Antibacterial Effects of Honey in Nigeria on Selected Diarrhoeagenic Bacteria

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Authors' contributions

This work was carried out in collaboration among all authors. Author JFJ designed the study, performed the statistical analysis, wrote the protocol, and wrote the first draft of the manuscript. Authors TTA and VOO managed the analyses of the study. Author TTA managed the literature searches. All authors read and approved the final manuscript.

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ABSTRACT

Aims: This study is geared to evaluating honey as an alternative of conventional antibiotics to treat infections caused by the selected diarrhoeagenic bacteria.

Place and duration of Study: Research laboratory of Federal University of Technology Akure (FUTA), Ondo State, Nigeria between December 2017 to May 2018.

Methodology: Honey samples from ten (10) different locations in Nigeria were screened for possible antibacterial activity on both the clinical and typed cultures of the selected diarrhoeagenic bacteria; Escherichia coli, Salmonella typhimurium, Shigella dysenteriae, Bacillus cereus and Staphylococcus aureus using agar well diffusion method. Conventional antibiotics were used as control. Data obtained were subjected to one way analysis of variance (ANOVA) using XL-Start, 2016 version.

Results: All the honey samples used exerted growth inhibitory activity on all the test bacteria including the ones that were resistant to the conventional antibiotics (Ofloxacin and augmentin).

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1. INTRODUCTION

Diarrhoeal diseases are amongst the most frequent childhood illnesses and leading cause of death especially among children under five years in developing countries, in areas of inadequate water supplies, sanitation and little or no health education [1]. Loss of water and electrolytes from the body can lead to severe dehydration which can be fatal in young children, especially those already in poor health and malnourished. Diarrhoea can be caused by organisms such as certain serotypes of Escherichia coli, Shigella spp. and other organism such as Salmonella spp., Campylobacter spp., and Yersinia enterocolitica [2]. All sorts of diarrhoea including watery diarrhoea, invasive diarrhoea and inflammatory diarrhoea are caused by Salmonella typhimurium, Escherichia coli, Shigella dysenteriae through infected food and Staphylococcus aureus and Bacillus cereus via food poisoning [3]. Although, diarrhoea is self-limiting, the issue of dehydration is of great concern and also when the illness is as a result of bacterial infections and antibiotic therapy is required, the problem of antibiotic resistance is also a serious problem because almost all known bacteria have developed resistant to most of the commonly employed antibiotics [4]. Also, some of these antibiotics can induce diarrhoea known as “antibiotic induced diarrhoea” [5]. Therefore, it becomes imperative to search for alternatives to conventional antibiotics to treat this disease.

Honey has been reported to exert antibacterial activity against many bacterial species [6-9]. Honey is a natural and sweet product which has a high nutritive value. It is produced when the nectar and sweet deposits from plants are brought together, modified and stored inside the honeycombs by the honeybees of the genera, Apis and Meliponin [10]. It can be classified based on the source of nectar. Honeys can either be unifloral or multifloral, depending whether the honey is produced from the nectar of only one type of flower or from nectar of flowers of various types [11]. In addition to this, honey can also be made by bees by extracting sugars from the living tissues of plants or fruits, and/or scavenge the excretions of insects (aphids) that tap the veins of higher plants. This type of honey is referred to as non-floral honey (honey dew) [12]. Honey is composed mainly of carbohydrates, smaller amount of water and a great number of minor components. Sugars are the main constituents of honey, constituting of about 95%. Honey characterization is based on the determination of its chemical, physical or biological properties [13]. Although, there are many reports of antibacterial activity of honey against many bacterial species, this present study was carried out to investigate the antibacterial effect of local honey samples from different geographical zones of Nigeria on some selected diarrhoeagenic bacteria commonly implicated in diarrhoeal illness in the region in order to know whether the locality of source of the honey sample has any effect on its antibacterial activity on the selected bacteria.

2. MATERIALS AND METHODS

2.1 Location and Duration of the Research

The research was carried out in the Graduate Research Laboratory of Department of Microbiology, Federal University of Technology, Akure, Ondo State, Nigeria between February to May, 2018.

2.2 Collection of Honey Samples

Honey samples were collected from ten (10) different locations in Nigeria; Emure – Ile and Afo – Akoko, Ondo State, Enugu, Enugu State, Ibadan, Oyo State, Ikere-Ekiti, Ekiti State, Lagos, Lagos State, Nasarawa, Nasarawa State, FUNAAB, Abeokuta Ogun State, Zamfara, Zamfara State and Iree, Osun State. Table 1 shows the location and the floral source of the honey samples used.

Conclusion: This study showed that honey has antibacterial activity against the selected bacteria and therefore can be exploited as an alternative to conventional antibiotics to treat infections caused by the selected diarrhoeagenic bacteria especially the ones that were resistant to conventional antibiotics.

Keywords: Diarrhoeagenic bacteria; antibiotics; honey; antibacterial activity; infections; alternative therapy.
Table 1. Honey samples from different locations in Nigeria

<table>
<thead>
<tr>
<th>S/N</th>
<th>Location</th>
<th>Floral source</th>
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<tbody>
<tr>
<td>1</td>
<td>Emure – Ile, Ondo State (Roadside)</td>
<td>Wildflower Honey</td>
</tr>
<tr>
<td>2</td>
<td>Ikere- Ekiti, Ekiti State</td>
<td>Wildflower Honey</td>
</tr>
<tr>
<td>3</td>
<td>Nasarawa, Nasarawa State</td>
<td>Wildflower Honey</td>
</tr>
<tr>
<td>4</td>
<td>Ibadan, Oyo State</td>
<td>Wildflower Honey</td>
</tr>
<tr>
<td>5</td>
<td>Afo, Ondo State</td>
<td>Wildflower honey</td>
</tr>
<tr>
<td>6</td>
<td>Ire, Osun State</td>
<td>Bitter leaf</td>
</tr>
<tr>
<td>7</td>
<td>FUNAAB, Abeokuta, Ogun State</td>
<td>Wildflower Honey</td>
</tr>
<tr>
<td>8</td>
<td>Enugu, Enugu State (Cinomis Honey)</td>
<td>Wildflower Honey</td>
</tr>
<tr>
<td>9</td>
<td>Lagos, Lagos State (Kaybeck Honey)</td>
<td>Wildflower Honey</td>
</tr>
<tr>
<td>10</td>
<td>Zamfara, Zamfara State (A &amp; Shine Honey)</td>
<td>Wildflower Honey</td>
</tr>
</tbody>
</table>

2.3 Test Diarrhoeagenic Bacteria

The following bacteria were used in this study; *Salmonella typhimurium* ATCC 14028, *Salmonella typhimurium* clinical, *Shigella dysenteriae* ATCC 11836, *Shigella dysenteriae* clinical, *Escherichia coli* ATCC 700728, *Escherichia coli* clinical, *Bacillus cereus* ATCC 14579, *Bacillus cereus* clinical, *Staphylococcus aureus* ATCC 29213 and *Staphylococcus aureus* clinical. The test bacteria were obtained from Spectra Medics Laboratories Shagamu, Ogun State and Medical Microbiology Laboratory in University College Hospital, Ibadan, Oyo State. The isolates were further characterized in the laboratory to establish their identity based on morphological and biochemical characteristics according to the method of [3].

2.4 Antibacterial Activities of Honey on the Test Bacteria

The test bacteria were prepared and standardized to achieve the turbidity of 0.5 McFarland according to [14]. The conventional antibiotics used in this study were Ofloxacin and Augmentin and their antibiotic resistant testing was determined by testing them on the test bacteria using disk diffusion method as described by [15]. The antibacterial activity of raw unpasteurized honey on the test bacteria was determined using agar diffusion method along side with the Ofloxacin and Augmentin used as control as described by [16].

2.5 Statistical Analysis

All experiments were done in triplicates. Mean, Standard deviation were calculated for all data using Descriptive Statistics, all data obtained were subjected to one way analysis of variance (ANOVA) using XL-Stat. 2016 version.

3. RESULTS AND DISCUSSION

All the ten honey samples used in this study exerted varying degrees of growth inhibition of all the test bacteria. Out of these honey samples, honey sample from Zamfara (HZ) exerted the highest growth inhibitory activity on five of the ten bacteria worked on (Table 2; values in red colour). The five bacteria are: *Bacillus cereus* ATCC 14579 (18.00 mm), *E. coli* ATCC 700728 (22.67 mm), *E. coli* clinical (26.00 mm), *S. aureus* ATCC 29213 (21.67 mm) and *S. aureus* clinical (21.43mm). This was closely followed by honey from FUNAAB (HF) which exerted the greatest growth inhibition of three of the test bacteria; *Bacillus cereus* clinical (20.33 mm), *S. typhimurium* clinical (26.00 mm) and *S. typhimurium* ATCC 14028 (23.00 mm).

On comparing the growth inhibition mediated by individual honey samples with the control antibiotics, it was observed that some of the honey samples exerted superior growth inhibition of the test bacteria than the antibiotics; ofloxacin and augmentin used as control. For example, honey from FUNAAB (HF) exerted superior growth inhibition of *Staph aureus* ATCC 29213, *S. typhimurium* clinical, *S. typhimurium* ATCC 14028, *Shigella dysenteriae* ATCC 11836 and *Shigella dysenteriae* clinical than that of the two conventional antibiotics used as control (Fig. 1).

Similar trend was also observed with honey from Zamfara (HZ). This honey sample also exerted superior growth inhibitory activity on five of the test bacteria than the two antibiotics used as control. The bacterial species are *Staph aureus* ATCC 29213, *S. typhimurium* clinical, *E. coli* ATCC 700728, *Sh. dysenteriae* ATCC 11836 and *Sh. dysenteriae* clinical (Fig. 2).
Table 2. Comparative effects of honey samples from different localities in Nigeria on the growth inhibitory activity on selected diarrhoeagenic bacteria (zone diameter in mm)

<table>
<thead>
<tr>
<th>Type of bacteria</th>
<th>HEI ± SD</th>
<th>HIK ± SD</th>
<th>HN ± SD</th>
<th>HI ± SD</th>
<th>HA ± SD</th>
<th>HIR ± SD</th>
<th>HF ± SD</th>
<th>HE ± SD</th>
<th>HL ± SD</th>
<th>HZ ± SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bacillus cereus ATCC 14579</td>
<td>13.00 ± 1.00&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.00 ± 0.00&lt;sup&gt;c&lt;/sup&gt;</td>
<td>13.33 ± 0.58&lt;sup&gt;ab&lt;/sup&gt;</td>
<td>11.00 ± 1.00&lt;sup&gt;c&lt;/sup&gt;</td>
<td>14.33 ± 2.08&lt;sup&gt;abc&lt;/sup&gt;</td>
<td>11.5 ± 0.50&lt;sup&gt;cd&lt;/sup&gt;</td>
<td>15.33 ± 1.53&lt;sup&gt;cd&lt;/sup&gt;</td>
<td>10.67 ± 1.15&lt;sup&gt;c&lt;/sup&gt;</td>
<td>10.50 ± 0.50&lt;sup&gt;c&lt;/sup&gt;</td>
<td>18.00 ± 2.65&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>Bacillus cereus clinical</td>
<td>10.00 ± 0.00&lt;sup&gt;c&lt;/sup&gt;</td>
<td>11.67 ± 2.08&lt;sup&gt;bc&lt;/sup&gt;</td>
<td>12.33 ± 2.52&lt;sup&gt;ab&lt;/sup&gt;</td>
<td>15.00 ± 0.00&lt;sup&gt;c&lt;/sup&gt;</td>
<td>16.00 ± 2.65&lt;sup&gt;abc&lt;/sup&gt;</td>
<td>15.67 ± 5.13&lt;sup&gt;abc&lt;/sup&gt;</td>
<td>20.33 ± 4.51&lt;sup&gt;bcd&lt;/sup&gt;</td>
<td>0.00 ± 0.00&lt;sup&gt;c&lt;/sup&gt;</td>
<td>0.00 ± 0.00&lt;sup&gt;c&lt;/sup&gt;</td>
<td>16.33 ± 3.79&lt;sup&gt;c&lt;/sup&gt;</td>
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<tr>
<td>E. coli ATCC 700728</td>
<td>12.67 ± 4.62&lt;sup&gt;ab&lt;/sup&gt;</td>
<td>10.00 ± 0.00&lt;sup&gt;c&lt;/sup&gt;</td>
<td>10.33 ± 0.58&lt;sup&gt;ab&lt;/sup&gt;</td>
<td>17.33 ± 1.53&lt;sup&gt;abc&lt;/sup&gt;</td>
<td>15.67 ± 1.15&lt;sup&gt;abc&lt;/sup&gt;</td>
<td>15.1 ± 0.50&lt;sup&gt;cd&lt;/sup&gt;</td>
<td>16.00 ± 1.00&lt;sup&gt;c&lt;/sup&gt;</td>
<td>11.33 ± 0.58&lt;sup&gt;cd&lt;/sup&gt;</td>
<td>11.67 ± 2.89&lt;sup&gt;abc&lt;/sup&gt;</td>
<td>22.67 ± 3.21&lt;sup&gt;b&lt;/sup&gt;</td>
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<td>E. coli clinical</td>
<td>12.33 ± 2.52&lt;sup&gt;a&lt;/sup&gt;</td>
<td>13.00 ± 2.00&lt;sup&gt;c&lt;/sup&gt;</td>
<td>12.33 ± 0.58&lt;sup&gt;ab&lt;/sup&gt;</td>
<td>17.00 ± 3.61&lt;sup&gt;abc&lt;/sup&gt;</td>
<td>14.00 ± 1.73&lt;sup&gt;abc&lt;/sup&gt;</td>
<td>16.00 ± 2.65&lt;sup&gt;abc&lt;/sup&gt;</td>
<td>15.00 ± 0.00&lt;sup&gt;c&lt;/sup&gt;</td>
<td>12.00 ± 2.65&lt;sup&gt;abc&lt;/sup&gt;</td>
<td>13.33 ± 2.89&lt;sup&gt;abc&lt;/sup&gt;</td>
<td>24.33 ± 3.06&lt;sup&gt;b&lt;/sup&gt;</td>
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<tr>
<td>S. typhimurium ATCC 14028</td>
<td>10.0 ± 0.00&lt;sup&gt;c&lt;/sup&gt;</td>
<td>14.67 ± 2.52&lt;sup&gt;ab&lt;/sup&gt;</td>
<td>15.33 ± 0.58&lt;sup&gt;ab&lt;/sup&gt;</td>
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<td>14.33 ± 2.52&lt;sup&gt;abc&lt;/sup&gt;</td>
<td>17.33 ± 4.04&lt;sup&gt;abc&lt;/sup&gt;</td>
<td>23.67 ± 2.31&lt;sup&gt;abc&lt;/sup&gt;</td>
<td>19.00 ± 2.65&lt;sup&gt;c&lt;/sup&gt;</td>
<td>11.0 ± 1.00&lt;sup&gt;c&lt;/sup&gt;</td>
<td>10.0 ± 0.00&lt;sup&gt;c&lt;/sup&gt;</td>
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<tr>
<td>S. typhimurium clinical</td>
<td>11.33 ± 2.31&lt;sup&gt;bc&lt;/sup&gt;</td>
<td>17.67 ± 2.08&lt;sup&gt;c&lt;/sup&gt;</td>
<td>14.33 ± 4.04&lt;sup&gt;ab&lt;/sup&gt;</td>
<td>13.33 ± 1.15&lt;sup&gt;abc&lt;/sup&gt;</td>
<td>13.67 ± 1.15&lt;sup&gt;abc&lt;/sup&gt;</td>
<td>16.37 ± 1.53&lt;sup&gt;abc&lt;/sup&gt;</td>
<td>26.00 ± 1.73&lt;sup&gt;a&lt;/sup&gt;</td>
<td>11.0 ± 1.00&lt;sup&gt;c&lt;/sup&gt;</td>
<td>11.67 ± 2.89&lt;sup&gt;abc&lt;/sup&gt;</td>
<td>24.67 ± 2.08&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>Shigella dysenteriae clinical</td>
<td>12.00 ± 0.00&lt;sup&gt;bc&lt;/sup&gt;</td>
<td>12.33 ± 1.53&lt;sup&gt;bc&lt;/sup&gt;</td>
<td>13.67 ± 2.52&lt;sup&gt;ab&lt;/sup&gt;</td>
<td>13.00 ± 3.00&lt;sup&gt;abc&lt;/sup&gt;</td>
<td>16.33 ± 3.21&lt;sup&gt;a&lt;/sup&gt;</td>
<td>11.33 ± 1.15&lt;sup&gt;abc&lt;/sup&gt;</td>
<td>12.00 ± 1.73&lt;sup&gt;a&lt;/sup&gt;</td>
<td>14.67 ± 0.58&lt;sup&gt;abc&lt;/sup&gt;</td>
<td>10.33 ± 0.58&lt;sup&gt;c&lt;/sup&gt;</td>
<td>12.67 ± 1.15&lt;sup&gt;abc&lt;/sup&gt;</td>
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<tr>
<td>Shigella dysenteriae ATCC 11836</td>
<td>12.33 ± 1.53&lt;sup&gt;bc&lt;/sup&gt;</td>
<td>10.00 ± 0.00&lt;sup&gt;c&lt;/sup&gt;</td>
<td>13.33 ± 2.08&lt;sup&gt;abc&lt;/sup&gt;</td>
<td>14.00 ± 2.65&lt;sup&gt;abc&lt;/sup&gt;</td>
<td>12.33 ± 2.31&lt;sup&gt;abc&lt;/sup&gt;</td>
<td>10.33 ± 0.58&lt;sup&gt;c&lt;/sup&gt;</td>
<td>16.33 ± 2.31&lt;sup&gt;a&lt;/sup&gt;</td>
<td>11.33 ± 1.15&lt;sup&gt;abc&lt;/sup&gt;</td>
<td>17.67 ± 1.53&lt;sup&gt;a&lt;/sup&gt;</td>
<td>13.00 ± 3.00&lt;sup&gt;abc&lt;/sup&gt;</td>
</tr>
<tr>
<td>S. aureus ATCC 29213</td>
<td>16.67 ± 1.53&lt;sup&gt;a&lt;/sup&gt;</td>
<td>10.0 ± 0.00&lt;sup&gt;c&lt;/sup&gt;</td>
<td>11.33 ± 0.58&lt;sup&gt;ab&lt;/sup&gt;</td>
<td>20.67 ± 2.31&lt;sup&gt;ab&lt;/sup&gt;</td>
<td>14.67 ± 1.53&lt;sup&gt;cd&lt;/sup&gt;</td>
<td>18.00 ± 2.65&lt;sup&gt;a&lt;/sup&gt;</td>
<td>14.67 ± 1.53&lt;sup&gt;ab&lt;/sup&gt;</td>
<td>15.33 ± 3.06&lt;sup&gt;c&lt;/sup&gt;</td>
<td>14.33 ± 4.04&lt;sup&gt;abc&lt;/sup&gt;</td>
<td>21.00 ± 4.36&lt;sup&gt;abc&lt;/sup&gt;</td>
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<td>S. aureus clinical</td>
<td>15.33 ± 2.52&lt;sup&gt;ab&lt;/sup&gt;</td>
<td>15.33 ± 4.51&lt;sup&gt;ab&lt;/sup&gt;</td>
<td>15.67 ± 4.51&lt;sup&gt;a&lt;/sup&gt;</td>
<td>19.67 ± 0.58&lt;sup&gt;cd&lt;/sup&gt;</td>
<td>12.00 ± 2.65&lt;sup&gt;a&lt;/sup&gt;</td>
<td>18.67 ± 1.15&lt;sup&gt;a&lt;/sup&gt;</td>
<td>14.00 ± 1.00&lt;sup&gt;c&lt;/sup&gt;</td>
<td>15.33 ± 3.06&lt;sup&gt;c&lt;/sup&gt;</td>
<td>16.00 ± 3.46&lt;sup&gt;abc&lt;/sup&gt;</td>
<td>21.00 ± 1.73&lt;sup&gt;abc&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

Key: HEI= Honey from Emure-Ile, HIK= Honey from Ikere-Ekiti, HN= Honey from Nasarawa, HI= Honey from Ibadan, HA= Honey from Afo-Akoko, HIR= Honey from Iree, HF= Honey from FUNNAB, HE= Honey from Enugu, HL= Honey from Lagos and HZ= Honey from Zamfara Data are presented as Mean ± standard deviation (SD) (n=3). Values with different alphabet as superscript along the column are significantly different at (P< .05)
Honey from Emure-Ile (HEI) on the other hand exerted superior growth inhibitory activity only on three of the test bacteria than that of the two antibiotics used as control. The bacterial species highly susceptible are *Staph aureus* ATCC 29213, *Sh. dysenteriae* ATCC 11836 and *Sh. dysenteriae* clinical (Fig. 3).

Similar results were also observed with honey from Ibadan (HI) and honey from Afo-Akoko (HA), honey from Iree (HIR), honey from Enugu (HE), honey from Lagos (HL) and honey from Nasarawa (HZ) which also exerted superior growth inhibitory on exactly the same three of the test bacteria that were highly susceptible to HZ than the control antibiotics (Figs. 4-9 respectively). Honey from Ikere-Ekiti (HIK) however exerted highest growth inhibition of only two of the test bacteria; *Sh. dysenteriae* ATCC 11836 and *Sh. dysenteriae* clinical (Fig. 10). One
unique observation however in this study is that all the honey samples used inhibited the growth of *Sh. dysenteriae* ATCC 11836 and *Sh. dysenteriae* clinical both of which were resistant to the two antibiotics used as control.

The results of this study agrees with previous report on the antibacterial activity of honey against *Staphylococcus aureus*, *Escherichia coli* and *Salmonella typhi* [17] although in this present study, *Salmonella typhimurium* was
Fig. 5. Antibacterial effect of honey sample from Afo-Akoko on selected diarrhoeagenic bacteria

Key: A = Shigella dysenteriae clinical, B = Bacillus cereus clinical, C = E. coli ATCC 700728, D = Staph. aureus ATCC 29213, E = Bacillus cereus ATCC 14579, F = Salm. typhimurium ATCC 14028, G = E. coli clinical, H = Salm. typhimurium clinical, I = Shigella dysenteriae ATCC 11836, J = Staph. aureus clinical and HA = Honey from Afo-Akoko

Fig. 6. Antibacterial effect of honey sample from Iree on selected diarrhoeagenic bacteria

Key: A = Staph. aureus clinical, B = Staph. aureus ATCC 29213, C = Salm. typhimurium ATCC 14028, D = E. coli clinical, E = Bacillus cereus clinical, F = Salm. typhimurium clinical, G = Bacillus cereus ATCC 14579, H = E. coli ATCC 700728, I = Shigella dysenteriae clinical, J = Shigella dysenteriae ATCC 11836 and HIR = Honey from Iree

used instead of Salmonella typhi. This work however disagrees with the report of Mohapatra [18] that Staph aureus was the most sensitive to all the honey samples they worked on among
the test bacterial strains they used. It is also in disagreement with the report of Sohaimy et al. [19] and Almasaudi et al. [20] that S. aureus is the most susceptible bacterial species to honey collected in Iraq and Egypt. Omфuvbe and Aканbi [21] found similar results through well

![](image7.png)

**Fig. 7. Antibacterial effect of honey sample from Enugu on selected diarrhoeagenic bacteria**

*Key:* A = Salm. typhimurium ATCC 14028, B = Staph. aureus ATCC 29213, C = Staph. aureus clinical, D = Shigella dysenteriae clinical, E = E. coli clinical, F = E. coli ATCC 700728, G = Shigella dysenteriae ATCC 11836, H = Salm. typhimurium clinical, I = Bacillus cereus ATCC 14579, J = Bacillus cereus clinical and HE = Honey from Enugu

![](image8.png)

**Fig. 8. Antibacterial effect of honey sample from Lagos on selected diarrhoeagenic bacteria**

*Key:* A = Shigella dysenteriae ATCC 11836, B = Staph. aureus clinical, C = Staph. aureus ATCC 29213, D = E. coli clinical, E = E. coli ATCC 700728, F = Salm. typhimurium clinical, G = Salm. typhimurium ATCC 14028, H = Bacillus cereus ATCC 14579, I = Shigella dysenteriae clinical, J = Bacillus cereus clinical and HL = Honey from Lagos
**Fig. 9. Antibacterial effect of honey sample from Nasarawa State on selected diarrhoeagenic bacteria**

Key: A = Staph. aureus clinical, B = Salm. typhimurium ATCC 14028, C = Salm. typhimurium clinical, D = Shigella dysenteriae clinical, E = Bacillus cereus ATCC 14579, F = Shigella dysenteriae ATCC 11836, G = Bacillus cereus clinical, H = E. coli clinical, I = Staph. aureus ATCC 29213, J = E. coli ATCC 700728 and HN = Honey from Nasarawa

**Fig. 10. Antibacterial effect of honey sample from Ikere-Ekiti on selected diarrhoeagenic bacteria**

Key: A = Salm. typhimurium clinical, B = Staph. aureus clinical, C = Salm. typhimurium ATCC 14028, D = E. coli clinical, E = Shigella dysenteriae clinical, F = Bacillus cereus clinical, G = Staph. aureus ATCC 29213, H = E. coli ATCC 700728, I = Shigella dysenteriae ATCC 11836, J = Bacillus cereus ATCC 14579, and HIK = Honey from Ikere-Ekiti

diffusion method that Nigerian honey showed activity against *Salmonella typhimurium* (12 – 22 mm), *B. cereus* (12 – 29 mm), and *E. coli* (19 – 38 mm). In contrast, the same author reported that honeys from different regions in Nigeria were not active against *S. aureus*, Also in Nigeria, Omoya et al. [22] reported a similar result on antimicrobial activity of honeys against
E. coli (13 – 20 mm) and Salmonella typhimurium (8 – 18 mm). The antibacterial activity observed in this study was bactericidal more than bacteriostatic. This goes contrary to the work of Laallam et al. [23] which reported that the antibacterial action of honey is essentially bacteriostatic but is in agreement with the report of Lusby et al. [24] that it is bactericidal. Comparison of the results in the different figures showed that some of the honey samples were more efficient in inhibiting the growth of the studied pathogenic bacteria than the other. Literature has shown that different honey types possess different efficacies against the same type of bacteria [10,20]. The differences might be due to origin, composition and the harvest period of the honeys that are used.

4. CONCLUSION
This study has shown that the antibacterial activity of honey samples used vary from one locality to the other. For example, honey samples from FUNAAB (HF) was the most effective in inhibiting the growth of S. typhimurium (both typed and clinical) than the other honey samples tested. All the honey samples used however were effective against Shigella dysenteriae (both typed and clinical isolates used) that were resistant to the two antibiotics used as control. These results clearly indicate that local honey samples in Nigeria are endowed with a broad spectrum antibacterial activity on the test bacteria. These findings therefore could be exploited in the treatment of diarrheal diseases caused by these bacteria as an alternative to conventional antibiotics to which some of the test bacteria have developed resistance especially Shigella dysenteriae, the aetiological agent of shigellosis.

ACKNOWLEDGMENTS
The authors appreciate the effort made by Mr Jimoh, Kabiru Ayobami for cross checking the statistical analysis.

ETHICAL APPROVAL
Scientific and ethical permit/clearance were obtained from the head of Department of Microbiology, Federal University of Technology Akure (FUTA) to Medical Microbiology Laboratory in University College Hospital, Ibadan, Oyo State before the release of test bacteria and commencement of the research.

COMPETING INTERESTS
Authors have declared that no competing interests exist.

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