ANTIBACTERIAL ACTIVITY OF CLOVE (*Syzigium aromaticum*) POWDER IN THE DIETS OF COCKROACH NYMPHS

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Hafsat Muhammad Oladunni[1]*, Kabir Mohammed Adamu[1], John Baba[2] and Diana Bmazazhin David[1]
[1]Department of Biological Sciences, Ibrahim Badamasi Babangida University, Lapai, Niger State.
[2]Department of Microbiology, Ibrahim Badamasi Babangida University, Lapai, Niger State.
***Correspondence author: email: hafsata96@gmail.com;**

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Abstract

Cockroaches have become the most common pest in many households. Their presence usually raises concern, especially as carriers of pathogenic bacteria. The present study was conducted to assess the antibacterial activity of clove (*Syzigium aromaticum*) in the diet of cockroaches (*Supella longipalpa* and *Blattodea germanica*) sampled from Lapai. Adult cockroaches carrying eggs were caught and reared for ten (10) weeks until the eggs hatched into nymphs. Diets with the inclusion of cloves were formulated as; D1 (carrot, lettuce, milk, sorghum flour and yeast (1:1:2:10:1) control), D2 (0.1 g clove meal with D 1), D3 (0.2 g clove meal with D1), D4 (0.3 g clove meal with D1) and D5 (commercial biscuit; control). At the end of the study period, cockroaches were sacrificed randomly to assess the bacterial load on the body surface and gastrointestinal tract of both species. It was revealed that the bacterial load on the body surface of *B. germanica* ranged from 6.10±2.15 to 9.50±0.25 while the GIT ranged from 7.17±0.33 to 9.80±0.06 cfu/ml. Similarly, the bacterial load on *S. longipalpa* ranged from 70±0.20 to 9.57±0.28 on the body surface and 7.13±0.29 to 9.33±0.15 CFU/ml in the GIT contents. The bacteria distribution in samples fed clove meal showed lesser occurrence of bacteria isolates than those fed the control diet. It can therefore be concluded that the inclusion of clove in cockroach diets showed good antibacterial activity.

Keywords: Bacteria isolation, Body surface, Brown banded cockroach, Clove, Gastrointestinal tract, German cockroach

Introduction

Cockroaches have survived on the earth for more than 300 million years virtually without change (Zurek and Schal, 2004). There are approximately 3500 species of cockroaches worldwide. Fifty species of them have been reported living in or around human structures (Kinfua and Erkob, 2008). Cockroaches have become most vital pest commonly found in association with man in areas such as restaurants, kitchens and in bakeries. These insects live in different environments, like sewage pipes, latrines, garbage, wall slits, baseboards and filthy places, as they are attracted by food, organic waste and fluids regularly discharged in such sites (Graczyk *et al*., 2001; Bell *et al*., 2007). Cockroaches are known as one of the most important agents in transmission and distribution of many bacteria, viruses, protozoa and fungi to human, and they act as intermediate host for some pathogenic intestinal worms (Cloarec *et al*., 1992; Thyseen *et al*., 2004).

Two most significant pest cockroaches are the German cockroach (*B. germanica*) and the brown banded cockroach (*S. longipalpa*) (Akbari *et al*., 2014) . Cockroaches are known to be good source of protein with high quality values of amino acid profiles (Adamu *et al*., 2021). That is comparable to other insect species (housefly, mealworm and cricket) that serve as protein sources in the diets of livestock (Oghale *et al*., 2014).

As a result of the cockroach's distinct advantage as a protein source, there is a greater need to use natural products with antibacterial, antifungal and antimicrobial active ingredients to reduce or eliminate the associated pathogen becomes necessary and timely. The natural products contained in therapeutic plants might act as a new source of antibacterial, antifungal and antimicrobial agents. Prior investigations have affirmed that onions, cinnamon, thyme, sage, cloves, garlic and different spice inhibit the growth of both Gram-negative and Gram-positive microbes (Paster *et al*., 1995) and have also been studied on various insects as an insecticide. Studies have shown that the bulb powder of some medicinal plants at higher concentration are capable of blocking the spiracles of various insects and can lead to suffocation and death (Asawalam *et al*., 2012).

Cloves (*Syzigium aromaticum*) are a perrenial tree of the Myrtaceae family. Because they are used in traditional medicine, they are most popular as sweet and aromatic flavors. The compounds in cloves have been accounted to have a few medical health significance including supporting liver health and balancing glucose levels. Therefore, this research was conducted to assess the anti-bacterial potentials of clove on bacterial load of cockroaches.

Materials and Methods

Study area

The study was conducted at the Department of Biological Sciences, Ibrahim Badamasi Babangida University Lapai, Niger State. Lapai is located within latitude 9°02'N and longitude 6°34'.

Sample collection and maintenance

Brown banded cockroach (*Supella longipalpa*) and German cockroaches (*Blattella germanica*) were captured with eggs from houses within Lapai. They were captured using brooms and hand-picked; then transferred to a clear cylindrical plastic container (15×20cm) with a net-covered opening for air circulation. Nymphs originating from eggs were carefully sorted and isolated prior to the start of the third nymph stage experiment. To prevent cockroaches from escaping, the container was glued 2 cm from the top with petroleum jelly. Commercial egg box was placed in each container to provide shelter and harbourage. The nymphs were fed formulated diets and water for a period of 8 weeks. After which bacteriological analysis was conducted.

Processing of plant material

The bulb of clove (*S. aromaticum*) was purchased from lapai market and air dried in the laboratory for 5 days. The dried plant was ground into powder using a blender, sieved and kept in a plastic container prior to the experiment (Rahman *et al*., 2009). Similarly, other ingredients which include carrot, lettuce, sorghum flour, yeast and milk were purchased from lapai market, dried and ground into powder.

Diet formulation

Diets were prepared by mixing dried carrot, lettuce, milk, sorghum flour and yeast as supplement in the ratio; 1:1:2:10:1. Five (5) different diets (D1, D2, D3, D4 and D5) were formulated adopting methods from previous studies with slight modification (Hadeel *et al*., 2014). D1 (carrot, lettuce, milk, sorghum flour and yeast (1:1:2:10:1) control), D2 (0.1 g clove meal with D 1), D3 (0.2 g clove meal with D1), D4 (0.3 g clove meal with D1) and D5 (commercial biscuit; control).

Surface and GIT sterilization of cockroach

Four cockroaches per set up were collected randomly using a sterile forceps and anaesthetized using a cotton soaked in chlorofoam. The cockroaches were then placed in sterile physiological saline (0.85%) and shaked vigorously for two minutes to dislodge the bacteria from its body surface. The wash was taken as the external body sample for bacteria isolation. Thereafter, cockroaches were placed in placed in 70% ethanol in a sterile conical flask, before being rinsed in 0.9% normal sterile saline for 2 minutes to remove the effect of alcohol. And then transferred to sterilized flasks, and allowed to dry at room temperature under sterile conditions. The GIT of each cockroach was dissected and was prepared in a homogenous suspension of 5ml nutrient agar in order to assess the internal bacteria sampling.

Bacteria isolation

Aliquots (0.01 ml) of both prepared samples including internal and external suspensions were separately cultured on plates of MacConkey Agar (L.S Biotech), Salmonella-shigella Agar (T.M Media), Nutrient Agar (L.S Biotech) and Eosin methylene blue Agar (Sisco Research Laboratory) at 37ºC overnight (24 hours). The isolated colonies were identified by standard bacteriological procedures. Each representative colony was characterized by its phenotypic characteristics, gram stain, and several conventional approaches including production of catalase and coagulase.

Data analysis

The data obtained were subjected to analysis for mean and standard error and analyzed using one-way analysis of variance (ANOVA). Individual means were compared using Bonferroni multiple comparison test. Differences were considered statistically significant at P<0.05. All statistical analysis was performed using GraphPad prism version 5.0 software package.

Results and discussion

Bacteria load on the body surface and GIT of B. germanica fed clove meal

The total bacterial counts on the body surface ranged from 6.10±2.15 to 9.50±0.25 CFU/ml while the GIT ranged from 7.17±0.33 to 9.80±0.06 CFU/ml (Table 1). The body surface revealed the highest bacteria count in D5 while the least was recorded at D2. It was also noted that there were significant differences (P<0.05) in the bacterial count on the body surface in cockroach fed D2 and D3 when compared with other diet. The GIT samples revealed the highest bacteria count in the D5 while the least was observed in D3. However, the samples revealed significant differences (P<0.05) in cockroach fed diet D3 when compared with the control diet. Studies on the bacteria load on the body surface and GIT of *B. germanica* were lower than those reported in previous studies (11.00×10^9) (Clement *et al*., 2014). The values obtained were also observed to be lower than the average values (1.35×10^8 and 5.99×10^7) for *B. germanica* (Paul *et al*., 1992).

Table 1: Mean± standard error of bacterial count on the body surface and GIT of *B. germanica* fed clove diets

Diets	Sampling Sites (CFU/ml×10^5)	
	External body surface	Gut
D1	8.90±0.49 ^{b}	9.73±0.12 ^{a}
D2	6.10±2.15 ^{a}	9.20±0.36 ^{a}
D3	6.70±0.15 ^{a}	7.17±0.33 ^{b}
D4	8.23±0.15 ^{b}	8.00±0.29 ^{a}
D5	9.50±0.25 ^{b}	9.80±0.06 ^{a}

D1 (carrot, lettuce, milk, sorghum flour and yeast (1:1:2:10:1) control), D2 (0.1 g clove meal with D 1), D3 (0.2 g clove meal with D1), D4 (0.3 g clove meal with D1) and D5 (commercial biscuit; control). Different superscript on the column are significantly different at P<0.05

Bacteria load on the body surface and GIT of S. longipalpa fed clove meal

The total bacterial counts of the body surface ranged from 6.70±0.20 to 9.57±0.28 CFU/ml while the GIT ranged from 7.13±0.29 to 9.33±0.15 CFU/ml (Table 2). The body surface recorded its highest count in the cockroach fed D5 while the least was observed in D3. Similarly, there were significant differences (P<0.05) on the bacteria count on the body surface in cockroaches fed D3 when compared with other diets. The GIT samples revealed highest bacteria count in D1 while the least was observed in D3. However, significant differences (P<0.05) was observed in cockroach fed D3 when compared with the control diets. The bacterial load assessed from all samples of *S. longipalpa* fed clove meal was below (1.0×10^6) the stipulated values capable of causing diseases in humans (Prescott *et al*., 2008). The lower values reported for both species might be as a result of the cleanliness of their rearing environment.

Table 2: Mean± standard error of bacterial count on the body surface and GIT of *S. longipalpa* fed clove diets

Diets	Sampling Sites (CFU/×10^5)	
	External body surface	Gut
D1	9.20±0.12^a	9.33±0.15^a
D2	8.57±0.22^a	8.93±0.03^a
D3	6.70±0.20^b	7.13±0.29^b
D4	8.00±0.12^a	7.97±0.32^a
D5	9.57±0.28^a	9.17±0.09^a

D1 (carrot, lettuce, milk, sorghum flour and yeast (1:1:2:10:1) control), D2 (0.1 g clove meal with D 1), D3 (0.2 g clove meal with D1), D4 (0.3 g clove meal with D1) and D5 (commercial biscuit; control). Different superscript on the column are significantly different at P<0.05

Distribution of bacteria on the body surface and GIT of B. germanica

The distribution of bacteria isolates on the body surface of *B. germanica* (Table 3a) revealed that *Escherichia coli* was present only in cockroaches fed D2, D4, D1 and D5 but absent in D3. *Klebsiella* spp and *Bacillus* spp were both present in D2 and D1 but absent in other diets. *Streptococcus* spp was completely absent in all samples containing clove meal. However, *Proteus* spp, *Pseudomonas aeruginosa* and *Salmonella* spp was absent in diet D2 but present in all other diets.

Table 3a Summary of Bacteria isolates on the body surface of *B. germanica* fed practical diets

Diets	Media	*Escherichia coli*	*Streptococcus spp.*	*Klebsiella* spp	*Proteus* spp	*Pseudomonas aeruginosa*	*Salmonella* spp	*Shigella* spp	*Bacillus* spp	*Staphyloccus aureus*
D1	NA	+	-	+	-	+	-	-	-	-
	MAC	+	-	-	+	-	+	-	-	-
	EMB	-	+	-	-	-	+	-	+	-
	SS	-	-	-	-	-	+	+	-	-
D2	NA	+	-	+	-	-	-	-	-	-
	MAC	+	-	+	-	-	-	-	-	-
	EMB	+	-	-	-	-	-	-	+	-
	SS	-	-	-	-	-	-	+	-	-
D3	NA	-	-	-	-	+	+	-	-	+
	MAC	-	-	-	-	+	+	-	-	-
	EMB	-	-	-	+	-	+	-	-	-
	SS	-	-	-	-	-	+	+	-	-
D4	NA	+	-	-	+	-	-	-	-	+
	MAC	+	-	-	+	-	-	-	-	-
	EMB	+	-	-	+	-	+	-	-	-
	SS	-	-	-	-	-	+	-	-	-
D5	NA	-	-	-	+	+	-	-	-	+
	MAC	+	-	-	+	-	+	-	-	-
	EMB	+	+	-	-	-	-	-	+	-
	SS	-	-	-	-	-	+	+	-	-

Key= NA= Nutrient agar, Mac-Agar= Mac-Conkey agar, EMB agar, SS= *Salmonella-Shigella* agar
+=present, -=absent

The result of bacteria isolates in the GIT of *B. germanica* (Table 3b) revealed that *E. coli* and *Salmonella* spp were present in almost all samples containing clove meal. *Streptococcus* spp was present only in samples fed D1, D2, D3 and D5 but was absent in D4. *Klebsiella* spp was present in D1, D2 and D4 but absent in D3 and D5. *Proteus* spp on the other hand was absent in D2 and D3 but present in other diets. *Pseudomonas aeruginosa* was absent in D3 and D4 but present in other diets. *Bacillus* spp and *Shigella* spp was completely absent in all diets containing clove meal.

Table 3b Summary of Bacteria isolates in the gut of *B. germanica* fed practical diets

Diets	Media	Bacteria isolates in the gut of *B. germanica*								
		Escherichia coli	*Streptococcus* spp.	*Klebsiella* spp	*Proteus* spp	*Pseudomonas aeruginosa*	*Salmonella* spp	*Shigella* spp	*Bacillus* spp	*Staphyloccus aureus*
D1	NA	+	+	-	-	+	-	-	-	-
	MAC	-	-	+	-	-	-	+	+	-
	EMB	+	-	-	+	-	+	-	-	-
	SS	-	-	-	-	-	+	+	-	-
D2	NA	+	+	-	-	-	-	-	-	-
	MAC	-	-	+	-	+	-	-	-	-
	EMB	+	+	-	-	-	-	-	-	-
	SS	-	-	-	-	-	+	-	-	-
D3	NA	-	+	-	-	-	-	-	-	+
	MAC	+	-	-	-	-	+	-	-	-
	EMB	+	+	-	-	-	-	-	-	-
	SS	-	-	-	-	-	+	-	-	-
D4	NA	+	-	+	-	-	-	-	-	-
	MAC	-	-	+	-	-	+	-	-	-
	EMB	-	-	-	+	-	+	-	-	-
	SS	-	-	-	-	-	-	-	-	-
D5	NA	-	-	+	-	-	-	-	+	+
	MAC	+	-	-	+	+	-	-	-	-
	EMB	-	+	-	+	-	+	-	-	-
	SS	-	-	-	-	-	+	+	-	-

Key= NA= Nutrient agar, Mac-Agar= Mac-Conkey agar, EMB agar, SS= *Salmonella-Shigella* agar
+=present,-=absent

Distribution of bacteria on the body surface and GIT of S. longipalpa

The distribution of bacteria isolates on the body surface of *S. longipalpa* (Table 4a) revealed that *Escherichia coli* and *Salmonella* spp were present in almost all samples containing clove meal. *Streptococcus* pp and *Shigella* spp were present in samples fed D2, D3 and D5 but absent in D1 and D4. *Klebsiella* spp was present in D1, D3 and D5 but absent in D2 and D4. *Bacillus* spp was present in D1, D2 and D5 and absent in D3 and D4. *Staphylococcus aureus* was present in D1, D2, D4 and D5 but absent in D3. *Pseudomonas aeruginosa* was completely absent in all diets containing clove meal.

Table 4a Summary of Bacteria isolates on the external body surface of *S. longipalpa* fed practical diets

Diets	Media	Bacteria isolates on the body surface of *S. longipalpa*								
		Escherichia coli	*Streptococcus* spp.	*Klebsiella* spp	*Proteus* spp	*Pseudomonas aeruginosa*	*Salmonella* spp	*Shigella* spp	*Bacillus* spp	*Staphyloccus aureus*
D1	NA	+	-	+	-	-	-	-	-	+
	MAC	+	-	-	-	+	-	-	+	-
	EMB	-	-	-	-	-	+	-	+	-
	SS	-	-	-	-	-	+	+	-	-
D2	NA	+	-	-	+	-	-	-	-	+
	MAC	-	-	-	-	-	+	-	+	-
	EMB	+	+	-	-	-	-	-	-	-
	SS	-	-	-	-	-	+	+	-	-
D3	NA	-	+	+	-	-	+	-	-	-
	MAC	+	+	-	-	-	-	-	-	-
	EMB	-	+	-	+	-	+	-	-	-
	SS	-	-	-	-	-	+	+	-	-
D4	NA	+	-	-	-	-	-	-	-	+
	MAC	+	-	-	+	-	-	-	-	-
	EMB	+	-	-	-	-	-	-	-	-
	SS	-	-	-	-	-	+	-	-	-
D5	NA	-	+	+	-	-	-	-	-	+
	MAC	+	-	-	-	+	-	-	+	-
	EMB	+	+	-	+	-	-	-	-	-
	SS	-	-	-	-	-	+	+	-	-

Key= NA= Nutrient agar, Mac-Agar= Mac-Conkey agar, EMB agar, SS= *Salmonella-Shigella* agar +=present, -=absent

The result of bacteria isolates in the GIT of *S. longipalpa* (Table 4b) revealed that *Salmonella* spp was present in almost all samples containing clove meal. *Escherichia coli* was absent in D4 and present in all other diets. *Streptococcus* spp was absent in D3 but present in other diets. *Staphylococcus aureus* and *Proteus* spp were absent in D3 and D5 but present in other diet. *Klebsiella* spp was absent in D1 and D2 but present in other diet. *Pseudomonas aeruginosa* was absent in diet D2 and D4 but present in other diets. *Shigella* spp and *Bacillus* spp was completely absent in all samples containing clove meal.

Table 4b Summary of Bacteria isolates in the gut of *S. longipalpa* fed practical diets

Diets	Media	Bacteria isolates in the gut of *S. longipalpa*								
		Escherichia coli	*Streptococcus* spp.	*Klebsiella* spp	*Proteus* spp	*Pseudomonas aeruginosa*	*Salmonella* spp	*Shigella* spp	*Bacillus* spp	*Staphyloccus aureus*
D1	NA	+	+	-	-	-	-	-	-	+
	MAC	-	-	-	+	+	+	-	-	-
	EMB	+	-	-	-	-	+	-	-	-
	SS	-	-	-	-	-	+	-	-	-
D2	NA	+	+	-	-	-	-	-	-	+
	MAC	+	-	-	+	-	+	-	-	-
	EMB	-	+	-	+	-	-	-	-	-
	SS	-	-	-	-	-	+	-	-	-
D3	NA	+	-	-	-	+	-	-	-	-
	MAC	-	-	+	-	+	-	-	-	-
	EMB	+	-	-	-	-	+	-	-	-
	SS	-	-	-	-	-	+	-	-	-
D4	NA	-	+	-	-	-	-	-	-	+
	MAC	-	-	+	-	-	-	-	-	-
	EMB	-	+	-	+	-	-	-	-	-
	SS	-	-	-	-	-	+	-	-	-
D5	NA	+	+	+	-	-	-	-	-	-
	MAC	-	-	-	-	+	-	-	+	-
	EMB	+	+	-	-	-	-	-	-	-
	SS	-	-	-	-	-	+	+	-	-

Key= NA= Nutrient agar, Mac-Agar= Mac-Conkey agar, EMB agar, SS= *Salmonella-Shigella* agar
+=present, -=absent

The present study revealed nine (9) species of bacteria isolated from the body surface and GIT of the two species of cockroach under study. The bacteria identified were as follows; *Escherichia coli*, *Salmonella* spp, *Shigella* spp, *Klebsiella* spp, *Pseudomonas aeruginosa*, *Proteus* spp, *Streptococcus* spp, *Staphylococcus aureus* and *Bacillus* spp. Among the bacteria species isolated, four species which belong to the family enterobacteriaceae was isolated (*Klebsiella* spp, *Proteus* spp, *Salmonella* spp and *Escherichia coli*). Mostapha *et al*. (2018) and Adamu *et al*. (2018) had reported that some of these bacteria species are causative agents of food poisoning. Food poisoning is one of the leading causes of illness and death in developing countries. (Sapkota *et al*., 2012). The presence of non pathogenic isolates such as *Bacillus* sp. and *Escherichia coli* are related to infestation from faeces which may be an indication of higher risk of other pathogenic isolates thus may be harmful to man (Doyle and Ericson, 2006). *Bacillus* spp. are known to cause a wide range of infectious diseases such as bacterimia, abscesses, wound and food borne infections, ear infections, ophthalmitis, endocarditis, meningitis, peritonitis, Osteomyelitis and respiratory and urinary infections, (Adamu *et al*., 2020). *Staphylococcus aureus* have been recognized as the commonest bacteria isolated from the body surface of most organism and are known globally as causative agent of Streptococcal infections (Yuasa *et al*., 2008). The distribution of bacterial organism in the present study was not so different from the reports of Tatfeng *et al*. (2005) except that in the present work, *Escherichia coli* and *Salmonella* spp appeared to be the most predominant bacteria isolated from both species of cockroaches which was not in the case of previous investigations by Clement *et al*. (2014). However, similar results were obtained by previous researchers to show that *Escherichia coli* was the most frequent extracted bacterium from the body surface of cockroaches (Vahabi *et al*., 2007). *Escherichia coli* was higher in cockroaches sampled from all diets which also correspond with the findings of Nejati *et al*. (2012).

Occurrence of bacteria isolates on the body surface of B. germanica and S. longipalpa fed clove meal

Nine (9) bacteria species were isolated from the body surface of *B. germanica* and *S. longipalpa* (fig 1). It was observed that the occurrence of *E. coli, P. aeruginosa* and

Proteus spp were higher on the body surface of *B. germanica* than *S. longipalpa*. The highest isolate recorded in abundance for both specie was *E. coli* (28.57, 25.00%), followed by *Salmonella* spp (18.37,18.75%) while the least isolate on *B. germanica* is *Streptococcus* spp (4.08%) and the least on *S. longipalpa* is *P. aeruginosa* (4.17%) respectively.

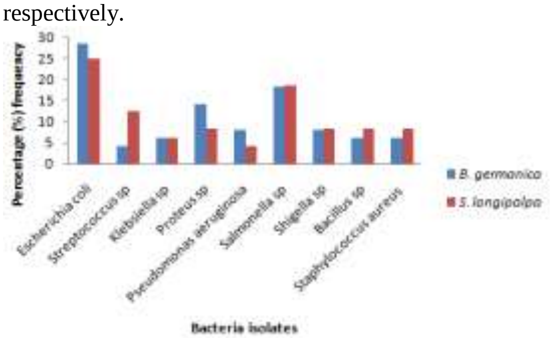

Figure 1. Occurrence of bacteria isolates on the body surface of *B. germanica* and *S. longipalpa*

Occurrence of bacteria isolates in the GIT of B. germanica and S. longipalpa fed clove meal

Nine (9) bacteria species was also isolated from the GIT of *B. germanica* and *S. longipalpa* (Fig 2). It was recorded that the occurrence of *E. coli, Klebsiella spp, Proteus* spp, *Shigella* spp and *Bacillus* spp were higher in the GIT of *B. germanica* than *S. longipalpa*. The highest isolate in abundance in the GIT of both specie was *Salmonella* spp (22.22, 27.03%), which was followed by *E. coli* (20.00, 21.62%) while the least encountered organism on *B. germanica* is *Staphylococcus aureus* and *Bacillus* spp (4.44%) and the least on *S. longipalpa* was *Shigella* spp and *Bacillus* spp (2.70%) respectively.

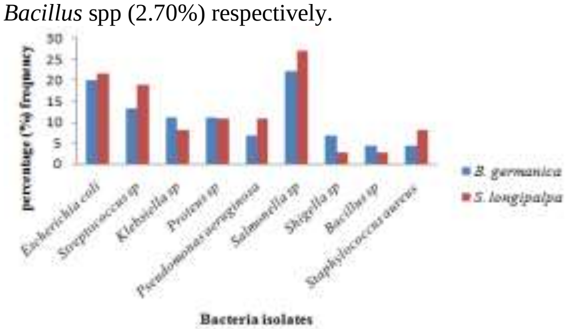

Figure 2. Occurrence of bacteria isolates in the GIT of *B germanica* and *S. longipalpa*

The antimicrobial activity of clove has been proven against several strains of bacteria and fungi. Cloves have also been shown to inhibit the growth of several pathogenic bacteria just like other spices, but comparatively have a lower effect on pathogenic strains of bacteria (Mohamed, 2014). Cloves have been shown to inhibit maximum effect on *Staphylococcus typhi* and minimum effect on *Escherichia coli* which corresponds with the findings of the present study. Diet which contains cloves showed a lower occurrence of *Salmonella* spp as well as in *Escherichia coli*. The inclusion of cloves at different concentrations showed good inhibitory activity against the bacteria. The best effect was shown in *Streptococcus* spp while the least in *Escherichia coli*. Clove extract was found effective against non-toxigenic strains of *Escherichia coli* (Burst, 2004) which are also in line with the present study. In another study, clove extract was found active against food borne gram positive bacteria; *Staphylococcus aureus, Bacillus cereus, Enterococcus faecalis* and *Listeria monocytogenes* and gram negative bacteria; *Escherichia coli, Yersinia enterocolitica, Salmonella* spp and *Pseudomonas aeruginosa* (Saeed and Tariq, 2008). Clove could destroy cell walls and membranes of microorganisms, and permeate the cytoplasmic membranes or enter the cells, then inhibit the normal synthesis of DNA and proteins (Xu *et al*., 2016). Eugenol, the major component of clove, could inhibit the production of amylase and proteases in *Bacillus cereus* and has the ability of cell wall deterioration and cell lysis.

Conclusion

A considerable number of bacteria isolates were analyzed from nearly all the cockroaches sampled, suggesting the importance of cockroaches in the transmission of several bacteria. However, the inclusion of cloves in the diets of these insects inhibited the growth of a few number of these bacteria isolates which confirms the antibacterial property of cloves.

Conflict of interest

There are no conflicts of interest.

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