Original Article

Pediatric health implication of ògì and omi ’dùn as potential complementary therapy for infantile teething-diarrheal control

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ABSTRACT

Objective

To evaluate the bacterial contamination of ògì and omi’dùn by determination of viable and culturable, indicator bacterial composition, and antimicrobial potentials of omi’dùn and ògì.

Methods

Modified agar well-diffusion method was used to assay for the potential in vitro inhibitory activities of ògì and omi’dùn towards gastroenteritic bacterial species of infantile origin.

Results
Antibiotic resistant patterns (using discs) of fifty-one bacterial isolates, were between 0.0 and 100%. Higher antibiotic resistance rates were generally exhibited by the bacterial strains towards oral pediatric antibiotic suspensions except Sporidex in which lowest resistance rates of 10.5-58.8% were recorded. *E. coli* (63.6%), *Ent. aerogenes* (9.1%), *Kleb. pneumoniae* (13.6%) and *Pr. mirabilis* (13.6%) were the isolated bacterial species from ògì and omidùn samples (pH 5.9 - 6.8) with antibiotic resistance of 36.4% - 86.4% (antibiotic discs) and 27.3% - 95.5% (pediatric antibiotic suspensions). Multiple antibiotic resistance (MAR) rates of 12.5%-100% (antibiotic discs) and 25.0%-100% (pediatric antibiotic suspensions) were also recorded. *In vitro* inhibitory assay results of ògì and omidùn indicated that none of the omidùn samples inhibited the teething-diarrhea bacteria, while only 8.1% of ògì samples and 24.1% of *Lactobacillus* strains from ògì and omidùn were inhibitory *in vitro* but a total of 68.4% and 53.2% of the teething-diarrhea bacterial pathogens were however inhibited by laboratory-fermented ògì and omidùn respectively.

**Conclusion**

There is currently no microbial stability and safety in consumption of cottage-produced ògì and omidùn for the control of infantile diarrhea but controlled fermented ògì and omidùn can serve as adjuncts in cases of infantile gastroenteritis. (Rawal Med J 2011;36:45-49).

**Keywords**

Antibiotic resistance, foodborne pathogens, infant mortality, diarrhea, nutrition, ògì.

**INTRODUCTION**

It is estimated that 1400 million episodes of diarrhea occur annually in children under-five-years, resulting in about 5 million deaths,\(^1\)\(^2\) and these deaths are due to diseases and infections that are easily treatable, and therefore, the deaths are preventable. Indigenous cereal-based
weaning foods are significant sources of such pathogens, and causes of childhood diarrhea.\textsuperscript{2,3} Fermentation is widely believed to be protective against foodborne diseases\textsuperscript{4} and it is usually recommended as a cheaper way of preparing weaning foods.\textsuperscript{5} Several maize-based fermented products, such as \textit{ogi} in Nigeria, \textit{bouza} and \textit{kishk} in Egypt, \textit{togwa} in Tanzania, \textit{asida} and \textit{nasha} in Sudan, \textit{banku} and \textit{kenkey} in Ghana, \textit{mahewu} in South Africa, \textit{mawe} in Benin, \textit{kwete} in Uganda have been used.\textsuperscript{6} There is possibility of some microbial pathogens surviving and growing in some of the fermented foods.\textsuperscript{7,8} It has been reported that uncooked \textit{ogi} liquors from different varieties of grains have antibacterial activities against common bacteria that cause diarrhea, and people having diarrhea should drink raw \textit{ogi} liquor to treat it, especially in rural areas where they may not have access to medical attention.\textsuperscript{9} This study tried to evaluate the bacterial contamination of \textit{ogi} and \textit{omidùn} by determination of viable and culturable, indicator bacterial composition, as well as the \textit{in vitro} antimicrobial potentials of \textit{omidùn} and \textit{ogi}, the most popular indigenous weaning food in Nigeria.

**MATERIALS AND METHODS**

**Collection of samples and isolation of bacterial contents of \textit{ogi} and \textit{omidùn}:** Five hundred samples of retailed \textit{ogi} and \textit{omidùn} were randomly purchased over a period of 9 months from Lagos, Abeokuta and Ibadan metropolis of Nigeria for the determination of presence of total and fecal coliform bacterial flora. Sixty two samples were obtained from known producers/sellers within the three metropolises. Information on the sources of water used for \textit{ogi} processing and methods of processing were obtained from the producers through an interview method, while some water samples used for \textit{ogi} processing were also collected in sterile specimen bottles. White \textit{ogi} is produced from white maize grains [\textit{Zea mays} (L.)], while \textit{ogi-bàbà} (brown \textit{ogi}) is produced from sorghum [\textit{Sorghum bicolor} (L.)]. The bacterial isolates from the \textit{ogi} and \textit{omidùn}/samples were characterised using standard, phenotypic taxonomic tools.\textsuperscript{10}
Stool specimen collection: Stools were obtained from children with teething/weaning diarrhea who attended Oni Memorial Children Hospital, Ibadan, Oyo State, Nigeria. Subjects were solicited by questionnaires administered on nursing parents during hospital visits. Questionnaires were completed to provide demographic information and details concerning any use of antimicrobial agents by the child, at least 4 weeks prior to the collection of the stool specimens. The bacterial strains isolated from the faecal specimens of the children presented with teething/weaning diarrhoea were characterised using standard phenotypic taxonomic tools, on the basis of their cultural, morphological, biochemical and physiological characteristics.

Agar disc-diffusion method: The bacterial isolates were screened against the most commonly used antibiotics [discs – ampicillin (AMP 25µg); cotrimoxazole (COT 25µg); gentamicin (GEN 10µg); nalidixic acid (NAL 30µg); nitrofurantoin (NIT 300µg); colistin (COL 10µg); streptomycin (STR 10µg); tetracycline (T 30µg)] using the agar disc-diffusion method. Zones of inhibition were measured and recorded in millimetre diameter. Zones of inhibition less than 10.0 mm in diameter or absence of inhibition zones were recorded as resistant (negative).

Agar well-diffusion method: Inhibitory activities of paediatric antibiotic suspensions, Danacillin, Emicillin [ampicillin; 125mg/5ml], Jawaclox [ampicillin trihydrate / cloxacillin sodium; 250 mg/5ml], Cloxacillin [cloxacillin sodium; 250 mg/5ml], Bacitex, Sporidex [anhydrous cephalexin; 250 mg/5m], Barbicillin [ampicillin trihydrate; 125mg/5ml], Jawamox [ampicillin trihydrate; 250mg/5ml], Cadprim, Parkaprim, Primdex [sulfamethoxazole + trimethoprim 240 mg/5m] and Metazole [metronidazole; 200mg/5ml] were assayed for in this study using modified agar well-diffusion method. Zones of inhibition were measured and recorded in millimetre diameter. Zones of inhibition less than 10.0 mm in diameter or absence of inhibition zones were recorded as resistant (negative).

In vitro antimicrobial bioassays: Using the modified agar well-diffusion method, a total of 62 ògì and omidùn/ samples were microbially assayed for in vitro inhibitory potentials against the bacterial isolates implicated in teething/weaning diarrhea. Zones of inhibition and the
diameters of the zones surrounding the agar wells after incubation were measured and recorded in mm, while wells with no surrounding inhibition zones or with inhibition zones less than 10.0 mm were considered not to have inhibitory activity (resistant).

RESULTS
A total of 51 (n = 2 Gram-positive; n = 49 Gram-negative) bacterial isolates were obtained from the fecal specimens of children having teething diarrhea. The bacterial isolates were characterised as *Bacillus cereus* 2 (3.9%), *Enterobacter aerogenes* 1 (2.0%), *Escherichia coli* 20 (39.2%), *Klebsiella pneumoniae* 7 (13.7%), *Proteus mirabilis* 19 (37.3%), *Salmonella typhii* 2 (3.9%). The antibiotic susceptibility/resistant patterns of the bacterial species from teething-diarrhea, based on the zones of inhibition are as shown in Tables 1 & 2. The only strain of *Enterobacter aerogenes* was susceptible to all the test antibiotics but *E. coli* exhibited low to moderate resistance (10.0-45.0%) towards the test antibiotics except ampicillin (85.0%), while *Kleb. pneumoniae* and *Pr. mirabilis* exhibited high resistance to ampicillin (85.7%; 94.7%), colistin (71.4%; 68.4%) and tetracycline (57.1%; 78.9%) but moderate resistance were displayed towards other test antibiotics (Table 1).

Table 2 shows the antibiotic susceptibility and resistant patterns of the bacterial strains using oral pediatric antibiotic suspensions. Higher antibiotic resistance rates were generally exhibited by the bacterial strains compared with those recorded against antibiotic discs. Thirty seven water samples (n=2 boreholes, n=4 broken water pipes; n=31 wells) used in ògì production were obtained from the ògì producers. Thirty one (83.8%) of the water samples were total coliform positive and 24 (64.9%) were faecal coliform positive. One borehole, 3 broken pipes and 27 well water samples were total coliform positive respectively, while 2 broken pipes and 22 well water samples were total coliform positive respectively. The pH of the water samples were between 7.1 and 8.3 but the pH of the ògì and omidùn samples were between 5.9 and 6.8.
Most of the bacterial strains randomly isolated from ògì and omidùn samples (obtained from ògì producers) were lost but the remaining 22 Gram-negative bacterial strains were phenotypically characterised as E. coli 14 (63.6%), Enterobacter aerogenes 2 (9.1%), Klebsiella pneumoniae 3 (13.6%) and Proteus mirabilis 3 (13.6%). The resistance rates (antibiotic discs) of the Gram-negative bacterial species from ògì and omidùn were ampicillin (86.4%), cotrimoxazole, nitrofurantoin (59.1%), gentamicin (36.4%), nalidixic acid (63.6%), colistin (40.9%), streptomycin (40.0%) and tetracycline (54.5%); the MAR of the isolates were 12.5% - 100%, while about 55.0% of the bacterial isolates had MAR of ≥50.0%. The inhibitory assay results of ògì and omidùn indicated that none of the omidùn samples inhibited the indicator (teething-diarrhea) bacterial strains, while only 5 (8.1%) of the ògì samples (n = 62) and 6 (24%) of the Lactobacillus strains (n = 25) from ògì and omidùn were inhibitory in vitro against the indicator bacterial isolates.

**DISCUSSION**

Diarrhoeal diseases have been noted to be most frequent in children aged 6-11 months, when weaning foods of various types are generally introduced. Ògì is also usually introduced in cases when breast milk is not sufficient to feed babies. The pH in lactic acid fermented foods is usually reduced to <4 and this is normally sufficient to suppress the growth of most foodborne pathogens. Olsen et al. reported that maize fermentation from raw materials to the final product involves different micro-environments with strong antimicrobial activities, which determines the composition of the microflora of the final products, especially with the reduction of the pH from 6.5-3.7. The relatively higher pH (5.9 - 6.8) of ògì and omidùn as recorded in this study may therefore, be responsible for the high recovery rates of the foodborne bacterial pathogens.

Factors which contribute to a successful natural fermentation of carbohydrate-rich food and feed products include metabolic activities of lactic acid bacteria (LAB) and their ability to rapidly produce copious amounts of acidic end products with a concomitant pH reduction, which are
expected to have pronounced antimicrobial effects. In most of the cereal-based African fermented foods, coliforms disappearance and inhibition of Enterobacteriaceae have been found to correspond to increase in acidity (drop in pH) during fermentation \(^{17}\) but the pH of most ògì and omidùn samples currently produced in many parts of Southwest Nigeria are generally above 5.5.

Some foodborne pathogens have been reported to develop acid tolerance and ability to survive at pH <4.0.\(^{18}\) It was also observed in this study that only 8.1% of the ògì samples and none of the omidun samples inhibited the indicator (teething-diarrhea) bacterial strains in vitro. Similar minimal inhibitory activities were earlier reported in some Nigerian fermented food and beverages including ògì Ogunshe et al.\(^{8}\) We found ògì and omidùn samples were harbouring multiple antibiotic resistant food indicator bacterial species, even at pH of 5.9-6.8, indicating the non-safety of not properly prepared ògì and omidùn samples, in addition to their non- or very minimal inhibitory activities against the target diarrhogenic bacterial species.

The most commonly encountered pathogens in most African fermented foods include *B. cereus*, *E. coli*, *Salmonella* spp., *Staphylococcus aureus*, *Vibrio cholerae*, *Aeromonas*, *Klebsiella*, *Campylobacter* and *Shigella* spp., which have been implicated in diarrhoeal cases. An earlier review reported that indirect evidence suggested that 15-70% of all diarrheal episodes may be associated with practices of food preparation, handling and storage, as well as feeding methods.\(^{19}\)

Each African country has indigenous means of alternative therapy, especially in pediatric health conditions,\(^{20}\) however, importance must be given to the improvement of the nutritional value and the overall product safety of fermented foods. The investigation of the natural fermenting ecosystem has also shown that microbial developments are controlled by complex interactions of acid production, pH and several specific antimicrobial components,\(^{14}\) therefore, further studies on the microbial shifts, stability and safety of fermented ògì as food/food supplement/adjunct therapy, and the development of indigenous starter cultures in the control of infantile diarrhea is on-going in our laboratory.
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Fax: (234)-2-8103043.
Table 1. Antibiotic resistant patterns of bacterial strains (antibiotic discs).

<table>
<thead>
<tr>
<th>Diarrhogenic bacteria</th>
<th>AMP</th>
<th>COT</th>
<th>GEN</th>
<th>NAL</th>
<th>NIT</th>
<th>COL</th>
<th>STR</th>
<th>TET</th>
<th>MAR</th>
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<tbody>
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<td><strong>B. cereus</strong> [2]</td>
<td>50.0</td>
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<td>50.0</td>
<td>50.0</td>
<td>100</td>
<td>0.0</td>
<td>50.0</td>
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<td></td>
<td>(20.0)</td>
<td>(18.0-20.0)</td>
<td>(20.0)</td>
<td>(22.0)</td>
<td>(16.0)</td>
<td></td>
<td>(20.0)</td>
<td>(20.0)</td>
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<tr>
<td><strong>Salm. typhii</strong> [2]</td>
<td>50.0</td>
<td>0.0</td>
<td>0.0</td>
<td>50.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
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<tr>
<td></td>
<td>(26.0)</td>
<td>(10.0-15.0)</td>
<td>(20.0)</td>
<td>(20.0)</td>
<td>(20.0)</td>
<td>(20.0)</td>
<td>(20.0)</td>
<td>(20.0-24.0)</td>
<td></td>
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<tr>
<td><strong>Ent. aerogenes</strong> [1]</td>
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<td>-</td>
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<td>-</td>
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<td></td>
<td>(20.0)</td>
<td>(20.0)</td>
<td>(20.0)</td>
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<td>(20.0)</td>
<td>(20.0)</td>
<td>(20.0)</td>
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<tr>
<td><strong>E. coli</strong> [20]</td>
<td>85.0</td>
<td>10.0</td>
<td>10.0</td>
<td>15.0</td>
<td>35.0</td>
<td>15.0</td>
<td>45.0</td>
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<td></td>
<td>(18.0-22.0)</td>
<td>(12.0-20.0)</td>
<td>(18.0-25.0)</td>
<td>(16.0-28.0)</td>
<td>(20.0-30.0)</td>
<td>(12.0-28.0)</td>
<td>(15.0-30.0)</td>
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<td><strong>Kleb. pneumoniae</strong> [7]</td>
<td>85.7</td>
<td>14.3</td>
<td>14.3</td>
<td>28.6</td>
<td>143.0</td>
<td>71.4</td>
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<td>57.1</td>
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<td></td>
<td>(14.0-20.0)</td>
<td>(18.0-30.0)</td>
<td>(18.0-28.0)</td>
<td>(14.0-23.0)</td>
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<td>(14.0-20.0)</td>
<td>(20.0)</td>
<td></td>
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<tr>
<td><strong>Prot. mirabilis</strong> [19]</td>
<td>94.7</td>
<td>31.6</td>
<td>21.0</td>
<td>26.3</td>
<td>68.4</td>
<td>15.8</td>
<td>78.9</td>
<td>12.5-1003</td>
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<td>(18.0)</td>
<td>(14.0-20.0)</td>
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<td>(16.0-26.0)</td>
<td>(20.0-30.0)</td>
<td>(14.0-22.0)</td>
<td>(18.0-22.0)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>*<strong>Gram-ve bacteria</strong> [22] Ogi and omidun</td>
<td>86.4</td>
<td>59.1</td>
<td>36.4</td>
<td>63.6</td>
<td>59.1</td>
<td>40.9</td>
<td>40.0</td>
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<tr>
<td></td>
<td>(12.0-18.0)</td>
<td>(10.0-20.0)</td>
<td>(12.0-22.0)</td>
<td>(14.0-18.0)</td>
<td>(10.0-19.0)</td>
<td>(12.0-20.0)</td>
<td>(10.0-22.0)</td>
<td>(10.0-18.0)</td>
<td></td>
</tr>
</tbody>
</table>

**Keys:** AMP = ampicillin; COT = cotrimoxazole; GEN = gentamicin; NAL = nalidixic acid; NIT = nitrofurantoin; COL = colistin; STR = streptomycin; TET = tetracycline  MAR = multiple antibiotic resistance
* = Gram negative bacteria isolated from *ogi* and *omidun* samples. Values in parenthesis are zones of inhibition (mm diameter)
Table 2. Antibiotic resistant patterns of bacterial strains (pediatric suspensions).

<table>
<thead>
<tr>
<th>Diarrhogenic bacteria</th>
<th>Paediatric antibiotic suspensions (mg l(^{-1}))</th>
<th>MAR</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td><em>B. cereus</em> [2]</td>
<td>50.0</td>
<td>0.0</td>
</tr>
<tr>
<td><em>Salmonella typhi</em> [2]</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td><em>Ent aerogenes</em> [1]</td>
<td>7.1</td>
<td>1</td>
</tr>
<tr>
<td><em>E. coli</em> [19]</td>
<td>73.7</td>
<td>68.4</td>
</tr>
<tr>
<td><em>Kleb pneumoniae</em> [7]</td>
<td>71.4</td>
<td>57.1</td>
</tr>
<tr>
<td><em>Proteus</em> sp. [19]</td>
<td>94.1</td>
<td>94.1</td>
</tr>
<tr>
<td><em>Gram-ve bacteria</em> [22]</td>
<td>90.9</td>
<td>86.4</td>
</tr>
</tbody>
</table>

**Keys:**  1 = Prindex [sulfamethoxazole + trimethoprim 240mg/5ml]; 2 = Cadiprim [sulfamethoxazole + trimethoprim 240mg/5ml]; 3 = Parkaprim [sulfamethoxazole + trimethoprim 240mg/5ml]; 4 = Danacillin [ampicillin; 125mg/5ml]; 5 = Sporidex [anhydrous cephalexin; 250mg/5ml]; 6 = Metazole [metronidazole; 200mg/5ml]; 7 = Cloxacillin [cloxacillin sodium; 250mg/5ml]; 8 = Bacitex [anhydrous cephalexin; 250mg/5ml]; 9 = Barbicillin [ampicillin trihydrate; 125mg/5ml]; 10 = Emcillin [ampicillin; 125mg/5ml]; 11 = Jawaclox [ampicillin trihydrate / cloxacillin sodium; 250mg/5ml]; 12 = Jawamox [ampicillin trihydrate; 250mg/5ml]

* = Gram negative bacteria isolated from *ôgì* and *omidùn* samples.  MAR = multiple antibiotic resistance
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16. Lindgren SE, Dobrogosz WJ. Antagonistic activities of lactic acid bacteria in food and feed fermentation. FEMS Microbiol Letts 1990;87:149-63.

