Morganella morganii***
MS3	+	-	+	+	-	+	+	-	+	-	-	+	-	-	-	-	-	-	-	-	-	-	-	+	***Proteus mirabilis***
MA1	+	-	+	+	-	+	+	-	+	-	-	+	-	-	-	-	-	-	-	-	-	-	-	+	***Morganella morganii***
MA2	+	-	+	+	-	+	+	-	+	-	-	+	-	-	-	-	-	-	-	-	-	-	-	+	***Proteus mirabilis***
MA3	+	-	+	+	+	+	+	+	+	+	+	+	-	+	+	+	+	+	+	+	+	+	+	+	***Klebsiellia oxytoca***

2.5 Streak Plate Technique

The colonies were purified by aseptically picking characteristics discrete colony and streaked on selective media, Manitol Salt Agar (MSA), Mac Conkey Agar (MA), Eosin Methylene Blue Agar (EMBA), and Salmonella Shigella Agar (SSA). And was prepared according to the manufacturer's instruction and was incubated at 37°C for 24 hours.

2.6 Isolation and Identification of Organisms

2.6.1 Gram technique

Gram staining reaction is used to identify pathogens in specimens and cultures by their gram reaction (Gram positive or Gram negative) and morphology.

2.6.2 Isolation of *Staphylococcus aureus*

A colony of suspected *Staphylococcus aureus* which appeared off-white on nutrient agar was picked and inoculated using a sterile inoculating loop on Manitol Salt Agar plate and incubated at 37°C for 12-18 h.

2.6.3 Isolation of *Klebsiella specie*

Klebsiella specie formed typical pink colonies which were wet and raised on MacConkey. Colonies suspected to be Klebsiella were subjected to biochemical tests for confirmation.

2.7 Biochemical Characteristics Tests

2.7.1 Catalase test

Catalase test is used to identify organisms that produce the enzyme catalase using reagent or hydrogen peroxide by breaking it down into water and oxygen gas.

2.7.2 Indole test

The peptone water medium was inoculated with the test culture and incubated for 24 h at 37°C, after this period 0.5 ml Kovac's reagent was added to the broth culture.

2.7.3 Citrate utilization test

Simmon's citrate agar slants which had been prepared according to the manufacturer's instruction were inoculated by aseptically streaking the slanted region with an isolated colony from Mac conkey agar plate. The tubes were incubated at 37°C for 24 h.

2.8 Identification and Characterization

Identification system was done using the Oxiod MICROBACT 12A and 12B which is used for the identification of Gram negative organisms.

3. RESULTS AND DISCUSSION

A total number of 133 isolates consisting of one (1) gram positive bacteria, *S. aureus,* and four (4) are gram negative namely; *Klebsiella oxytoca, Morganella morganii, Proteus mirabilis* and *Yersinia pseudotuberculosis* were obtained from 90 samples of Fast Moving Consumer Goods in Ogun, Lagos and Agbara. The ninety samples of FMCGs were prepared using peptone water, visible colonies showed in triplicate plates of 10^{-5} dilution. The percentage prevalence for isolated and identified organisms was highest for *S.aureus* (67.66%) while the least is *Morganella morganii* (3.75%) as shown in Table 4. The total number of gram positive bacteria isolates is 90 and the percentage prevalence is 67.66%, while the total number of gram negative is 43 and the percentage prevalence is 32.33%.

The aerobic colony count (ACC) of Sausage obtained from Lagos ranged from 106 to 130. Sausage from Sango ranged from 94.3 to 135.3 while Sausage from Agbara had a range of 78.6 to 117. The aerobic colony count (ACC) of Indomie obtained from Lagos ranged from 109 to 126.6, the ACC from Sango ranged from 121.3 to 127, while ACC Indomie from Agbara ranged of 101.3 to 133.3. The ACC of Maggi seasoning obtained from Lagos ranged from 106 to 133.6. Maggi seasoning from Sango ranged from 105.6 to 137.3 while Maggi seasoning from Agbara had a range of 90 to 140.6. The ACC of Golden morn obtained from Lagos ranged from 59 to 119. Golden morn from Sango ranged from 29 to 85 while Golden morn from Agbara had a range of 22 to 101.6. The ACC of Milo obtained from Lagos ranged from 27 to 47.3. Milo from Sango ranged from 18.3 to 36.6 while the ACC of Milo from Agbara had a range of 21.3 to 34. Lastly, the ACC of Lucozade boost obtained from Lagos ranged from 70 to 104. Lucozade boost from Sango ranged from 107.6 to 127.6 while Lucozade boost from Agbara had a range of 111.6 to 128.3.

The percentage prevalence for isolated and identified organism in Lagos and Agbara was highest for *Morganella morganii* (1.50) and least in Sango (0.75). The percentage prevalence for isolated and identified organism in Lagos was highest for *Klebsiella oxytoca* (4.51) and least in Agbara (3.00). The percentage prevalence for isolated and identified organism in Lagos was highest for *Proteus mirabilis* (3.75) and least in Lagos and Agbara (3.00). The percentage prevalence for isolated and identified organism in Lagos was highest for *Yersinia pseudotuberculosis* (3.00) and least in Lagos and Agbara (2.25). The percentage prevalence for *Staphylococcus aureus* was (22.55) for the three locations (Lagos, Agabara and Sango) as shown in Table 2.

This research also revealed that the highest prevalence in the state was highest for *S.aureus* (22.55%) in Lagos, Sango and Agbara and least in Sango –Ota with percentage prevalence for *Morganella morganii* at (0.75%) in Sango-Ota. In Lagos State, the most prevalent organism is *S. aureus* (22.55%) while the lowest is *Morganella morganii* (1.50%). In Agbara, the most prevalent organism is *S. aureus* (22.55%) while the lowest is *Morganella morganii* at (1.50%) as shown in Table 2.

The mean colony forming unit per ml (CFU/ml) for various FMCGs samples collected include sausage (1.1×10^7), Indomie noodle (1.1×10^7), Maggi seasoning (1.2×10^7), Golden morn cereal (8.2×10^6), Milo beverage (3.1×10^6) and Lucozade boost energy drink(1.1×10^7) as shown in Table 3.

It was observed that Sausage from Lagos and Sango had colony forming unit of (1.2×10^7), while Sausage from Agbara had the colony forming unit of (1.0×10^7). Indomie form Lagos and Agbara had colony forming unit of (1.1×10^7), while Indomie from Sango had colony forming unit of 9.6×10^6. Maggi seasoning from Lagos, Agbara and Sango had the colony forming unit of (1.2×10^7). Golden morn from Lagos had colony forming unit of (9.4×10^6), Golden morn from Sango had the colony forming unit of (6.7×10^6) and Golden morn from Agbara had the colony forming unit of (7.6×10^6). Milo from Lagos had colony forming unit of (3.5×10^6), Milo from Sango had colony forming unit of (3.0×10^6) and Agbara had colony forming unit of (2.6×10^6), while Lucozade boost from Lagos had the colony forming unit of (8.9×10^6) and Lucozade boost from Sango and Agbara had the colony forming unit of (1.2×10^7) as shown in Table 4.

This HACCP study revealed that factors such as poor hygiene, poor storage, and poor handling of raw food products contributes to the contamination of consumable goods. This study revealed the presence of 133 isolates comprising of *Staphylococcus aureus, Klesiellia oxytoca, Proteus mirabilis, Yersinia pseudotuberculosis, Morganella morganii* respectively in the following order of prevalence 67.66%, 11.27%, 9.77%, 7.51% and 3.75%. The organism with the highest percentage prevalence is *S. aureus* (67.66%) and the least prevalent is *M. morganii* (3.75%). Four of the isolated organisms are gram negative while *S. aureus* is the only gram positive. *S. aureus* have been identified as the cause of food poisoning leading to symptoms like nausea, vomiting, cramps and diarrhea. Food-borne diseases are a major public health concern worldwide [14]. WHO defines food-borne disease (FBD) as disease of infectious or toxic nature caused by, or thought to be caused by, the consumption of food or water.

It was observed that Forty nine bacterial isolates were obtained from sausage samples of which Gala had eighteen; Superbite had sixteen while Rite had fifteen isolates. The total number of isolates from the seasoning samples is twenty four of which Knorr had nine, Dan Q had seven, and Star had eight bacterial isolates. Indomie, Lucozade boost, Milo and Golden Morn each had fifteen bacterial isolates as shown in Table 5.

This research revealed that the average aerobic colony count for Gala and Indomie in Lagos, Sango and Agbara are satisfactory as they fall

Table 2. Percentage prevalence of individual organism per location (%)

Organisms	Lagos	Sango	Agbara
Morganella morgani	1.50	0.75	1.50
Klebsiellia oxytoca	4.51	3.75	3.00
Proteus mirabilis	3.00	3.75	3.00
Yersinia pseudotuberculosis	2.25	3.00	2.25
Staphylococcus aureus	22.55	22.55	22.55

Table 3. Mean colony forming unit (CFU/ml) per product

Product	Mean CFU/ml = ∑fx/∑f
Sausage	$1.1x10^7$
Indomie	$1.1x10^7$
Maggi seasoning	$1.2x10^7$
Golden morn	$8.2x10^6$
Milo	$3.1x10^6$
Lucozade Boost	$1.1x10^7$

Table 4. Colony forming unit (CFU/ml) per location

Products	Location	CFU/ml = ∑fx/∑f
Sausage	Lagos	$1.2x10^7$
	Sango	$1.2x10^7$
	Agbara	$1.0x10^7$
Indomie	Lagos	$1.1x10^7$
	Sangdo	$9.6x10^6$
	Agbara	$1.1x10^7$
Maggi	Lagos	$1.2x10^7$
	Sango	$1.2x10^7$
	Agbara	$1.2x10^7$
Golden morn	Lagos	$9.4x10^6$
	Sango	$6.7x10^6$
	Agbara	$7.7x10^6$
Milo	Lagos	$3.5x10^6$
	Sango	$3.0x10^6$
	Agbara	$2.6x10^6$
Lucozade boost	Lagos	$8.9x10^6$
	Sango	$1.2x10^7$
	Agbara	$1.2x10^7$

Table 5. Distribution of isolates per product

Products	*Morganella morganii*	*Klebsiellia oxytoca*	*Proteus mirabilis*	*Yersinia pseudotuberculosis*	*Staphylococcus aureus*
Gala	0	5	3	5	5
Superbite	0	4	4	3	5
Rite	5	2	3	0	5
Knorr	-	4	-	-	5
Dan Q	-	-	-	2	5
Star	-	-	3	-	5
Lucozade Boost	-	-	-	-	15
Indomie	-	-	-	-	15
Milo	-	-	-	-	15
Golden morn	-	-	-	-	15

under the satisfactory figures according to Codex Alimentarius which is $<10^4$ as shown in Table 3. Lagos Gala (130), Sango Gala (135.3), Agbara Gala (117), Lagos Indomie (126.6), Sango Indomie (127) and Agbara Indomie (133.3). Also the average aerobic colony count for Maggi and Lucozade boost are satisfactory as they fall under the satisfactory figures according to Codex Alimentarius which is $<10^3$ as shown in Table 3. Lagos Maggi (133.6), Sango Maggi (137.3), Agbara Maggi (140.6), Lagos Lucozade boost (104), Sango Lucozade boost (127.6) and Agbara Lucozade boost (128.3). Lastly, the average aerobic colony count for Golden morn and Milo are satisfactory as they also fall under the satisfactory figures according to Codex

Alimentarius which is <10^6 as shown in Table 3. Lagos Golden morn (119), Sango Golden morn (85), Agbara Golden morn (101.0), Lagos Milo (47.3), Sango Milo (36.0) and Agbara Milo (34).

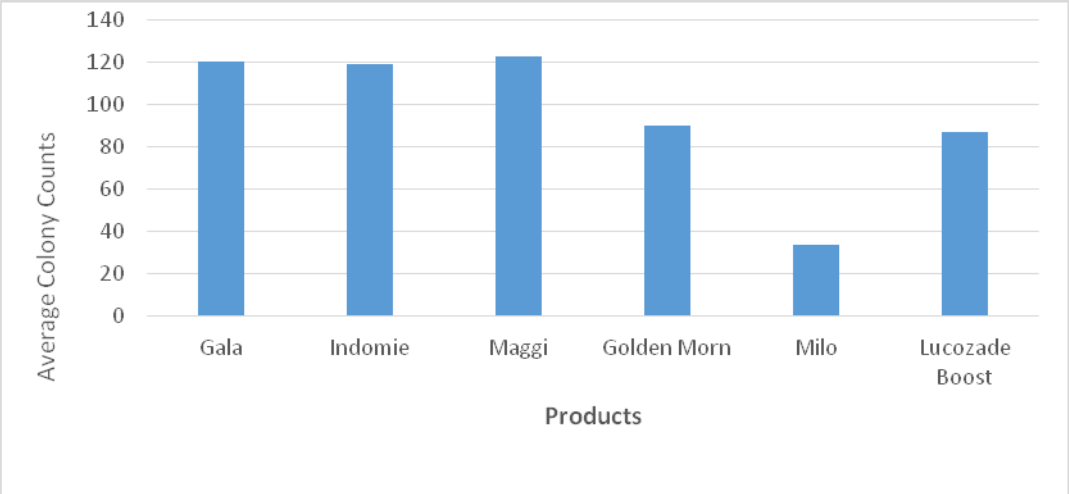

Fig. 1. Average colony counts from triplicate cultures in Lagos

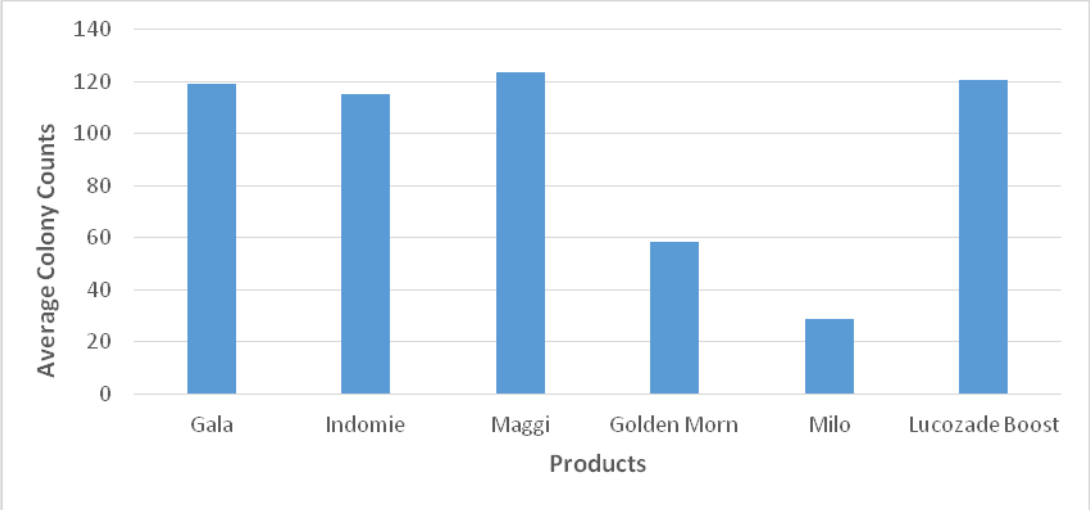

Fig. 2. Average colony counts from triplicate cultures in Sango

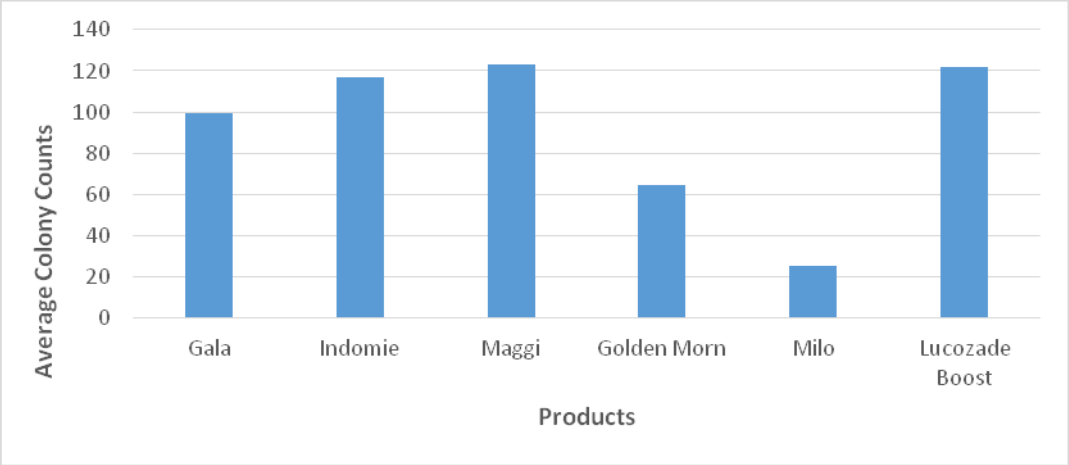

Fig. 3. Average colony counts from triplicate cultures in Agbara

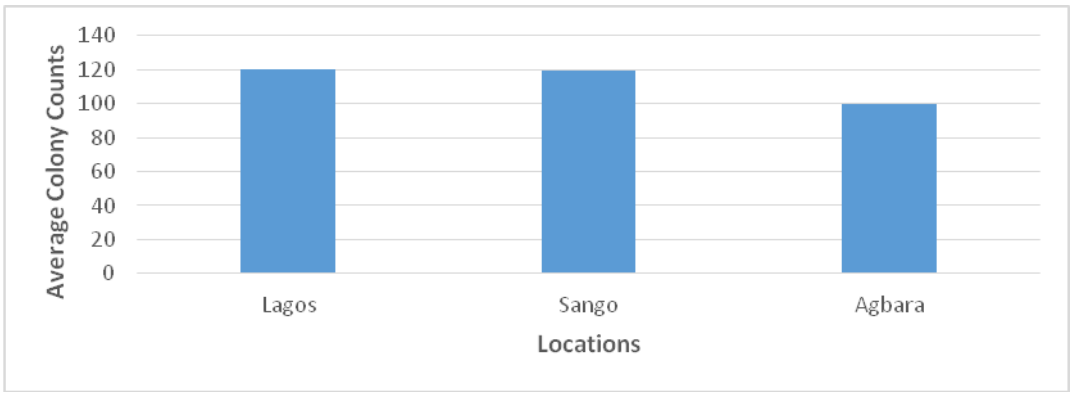

Fig. 4. Average colony counts for Gala per location

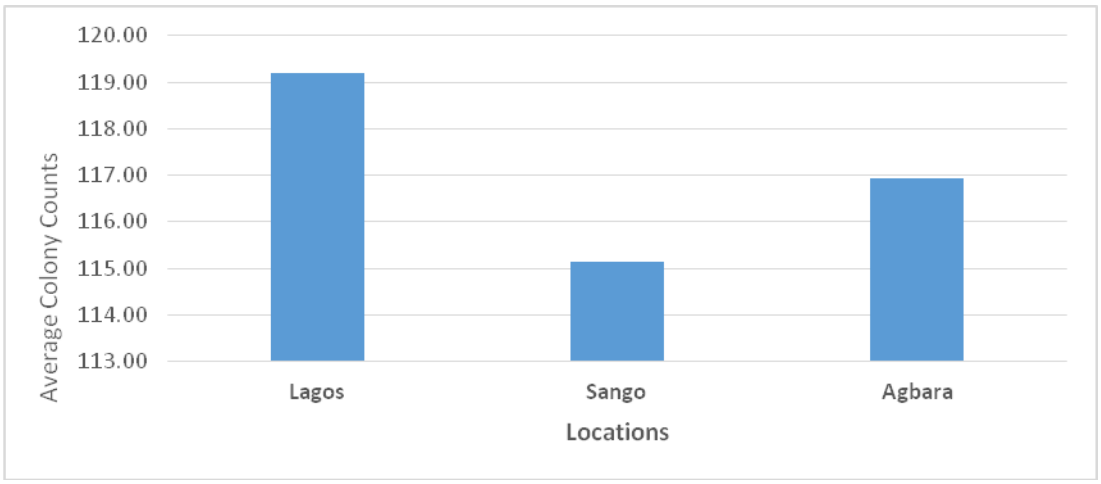

Fig. 5. Average colony counts for Indomie per location

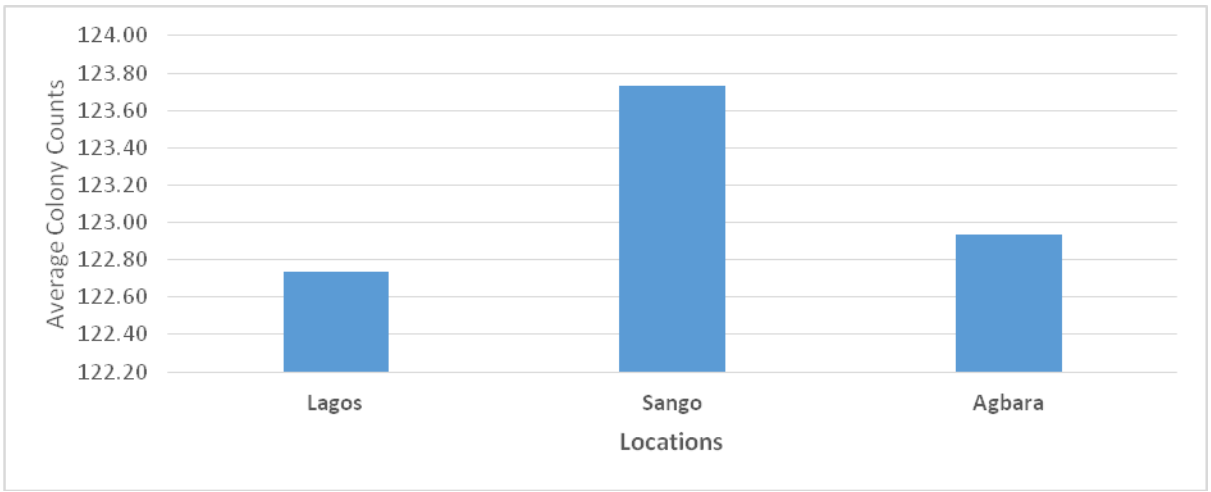

Fig. 6. Average colony counts for Maggi per location

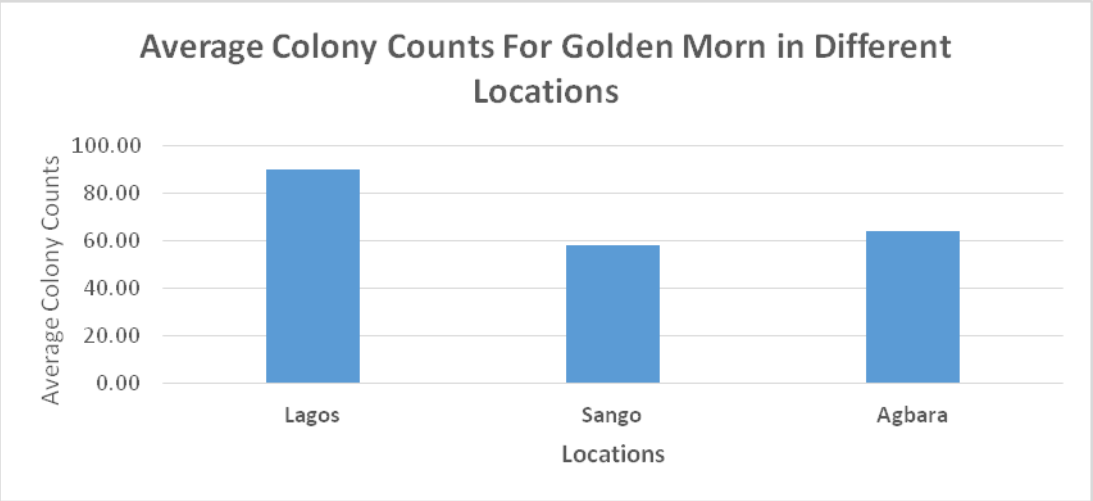

Fig. 7. Average colony counts for Golden Morn per location

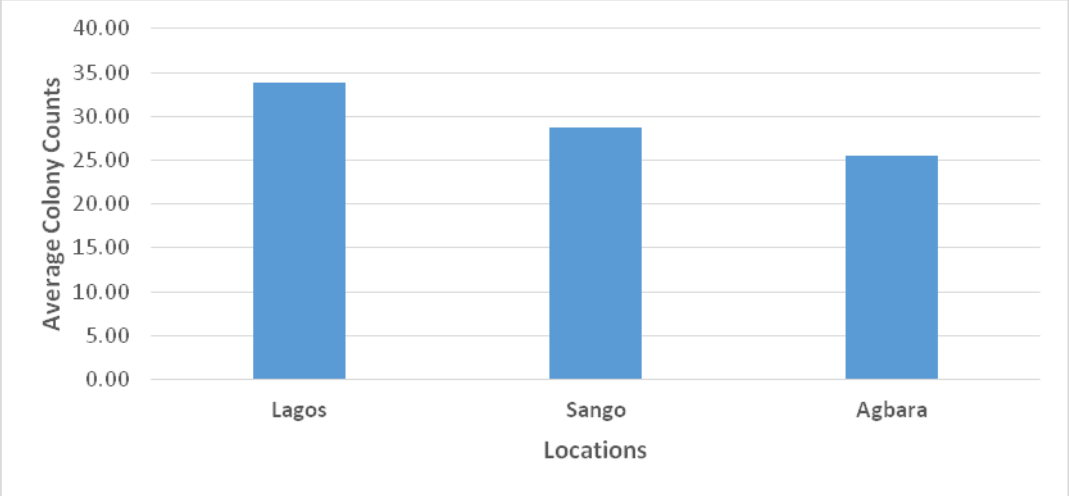

Fig. 8. Average colony counts for Milo per location

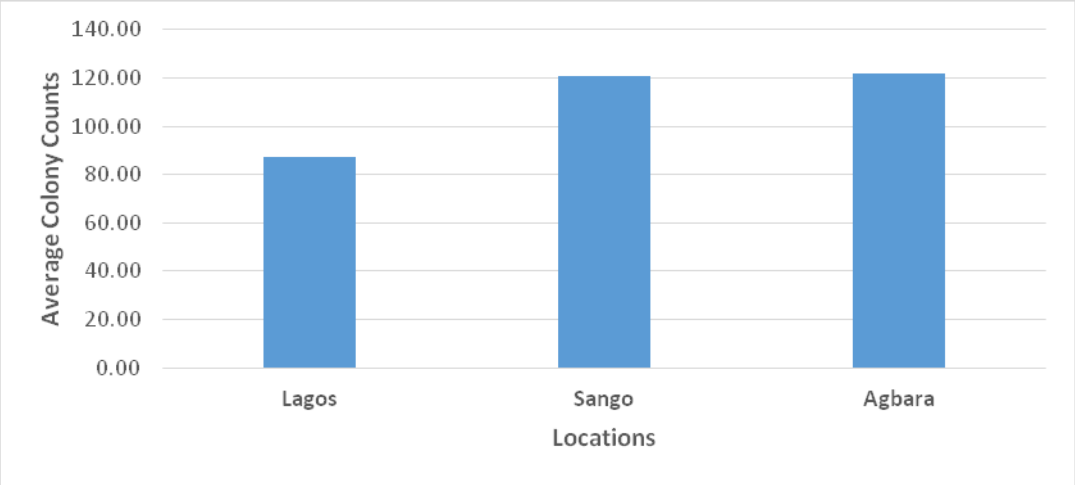

Fig. 9. Average colony counts for Lucozade Boost per location

S. aureus is the common pathogenic bacteria found to be the prevalent in ready to eat food. *S. aureus* is the most implicated bacteria responsible for ready to eat food due to its highest percentage prevalence in Ogun, Agbara, Lagos State and prolonged storage without refrigeration allows the bacteria to grow and form toxins since the toxins are heat stable. *S. aureus* was also frequently found on handlers gloves. Pathogenic microbes can adhere to the surface of the gloves worn by food employees and can serve as a source of cross-contamination if not changed frequently [15]. *Staphylococcus aureus* does not form spores but can cause contamination of food products during food preparation and processing. Staphylococcal food-borne disease (SFD) is one of the most common food-borne diseases worldwide resulting from the contamination of food by preformed *S. aureus* enterotoxins. It is one of the most common causes of reported food-borne diseases. Outbreak investigations have found that improper food handling practices in the retail industry account for the majority of SFD outbreaks. However, several studies have documented prevalence of *S. aureus* in many food products including raw retail meat indicating that consumers are at potential risk of *S. aureus* colonization and subsequent infection. *Klebsiellia oxytoca* like other *Klebsiellia* can be found in a wide range of environments and are opportunistic in nature. *K. oxytoca* have been found in mammals. In humans, the specie tends to colonize along the mucosa membranes of the colon and skin. However, they can be found colonizing on all parts of the body [16].

4. CONCLUSION

This research study reveals that the hygienic quality of all the food samples from the fast moving consumer goods industries assessed have a high hygienic quality especially when the microbial load was compared with the predetermined benchmarks established by the Codex Alimentarius Commission classifying foods into Class A (Satisfactory), Class B (Acceptable), Class C (Unsatisfactory) and Class D (Unacceptable). In all, the assessed ready-to-eat food products are Class A products and are satisfactory for human consumption because the aerobic colony count falls well below the ACC range for such products for the class. This implies a very stringent microbiological quality control process. It is also obvious that the level of microbiological quality control is not only very high at the storage critical control point but also along the various critical control points cumulatively, else the microbial load will be high. It is obvious that Nestle has the best compliance level to HACCP and have the highest quality control as their brand recorded the lowest percent prevalence of isolates per product per location and the lowest aerobic colony counts. Agbara has the highest hygiene level because it has the least value of bacterial load. However, the question that remains to be answered is why is it that the isolated bacteria are the resident bacteria in the various locations and not some other species or strains and what, if any are the molecular mechanisms favouring their localization?

5. RECOMMENDATION

The various FMCGs analyzed are acceptable for public consumption because they complied with the level of quality assessment and standards of Codex Alimentarius Commission. Evidently, the various brands complied with the principles of HACCP but need to put in more effort for proper hygiene. A further study to determine the reasons why the isolated pathogens are the resident bacteria and the factors contributing to their survival is strongly recommended.

DISCLAIMER

The products used for this research are commonly and predominantly use products in our area of research and country. There is absolutely no conflict of interest between the authors and producers of the products because we do not intend to use these products as an avenue for any litigation but for the advancement of knowledge. Also, the research was not funded by the producing company rather it was funded by personal efforts of the authors.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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