Chemical Properties and Microbiological Profile of kunu zaki, A Non-Alcoholic Beverage

Braide W*1, Ukagwu N2, Lugbe PB3, Akien Ali AI3 and Adeleye SA1

1Department of Microbiology, Federal University of Technology, Nigeria
2Department of Science Laboratory Technology, Federal Polytechnic, Nigeria
3Department of Science Laboratory Technology, Rivers State Polytechnic, Nigeria

Received: April 11, 2018; Published: April 25, 2018

*Corresponding author: Braide W, Department of Microbiology, Federal University of Technology, PMB 1526, Owerri, Imo State, Nigeria

Abstract

Kunu zaki is a popular indigenous cereal based non-alcoholic beverage widely consumed, especially in the Northern Nigeria. Composite samples randomly collected were screened for pH, titratable and microbiological characteristics using standard methods. Antibiotics susceptibility pattern of pathogenic bacteria was also determined using Kirby-Bauer disc diffusion method. The pH was slightly acidic to neutral (6.83-7.13), while titratable acidity was directly proportional to incubation time (mean value, 0.50%-1.53%). Total plate counts were high for bacteria (1.5 x 10^7 Cfu/ml - 9.5 x 10^7 Cfu/ml), coliform (0 - 7.0 x 10^6 Cfu/ml) and fungi (6.0 x 10^6 - 1.0 x 10^7) and indicates gross contamination. Bacterial isolates include species of Bacillus, Escherichia coli, Lactobacillus, Staphylococcus, Salmonella and Shigella, whereas molds isolated belongs to the genera, Fusarium, Aspergillus, Penicillium, Rhizopus and Mucor. Saccharomyces species were the only yeast isolated. The health implications of the presence of Escherichia coli, Staphylococcus aureus, Salmonella species in foods and beverages had been widely reported.

Some species of Aspergillus, Fusarium, Rhizopus and Penicillium produces mycotoxins, a secondary metabolite associated with serious mycotoxicosis of animals and humans. Bacillus, Lactobacillus and Saccharomyces are involved in food deterioration and spoilage as they utilize the sugars present in the substrate to produce acids and other metabolites. The results of the antibiotic susceptibility test are worrisome as some of the organisms showed resistance to the tested antibiotics. For instance, Staphylococcus aureus and Salmonella sp were resistant to amoxicillin antibiotic whereas Escherichia coli, Bacillus cereus and Salmonella sp were resistant to cefotaxime antibiotic. Adequate sanitary measures should be employed during and after the production of Kunu zaki to reduce the microbial load.

Keywords: Kunu Zaki; Chemical and Microbial Profile; Antibiotic Assay

Introduction

Kunu zaki is a popular nonalcoholic drink processed from cereal grains such as millet, maize, sorghum and rice [1-4]. It is highly nutritious and widely consumed in the Northern part of Nigeria for its thirst quenching properties. Kunu is traditionally prepared by women under unhygienic condition and packaged in inadequately sterilized containers which predispose it to contamination Aminat et al. [5]. During processing sweeteners, adjunct and thickeners are added which further contaminate the product. Kunu is not shelf stable because of local technology employed. Adeyemi and Umar [6] had reported the shelf life of 24h at ambient temperature. Kunu contains lactic acid bacteria such as Lactobacillus, Streptococcus and Leuconostoc species which could cause spoilage. Bacteria such Staphylococcus, Pseudomonas, Bacillus and fungi such as Penicillium, Aspergillus, Trichoderma and yeast have been isolated from processed kunu Osuntoki and Korie, [7]. The presence of these organisms in small number could render a beverage unsuitable for human consumption [8-10]. Kunu has a very high moisture content and total solid which may encourage the growth of strains of microorganisms to hazardous levels during storage at ambient temperature Olasupo et al. [11]. This study reports on the microbiological quality and chemical properties of kunu zaki stored at ambient temperature. The antibiogram of notable food borne bacteria was also determined.

Materials and Methods

Collection of Samples

Composite samples were randomly collected from three densely populated locations in Owerri, Imo State, Nigeria. Labeled
samples in plastic bottles and cellophane bags were transported immediately in an ice chest to the laboratory for analysis. Figure 1 shows the procedure for preparation of kunu zaki.

**Figure 1:** Flow chart for the production of conventional kunu zaki [Aminat et al. [5]].

**Microbiological Analysis**

Samples were analyzed microbiologically using standard methods [12-14]. Isolates were characterized according to the methods of Sharma [14]. Colony count was done using digital colony counter for bacteria and hand lens for fungi. Total colony was expressed as colony forming units in milliliters (CFU/ml) with reference to Harrigan and McCance [15]. Fungal colonies were identified colonially using characteristics such as pigmentation on the surface and reverse, sporulation, mycelia and spore arrangement microscopically [16-18]. Bacteria and yeast were identified colonially, microscopically and a few biochemical test [13,14,19].

**Determination of pH and Titratable Acidity**

Digital Uniscope pH meter was used to determine the level of acidity of the samples. The pH probe was inserted into a 100mls beaker containing 50mls of the samples and the values recorded when the reading was stable. Ten milliliters of the sample were titrated with 0.1N of sodium hydroxide using phenolphthalein as an indicator. Titration continues until a faint pink colour was obtained. Titration was done in triplicates and mean value obtained was used to calculate the percentage titratable acidity [14,20].

**Antibiotic Susceptibility Test**

Potential pathogenic bacteria isolated from the samples were screened for their antibiotic susceptibility using the Kirby-Bauer agar disc diffusion method CLSI, [21]. Suspension of inoculums prepared in 10mls peptone water was standardized to 0.5 McFarland turbidity equivalents. One milliliter of each standardized inoculums was seeded onto the surface of freshly prepared Mueller Hinton agar plates and allowed to stand for 30mins. Different concentrations of antibiotic discs (oxoid) were placed at equidistant and incubated at 370°C for 24h. Zones of inhibition (in millimeter) were measured and recorded and compared with standards CLSI [21].

**Results**

**Table 1:** pH values of the Kunu-zaki.

| Sample | pH |
|--------|----|
| 1      | 6.83 |
| 2      | 6.96 |
| 3      | 6.83 |
| 4      | 7.05 |
| 5      | 6.92 |
| 6      | 7.05 |
| 7      | 7.13 |
| 8      | 7.04 |
| 9      | 7.02 |
| 10     | 6.93 |
| 11     | 6.71 |
| 12     | 6.77 |
| 13     | 6.80 |
| 14     | 6.86 |
| 15     | 6.80 |
| 16     | 6.86 |

**Table 2:** Titratable Acidity of Kunu zaki samples (% of lactic acid).

| Samples | 1st day | 2nd day | 3rd day | 4th day | 5th day |
|---------|---------|---------|---------|---------|---------|
| KZ1     | 0.594   | 0.677   | 0.792   | 0.883   | 0.923   |
| KZ2     | 0.468   | 0.620   | 0.816   | 0.984   | 1.233   |
| KZ3     | 0.243   | 0.476   | 0.621   | 0.701   | 0.882   |
| KZ4     | 0.360   | 0.698   | 0.929   | 1.208   | 1.463   |
| KZ5     | 0.594   | 0.766   | 0.847   | 0.928   | 1.134   |
| KZ6     | 0.297   | 0.742   | 1.049   | 1.346   | 1.557   |
| KZ7     | 0.567   | 0.763   | 0.937   | 1.024   | 1.224   |
| KZ8     | 0.630   | 0.799   | 0.882   | 0.901   | 0.954   |
| KZ9     | 0.600   | 0.775   | 0.861   | 0.899   | 0.936   |
| KZ10    | 0.603   | 0.799   | 0.878   | 0.960   | 1.098   |
| KZ11    | 0.594   | 0.687   | 0.753   | 0.880   | 0.981   |
| KZ12    | 0.585   | 0.793   | 0.922   | 1.042   | 1.248   |
| KZ13    | 0.585   | 0.682   | 0.744   | 0.832   | 0.927   |
| KZ14    | 0.612   | 0.827   | 0.904   | 0.996   | 1.058   |
| KZ15    | 0.225   | 0.576   | 0.747   | 0.801   | 0.977   |
| KZ16    | 0.495   | 0.743   | 0.922   | 1.106   | 1.238   |

**Note:** Total aerobic bacteria, coliform and fungal count is shown in Table 3. Total colony count expressed in CFU/ml is high ranging from $1.5 \times 10^7 - 9.5 \times 10^7; 0 - 7.0 \times 10^6$ and $1.0 \times 10^6 - 6.0 \times 10^6$ for aerobic bacteria, coliform and fungi respectively.
Table 3: Microbial population of kunu zaki samples.

| Sample code | Total aerobic count (Cfu/ml) | Total coliform count (Cfu/ml) | Total fungi count (Cfu/ml) |
|-------------|-----------------------------|------------------------------|---------------------------|
| KZ1         | 2.1 x 10^9                  | 4.0 x 10^4                   | 3.6 x 10^6                |
| KZ2         | 1.5 x 10^9                  | 5.0 x 10^7                   | 5.3 x 10^6                |
| KZ3         | 2.6 x 10^9                  | 5.0 x 10^7                   | 3.0 x 10^6                |
| KZ4         | 2.7 x 10^9                  | 1.5 x 10^8                   | 5.5 x 10^6                |
| KZ5         | 5.0 x 10^9                  | 6.0 x 10^8                   | 5.0 x 10^6                |
| KZ6         | 4.7 x 10^9                  | 1.1 x 10^9                   | 2.0 x 10^5                |
| KZ7         | 6.3 x 10^9                  | 1.0 x 10^9                   | 3.0 x 10^5                |
| KZ8         | 5.5 x 10^9                  | 2.0 x 10^9                   | 1.6 x 10^6                |
| KZ9         | 4.4 x 10^9                  | 0                            | 6.0 x 10^6                |
| KZ10        | 7.0 x 10^9                  | 3.0 x 10^9                   | 1.3 x 10^6                |
| KZ11        | 4.0 x 10^9                  | 7.0 x 10^4                   | 1.2 x 10^5                |
| KZ12        | 8.6 x 10^9                  | 7.0 x 10^4                   | 2.0 x 10^5                |
| KZ13        | 5.7 x 10^9                  | 0                            | 6.0 x 10^6                |
| KZ14        | 9.5 x 10^9                  | 4.0 x 10^4                   | 1.0 x 10^6                |
| KZ15        | 3.0 x 10^9                  | 0                            | 1.5 x 10^6                |
| KZ16        | 5.0 x 10^9                  | 1.2 x 10^4                   | 4.0 x 10^5                |

Note: The distribution and percentage of the isolates is shown in Tables 4-5. Bacillus (14.75%), Salmonella (9%) and Staphylococcus (8.25%) species were the predominant bacteria, whereas Saccharomyces (8.96%) species predominate the fungi group.

Table 4: Percentage Distribution of Bacteria and Fungi isolates.

| Bacterial isolates       | % Distribution | Fungal isolates       | % Distribution |
|--------------------------|----------------|-----------------------|----------------|
| Escherichia coli         | 13 (9.75%)     | Geotrichum candidum   | 5 (2.8%)       |
| Bacillus sp              | 14 (14.75%)    | Fusarium sp           | 4 (2.24%)      |
| Lactobacillus sp         | 7 (5.25%)      | Saccharomyces sp      | 16 (8.96%)     |
| Staphylococcus aureus    | 11 (8.25%)     | Penicillium sp        | 4 (2.24%)      |
| Shigella sp              | 8 (6.0%)       | Aspergillus sp        | 10 (5.6%)      |
| Salmonellasp             | 12 (9.0%)      | Mucor sp              | 7 (3.92%)      |
| Enterococcus faecalis    | 7 (5.25%)      | Rhizopus sp           | 10 (5.6%)      |
| Serratia marcesence      | 3 (3.25%)      |                       |                |

Table 5: Distribution of Bacteria and Fungi isolated from kunu zaki.

| Sample | Bacterial isolates       | Fungal isolates       |
|--------|--------------------------|-----------------------|
| KZ1    | E. coli, S. aureus, Bacillus sp, Salmonella sp | Rhizopus sp, Aspergillus sp, Fusarium sp, Saccharomyces sp |
| KZ2    | E. coli, Staph, Bacillus sp, Lactobacillus sp, Salms, Shigella sp | Geotrichum sp |
| KZ3    | Staph, Bacillus sp, Salmsp, Ent. Faecalis Serratia sp | Rhizopus sp, Saccharomyces sp, Aspergillus sp |
| KZ4    | E. coli, Shigella sp, Bacillus sp, Staph | Penicillium sp, Aspergillus sp, Fusarium sp, Saccharomyces sp |
| KZ5    | Bacillus sp, Staph, E. coli, Salmsp, Shigella sp | Mucor sp, Rhizopus sp, Saccharomyces sp |
| KZ6    | Lactobacillus sp, Bacillus sp, E. coli, Shigella sp | Mucor sp, Saccharomyces sp, Rhizopus sp, Aspergillus sp |
| KZ7    | Shigella sp, Salmsp, E. coli, Bacillus sp | Aspergillus sp, Penicillium sp, Mucor sp, Saccharomyces sp |
| KZ8    | E. coli, Salmsp, Lactobacillus sp, Bacillus sp | Saccharomyces sp, Rhizopus sp, Mucor sp, Geotrichum sp |
| KZ9    | E. coli, Lactobacillus sp, Shigella sp, Salmsp, Enterococcus sp, Staph | Saccharomyces sp, Rhizopus sp, Mucor sp |
| KZ10   | E. coli, Staph, Salmsp, Bacillus sp | Saccharomyces sp, Aspergillus sp, Rhizopus sp, Mucor sp |
| KZ11   | Bacillus sp, Lactobacillus sp, Staph | Fusarium sp, Saccharomyces sp, Aspergillus sp |
| KZ12   | Shigella sp, Lactobacillus sp, E. coli, Enterococcus sp | Aspergillus sp, Penicillium sp, Saccharomyces sp |
| KZ13   | Lactobacillus sp, E. coli, Staph sp, Bacillus sp, Enterococcus sp | Saccharomyces sp, Rhizopus sp, Geotrichum sp |
| KZ14   | Bacillus sp, E. coli, Staph, Salmsp | Saccharomyces sp, Rhizopus sp, Mucor sp |
| KZ15   | Shigella sp, Staph, Bacillus sp, Salmsp | Aspergillus sp, Saccharomyces sp, Geotrichum sp |
| KZ16   | Enterococcus sp, Shigella sp, E. coli, Salmsp, Serratia sp | Aspergillus sp, Saccharomyces sp, Geotrichum sp |

Table 1 shows the pH values of kunu zaki analyzed. The pH is slightly acid (6.83-7.13). Titratable acidity calculated in percentage is shown in (Table 2). Titratable acidity is directly proportional to incubation time in days. Total aerobic bacteria, coliform and fungal count is shown in (Table 3). Total colony count expressed in Cfu/ml is high ranging from 1.5 x 10^7 - 9.5 x 10^7; 0 - 7.0 x 10^8 and 1.0 x 10^8 - 6.0 x 10^8 for aerobic bacteria, coliform and fungi respectively. The distribution and percentage of the isolates is shown in (Tables 4 & 5). Bacillus (14.75%), Salmonella (9%) and Staphylococcus (8.25%) species were the predominant bacteria, whereas Saccharomyces
tested against (Table 6). Complete resistance of Bacillus cereus isolates showed varying level of susceptibility to the antibiotics fruit juice consumed in Nigeria. Anibiogram of the bacterial test et al. [31-33] had reported on the microbial contamination and enhancers in foods and beverages are sources of contamination current [9,10,29] reported that spices used as additives and flavour can survive in low acid environment and spread by slight air common spoilage organisms of carbohydrate foods. Their spores and resultant mycotoxicosis in animals and humans [27,28]. Penicillium, Fusarium, Rhizopus and Aspergillus species isolated had reported that E. coli may remain viable in acidic foods for days. where kunu was being processed and hawked. Oshoma et al. [26] of contaminated water, containers as well as dirty environment report of [8,9] revealed that coliform group Makut et al. [10]. The detection of Salmonella and Shigella species is an indication that the beverage of spoilage and pathogenic organisms. Mean titratable acidity at varying degree of susceptible to the other antibiotics.

Discussion

The pH of sample ranged between 6.83-7.13, indicating slight acidity to neutrality. This condition may account for proliferation of spoilage and pathogenic organisms. Mean titratable acidity at ambient temperature is direct proportional to incubation or storage time. Increase in lactic acid indicates the fermentation of lactose sugar present in the substrate by Saccharomyces species and other lactic acid bacteria. The result showed significant different in total acidity throughout the duration of storage at 0.05% confidence limit. Total aerobic counts of 1.5 × 10^7 - 9.5 × 10^7 Cfu/ml indicate high level of microbial contamination. Total coliform count ranged from 0 - 7.0 × 10^6 Cfu/ml, while total fungal counts is 1.0 × 10^6 - 6.0 × 10^6 (Table 3). The isolation of E. coli, Staphylococcus aureus, Shigella and Salmonella species is an indication that the beverage is contaminated with potentially pathogenic bacteria [8,22,23] had reported that water and crude method of production and packaging under unhygienic conditions predisposes Kunu zaki to microbial contamination. Staphylococcus aureus cause food intoxication, where as Salmonella and Shigella species have been implicated in typhoid fever and shigellosis respectively Willey et al. [24].

Lactic acid bacteria such as Lactobacillus, Saccharomyces and Bacillus species thrives in sugar rich substrate and produce lactic acids Walker [25] via Embden-Meyerhof fermentation pathway Willey et al. [24], thus lowering the pH and increasing the titratable acidity (Tables 1 & 2). The presence of Escherichia coli in water and food is an indication of faecal contamination. Escherichia coli are an indicator organism and are an important member of the coliform group Makut et al. [10]. The report of [8,9] revealed that the presence of E. coli in hawked kunu zaki was as a result of contaminated water, containers as well as dirty environment where kunu was being processed and hawked. Oshima et al. [26] had reported that E. coli may remain viable in acidic foods for days. Penicillium, Fusarium, Rhizopus and Aspergillus species isolated from the samples have been implicated with mycotoxins production and resultant mycotoxicosis in animals and humans [27,28].

Moulds are naturally found in the soil and may contaminate the raw materials from the field and during storage; and are common spoilage organisms of carbohydrate foods. Their spores can survive in low acid environment and spread by slight air current [9,10,29] reported that spics used as additives and flavour enhancers in foods and beverages are sources of contamination among other environmental factors. Oranusi et al. [30] and Braide et al. [31-33] had reported on the microbial contamination and antibiotic susceptibility of some locally fermented beverages and fruit juice consumed in Nigeria. Antibiogram of the bacterial test isolates showed varying level of susceptibility to the antibiotics tested against (Table 6). Complete resistance of Bacillus cereus and Escherichia coli to ceftazidime and Staphylococcus aureus and Salmonella sp to Amoxicillin may stern from drug abuse and genetic modification of the organisms to resist the antibiotics. This trend is worrisome as unwholesome and adulterated Kunu zaki contaminated with food borne pathogens may result in outbreak of food borne illnesses, especially in localities where the beverage is consumed voraciously.

References

1. Adejobiyan JA, Adekalu OE, Olaniyin SA, Popola FI (2008) Evaluating the quality characteristics of kunu produced by dry-milled sorghum. African Journal of Biotechnology 7(13): 2244-2247.
2. Ahmed EU, Musa N, Ngoddy PO (2003) Sensory attributes of extended cereal legume blends of instant Kunu zaki. African Journal of Biotechnology 5(10): 996-1000.
3. Gaffa T, Jideani IA, Nkana I (2002) Traditional production, consumption and storage of Kunu non-alcoholic cereal beverage. Plant food for human consumption. African Journal of Food Science 57(1): 73-81.
4. Ikpoh IS, Lennox JA, Ekpo IA, Agbo BE, Henshawe EE et al. (2013) Microbial quality assessment of kunu beverage locally prepared and hawked in Calabar, Cross River State, Nigeria. Global Journal of Biodiversity Science and Management 3(1): 58-61.
5. Aminat OA, Adeiran EA, Ngozi UA, Yetunde O, Abideni SD (2013) Nutritional, microbiological sensory characteristics of malted soy-kunu zala: An improved traditional beverage. Advances in Microbiology, 3(4): 389-397.
6. Adeyemi IA, Umar S (1999) Effect of methods of manufacture on the quality characteristics of Kunu zaki milllet based beverage. Nigerian Food Journal 12: 34-40.
7. Osuntok F, Korie F (2009) Antioxidant activity of whey from fermented milk, fermented with Lactobacillus species, isolated from Nigerian fermented foods. Food Technological 48(4): 505-511.
8. Amusa NA, Odunbaku OA (2009) Microbiological and Nutritional quality of hawked kunu (Sorghum based non-alcoholic beverage) in Rivers state, Nigeria. The Internet Journal of Nutrition and Wellness 10(2): 1-4.
9. Essien E, Monago, C. and Edor, E. (2009) Evaluation of the nutritional and microbiological quality of kunu (A cereal based non-alcoholic beverage) in Rivers state, Nigeria. The Internet Journal of Nutrition and Wellness 8(1). 20-25.
10. Lawal OA (2012) Microbial quality of kunu zaki beverage sold in Ile Ife, Osun State. Journal of Food Technology 10: 4-7.
11. Olasup, NA, Smith SI, Akinside KA (2002) Examination of microbial status of selected indigenous fermented foods in Nigeria Journal of Food Safety 22(2): 85-87.
12. Beishir l (1987) Microbiology in Practice. A Self-Instructions Laboratory Course, 4th edition, Harper and Row Publishers, New York, pp. 96-111.
13. Cheesbrough M (2005) District Laboratory Practice in Tropical Countries (part 2). Cambridge University Press, New York, USA, 32: p. 64-68.
14. Sharma K (2009) Manual of Microbiology: Tools and Techniques, 2nd (Edn.), Ane Books Pvt., Limited, New Delhi, India, p. 405.
15. Harrigan WF, McCance ME (1990) Laboratory Methods in Food and Dairy Microbiol 8th (Edn.), Academic Press Inc, London, p. 7-23.
16. Bannett HI, Hunter BB (1987) Illustrative Genera of imperfect fungi, 4th (Edn.), Macmillan publishing Company, New York, USA, Pp. 106, 130.
17. Adams MR, Moss MO (1995 Food Microbiology. The Royal Society of Chemistry, Cambridge, UK, Pp. 50-51.
18. Fawole MO, Oso BA (2007) Laboratory Manual of Microbiology. Spectrum Books Limited. pp 22-33.
19. Buchanan RE, Gibbon NE (2000) Bergeys Manual of Determinative Bacteriology. Williams and Wilkins Co. Baltimore, USA.

20. Njosi JA (2013) Water Quality Management Analysis and Analytical Techniques, Ownit publishers, Delta. Pp. 163-164.

21. (2009) Clinical and Laboratory Standards Institute, CLSI Performance Standards for Antimicrobial Susceptibility Testing: Nineteenth Informational Supplement. Clinical and Laboratory Standards Institute, Wayne pp. 149-150.

22. Innocent O, Mariam YO, Blessed K, James TW (2011) Microbial evaluation and proximate composition of kunu zaki, an indigenous fermented food drink consumed predominantly in Northern Nigeria. Internet Journal of Food Safety 13: 93-97.

23. Akoma O, Agarry OO, Nkama I (2012) The microbiological quality of freeze dried kunu-zaki during production and storage. Intl J Biol Pham 1: 1397-1410.

24. Willey JM, Shewood LM, Woolverton CJ (2008) Prescott, Harley and Klein’s Microbiology. 7th (Edn.). McGraw-Hill higher Education, Boston, pp.1083-1088.

25. Walker PMB (1988) Chambers Science and Technology Dictionary. University press, UK.

26. Oshoma CE, Aghimen MO, Bello ZD (2009) Growth and survival of Escherichia coli in kunu zaki during storage. World Journal of Agricultural Science 5(4): 447-497.

27. Efiuvwevore BJO (2000) Microbial Spoilage agents of Tropical and Assorted Fruits and Vegetables: An Illustrative Reference Book. 1st (Edn.). Published by Paragraphics, Port Harcourt, Nigeria, p. 3-8.

28. Abbey SD (2007) Foundation in Medical Mycology. 4th edn.). Kenak Publication, Port Harcourt, Nigeria. p. 22-30.

29. Oranusi US, Braide W, Nezianya HO (2012) Microbiological and Chemical quality assessment of some commercially packed fruit juice sold in Nigeria. Greener Journal of Biological Sciences 2(1): 001-006.

30. Makut DM, Nyam MA, Obiekezie SO, Abubakar AE (2013) Antibiogram of bacteria isolated from kunu zaki drink sold in Keffi metropolis. American Journal of Infectious Diseases 9(3): 71-76.

31. Braide W, Oranusi U, Peter Ikechukwu A (2012a) Perspective in the hurdle techniques in the preservation of a nonalcoholic beverage, Zobo. African Journal of Food Science and Technology 3(2): 46-52.

32. Braide W, Ornusui SJ, Olati CC (2012b) Microbiological status of processed fruit juice sold in the commercial city of Onitsha. Scholarly Journal of Biological Sciences: 1(3): 25-30.

33. Braide W, Aniya H, Akien Ali IJ, Lugbe PB, Oranusi USM, et al. (2015) Bacteriological examination of fresh cow milk and Fura De Nunu using Rapid Dye Reduction Test. Pyrex Journal of Microbiology and Biotechnology Research.