Antibacterial activity of certain medicinal plants on different bacterial strains associated with colorectal cancer

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Abstract

The antibacterial activity of aqueous extracts and essential oils of twenty medicinal plants of Egypt were determined by the agar diffusion-method against three bacterial species, Escherichia coli, Pseudomonas aeruginosa and Bacillus subtilis, isolated from colorectal cancer tissues and normal adjacent tissues. Aqueous extracts and essential oils showed significant antibacterial activity against all the bacterial species tested. The highest significant inhibition zone and percentage relevant to tetracycline (positive control) was found for marjoram, black cumin and peppermint essential oils against B. subtilis isolated from tumoral and normal tissues. Marjoram and basil showed significant antibacterial activity against E. coli. Meanwhile, thyme and rosemary showed significant inhibitory activity against P. aeruginosa. The data also suggested that the best aqueous extract was from Albizia lebbeck, which inhibited the growth of all bacterial strains tested except for B. subtilis isolated from tumoral tissues.

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Introduction

**Phytochemical constituents of medicinal plants**

Plant compounds are of interest as a source of safer or more effective substitutes than synthetically produced antimicrobial agents. Phytochemical research progress has been aided enormously by the development of rapid and accurate methods of screening plants for particular chemicals. These procedures have shown that many substances originally thought to be rather rare in occurrence are of almost universal distribution in the plant kingdom. The drugs contained in medicinal plants are known as active principles. The active principles are divided chemically into a number of groups including alkaloids, volatile essential oils, phenols and phenolic glycosides, resins, oleosins, steroids, tannins and terpenes (Mitcher et al., 1988; Habtermariam, 1993).

The increasing interest in traditional ethno medicine may lead to the discovery of novel therapeutic agents. Medicinal plants are finding their way into pharmaceuticals, nutraceuticals, cosmetics and food supplements. The World Health Organization (WHO, 2000) estimated that 80% of the population of developing countries still relies on traditional medicines, mostly plant drugs, for their primary health care needs. Herbs are supposed to be safe but many unsafe and fatal side effects have recently been reported (Ikegami et al., 2003; Izzo, 2004). Hence, there is an urgent need to study the screening of antimicrobial properties of herbs, which will be helpful in the treatment of several diseases caused by microorganisms.

*Human microflora in relation to cancer*

Traditionally, bacterial infections have not been considered a major cause of cancer. However, bacteria have been linked to cancer by two mechanisms: chronic inflammation and production of carcinogenic metabolites (Parsonnet, 1995). It was stated that bacteria in general are thought to contribute to carcinogenesis by the formation of potentially toxic by-products of carbohydrates or bile acid metabolism, as well as hydrolysis of other mutagenic precursors (Parsonnet, 1995). The association of *Helicobacter pylori* with gastric cancer is the best studied relationship between a bacterial infection and cancer (Parsonnet et al., 1991). *Helicobacter pylori* has been recognized as a class I human gastric carcinogen by the International Agency for Research on Cancer (WHO, 2007). The mechanisms by which bacteria contribute to cancer formation are complex and involve the interplay among chronic inflammation, direct microbial effects on host cell physiology, and changes in tissue stem cell homeostasis. In fact, there is recent evidence that some chronic bacterial infections are associated with tumor formation; therefore, it might be possible to prevent or treat some forms of cancer if the infectious source is addressed (Malfertheiner et al., 2005).

*The intestinal microflora and its colon cancer connection*

The incidence of colorectal cancer varies widely among countries. In the developed world, colorectal cancer represents a major public health problem. In the UK and the USA, colorectal cancer is the second most common cancer after breast cancer for women, and prostate or lung cancer for men (Hewitson et al., 2008; Parkin et al., 2005). The involvement of the intestinal microflora in the pathogenesis of colon cancer has been hypothesized. Many cancers arise from sites of infection, chronic irritation, and inflammation (Miki et al., 2010). The strongest association of chronic inflammation with malignant diseases is found in inflammatory bowel diseases of the colon (Balkwill and Mantovani, 2010) with a lifetime incidence of 10% (Choi and Zelig, 1994; Wang and Dubois, 2010).

In fact, the gut in newborns is considered sterile, but bacterial colonization occurs quickly and the adult human intestinal tract hosts a complex microbial system. The number of microbes significantly overcomes the entire number of host eukaryotic cells, playing a crucial role in the regulation of both enteric and systemic homeostasis. Even though a beneficial relationship between the host and the microbiota has been demonstrated, in certain conditions the intestinal microflora can increase the risk of carcinogenesis and promote tumoral growth.
In fact, intestinal autochthonous bacteria are involved in the catabolism of several elements derived from the diet or from endogenous secretions, they can modulate the expression of host genes participating in several pathological functions and can interfere with the immune system and the inflammation mechanisms. Furthermore, the gut microbiota is involved in redox stress damage, motility, angiogenesis, proliferation, differentiation, and fat storage regulation (Huycke & Gaskins, 2004).

Several species of bacteria have been linked to chronic infections of the colon and have been shown to increase the risk of colon cancer by several microorganisms including E. coli (Martin et al., 2004). Only a restricted number of bacterial types colonise the gut. The dominant flora belongs to at least five bacterial phyla: Firmicutes, Bacteroidetes, Actinobacteria, Proteobacteria and Fusobacteria. There are six genera of strict anaerobes: Bacteroides, Eubacteria, Bifidobacteria, Clostridia, Peptostreptococi and Ruminococi, while most represented aerobic bacteria belonging of the genera Escherichia, Enterococcus, Streptococcus and Klebsiella (O’Hara & Shanahan, 2006). The number of bacterial species present in the human intestine is high, and 57 species are common to over 90% of subjects (Qin et al., 2010). The most common Inflammatory Bowel Disease (IBD)-related bacterium is E. coli belonging to the Enterobacteriaceae. In IBD patients, an increase of E. coli was observed (Kotlowski et al., 2007). The adherent invasive E. coli was associated with ileal mucosal lesions in Crohn’s disease (CD) patients, with increased number and capability to adhere to the intestinal epithelial cells, disrupting the intestinal barrier (Rolhion and Darfeuille-Michaud, 2007). This bacterium is more invasive in CD patients compared to ulcerative colitis (UC) patients (Sasaki et al., 2007).

The purpose of this work was to evaluate the antibacterial activity of aqueous extracts and essential oils from medicinal plants of Egypt towards the bacterial strains associated with colorectal cancer.

**Methods**

**Medicinal plants**

The current study was conducted during 2013 and 2014 years at Fundamental Medicine and Biology Institute, Kazan (Volga region) Federal University, Russia. The medicinal plants were obtained from the botanical gardens of the Faculty of Agriculture at Assiut University in Assiut, Egypt. The plant materials were collected during 2013 and authenticated by the botanists in the Faculty of Science at Assiut University. Once the plants from Egypt were harvested, they were cleaned and chopped into small pieces that were shade dried and ground into powdered form and stored under dark refrigerated conditions. Medicinal plants used for the study are shown in Table 1:

**Extraction**

**Aqueous extract**

Aqueous extracts of Brachychiton opulneus, Ceiba pentandra, Bombax malabaricum, Chorisia speciosa, Albizia lebbeck, Bauhinia variegate, Kigelia Africana and Pinus halepensis were prepared by maceration of the plant material powder with distilled water at a ratio of 1 g: 10 ml and put on a shaker for two days at room temperature. The macerate was first filtered through double layer muslin cloth then filtered through Whatman No. 1. Subsequently, each extract was sterilized using 0.22-µm filters. Each sterile extract was stored at –20 °C.

**Essential oil extract**

Plant samples (100 g) of Zingiber officinale, Pimpinella anisum, Piper nigrum, Origanum majorana, Rosmarinus officinalis, Ocimum basilicum, Thymus vulgaris, Mentha piperita, Simmondsia chinensis, Nigella sativa, Linum usitatissimum and Eruca sativa were subjected to hydro-distillation for 2 hours using the Clevenger apparatus for essential oils (Clevenger, 1928). Currently, the most popular method of extraction is steam distillation, in which water is heated to produce steam, which carries the most volatile chemicals and aromatic material. Essential oils usually float on the surface Hydrosol (a
component of distilled water). Extracted essential oils are stored in a dark clean glass bottle and stored at 4 °C.

**Biopsy samples**

Biopsy samples (approximately 1 mm³) of tumor colonic epithelial cells and normal tissue from a nearby intact area were obtained during surgical laparotomic colorectal resection for CRC with curative intent. 17 samples of intact epithelia and 19 of neoplastic epithelia were obtained from 23 patients with diagnosed CRC. The study was approved by the Research Ethics Committee of Kazan Medical University, Russia (protocol No. 4, the 7th of May, 2009).

**Bacterial strains isolation**

Biopsy samples were transferred into 5 ml of sterile physiological solution and incubated for 30 min with gentle stirring. A sample of 50 µl (also with dilution 10^{-2} – 10^{-5}) was transferred to an LB agar plate and then distributed evenly over the surface by a special streaking technique. After 1–2 days of incubation at 37 °C, single colonies were scored. The total number of microorganisms was reported as CFU/ml. Bacterial isolates were identified using matrix-assisted laser desorption ionization time-on-flight mass spectrometry (MALDI-TOF MS).

MALDI-TOF MS analysis was performed using the Bruker Boityper system (Bruker Daltonics, Germany), which included Microflex LT instrument and FlexControl, Biotyper 3.0 programme software. Single colonies were identified by direct smearing onto a ground steel target. One microliter of chemical matrix (saturated solution of alpha-cyano-4-hydroxycinnamic acid in 50% acetonitrile and 2.5% trifluoroacetic acid organic mixture) was added to each sample and dried at room temperature. According to manufacturer’s instruction, the mass spectra were recorded. Obtained spectra were compared with reference spectra in an integrated database. Score values greater than 2.0 were used for identification of genus (2.000–2.299) and species (2.300–3.000).

Three bacterial species; *Escherichia coli*, *Pseudomonas aeruginosa* and *Bacillus subtilis* isolated from tumoral (T) and normal (N) tissues were used for the antibacterial assays.

**Antibacterial assay (Disc-diffusion method)**

Kirby-Bauer method was used for disc diffusion assays (Baur et al., 1966) to determine the sensitivity or resistance of bacteria to plant extracts and essential oils. *In vitro* antimicrobial activity was screened using Meat Peptone Agar (MPA) obtained from the Scientific Research Center of Pharmacotherapy (SRCP), Saint Petersburg, Russia. The sterile filter-paper disks impregnated with different extracts (10 µl/disc) were placed on the surface of the MPA in Petri plates. Distilled water was used as a negative control and tetracycline (30 µg/disc) as a positive control. The plates were incubated at 37 °C for 24 h. Inhibition zones formed around the discs were measured in millimeters. These studies were performed in five replicates.

**Statistical analysis**

In order to determine whether there was a statistically significant difference among the results of the antibacterial effects of tested plant essential oils, variance analyses were carried out using the Statistix version 8.1 software package. Values of p < 0.05 were considered as significantly different. The results are presented as means ± SDs (standard deviations).

**Results**

The aqueous and essential oil extracts of twenty medicinal plants and tetracycline (positive control) showed different degrees of antibacterial activity as evidenced by the zones of inhibition—an area of no bacterial growth (Table 2).

All the tested bacteria including *E. coli*, *P. aeruginosa* and *B. subtilis* showed susceptibility to all the medicinal plant extracts tested. The highest zones of inhibition were observed for essential oil extract of *Origanum majorana* (22.80 ± 1.92 mm), *Nigella sativa* (22.80 ± 3.03 mm), *Mentha piperita* (21.20 ± 2.39 mm) against *B. subtilis* isolated from tumoral
tissues, and *Nigella sativa* (22.40 ± 2.07 mm) against *B. subtilis* isolated from normal tissues) (Table 2 and Fig. 2). The observed antibacterial activities had significant degrees of inhibition zones when compared with that of the synthetic antibiotic tetracycline. Notable activity against *E. coli* isolated from normal tissues was demonstrated by *Origanum majorana* (17.20 ± 2.28 mm). Substantial antibacterial activity against *P. aeruginosa* isolated from tumoral tissues was observed for the essential oil of *Thymus vulgaris* (15.00 ± 3.39 mm). The largest inhibition zone for aqueous extracts was found for *Albizia lebbeck* against *P. aeruginosa* isolated from both tumoral (10.60 ± 0.89 mm) and normal tissues (10.60 ± 0.89 mm).

Table 1. Plant extract sources.

<table>
<thead>
<tr>
<th>No.</th>
<th>Botanical name</th>
<th>Common name</th>
<th>Family</th>
<th>Part used</th>
<th>Extract form</th>
<th>Month gathered</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td><em>Brachychiton populneus</em> Schott &amp; Endl.</td>
<td>kurrajong</td>
<td>Malvaceae</td>
<td>Stem bark</td>
<td>Aqueous extract</td>
<td>September</td>
</tr>
<tr>
<td>2</td>
<td><em>Ceiba pentandra</em> L.</td>
<td>Kapok</td>
<td>Malvaceae</td>
<td>Stem bark</td>
<td>Aqueous extract</td>
<td>September</td>
</tr>
<tr>
<td>3</td>
<td><em>Bombax malabaricum</em> DC</td>
<td>Bombax</td>
<td>Malvaceae</td>
<td>Stem bark</td>
<td>Aqueous extract</td>
<td>September</td>
</tr>
<tr>
<td>4</td>
<td><em>Chorisia speciosa</em> A.St.-Hil.</td>
<td>Drunken tree</td>
<td>Malvaceae</td>
<td>Stem bark</td>
<td>Aqueous extract</td>
<td>September</td>
</tr>
<tr>
<td>5</td>
<td><em>Albizia lebbeck</em> (L.) Benth.</td>
<td>Lebbeck</td>
<td>Fabaceae</td>
<td>Stem bark</td>
<td>Aqueous extract</td>
<td>September</td>
</tr>
<tr>
<td>6</td>
<td><em>Bauhinia variegata</em> L.</td>
<td>Camel’s foot</td>
<td>Fabaceae</td>
<td>Stem bark</td>
<td>Aqueous extract</td>
<td>September</td>
</tr>
<tr>
<td>7</td>
<td><em>Kigelia africana</em> (Lam.) Benth.</td>
<td>Kigelia</td>
<td>Bignoniaceae</td>
<td>Stem bark</td>
<td>Aqueous extract</td>
<td>September</td>
</tr>
<tr>
<td>8</td>
<td><em>Pinus halepensis</em> Miller</td>
<td>Aleppo pine</td>
<td>Pinaceae</td>
<td>Stem bark</td>
<td>Aqueous extract</td>
<td>September</td>
</tr>
<tr>
<td>9</td>
<td><em>Zingiber officinale</em> Roscoe</td>
<td>Ginger</td>
<td>Zingiberaceae</td>
<td>Rhizome</td>
<td>Essential oil</td>
<td>July</td>
</tr>
<tr>
<td>10</td>
<td><em>Pimpinella anisum</em> L.</td>
<td>Anise</td>
<td>Apiaceae</td>
<td>Fruit</td>
<td>Essential oil</td>
<td>May</td>
</tr>
<tr>
<td>11</td>
<td><em>Piper nigrum</em> L.</td>
<td>Black pepper</td>
<td>Piperaceae</td>
<td>Fruit</td>
<td>Essential oil</td>
<td>July</td>
</tr>
<tr>
<td>12</td>
<td><em>Ocimum basilicum</em> L.</td>
<td>Basil</td>
<td>Lamiaceae</td>
<td>Leaf+stem</td>
<td>Essential oil</td>
<td>July</td>
</tr>
<tr>
<td>13</td>
<td><em>Rosmarinus officinalis</em> L.</td>
<td>Rosemary</td>
<td>Lamiaceae</td>
<td>Leaf</td>
<td>Essential oil</td>
<td>September</td>
</tr>
<tr>
<td>14</td>
<td><em>Simmondsia chinensis</em> (Link) C. K. Schneid.</td>
<td>Jojoba</td>
<td>Simmondsiaceae</td>
<td>Seed</td>
<td>Essential oil</td>
<td>July</td>
</tr>
<tr>
<td>15</td>
<td><em>Nigella sativa</em> L.</td>
<td>Black cumin</td>
<td>Ranunculaceae</td>
<td>Seed</td>
<td>Essential oil</td>
<td>May</td>
</tr>
<tr>
<td>16</td>
<td><em>Linum usitatissimum</em> L.</td>
<td>Flax</td>
<td>Linaceae</td>
<td>Seed</td>
<td>Essential oil</td>
<td>May</td>
</tr>
<tr>
<td>17</td>
<td><em>Eruca sativa</em> Mill.</td>
<td>Rocket</td>
<td>Brassicaceae</td>
<td>Seed</td>
<td>Essential oil</td>
<td>May</td>
</tr>
</tbody>
</table>

On the other hand, the smallest zones of inhibition were observed for the aqueous extract of *Chorisia speciosa* (7.00 ± 0.00 mm) against *P. aeruginosa* isolated from tumoral tissues, *Bombax malabaricum* (7.00 ± 0.00 mm) against both *E. coli* isolated from tumoral tissues and *P. aeruginosa* isolated from normal tissues and *Bauhinia variegata* (7.00 ± 0.71 mm) against *P. aeruginosa* isolated from normal tissues. The mean bacterial growth inhibition for tetracycline (positive control) was 18.00–21.00 mm. Figure 1 shows that the highest inhibition zone percentage of twenty medicinal plants relative to tetracycline was against *B. subtilis* (C) isolated from tumoral and normal tissues. *Origanum majorana, Nigella sativa* and *Mentha piperita* had the strongest antibacterial zone inhibition against *B. subtilis* (C). *Origanum majorana* followed by *Ocimum basilicum* showed a significant inhibition zone % relative to tetracycline against *E. coli* (A) in comparison with other used medicinal plants. Meanwhile, Figure 1 (B) shows significant inhibition zones relative to the positive control against *P. aeruginosa* after exposure to *Thymus vulgaris* and also to *Rosmarinus officinalis* compared with other medicinal plants. *Albizia lebbeck* had the highest inhibition zone % relative to tetracycline against all bacterial strains except in the case of *B. subtilis* from tumoral tissues.

**Discussion**

Recently, much attention has been directed toward plant extracts and biologically active compounds isolated from popular plant species. The use of medicinal plants plays a vital role in covering the basic health needs in developing countries, and these
plants may offer a new source of antibacterial, antifungal and antiviral agents with significant activity against infective microorganisms (Mun’oz-Mingarro et al., 2003; Coelho de Souza et al., 2004). The mechanism of action of essential oils and their components as antimicrobials has not been fully elucidated. This is complicated by the fact that there are a large number of chemical compounds present in essential oils, and often they are all needed for antibacterial activity and the essential oils do not seem to have a specific cellular target. Thus, the antimicrobial mechanism of essential oils may not be attributable to one specific mechanism, but rather there may be several targets in the cell. Most of the focus on antimicrobial mechanisms for essential oils has been on the cell membrane and targets interconnected with the membrane. For bioactivity, the essential oils pass through the cell wall and cytoplasmic membrane (Bakkali et al. 2008), disrupt the structure of different layers of polysaccharides, fatty acids and phospholipids and permeabilize those (Chaieb et al., 2007).

Table 2. Antibacterial activity of twenty medicinal plants against bacterial species isolated from tumoral (T) and normal tissues (N).

<table>
<thead>
<tr>
<th>Plant extracts</th>
<th>Zone of inhibition (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>E. coli</td>
</tr>
<tr>
<td></td>
<td>T</td>
</tr>
<tr>
<td>Tetracycline</td>
<td>19.00±0.00</td>
</tr>
<tr>
<td>Brachychiton populneus</td>
<td>7.60±0.89</td>
</tr>
<tr>
<td>Celastra pentandra</td>
<td>8.40±0.55</td>
</tr>
<tr>
<td>Bombax malabaricum</td>
<td>7.00±0.00</td>
</tr>
<tr>
<td>Chorisia speciosa</td>
<td>7.40±0.55</td>
</tr>
<tr>
<td>Albizia lebbeck</td>
<td>10.00±0.00</td>
</tr>
<tr>
<td>Bauhinia variegata</td>
<td>9.00±1.00</td>
</tr>
<tr>
<td>Kigelia africana</td>
<td>9.60±0.55</td>
</tr>
<tr>
<td>Pinus halepensis</td>
<td>8.40±0.55</td>
</tr>
<tr>
<td>Zingiber officinale</td>
<td>7.40±0.55</td>
</tr>
<tr>
<td>Pimpinella anisum</td>
<td>10.80±0.84</td>
</tr>
<tr>
<td>Piper nigrum</td>
<td>7.40±0.55</td>
</tr>
<tr>
<td>Origanum majorana</td>
<td>11.60±1.82</td>
</tr>
<tr>
<td>Rosmarinus officinalis</td>
<td>9.80±0.84</td>
</tr>
<tr>
<td>Ocimum basilicum</td>
<td>12.80±1.92</td>
</tr>
<tr>
<td>Thymus vulgaris</td>
<td>8.40±0.55</td>
</tr>
<tr>
<td>Mentha piperita</td>
<td>10.20±0.45</td>
</tr>
<tr>
<td>Simmondsia chinensis</td>
<td>9.80±0.84</td>
</tr>
<tr>
<td>Nigella sativa</td>
<td>10.20±0.84</td>
</tr>
<tr>
<td>Linum usitatissimum</td>
<td>10.80±0.84</td>
</tr>
<tr>
<td>Eruca sativa</td>
<td>9.80±0.84</td>
</tr>
</tbody>
</table>

The results of antibacterial activity of essential oils analyzed using the disc diffusion method are shown in Tables 2 and Figures 1 and 2. The essential oils of marjoram, black cumin and peppermint showed strong antibacterial activity against B. subtilis isolated from both tumoral and normal tissues from colorectal cancer patients. Our results corroborate those of Ben et al. (2001) who reported a considerable antimicrobial activity of O. majorana extracts against several bacterial strains. Moreover, O. majorana leaves are cited to have important antibacterial activity (Ben et al., 2001; Leja and thoppil, 2007; Busatta et al., 2008). It is noted that among the six tested bacterial strains, Gram-positive bacteria (Bacillus subtilis) were the most sensitive to O. majorana essential oil, while E. coli and P. aeruginosa (Gram-negative) were the most resistant. The lower sensitivity of Gram-negative bacteria tested in this study to the extracts may be due to their cell wall structure and outer membrane (Zaika, 1988). It has been reported that Gram-negative bacteria are generally less sensitive to herb extracts than Gram-
positive bacteria, due to the significant outer layer differences between Gram+ and Gram- bacteria. The latter possess an outer membrane and a unique periplasmic space not found in Gram-positive bacteria (Shan et al., 2007; Duffy and Power, 2001). The Gram-bacterial resistance against antibacterial agents is related to the hydrophilic character of their outer membrane, which is rich in lipopolysaccharide molecules, and serves as a barrier to the penetration of these antibacterial agents. Farrag et al. (2000) found that the fixed oil of black cumin had an inhibitory effect against gram positives such as S. aureus and B. cereus and Gram-negative bacteria. The results of our study showed a stronger activity of essential oil of O. basilicum on Gram-positive than Gram-negative bacteria. In addition, these results are consistent with a previous study in which essential oil of peppermint exhibited good antibacterial activity against Gram-positive bacteria (Saeed and Tariq, 2005).

Fig. 1. Inhibition zone percentage of twenty medicinal plants relative to tetracycline against E. coli (A), P. aeruginosa (B) and B. subtilis (C) isolated from tumoral and normal tissues.
Significant inhibition zones and percentages relative to tetracycline were exhibited by marjoram and basil against *E. coli* in comparison with other plants. This is consistent with the results of Amer et al. (2011) and inconsistent with the results of Prasad et al. (1986) in which the oil extract of *O. basilicum* collected from different geographical regions was more effective against Gram-positive than Gram-negative bacteria. Meanwhile, thyme and rosemary compared with other plants had significant inhibition zones (15.00 ± 3.39) and percentages relative to the positive control (75%) against *P. aeruginosa*. Gram-negative *P. aeruginosa* is known to possess a high level of intrinsic resistance to most of antimicrobial agents due to a very restrictive outer membrane barrier (Mann et al., 2000). Resistance of *P. aeruginosa* to essential oils was also reported by other researchers. Essential oils of *Thymus* species contain mainly aromatic monoterpenes, carvacrol, thymol and p-cymene, and their activity is often attributed to these compounds (Daouk et al., 1995).

**Fig. 2.** Antibacterial activity of *O. majorana*, *N. sativa* and *M. piperita* which have the highest inhibition zone against *B. subtilis*.

Lebbeck (*Albizia lebbeck*) aqueous extract had the highest inhibition zone and percentage relative to tetracycline against all bacterial strains except against *B. subtilis* isolated from tumoral tissues. The bark of *A. lebbeck* has been previously shown to possess antimicrobial activities against *E. coli*, *S. typhi*, *P. aeruginosa*, *S. aureus*, *Bacillus cereus*, *Klebsiella aerogenes*, *Proteus vulgaris*, *Shigella boydii*, *Aspergillus fumigatus*, *Aspergillus flavus*, *A. niger* and *C. albicans* (Dabur et al., 2007).

**Conclusions**

The results showed varying effects of essential oils and aqueous extracts of the tested medicinal plants against bacterial co-occurrence with colorectal cancer. The most effective in inhibiting the growth of bacteria was essential oil from marjoram. Aqueous extracts of lebbeck had the highest significant antibacterial activity compared with other plant extracts. According to the results found in this study, we will further study the plants that demonstrated antibacterial activity to understand their potential as antibiotic sources.

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