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Antibiotic-Resistant *Enterococcus faecalis* Isolated from Food Canteens in Osun States, Nigeria

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Authors' contributions

This study was carried out in collaboration between all authors. Authors AKO and OF designed the study, authors RJS and AOO performed the statistical analysis, author AKO wrote the protocol, and wrote the first draft of the manuscript. Authors AKO and OF managed the analyses of the study and the literature searches. All authors read and approved the final manuscript.

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ABSTRACT

Enterococci have continued to attract considerable importance and attention as pathogens of public health concern both in the hospital and environmental settings. Therefore epidemiological studies of these organisms are now a major research interest. Incidence of multiple antibiotic resistance (MAR) among *Enterococcus faecalis* recovered from food canteens in Osun States, Nigeria was investigated. In all, 537 samples from canteens including; foods, plates and hand swabs of food handlers, were examined for contamination by *E. faecalis*. Out of 658 *E. faecalis* strains recovered from the samples, 71.30% were resistant to cloxacilin, 70.21% to erythromycin, 68.54% to cotrimoxazole, 65.05% to amoxicillin, 65.05% to chloramphenicol, 63.68% to tetracycline, 61.70% to augmentin, 53.04% to gentamicin and 11.7% to vancomycin. Resistance to the fluoroquinolones tested was in the order levofloxacin (34.04%), ciprofloxacin (28.72%), norfloxacin (26.6%), spafloxacin, (24.92%), and perfloxacin (24.32%). About 99.2% of the isolates were multiple resistant to between three and 12 of the antibiotics tested. The most common MAR phenotype was AMX/TET/COT/CLX/GEN/CLO/AUG/LEV/CIP/NOR. Of the ten medicinal plants investigated for

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antimicrobial activity on selected *E. faecalis* isolates, sweet acacia (*Acacia farneciana*) possessed the highest antibacterial activity. Crude methanol extract was most potent than the others (ethanol and aqueous extracts); an indication that the methanol extract probably possessed some active components not contained in the other extracts. This study has revealed that foods vended from a number of canteens and food outlets in Osun State, Nigeria were contaminated with antibiotic-resistant *E. faecalis* suggesting a possible significant reservoir of antibiotic-resistant bacteria. Hence, urgent and periodic epidemiological evaluation and enforcement of good hygiene practices in the study area are essential. Plant extracts were very effective on AR *E. faecalis*. Further studies on these plant extracts may provide evidence to confirm their roles as alternatives for the treatment and or control of *E. faecalis*-associated diseases.

Keywords: Antibiotic resistance; Enterococcus faecalis; ready-to-eat food; food canteen; food safety, medicinal plants.

1. INTRODUCTION

Since the past decades, enterococci have emerged as important pathogens [1] owing primarily to the high degree of antibiotic resistance exhibited by most clinical enterococci particularly vancomycin-resistant (VR) strains of *E. faecalis*. The rapid spread of vancomycin resistance among *E. faecalis* has been of great concern [2]. Enterococci are important human pathogens frequently implicated in human infections and *E. faecalis* is responsible for most infections in community, long-term care and hospital settings [3,4] and food animals [5]. *Enterococcus faecalis* emerged in the United States with high level resistance to gentamicin and aminoglycosides in the 1980 and creating therapeutic problems for patients with serious infections, such as endocarditis [6].

Enterococci are intrinsically resistant to many antimicrobial agents, including cephalosporins, clindamycin, and penicillinase-resistant penicilins [7]. They have low-level intrinsic resistance to aminoglycosides. Piperacillin and the carbapenems were reported to show a good activity against enterococci but had no advantage over ampicillin. Plasmid-mediated ß-lactamase production by some strains of *E. faecium* has led to further problems with treatment of serious enterococcal infections. In addition to vancomycin and high-level aminoglycoside resistance, most strains of VRE also have chromosomally mediated resistance to the penicillins. The number of antibiotic-resistant enterococci, especially VRE, is increasing [8,9] which is of great public health concern as this may lead to treatment failure and increased hospital costs with other attendant consequences.

Despite the fact that foods containing enterococci have a long history of safe use, these organisms are not considered as *generally recognized as safe* (GRAS). While some enterococci are used as probiotics [10,11] where they contribute to flavour and aroma [12], other species are important opportunistic and nosocomial pathogens of humans [13,14,15]. The resistance of enterococci to pasteurization temperature, and their adaptability to different substrates and growth conditions such as low and high temperatures, extreme pH, and salinity, implies that they can be found either in food products manufactured from raw materials (milk or meat) and in heat-treated food products. This means that these bacteria could withstand usual/normal conditions of food production. In addition, they can contaminate finished products during processing. Therefore, enterococci can become an important part of the fermented food microbiota, especially in fermented cheeses and meat products. The finding of Hayakawa *et al.* [16] suggests the presence of a non-hospital pool of VR *E. faecalis*, which is of great concern.

Ready-to-eat (RTE) foods refer essentially to foods that require no further significant processing prior to consumption [17,18]. It has been reported that RTE takeaway foods account for a large volume (33.0%) of sales in the catering service sector [19] and continues to be on the increase. However, little or no information is available about enterococci in our communities, particularly RTE foods from the food safety perspective. Therefore, we investigated the incidence and resistance of these organisms to antimicrobials.

2. MATERIALS AND METHODS

2.1 Sources and Collection of Samples

Isolates were recovered from three categories of food outlets which included Fast food canteen, Primary school canteen and *Bukataria* in the thirty Local Government Areas of Osun State,

Nigeria. Samples collected included 290 cooked and RTE foods, 80 and 167 swabs of serving plates and palms of food handlers, respectively were collected using the method of Lennox et al. [20].

2.2 Isolation and Identification of the Isolates

Hand swabs were inoculated directly onto sterile plates of Bile aesculin agar (Oxoid Ltd., Basingstoke, Hampshire, UK). Swabs of samples were processed, inoculated onto plates and incubated aerobically at 37°C for 24h. The plates were examined for colonies with characteristic reddish colour which is the presumptive feature feature for the identification of *Enterococcus* spp. on Bile aesculin agar.

Discrete colonies of the isolates were picked from plates, subcultured onto MacConkey agar No 2 and incubated overnight at 37°C after which discrete colonies were picked and stored on Nutrient agar slant at 4°C as stock. The isolates were identified using standard biotying methods [21,22,23].

2.3 Antibiotics Susceptibility Testing

Susceptibility testing was carried out on Müller-Hinton agar using the disc diffusion method according to the Clinical and Laboratory Standard Institute [24]. The following antibiotic disks (Abtek Biologicals, and Oxoid Ltd) with their concentrations (in μg) were used: amoxicillin (25), gentamicin (10), cotrimoxazole (25), augmentin (30) and tetracycline (30), erythromycin (5), chloramphenicol (30), cloxacillin (5), perfloxacin (5), norfloxacin (10), ciprofloxacin (10), levofloxacin (5), spafloxacin (10) and vancomycin (5).

2.4 Detection of β-Lactamase Production

All the isolates were tested for β-lactamase production with nitrocefin (Oxoid Ltd.) according to the manufacturer's instructions. Nitrocefin strip was dropped onto a single colony of an overnight culture. Development of a red colour within 60 sec. was indicative of β-lactamase production. *Staphylococcus aureus* strain ATCC 29213 was used as a positive control.

2.5 Antibacterial Effects of Plant Extracts

2.5.1 Collection and processing of plant materials

Plant specimens were obtained from Igbona market in Osogbo and Botanical garden of the Obafemi Awolowo University (O.A.U), Ile-Ife, Nigeria. The plants were thereafter identified and authenticated at the herbarium unit, Department of Botany, Obafemi Awolowo University, Ife-Ife, Nigeria and voucher specimens deposited. Table 1 depicts the different parts of the plants examined and their attributes including the local names.

2.5.2 Selection and standardization of isolates

Twenty vancomycin-resistant *E. faecalis* isolates were selected and further inoculated on Müller-Hinton Agar (Oxoid Ltd, Basingstoke, Hampshire, UK) containing 30μg vancomycin. This was repeated two times to confirm the stability of the isolates. They were later grown in separate tubes at 37°C in Müller-Hinton broth (Oxoid Ltd.) for 18h with shaking, standardized to an optical density of 0.1 (0.5 McFarland standard) at 625nm and stored at 4°C until used.

Table 1. Scientific and common names of plants examined against the selected *E. faecalis strains*

Common name (part used)	Scientific name	Local name
Pineapple (fruit)	*Ananas comosus* (L.)Merr.	*Ope oyinbo*
Mango (fruit)	*Mangifera indica* (L)	*Mangoro*
Nopal cactus (cladode)	*Opuntia ficus indica* (L)	*Oro agogo*
Basil (whole plant)	*Ocimum basilicum* (L)	*Efinrin ata, Efinrin wewe or Efinrin aaja.*
Honey mesquite (bark)	*Prosopis glandulosa* (Torr.)	*Ayan*
Naseberry (fruit)	*Manikara zapota* (L)	*Ako emido,emido or osere.*
Asparagus (fruit)	*Asparagus officinalis* (L)	*Aluki*
Sweet acacia (bark)	*Acacia farneciana* (L) Willd	*Ihun*
Lemon grass (leaves)	*Cymbopogon citratus* (Stapf.)	*Waapa or Kooko-oba*
Poblano pepper (fruit)	*Capsicum annuum* (L)	*Ata, Ata-jije, Ata- sisebe*

2.5.3 Extraction and determination of antibacterial activity of crude extracts of plant materials

The methods of CLSI [24] and Garcia-Migura et al. [25] were used for aqueous, ethanol and methanol extraction of plant materials and determination of susceptibility of the isolates to the different plant extracts.

The minimum inhibitory concentration (MIC) of the plant extracts was determined using the agar diffusion technique according to Oyagade et al. [26]. Briefly, a serial dilution of the extract was carried out to give final concentrations ranging from 3.175-100 mg/mL. Wells were prepared in previously seeded plates with standardized inoculum (10^8 cfu/mL), inoculated with 0.1 mL of the extract solutions (10^8 cfu/mL) of the bacterium, allowed to stand for 30 min and subsequently incubated at 37ºC for 24 h. The MIC was taken as the lowest concentration that inhibited the growth of the test organism. The experiment was performed in triplicates and the mean determined.

2.6 Statistical Analysis

Data obtained were subjected to analysis of variance (ANOVA) using the Statistical Package for Social Sciences (SPSS) version 17.0 (Inc., Chicago, IL).

3. RESULTS AND DISCUSSION

3.1 Isolation and Characterization of the Isolates

Table 2 shows the types and quantity of samples collected from various categories of food canteens and outlets. The food samples (n= 537) collected included 290 cooked foods such as meat, fish, samosa, salad, rice, beans and pounded yam; 80 plates and 167 palms of food handlers. Samples were collected according to canteen types following the pattern: *bukataria* (93), fast-food outlets (112) and primary school canteens (332). Five species of *Enterococcus* were identified to occur in the following order; *E. faecalis* (54.0%), *E. faecium* (26.0%), *E. avium* (10.8%), *E. gallinarum* (7.1%) and *E. raffinossus* (2.1%). This finding confirms the ubiquity and dominance of *E. faecalis* over the other members of the genus. In a similar study, Chajęcka-Wierzchowska et al. [27] recovered *Enterococcus* strains from retail food of animal origin in Olsztyn, Poland which were classified as *E. faecalis* (44 strains), *E. faecium* (32 strains) or *Enterococcus* spp.

The distribution of *E. faecalis* among the various canteen and food outlet sources is depicted on Table 3. Overall, 658 *E. faecalis* were recovered from 42.1% (226/537) samples collected. Due to their resistance to freezing, low pH, and moderate heat treatment among others, enterococci have been suggested as indicator organism in some types of food products [28] similar to the role it plays in the assessment of drinking water quality. Contrary to other faecal bacteria such as *Escherichia coli* that are released into the environment and have been traditionally used as indicator of faecal contamination, enterococci can survive for a long time even outside their natural intestinal hosts, which justifies their use as indicator organisms.

As shown on Table 3, *E. faecalis* was recovered from 52 (55.9%) of the 93 food samples collected from *bukataria*, followed by primary school canteens with 39.5% (131/332) while *E. faecalis* was least isolated from the fast-food outlets with 38.4% (43/112). The implication of this finding is that some food outlets in Osun State apparently did not comply with the good manufacturing practices and food-handling processes were not sufficiently hygienic; hence their products were highly contaminated. The situation is probably a reflection of the quality of human resources (personnel) engaged in these very important establishments with high public health importance on the one hand, an indication of low and or poor compliance with sanitary regulations in food safety [29,30,31,32,33]. On the other hand,

Table 2. Samples collected from various categories of food canteens

Samples	Canteen types			
	Primary school	Fast-food outlet	*Bukataria*	Total
Hand swab	102	32	33	167
Plate swab	60	-	20	80
Food	170	80	40	290
Total	332	112	93	537

it reveals the level of supervision and or inspection by the appropriate authorities charged with the responsibilities, function and duties of health management and regulation in the health management sector. The origins of microbial contaminants in food have been reported to include the food itself or its source (raw material), the environment, cross-contamination from an infected food handler while the microbial contaminants can be responsible for infectious disease outbreaks passed from food workers to consumers via food [18]. Heavy food contamination has equally been associated with the attitude of food vendors in tertiary institution in Nigeria [30-32,34-37].

3.2 Antibiotic Sensitivity Pattern

Resistance to the different classes of antibiotics tested varied. Of 658 *E. faecalis* strains recovered, resistance was mostly against cloxacilin with 469/658 (71.3%) while the least resistance was against vancomycin (77/658, 11.7%). Resistance to other antibiotics was in the following order; 462 (70.2%) to erythromycin, 451 (68.5%) to cotrimoxazole, 428 (65.1%) to amoxycilin, 428 (65.1%) to chloramphenicol, 419 (63.7%) to tetracycline, 406 (61.7%) to augmentin and 349 (53.0%) to gentamicin. There was no significant difference ($P > 0.01$) in the potency among the antibiotics used. Resistance to the fluoroquinolones (Table 4) was in the in the order, levofloxacin (34.0%), ciprofloxacin (28.7%), norfloxacin (26.6%), spafloxacin, (24.9%), and perfloxacin (24.3%).

The emergence of resistance to antibiotics among common pathogens has compromised the clinical usefulness of several major antimicrobial classes, including the β-lactams, macrolides, aminoglycosides and glycopeptides. The need for sourcing for other antimicrobial agents has therefore become compelling and critical for continued access to antimicrobials with clinical efficacy and balance of potencies against species of emerging pathogens [38]. Resistance to first-line antibiotics was by far the most common types of resistance observed in the *E. faecalis* isolates and statistically there was a significant difference ($P < 0.01$) with their source. High prevalence of resistance to antibiotics among *Enteroccus* spp. isolated from foods of animal origin have been similarly reported in Poland [27] and this can be a significant reservoir of antibiotic-resistant bacteria.

Antimicrobial agents have been used widely in animals in order to treat and/or prevent infections. They have also been used as growth promoters in animal feed in sub-therapeutic concentrations.

Table 3. Distribution of *E. faecalis* isolated from various canteens

Canteen Types	Sample tested	Sample positive for enterococci (%)	*E. faecalis* recovered
Fast-food outlet	112	43 (38.39)	132
Primary school	332	131 (39.46)	312
Bukataria	93	52 (55.91)	214
Total	537	226 (42.09)	658

Table 4. Resistance pattern of *E. faecalis* isolated from canteens to antibiotics

Antibiotics	Frequency	Percentage
Common antibiotics		
Amoxicilin	428	65.1
Tetracyclin	419	63.7
Cotrimoxazole	451	68.5
Erythromycin	462	70.2
Cloxacillin	469	71.3
Gentamycin	349	53.0
Chloramphenicol	428	65.1
Augmentin	406	61.7
Vancomycin	77	11.7
Fluoroquinolones		
Levofloxacin	224	34.0
Ciprofloxacin	189	28.7
Norfloxacin	175	26.6
Spafloxacin	164	24.9
Perfloxacin	160	24.3

This practice has been reported to facilitate emergence of resistant bacteria globally [39]. Resistance to fluoroquinolones recorded in this study was probably not unexpected. But the results disagree with the findings of Saxena et al. [40] that recorded higher average values of more than 50% among *E. faecalis*, while Omigie et al. [41] reported a general increase in resistance to fluoroquinolones in Nigeria. The extensive use of fluoroquinolones has obviously led to a rapid development of resistance among both clinical and environmental isolates including those of food origin. Therefore, the emergence of *Enterococcus* sp. expressing antimicrobial resistance and its potential spread in food suggest a situation of serious public health risk.

3.3 Multiple Antibiotic Resistances

The antibiotic susceptibility test revealed a trend in multiple antibiotic resistance among the isolates from the different categories of food outlets indicating resistance to at least three antibiotics and the highest resistance recorded was to 12 of the 14 antibiotics (Table 5). The number of strains that showed MAR was least among isolates from Fast food outlets. On the other hand, MAR was greatly manifested among isolates from Primary school canteens and *Bukatarias* with between 22 and 74 strains showing MAR to 8 antibiotics, while between 11 and 21 strains were resistant to 9 and 10 antibiotics, between 15 and 19 strains to 11 antibiotics and between 4 and 7 strains to 12 antibiotics.

The MAR strains showed diverse resistance phenotypes whereas only two strains (EFS 94 and EFS 96) were multiple resistant to 10 antibiotics and with the same phenotype AMX/ TET/ COT/CLX/GEN/CLO/AUG/LEV/CIP/NOR.

The results indicate that about 99.2% (653/658) showed multiple antibiotic resistance to between three and 12 of the 14 antibiotics tested (Table 5). About 1.7% (11/653) was resistant to three antibiotics, and 22.5% (147/653) were resistant to six antibiotics. There have been previous reports of MAR bacteria in foods (RTE) globally [42,43,44] and in Nigeria in particular [45,46,47,48]. This phenomenon presents a potential reservoir for the spread of MAR bacteria and genes in the community and a great source of concern and risks to public health. Foods have been reported to be major source of transmission and usually the environment, especially flies contribute to contamination of the foods. [49].

The potential for foods as a vehicle for transmission of MAR strains to humans and or as a reservoir for horizontal transfer between strains has been of particular interest. This phenomenon might be ascribed to the ability of enterococci, in particular, to survive gastric passage, multiply, and colonize the gastrointestinal tract for a significant amount of time, if ingested. Indeed, there has been a strong epidemiological evidence to link the use of antibiotics in human medicine and animal husbandry with the presence of resistant strains in animal products. In many instances where high rates of resistance have been recorded in food and humans, there is also a link to antimicrobial use in animals, thereby conferring cross-resistance [42].

3.4 β-Lactamase Production

Like most gram-positive bacteria, *E. faecalis* strains are resistant to cephalosporins by producing β-lactamase [50]. Of the 658 *E. faecalis* examined in this study, β-lactamase was detected in 44.0% of the total isolates from fast-food canteens, while 51.0% and 65.0% of isolates from primary school canteens and *bukataria* produced β-lactamase, respectively. This result negates the finding of Nikaido [51] who reported that strains of enterococci that produce β-lactamase are rare albeit in a different environment entirely. Thus, the observation may probably be ascribed to the fact that cephalosporins are no longer widely used while the level of β-lactamase production may be as a result of exposure to similar class of antimicrobials.

Table 5. Multiple antibiotic resistance patterns of *Enterococcus faecalis* isolates from various categories of canteens

Canteen category	Resistance to antibiotics										
	12	**11**	**10**	**9**	**8**	**7**	**6**	**5**	**4**	**3**	**Total**
Fast-food (n=129)	0	6	4	4	11	22	34	26	19	3	129
Primary school (n=310)	4	19	17	18	33	49	74	53	34	9	310
Bukataria (n=214)	7	15	11	21	26	41	39	28	22	4	214
Total	11	40	32	43	70	112	147	107	75	16	653

Table 6. Minimum Inhibitory concentration* of the extracts of plant materials

Plants	Solvent	Organisms																		
		EFT 119	EFT 148	EFT 156	EFT 100	EFT 194	EFS 12	EFS 18	EFS 50	EFS 86	EFS 38	EFS 134	EFS 172	EFS 296	EFC 12	EFC 21	EFC 44	EFC 59	EFC 86	EFC 111	EFC 162
Ananas comosus	Aqueous	25	-	-	-	25	-	-	100	25	25	-	-	50	-	-	-	25	-	-	50
	Ethanol	12.5	50	-	-	3.175	12.5	-	50	25	12.5	-	25	25	-	-	25	12.5	-	25	12.5
	Methanol	3.175	12.5	-	-	6.25	12.5	50	12.5	25	12.5	-	25	3.175	-	-	12.5	12.5	-	25	12.5
Ocimum basilicum	Aqueous	12.5	12.5	-	25	25	-	-	-	25	50	-	-	25	-	-	-	50	-	-	25
	Ethanol	12.5	12.5	-	25	12.5	-	-	-	12.5	25	-	25	25	-	-	25	25	-	25	25
	Methanol	6.25	12.5	-	25	6.25	12.5	-	-	12.5	12.5	-	25	12.5	12.5	-	12.5	12.5	-	12.5	25
Opuntia ficus indica	Aqueous	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Ethanol	50	50	-	-	50	-	-	-	-	50	-	25	25	-	-	25	-	-	-	25
	Methanol	25	25	-	-	12.5	-	-	-	12.5	25	-	25	12.5	-	-	25	-	-	-	25
Mangifera indica	Aqueous	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Ethanol	-	-	12.5	-	50	-	100	-	-	25	-	50	50	-	-	50	-	-	-	50
	Methanol	-	-	6.25	-	25	-	50	-	50	6.25	-	50	50	-	-	25	-	-	-	50
Prosopis glandulosa	Aqueous	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Ethanol	50	50	-	25	25	-	50	-	50	25	-	-	-	100	-	50	-	50	100	50
	Methanol	50	25	-	25	25	-	50	25	25	50	50	-	-	50	-	-	-	50	50	50
Manikara zapota	Aqueous	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Ethanol	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Methanol	6.25	12.5	6.25	-	12.5	-	50	12.5	-	3.175	50	-	12.5	-	6.25	-	-	12.5	100	25
Acacia farneciana	Aqueous	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Ethanol	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Methanol	-	6.25	25	3.175	-	6.25	50	100	25	-	3.175	50	6.25	50	25	-	25	25	12.5	-
Asparagus officinalis	Aqueous	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Ethanol	50	-	100	-	50	-	-	-	-	100	-	-	100	-	-	-	100	-	50	50
	Methanol	50	-	50	-	100	-	-	-	-	50	-	-	50	-	-	-	50	-	50	50
Cymbopogon citrates	Aqueous	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Ethanol	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Methanol	25	-	100	-	25	-	-	50	-	-	-	25	50	-	-	-	50	-	50	25
Capsicum annuum	Aqueous	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Ethanol	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Methanol	3.175	-	25	6.25	3.175	-	-	12.5	6.25	3.175	12.5	3.175	25	-	-	50	50	-	6.25	-

*MIC mg/mL.

3.5 Antibacterial Effects of Medicinal Plants

Plants are known to possess complex chemical storehouse of biodynamic compounds that often serve as defence mechanism against external invasion notably from microorganisms. These compounds can be invaluable sources of natural antibacterial agents, hence, the active ingredients of the plants isolated may constitute important alternatives in the treatment of infectious diseases since such compounds from plant sources are known to exhibit little or no side effects and evidently possess unlimited bioavailability [52,53]. Antibacterial effect of the three types of plant extracts (aqueous, ethanol and methanol) of *Ocimum bacilicum* was investigated. The results revealed the high antibacterial activity of the plants inhibiting 14 (70.0%) of the selected 20 *E. faecalis* strains tested. Table 6 shows the MICs of the plant extracts against the selected test organisms which ranged between 3.175 and 100 mg/L indicating the diverse efficacy of the plant materials. The lowest MICs were recorded for *O. bacilicum*, while the same goes for methanol compared to other extracants. This finding agrees with the suggestion to use different solvent systems in the investigation of plant extracts for antimicrobial potency [53]. There have been several reports on the efficacy of plant extracts in the treatment of infectious diseases particular, MAR pathogens recovered from RTE foods [54,55]. *Ocimum bacilicum* extract is reportedly used in the treatment of gastrointestinal helminths of animals and man [56,57]. The antimicrobial potency of the plants could be as a result of the presence of phytochemicals which have been shown to possess medicinal values [58,53]. The ethanolic and methanolic extracts appeared to be very potent due to the high antibacterial activity of 31.0% and 60.0% exhibited, respectively. Meanwhile, methanol extract was however, the most potent which also corroborates the observation of Sen and Batra [53] that organic extractants appear better than the aqueous.

4. CONCLUSION

Food canteens and outlets have been revealed as possible reservoir for antibiotic-resistant *E. faecalis* which may be involved in or have resulted in foodborne infections. *Enterococcus faecalis* was the most predominant species of the enterococci isolated from different food outlet sources. The isolates generally showed high resistance to antibiotics tested with equally high MAR. Medicinal plants demonstrated an appreciable antibacterial activity against vancomycin-resistant *E. faecalis*. Hence, the usage of selected plants as potential alternative source of treatment for *E. faecalis* infections has been validated. In the light of several socio-economic factors in Nigeria, especially poverty and poor hygienic conditions, our study encourages the use of herbs and medicinal plants as alternative or supplementary medicine to reduce the burden of high cost of treatment, non-availability of effective antibiotics especially in the rural setting, dangers of side effects and ever increasing antimicrobial resistance of pathogens. Moreover, there is need to put in place effective control strategies which may include enforcement of improved environmental and personal hygiene by the food handlers in the study area while surveillance programmes for adequate inspection and monitoring of food outlets to ensure food safety and protect public health.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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