



Original Research Article

Microbiological quality of fermented Cassava (Gari) sold in Ota Ogun State Nigeria

B.K.Olopade, S.Oranusi*, R.Ajala, and S.J.Olorunsola

Biological Sciences Department, Covenant University, Ota, Ogun State, Nigeria

*Corresponding author

ABSTRACT

Keywords

Gari samples;
 Total aerobic plate count;
 coliform count;
 moisture content.

Thirty six gari samples (eighteen each of white and yellow types) were subjected to microbial analysis. Samples were serially diluted to 10^4 and appropriate dilutions inoculated by spread plate method onto Nutrient agar, MacConkey agar and Potato-Dextrose agar plates for Total aerobic plate count (TAPC), Coliform count (CC) and Fungal count respectively. TAPC for white gari ranged from 2.0×10^2 to 1.1×10^4 , coliform count ranged from no growth (NG) to 7.1×10^3 while fungal count ranged from no growth to 6.0×10^2 . The microbial load of yellow gari ranged from 1.0×10^2 to 5.0×10^3 for TAPC, NG to 6.0×10^3 for coliform count and NG to 3.0×10^3 for fungal count. The bacteria isolates from the various samples include *Bacillus spp*, *Enterobacter spp*, *Pseudomonas*, *Staphylococcus* and *Klebsiella spp*. Fungi isolated includes *Aspergillus niger*, *Aspergillus fumigatus*, *Fusarium*, *Rhizopus* and *Penicillium spp*. The pH of the samples ranged from 4.76 to 4.94 in the yellow type and 4.78 to 4.91 in the white type. The moisture content was 6 to 8 percent in yellow type and 4 to 7 percent in the white type. Application of good manufacturing practices (GMP) and HACCP in gari production is imperative.

Introduction

Cassava roots contain a fibrous peel (10-15% of tuber weight) and a core, the main region for starch (IITA, 1990). Cassava can be consumed in various forms: boiled, baked or fried and it is processed before consumption in order to detoxify and preserve it (Oyewole and Sanni, 1995; Obadina *et al.*, 2009). The main cassava food products of considerable domestic importance in Nigeria are gari, lafun and fufu. When cassava roots are processed into products such as gari and flour, the

biochemical contents of such products are affected (Kemdirim *et al.*, 1995).

Amongst the various fermented cassava products, Gari is the most commonly consumed in Nigeria and accounts for 70% of the entire cassava production in Nigeria (IITA, 1990). Several millions of people in the African continent consume Gari and it forms a significant part of the people's diet especially in the West African sub region (Edem *et al.*, 2001;

Ogiehor *et al.*, 2007 and Kostinek *et al.*, 2005).

Gari is a granulated and dehydrated, cassava product. It is classified/ grouped based on texture, length of fermentation, region or place where it is produced and colour imparted by the addition/non-addition of palm oil. It has a high swelling capability and can absorb up to four times its volume in water. (Jekayinfa and Olajide, 2007). Obtainable in the market is the dry form of post processed gari which can be consumed soaked in cold water. Sugar can also be added to the soaked gari and it can be eaten with meat, roasted groundnuts, smoked fish, boiled beans, coconut, palm kernel, groundnut cake-*kwuli kwuli*, and fermented maize snacks *kokoro*. Beverages and milk may also be added as complements. 'Eba' is another food prepared from gari. The granules are added into hot water and stirred to form a stiff paste which can be eaten with indigenous soups or stew (Asegbeloyin and Onyimonyi, 2007).

Gari production is a tasking and burdensome procedure and its method of production differs from one locality to another. In a typical production of Gari, the cassava tubers are peeled, washed, grated and packed into closely woven bags. The poisonous juice can then be removed by placing a heavy object on the bag and the contents of the bag are allowed to undergo spontaneous solid state fermentation for several days at ambient temperatures (Ray and Sivakumar, 2009; Huch *et al.*, 2008). According to Akindahunsi *et al.* (1999), Azam- Ali *et al.* (2003) the grated tubers are allowed to ferment in order to preserve the product, reduce cyanide and enhance its flavor. Osho and Dashiell (2002) stated that frying at high temperatures dries the

fermented pulp to about 10% moisture content and may result in partial dextrinization of starch. Asegbeloyin and Onyimonyi, (2007); Harbor and Ogundu (2009) also revealed that frying destroys enzymes and microorganisms and aids in eliminating cyanide gas from the product.

There are reports on the high load of microorganisms in gari sold in the market (Ogiehor *et al.*, 2007; Ijabadeniyi, 2007; Amadi and Adebola, 2008). The microorganisms reported for market samples include: *Salmonella spp.*, *Klebsiella spp.*, *Pseudomonas spp.*, *Bacillus spp.*, *Clostridium spp.*, *Fusarium spp.*, *Aspergillus spp.*, *Penicillium spp.*, *Rhizopus spp.* and *Cladosporium spp.* There may be economic losses and food borne illnesses as a result of contamination by these microorganisms. This study was carried out to assess the microbial quality of gari sold in Ota, with a view to educating the public on the need for food safety consciousness and contributing to the body of knowledge on this all important staple African food.

Materials and Methods

Collection of samples

The study was carried out between March and May, 2013. A total of thirty six (36) samples of gari were purchased from three major markets in Ota - Sango Ota, Oju-Ore and Oja-Ota. Six (6) each of yellow and white gari types were randomly purchased from each market in the order of duplicate samples from three different but major gari food vendors per market. The samples were appropriately labeled to indicate the name of the market, gari type (white or yellow), sample number, date and time of collection. Samples were

transported in sterile polyethylene bags to the laboratory for analysis within one hour of collection.

Sample Analysis

Ten gram (10g) samples of gari were homogenized in 90 ml sterile distilled water (10^{-1} dilution), further serial dilution of sample homogenate to 10^{-4} was carried out also in sterile distilled water. Approximate 0.1ml aliquot of appropriate dilutions were spread plated on plates of Nutrient agar, MacConkey agar and Potato Dextrose agar (all from Biolab, Hungary) for total aerobic plate count, coliform count and fungal counts respectively. Sample homogenates were also inoculated onto Manithol Salt agar (Biolab, Hungary), Salmonella-Shigella agar (Oxoid, England) after pre-enrichment in Selenite F broth, for isolation of staphylococci and salmonellae. One gram samples were inoculated into Lactose broth (Biomark, India) in screw capped test tubes with inverted Durham tubes for coliform test. All culture plates were incubated at 37°C aerobically for 24-48h. Potato Dextrose agar (PDA) plates for fungal culture was however, incubated for 72-120 h at laboratory room temperature of $29\pm 2^{\circ}\text{C}$. Culture plates were examined for enumeration and identification of colonies at the expiration of incubation period

Coliform Test

Aliquot 1g samples in test tubes with inverted Durham tubes in Lactose broth were incubated at 37°C for 24-48h. Tubes showing gas production and/or colour change of dye were reported as presumptive coliform test positive. These positive tubes were streaked out on duplicate plates of Eosin Methylene Blue

(EMB) agar for confirmatory test. Plates were incubated for 24h at 37°C and 44°C respectively. Growth of characteristic colonies on EMB constitute confirmatory test positive. Colonies from confirmatory test were Gram stained and inoculated into lactose broth for completed coliform test. Gas production and/or colour change of dye plus Gram negative non-spore bearing rod represent presence of coliform (Speck, 1976 Oranusi *et al.*, 2004). Absence of growth was recorded at 44°C incubation for all the samples indicating absence of fecal coliforms.

Enumeration and identification of microorganisms isolated

Colony counts at the expiration of incubation time was with digital colony counter (Gallenkamp, England), total microbial population was expressed as colony forming units per gram (cfug^{-1}) of sample. Pure cultures of isolates were obtained by repeated subculture on nutrient agar and were stored on slants at 4°C until characterized. Characteristic bacteria isolates were identified based on colonial morphology, microscopy and biochemical tests (Holt *et al.*, 1994). Identification of Fungal isolates was based on morphological characteristics and microscopy with reference to standard atlas and keys (Samson and Reenen-Hoekstra, 1988; Tsuneo, 2010).

Determination of pH and moisture content of gari samples

The pH of the samples was determined following the method described by Ogiehor and Ikenebomeh (2005). Ten grams of each sample were homogenized in 10ml of distilled water and the pH of the suspension determined using a reference glass electrode pH meter

(Mettler Delta 340, Mettler – tocedo limited. UK). The moisture content was determined by drying 2g sample at 100-105°C to constant weight (AOAC, 1990)

Results and Discussion

Table 1 shows the mean microbial count of white and yellow types of gari samples obtained from three major markets in Ota, Ogun state Nigeria. It reveals that most of the samples had TAPC within the limits of 10^1 to 10^3 cfug⁻¹ and are contaminated with coliforms and fungi to about the same order. The table also shows that only two samples of white gari had TAPC count to the order of 10^4 cfug⁻¹. The pH of the samples is of acidic range 4.76 to 4.94 in both the white and yellow types of gari. Table 2 reveals that the gari samples were contaminated by diverse microbial spp mainly of Bacillus, Pseudomonas, Klebsiella, Staphylococci and Moulds. The percentage moisture contents of the samples range from 4 to 7 in the white gari and 6 to 8 in the yellow types.

The gari samples contain total aerobic plate count and fungi counts within acceptable limit. Ready to eat foods with plate counts of $\leq 10^3$ are acceptable, counts of 10^4 to 10^5 are tolerable while counts $\geq 10^6$ are unacceptable (ICMSF, 1996). The presence of contaminants to the order of 10^4 in two of the gari samples however, negates the 10^3 stipulated requirements by the African Organization for Standardization. Coliform was detected in most of the gari samples at high counts 10^2 to 10^3 , although no fecal coliform was detected (absence of growth of coliform organisms at 44°C), the presence of coliforms generally signifies poor sanitary condition in the production of gari. Gari after frying (heat treatment) is often spread in the open to cool and air dry and it is

thereafter sieved. Products are often displayed in open basins/bowls for sales in the market place. The presence of coliform could therefore be from post process contamination via food handlers and the environment. The ICMSF (1996) and the African Organization for Standardization recommended absence of coliform in ready to eat foods. The presence of coliform in most of the gari samples therefore makes it of poor quality for human consumption.

The fermentation of gari is by mixed microbial cultures, this could have accounted for the diverse microbial population contaminating the product. Similarly post process contamination specifically associated with sieving of products after heat treatment and the spreading of products in the open to air dry, coupled with the practice of leaving gari open for sales could have accounted for the diverse microbial population. The isolation of diverse microbial species from this ready to eat food (gari) corroborate the findings of Nichols *et al.* (1999), Mensah *et al.* (2002), Idowu (2006), Tauro *et al.* (2008), Oranusi and Braide (2012), Oranusi *et al.*, (2013). The use of specific starter culture, effective HACCP application and good manufacturing practice from farm to fork will help curtail the level of contamination. Although the microbial load counts with the exception of coliform counts are within acceptable standard limits (ICMSF, 1996), the presence of *B. cereus* and *S. aureus* calls for concern because some strains of these organisms are known to be toxigenic and have been implicated in food borne intoxication (Mensah *et al.*, 1999; Oranusi *et al.*, 2007), their presence therefore calls for concern. *B. cereus* is common environmental contaminants while *S. aureus* is of human origin, their presence

Table.1 Mean microbial load cfug⁻¹ and pH of gari

| Sample outlet | White gari | | | | Yellow gari | | | | |
|------------------|------------|-------------------|-------------------|-------------------|-------------|-------------------|-------------------|-------------------|------|
| | TAPC | Coliform count | Fungi count | pH | TAPC | Coliform count | Fungi count | pH | |
| Sango-Ota market | 1 | 4.7×10^3 | 2.0×10^3 | 4.0×10^2 | 4.81 | 1.5×10^3 | 1.1×10^3 | 8.0×10^2 | 4.79 |
| | 2 | 3.1×10^3 | 3.0×10^3 | 3.0×10^2 | 4.90 | 2.8×10^3 | 1.0×10^3 | 3.0×10^2 | 4.88 |
| | 3 | 5.6×10^3 | 2.7×10^3 | 3.0×10^2 | 4.87 | 1.0×10^3 | 1.4×10^3 | 4.0×10^2 | 4.84 |
| | 4 | 4.7×10^3 | 3.0×10^2 | 4.0×10^2 | 4.82 | 2.1×10^2 | 4.0×10^3 | 7.0×10^2 | 4.80 |
| | 5 | 2.0×10^2 | NG | 4.0×10^2 | 4.78 | 1.1×10^2 | 1.4×10^2 | 2.0×10^2 | 4.89 |
| | 6 | 1.1×10^4 | 2.7×10^3 | 3.0×10^2 | 4.81 | 4.3×10^3 | 3.4×10^3 | 5.0×10^2 | 4.85 |
| Ojuore market | 1 | 2.0×10^2 | 2.0×10^2 | 3.0×10^2 | 4.91 | 3.0×10^2 | 6.0×10^3 | 1.0×10^3 | 4.92 |
| | 2 | 2.0×10^2 | 2.0×10^2 | 6.0×10^2 | 4.89 | 4.0×10^2 | 1.0×10^2 | 4.0×10^2 | 4.86 |
| | 3 | 4.0×10^2 | NG | NG | 4.89 | 2.0×10^2 | 8.0×10^2 | 6.0×10^2 | 4.92 |
| | 4 | 3.1×10^3 | 7.0×10^3 | 4.0×10^2 | 4.80 | 1.6×10^3 | 2.0×10^3 | 9.0×10^2 | 4.93 |
| | 5 | 2.0×10^2 | 2.0×10^2 | 3.0×10^2 | 4.89 | 2.9×10^3 | 2.0×10^2 | 4.0×10^2 | 4.87 |
| | 6 | 9.6×10^3 | 3.0×10^3 | 4.0×10^2 | 4.86 | 1.1×10^3 | 9.0×10^2 | 5.0×10^2 | 4.94 |
| Ojaota market | 1 | 1.0×10^4 | 8.0×10^2 | 4.0×10^2 | 4.83 | 1.0×10^2 | NG | NG | 4.80 |
| | 2 | 9.6×10^3 | 7.1×10^3 | 3.0×10^2 | 4.79 | 1.0×10^2 | 1.0×10^2 | 1.0×10^2 | 4.78 |
| | 3 | 4.0×10^2 | 3.0×10^2 | 1.0×10^2 | 4.82 | 1.9×10^3 | 4.2×10^3 | 4.0×10^2 | 4.84 |
| | 4 | 8.0×10^2 | NG | 6.0×10^2 | 4.90 | 5.0×10^3 | 3.1×10^3 | 3.0×10^3 | 4.78 |
| | 5 | 3.0×10^2 | 2.0×10^2 | 1.0×10^2 | 4.88 | 4.1×10^2 | 1.2×10^2 | 5.0×10^2 | 4.76 |
| | 6 | 5.6×10^3 | 2.0×10^3 | 3.0×10^2 | 4.88 | 6.0×10^2 | NG | 1.2×10^2 | 4.82 |

Key: NG= no growth; TAPC= total aerobic plate count

Table.2 Microorganisms isolated from gari

| Sample | Microorganisms isolated |
|-------------|--|
| White gari | <i>Klebsiella spp</i> , <i>Bacillus licheniformis</i> , <i>Pseudomonas aeruginosa</i> , <i>Lactobacillus spp</i> , <i>Staphylococcus aureus</i> , <i>Staphylococcus epidermidis</i> , <i>Penicillium spp</i> , <i>Aspergillus niger</i> , <i>Rhizopus spp</i> |
| Yellow gari | <i>Bacillus spp</i> , <i>Enterobacter spp</i> , <i>Pseudomonas</i> , <i>Bacillus cereus</i> , <i>Staphylococcus aureus</i> , <i>Bacillus megaterium</i> , <i>Klebsiella spp</i> , <i>Fusarium spp</i> , <i>Mucor spp</i> , <i>Aspergillus niger</i> , <i>Aspergillus fumigatus</i> |

could therefore be from the food handlers, utensils and the environment. The processing of gari for consumption often involve mild or no heat treatment, the toxins from *B. cereus* and *S. aureus* if and when elaborated in food are heat stable, the consumption of contaminated gari could therefore portend a potential risk to consumers.

Moulds are common environmental contaminants due to their ability to produce spores; this could explain their presence in gari. They have been implicated in ready to eat foods and in unregulated/ mixed fermentation. Species of *Aspergillus*, *Penicillium* and *Fusarium* are known to produce deleterious mycotoxins under favourable conditions (Sweeney and Dobson, 1998; Kabak *et al.*, 2006; Oranusi *et al.*, 2013), their presence in gari must therefore be treated with caution.

Gari is a basic staple food in Nigeria and some African countries, it accounts for 70% of the entire cassava production in Nigeria (IITA, 1990). There is therefore a need to maintain proper sanitary conditions so as to avoid health risks. The moisture content of gari samples analyzed is low and within standard specification, this could have accounted for keeping the microbial load of gari low. It is therefore recommended that gari should be sold well packaged in bags and not as exposed in

basins/ bowls. Optimization of the process to using a starter culture with reduced post process handling is imperative. Effective HACCP and GMP will help reduce or eliminate product contamination and thus make the product safe for consumption.

References

- Akindahunsi, A.A., Oboh, G. and Oshodi, A.A. 1999. Effect of fermenting cassava with *Rhizopusoryzae* on the chemical composition of its flour and garri. *Riv. Ital. DelleSost. Grasse*, **76**: 437-440.
- Amadi, J.E. and Adebola, M. O. 2008. Effect of moisture content and storage conditions on the storability of garri. *African Journal of Biotechnology*. **7**: 4591- 4594.
- AOAC 1990 Official Method of Analysis, 13th ed., The Association of Analytical Chemists.
- Asegbeloyin, J.N. and Onyimonyi, A.E. 2007. The effect of different processing methods on the residual cyanide of 'Garri'. *Pakistan. Journal of. Nutrition.*, **6**: 163-166.
- Azam -Ali, S., Judge, E., Fellows, P. and Battcock, M. 2003. Small-scale food processing. A directory of equipment and methods. 2nd edition. ITDG Publishing. pp: 256
- Edem, D. O., Ayatse, J.O.I. and Itam E.H. 2001. Effect of soy protein supplementation on the nutritive value

- of 'garri' farina from *Manihotesculenta*. *Food Chemistry*.75: 57-62.
- Harbor, C.I. and Ogundu, E.C. 2009. Effect of processing on cyanide reduction in different cassava products. *Nigerian Journal of Biochemistry and Molecular Biology*.24 1: 35-37.
- Holt, J.G., Krieg, N.R., Sneath, P.H., Staley J.T. and Williams, S.T. 1994. *Bergey's Manual of Determinative Bacteriology*, ninth edition. Lippincott Williams and Wilkins, Baltimore.
- Huch, M., Hanak, A., Specht, I., Dortu, C.M., Thonart, P., Mbugua, S., Holzapfel, W.H., Hertel, C. and Franz C.M. 2008. Use of *Lactobacillus* strains to start cassava fermentations for Garri production, *International Journal for Food Microbiology*.128: 258-267.
- International Commission on Microbiological Specifications for Foods ICMSF 1996 *Microorganisms in Foods 5: Microbiological Specifications of Pathogens*.
- Idowu, O. A., 2006. Oral faecal parasites and personal hygiene of food handlers in Abeokuta, Nigeria. *Africa Health Science*, 6:160–164.
- IITA 1990. *Cassava in tropical Africa. A reference manual*. International Institutes for Tropical Agriculture, Ibadan Nigeria.
- Ijabadeniyi, A. O. 2007 Microbiological safety of gari, lafun and ogiri in Akure metropolis, Nigeria. *African Journal of Biotechnology* 622:2633-2635
- Jekayinfa, S.O. and Olajide, J.O. 2007. Analysis of energy usage in the production of three selected cassava based foods in Nigeria. *Journal of Food Engineering* 82: 217-226.
- Kabak B, Dobson A, Var I 2006. Strategies to prevent mycotoxin contamination of food and animal feed: a review. *Crit. Rev. Food Sci.Nutr.* 46: 593-619.
- Kemdirim, O.C., Chukwu, O.A. and Achinenwhu S.C. 1995. Effect of traditional processing of cassava on the cyanide content of gari and cassava flour. *Plant Foods for Human Nutrition* 48: 335–339.
- Kostinek, M., Specht, I., Edward, V.A., Schillinger, U., Hertel, C., Holzapfel, W.H. and Franz C.M. 2005. Diversity and technological properties of predominant lactic acid bacteria from fermented cassava used for the preparation of Gari, a traditional African food. *Systematic and Applied Microbiology*.286: 527-540.
- Mensah P., Owusu-Darko K., Yeboah-Manu D., Ablordey A., Nkrumah F. K. and Kamiya H. 1999. The role of street food vendors in the transmission of enteric pathogens *Ghana Medical Journal*, 33, 19-29.
- Mensah, P., Yeboah-Manu, D., Owusu-Darko, K., and Ablordey, A. 2002. *Street foods in Accra, Ghana: How safe are they? Bulletin: World Health Organization*, 807: 546-554.
- Nichols, S. L., Little, C. L., Mithani, V. and de Louvois, J. 1999. The microbiological quality of cooked rice from restaurants and take-away premises in the United Kingdom. *Journal of Food Protection*, 62: 877-882.
- Obadina, A.O., Oyewole, O.B. and Odusami, A.O. 2009. Microbiological safety and quality assessment of some fermented cassava products lafun, fufu, gari. *Scientific research and essay*, 4 5: 432-435.
- Ogiehor, I.S. and Ikenebomeh, M.J. 2005. Extension of shelf life of garri by hygienic handling and sodium benzoate treatment. *African Journal*

- Biotechnology and Microbiology.47: 744-748.
- Ogiehor, I.S. and Ikenebomeh, M.J. and Ekundayo, A.O. 2007 The bioload and aflatoxin content of market gari from some selected states in Southern Nigeria: public health significance. *African Health Science* 7 4: 223-227
- Oranusi, S., Onyeike, E., Galadima, M., and Umoh, V.J. 2004 Hazard analysis critical control points of foods prepared by families in Zaria, Nigeria. *Nig. J. Microbiol.* 181-2: 346-362
- Oranusi S., Galadima M., Umoh V.J. and Nwanze P.I. 2007. Food safety evaluation in boarding schools in Zaria, Nigeria, using the HACCP system. *Scientific Research and Essay*, 210, 426-433.
- Oranusi, U.S., and Braide, W. 2012. A study of microbial safety of ready-to-eat foods vended on highways: Onitsha-Owerri, south east Nigeria. *International Research Journal of Microbiology* 32 : 066-071.
- Oranusi S., Wesley B. and Oguoma O.I. 2013 Antifungal properties of lactic acid bacteria LAB isolated from *Ricinus communis*, *Pentaclethra macrophylla* and Yoghurts. *Global Advanced Research Journal of Food Science and Technology*, 21, 01-06.
- Osho, S.M. and Dashiell, K.E. 2002. The processing and acceptability of fortified cassava based product garri with soybean. *DiscoveryInnovation*.14: 186-191.
- Oyewole, O.B. and Sanni, L.O.1995. Constraints in traditional cassava processing: A case of 'fufu' production. In: *Transformation Alimentaire Du Manioc Cassava Food Processing*. Editors: Tom AgborEgbe, AlainBrauman, Dany Griffon, Serge Treche. InstitutFrancais de RechercheScientifique Pour le Development en Cooperation ORSTOM, Paris, France. ISBN 2-7099-1279-1. pp. 523-529.
- Ray, R.C. and Sivakumar, P.S. 2009. Traditional and novel fermented foods and beverages from tropical root and tuber crops: review. *International Journal of Food Scienceand Technology*.44: 1073-1087.
- Tsuneo, W. 2010. Pictorial atlas of soil and seed fungi: Morphologies of cultural fungi and Key to Species. Third editions, CRC press 2010.
- Samson, R.A, andReenen-Hoekstra, E.S. 1988. Introduction to foodborne fungi.2nd edition.Baarn: Central bureau voorschimmel cultures. 540pp.
- Sweeney M, Dobson A 1998. Mycotoxin production by *Aspergillus*, *Fusarium* and *Penicillium* species. *Int. J. Food Microbiol.* 43: 141-158.
- Taulo, S., Wetlesen, A., Abrahamsen, R., Mkakosya R. and Kululanga, G. 2008. Microbiological quality of water, associated management practices and risks at source, transport and storage points in a rural community of Lungwena, Malawi. *Africa Journal of Microbiological Research*,72: 131-137.