Evaluation of the efficacy of Dettol in the Libyan market and its antimicrobial activity with *Artemisia spp* extract.

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تقييم وتحسين فعالية الديتول المتوفر في السوق الليبي باستخدام مستخلص نبات الشيح

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المستخلص:

الخلفية: يستخدم ديتول® بشكل شائع في المنازل ومرافق الرعاية الصحية لأغراض متعددة، مثل تطهير الجلد والأدوات والمعدات، وكذلك الأسطح. وقد أثبتت العديد من الدراسات أن المطهرات غير الفعالة يمكن أن تؤدي إلى ظهور سلالات مقاومة للمضادات الحيوية. **الهدف:** تهدف هذه الدراسة إلى تقييم فعالية منتجات الديتول في السوق الليبي واستكشاف التأثيرات التآزرية عند الجمع بين منتجات الديتول ومستخلص نبات الشيح المتوفرة محلياً. **الطرق:** تم استخدام طرق انتشار القرص وانتشار الحفر في الآجار لتحديد التأثير الضد بكتيري. تم استخدام طريقة التخفيف المتسلسل لتقدير الحد الأدنى للتركيز المثبط. تم استخدام طريقة الانتشار في الأجار باستخدام شرائح متقاطعة مشبعة مسبقًا بمركبات ذات فعل مضاد للبكتيريا لتقدير النشاط التآزري. تم استخدام مستحلب ديتول لتحديد الجودة والثبات الكيميائي للمنتجات. **النتيجة:** أشارت نتائج النشاط المضاد للبكتيريا إلى أن الديتول (أ) أظهر فعالية متفوقة مقارنة بالمنتجات الأخرى، وخاصة ضد البكتيريا الموجبة لصبغة جرام. كل من المستخلصات المائية والكحولية لنبات الشيح. أظهرت خصائص مضادة للميكروبات ضد السلالات الموجبة لصبغة جرام ولم يكن لها أي تأثير على البكتيريا السالبة لصبغة جرام. أن مزيج الديتول والمستخلصات النباتية أدى إلى تحييد آثارهما، مما أدى إلى نتيجة معادية. أظهرت اختبار ثبات المعلق المستحلب لمكونات الديتول الكيميائية أن منتج الديتول (أ) حافظ على ثباته كمستحلب حليبي لعدة أيام، مما يبرز تفوقه بين الأنواع المختلفة.

الاستنتاج: نستنتج من الدراسة أن منتجات ديتول أظهرت نشاطا متفاوتا ضد البكتيريا التي تم اختبارها. أظهرت منتجات ديتول تأثيرات مثبطة، وتميز منتج ديتول (أ) بثباته الكيميائي ومفعوله البيولوجي المتفوق. يمكن أن تؤدي المطهرات والمطهرات منخفضة الجودة إلى زيادة حالات عدوى المستشفيات، خاصة بين البكتيريا سالبة الجرام مثل الزائفة الزنجارية. ولذلك نقترح إجراء دراسات أكثر تفصيلاً حول هذه المنتجات وتطبيق لوائح أكثر صرامة على المنتجات سيئة الصنع.

الكلمات المفتاحية: *ديتول، نبات الشيح، التركيز المثبط الادنى، النشاط التآزري، البكتيريا الموجبة لصبغة جرام، البكتيريا السالبة لصبغة جرام، مقاومة المضادات الميكروبية، الزائفة الزنجارية.*

ما هو معروف عن هذا الموضوع:

إن سوء استخدام المعقمات والمطهرات قد يؤدي إلى نتائج سلبية، مثل ظهور الكائنات الحية الدقيقة المقاومة. الإفراط في الاستخدام أو الاستخدام غير السليم يمكن أن يعزز مقاومة المضادات الميكروبية في البكتيريا والكائنات الحية الدقيقة الأخرى داخل النظم الطبية والمجتمعية، مما يعقد علاج وإدارة العدوى. كما إن الاستخدام غير الكافي، مثل إهمال أوقات التعقيم الموصى بها أو نسب التخفيف، أو استخدام منتجات رديئة التصنيع يمكن أن يقلل من فعاليتها في قتل الجراثيم والوقاية من العدوى.

ما تضيفه هذه الورقة:

كشفت هذه الدراسة أن بعض منتجات الديتول في السوق الليبي تفتقر إلى الفعالية. إن بعض الممارسات الشائعة المتمثلة في خلطه مع بعض المنتجات والمستخلصات النباتية لتعزيز فعاليته ورائحته، كما يتم تداوله محليًا، تقلل من فعاليته.

Abstract:

Background: Dettol® is commonly used in households and healthcare facilities for multiple purposes, such as disinfecting skin, tools, equipment, and surfaces. Numerous studies have demonstrated that ineffective disinfectants can lead to the development of antibiotic-resistant strains. **Objective**: The study aims to assess the efficacy of Dettol products in the Libyan market and investigate the synergistic effects between Dettol and *Artemisia spp*. **Methods**: The disk diffusion, and well diffusion methods were used to determine antibacterial action. The serial dilution method was used to estimate the minimum inhibitory concentration. Agar diffusion using cross-strips previously saturated with antibacterial compounds was used to estimate the synergistic activity. Dettol emulsion was used to determine the quality and chemical stability of products. **Result**: Results of antibacterial activity indicated that Dettol (A) exhibited superior effectiveness compared to other products, particularly against Gram-positive bacteria. Both aqueous and alcoholic extracts of wormwood plant "*Artemisia spp.*" demonstrated antimicrobial properties against Gram-positive bacteria but had no impact on Gram-negative. The combination of Dettol and a plant extract produced an antagonistic activity due to their neutralizing effects. Stability tests on an emulsified suspension of Dettol's chemical components revealed that Dettol (A) maintained stability as a milky emulsion for several days, highlighting its superiority among the different types.

Conclusion: Based on the study, we can infer that Dettol products exhibited varying inhibitory activity against tested bacteria, with Dettol (A) standing out due to its chemical stability and superior biological action. Low-quality antiseptics and disinfectants can lead to a rise in nosocomial infections, especially among Gram-negative bacteria such as *Pseudomonas aeruginosa*. We therefore suggest conducting more detailed studies on these products and applying stricter regulations on poorly made products.

Keywords: *Dettol, Artemisia spp., MIC, Synergistic activity, Gram-positive, Gram-negative bacteria, Antimicrobial resistant, Pseudomonas spp.*

What is known about this topic: Misuse of disinfectants and antiseptics may result in negative outcomes, like the emergence of Resistant Microorganisms. Overuse or improper use can foster antimicrobial resistance in bacteria and other microorganisms within medical and community settings, complicating the treatment and management of infections. Inadequate use, such as neglecting recommended contact times or dilution ratios, can diminish their germ-killing efficacy and infection prevention.

What this paper adds: This study revealed that some Dettol products in the Libyan market lack effectiveness. The common practice of mixing it with some products or plant extracts to enhance its efficacy and fragrance, as circulated locally, diminishes its effectiveness.

1. Introduction:

Dettol® is an aromatic compound derived from phenol, which contains a significant chlorine atom 4-chloro-3,5-dimethylphenol, it is an antiseptic disinfectant utilized for disinfecting and cleaning surfaces. It is typically used to kill microbial pathogens and viruses to prevent infection spread, especially in nosocomial infections (Najim, 2017). With the emergence of life-threatening infections in humans, especially multidrug-resistant bacteria and recently emerging viruses, using disinfectants and sterilizing agents has increased (Maillard, 2002; Maillard, 2007, Ismail *et al*., 2022; Algammal *et al*., 2023). In healthcare facilities, disinfection of surfaces is important to protect patients, workers, and visitors to prevent the transmission of pathogens (Dumas *et al*., 2017; Rutala and Weber, 2004). However, misuse and overuse of disinfectants can reverse the effect of these products, cause resistance to disinfectants, and increase the development of antibiotic-resistant bacteria, which may change our way of life, and put human lives in general at risk (Rutala and Weber, 2004).

The scientific and medical community has been focusing on the problem of antimicrobial resistance and finding solutions for it (Beyth *et al*., 2015; Czaplewski *et al*., 2016; Rios *et al*., 2016; Abushiba *et al*., 2019; Sakudo *et al*., 2019; El-Sherbiny *et al*., 2022). However, less attention has been paid to commonly used disinfectants and antiseptics in clinical settings, Identifying resistant microorganisms to disinfectants and developing strategies to prevent their spread, neglecting this aspect could pose a risk (Gebel *et al*., 2013; Gomes *et al*., 2016). The use of poorly made products, misuse of these items, or/and overuse of disinfectants, may increase the resistance of microorganisms to clinically important antimicrobials due to mechanisms of co-resistance and cross-resistance (Russell *et al*., 2003; Yazdankhah *et al*., 2006; Forbes *et al*., 2015; Wieland al., 2017). In this regard, it was necessary to evaluate the effectiveness of these most widely used disinfectants and to develop some solutions to avoid the stress of disinfectants and the rising selectivity of resistant bacteria. One potential solution is to combine disinfectants with natural products that are safe for people and the environment (Chapman, 2003; Babeluk *et al*., 2014).

Libya is home to a vast and significant range of plants including the *Artemisia* genus, which contains more than 400 species of aromatic plants and boasts a variety of biological activities. Species within this genus have a broad range of pharmacological benefits and offer enormous potential for researchers. Some species of this genus were used as a remedy for getting rid of intestinal helminthes and species of this plant have been used as a preventative for diseases and to protect against malaria (Boulos, 1983; Maia, 2002; Mohamed *et al*., 2010; Moore, 2011; Eltawaty *et al*., 2020). This plant has antimicrobial, anti-inflammatory, and fertility-enhancing effects (Saad and Belteben, 2023). The aromatic compounds of this plant are extracted using ethanol or methanol (Cowan, 1999). Research indicates that the species of *Artemisia spp*. growing in Tunisia has a beneficial antibacterial activity against *Staphylococcus aureus* (*S. aureus*) and *Escherichia coli* (*E. coli*) (Imelouane *et al*., 2010). The species growing in Libya exhibit antimicrobial properties when extracted with ethanol against *E. coli*, *P. aeruginosa*, and *S. aureus* (Abdelah Bogdadi *et al*., 2007). Additionally, studies performed in Moroccan demonstrate the antimicrobial activity of this plant against *S. aureus*, *Klebsiella pneumoniae*, and *E. coli*, while showing no effect on *P. aeruginosa* (Eltawaty *et al*., 2020).

The rising incidence of disinfectant-resistant bacteria poses a major threat to healthcare and society, leading to the rise of multidrug-resistant strains. Unfortunately, there is a lack of local studies on the spread of such strains. On this basis, the study was designed to evaluate the efficiency of Dettol as an example of products used in cleaning and disinfection. The antimicrobial efficacy of Dettol products, combined with *Artemisia spp* extract was assessed using clinically significant bacterial strains, including Gram-positive and Gram-negative bacteria.

2. Material and methods:

2.1. Collection of Dettol products.

Dettol disinfectant available in the city markets, Tarhuna, Libya, was collected from the following companies: Citra Company, United Arab Emirates, referred to as Dettol (A); Green Planet Company, UAE, referred to as Dettol (B); Royal Cosmetics Company, Egypt, referred to as Dettol (C); Al-Najma Factory, Libya, referred to as Dettol (D).

2.2. Plant collection and identification.

The *Artemisia spp*. was collected from the Bensakrana area, Tarhuna, Libya, 32°19'25"N 13°47'04"E . The sample was collected by cutting some branches from the wormwood shrub. The plant parts were collected in clean plastic bags, transported to Microbiology Lab and stored in the fridge until work on them. Dr. Alsadegh Ali Zawia, a plant physiology lecturer in the Biology Department at the Faculty of Science, Azzaytuna University, verified the plant identification. The research was conducted at the Biology Department, Faculty of Science, Azzaytuna University, Tarhuna, Libya. The figure 2 shows a diagram of details of the experiments conducted in the study.

2.3. Preparation of plant extract.

The plant materials were thoroughly washed with distilled water and dried in the oven at 35 °C for about 5 days. The dried plant parts were ground well into a fine powder in a mixer grinder and sieved to give a particle size of 50-150 mm. The powders were stored in air-sealed polythene bags at room temperature, until further analysis. *Artemisia spp*. leaves were extracted with Aqueous and Alcoholic extract using 20 grams, and mixing with solvent, then placing them on a magnetic stirrer heater for 24 hours. The components were filtered with gauze. The final filtration was performed using a centrifuge at 500 revolutions for ten minutes. The supernatant was diluted to 10 diluents of the extract were made (Abushiba *et al*., 2023).

2.4. Tested strains.

Tested bacteria included Gram-positive *Bacillus cereus* BC-507 (*B. cereus* BC-507), Methicillin-Sensitive *Staphylococcus aureus* MSSA-342 (*S. aureus* MSSA-342), Methicillin-Resistant *Staphylococcus aureus* MRSA-28 (*S. aureus* MRSA-28) and Gram-negative *Escherichia coli* EC-506 (*E. coli* EC-506), *Pseudomonas aeruginosa* PA-500 (*P. aeruginosa* PA-500). These strains were sourced from the Bacteriology Lab, Botany and Microbiology Dept., Faculty of Science, Al-Azhar University, Egypt except for MRSA-28, which was obtained from Microbiology Lab, Biology dept., Faculty of Science, Azzaytuna University, Libya. The glycerol stocks of microbial strains were revived by sub-culturing on Nutrient agar (NA), and incubated at 37 °C for 24 h. The strain was stored at 4 °C For future studies. The bacterial inoculum was prepared by suspending 3-5 bacterial colonies in normal saline from fresh cultures to obtain a density of 0.5 McFarland (1* 10^8 CFU/ml).

2.5. Estimation of Antimicrobial Activity and Minimum Inhibitory Concentration.

Disc and well agar diffusion assays were performed using Nutrient agar to explore antibacterial efficacy. Following strain inoculation and incubation. The plates were placed in the fridge for two hours to diffuse the compounds within the agar. The plats were incubated at 35°C for 18-24 hours. The inhibition zone diameter was measured in millimeters (mm). The effectiveness of Dettol products was assessed by testing the antimicrobial activity. This involved applying 100 microliters of the diluted extract in the wells or on disc filter paper, letting it sit for a few minutes at room temperature, and the discs placed on a plate that had been freshly inoculated with the test organism. The experiment was replicated thrice (Kowalska-Krochmal, and Dudek-Wicher, 2021).

2.6. Estimation of Synergistic activity.

The synergistic effect of Dettol and plant extract was assessed using the filter paper strip method on agar media. Filter paper strips were immersed in the compounds to assess their synergistic action. Each strip was soaked in a compound individually at a concentration exceeding the MIC. These strips were placed intersecting on the inoculated nutrient agar plate. The plates were placed in the fridge for two hours to diffuse the compounds within the agar. The plates are incubated for 18-24 hours at a temperature of 35°C (Laishram *et al*., 2017; Jenkins and Maddocks, 2019). Synergistic activity was determined by calculating the average inhibition zone around the strips with the following equation:

$$A = \frac{X1 + Y1}{2}, \quad B = \frac{X2 + Y2}{2}, \quad C = \frac{X3 + Y3}{2}$$

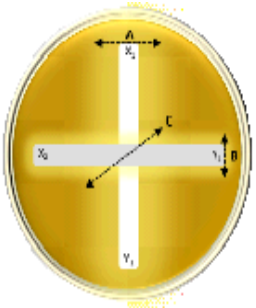


Figure 1: A diagram illustrates the points used to estimate zones of inhibition, which are crucial for identifying synergistic action between compounds. X and Y are the inhibition zones of the strips at the ends saturated with antimicrobials. X_1 and Y_1 for strip A; X_2 and Y_2 for strip B; X_3 and Y_3 for C that location where the two strips intersect.

The results are interpreted as shown in figure 1 in the following manner:

Synergistic: A + B < C

Additive: A + B = C

Antagonistic: A + B > C

2.7. Dettol emulsion stability test.

An emulsion stability test is used to measure the ability of an emulsion to resist phase separation or aggregation over time, which can decrease product effectiveness. To determine the quality of manufacturing, 10 ml of Dettol was mixed with 200 ml of water as recommended. This mixture should appear milky, indicating the disinfectant's ability to stabilize as an emulsion and not form a precipitate that is done by leaving the mixture undisturbed for three days to observe the stability of the emulsion (Slaga *et al*., 2022).

2.8. Data analysis.

Calculations for numerically solving the differential equation and the integral of the mathematical model were performed with the software program EXCEL 2016 (Microsoft).

Figure 2. A diagram shows the details of the experiments conducted in the study. The study was conducted in Lab 116, Biology Department, Faculty of Science, Azzaytuna University.

3. Results:

The results of Dettol (A) and Dettol (B) "Dettolarabia-Citra and Green Planet, UAE" respectively showed antimicrobial activity against Gram-positive and Gram-negative strains.

Table 1. Shows the antimicrobial activity of Dettol products and the extract of *Artemisia spp.* against the bacterial strains using Agar well diffusion method.

Antiseptic	Bacteria – code	Antiseptic dilution									MIC	Interpretation
		Undiluted	1:1	1:2	1:4	1:8	1:16	1:32	1:64	1:128		
Dettol (A)	*P. aeruginosa*PA-500	12	11	11	10	9	0	0	0	0	1:8	I
	E. coli EC-506	16	13	12	11	9	0	0	0	0	1:2	L
	B. cereus BC-507	28	27	30	23	13	0	0	0	0	1:8	I
	S. aureus MSSA-342	25	24	24	19	15	9	0	0	0	1:16	I
	S. aureus MRSA-28	39	36	33	12	12	9	9	0	0	1:32	E
Dettol (B)	*P. aeruginosa*PA-500	11	11	01	10	9	8	9	0	0	1:32	E
	E. coli EC-506	14	13	14	14	0	0	0	0	0	1:4	I
	B. cereus BC-507	29	29	27	23	22	0	0	0	0	1:8	I
	S. aureus MSSA-342	22	22	18	11	13	8	0	0	0	1:16	I
	S. aureus MRSA-28	36	34	36	35	24	11	13	0	0	1:32	E
Dettol (C)	*P. aeruginosa*PA-500	9	0	0	0	0	0	0	0	0	Undiluted	L
	E. coli EC-506	13	12	12	0	0	0	0	0	0	1:2	L
	B. cereus BC-507	28	25	23	22	19	12	0	0	0	1:16	I
	S. aureus MSSA-342	21	20	19	13	10	9	0	0	0	1:16	I
	S. aureus MRSA-28	36	34	25	19	0	0	0	0	0	1:4	I
Dettol (D)	*P. aeruginosa*PA-500	9	0	0	0	0	0	0	0	0	Undiluted	L
	E. coli EC-506	10	0	0	0	0	0	0	0	0	Undiluted	L
	B. cereus BC-507	26	20	15	20	12	0	0	0	0	1:8	I
	S. aureus MSSA-342	19	18	13	10	8	8	8	0	0	1:32	E
	S. aureus MRSA-28	30	29	20	9	8	8	8	10	0	1:64	E
Aqueous extract of *Artemisia spp.*	*P. aeruginosa*PA-500	0	0	0	0	0	0	0	0	0	< Undiluted	L
	E. coli EC-506	0	0	0	0	0	0	0	0	0	< Undiluted	L
	B. cereus BC-507	20	16	13	11	10	10	11	10	0	1:64	E
	S. aureus MSSA-342	13	9	0	0	0	0	0	0	0	1:1	L
	S. aureus MRSA-28	14	12	0	0	0	0	0	0	0	1:1	L
Alcoholic	*P. aeruginosa*PA-500	0	0	0	0	0	0	0	0	0	< Undiluted	L

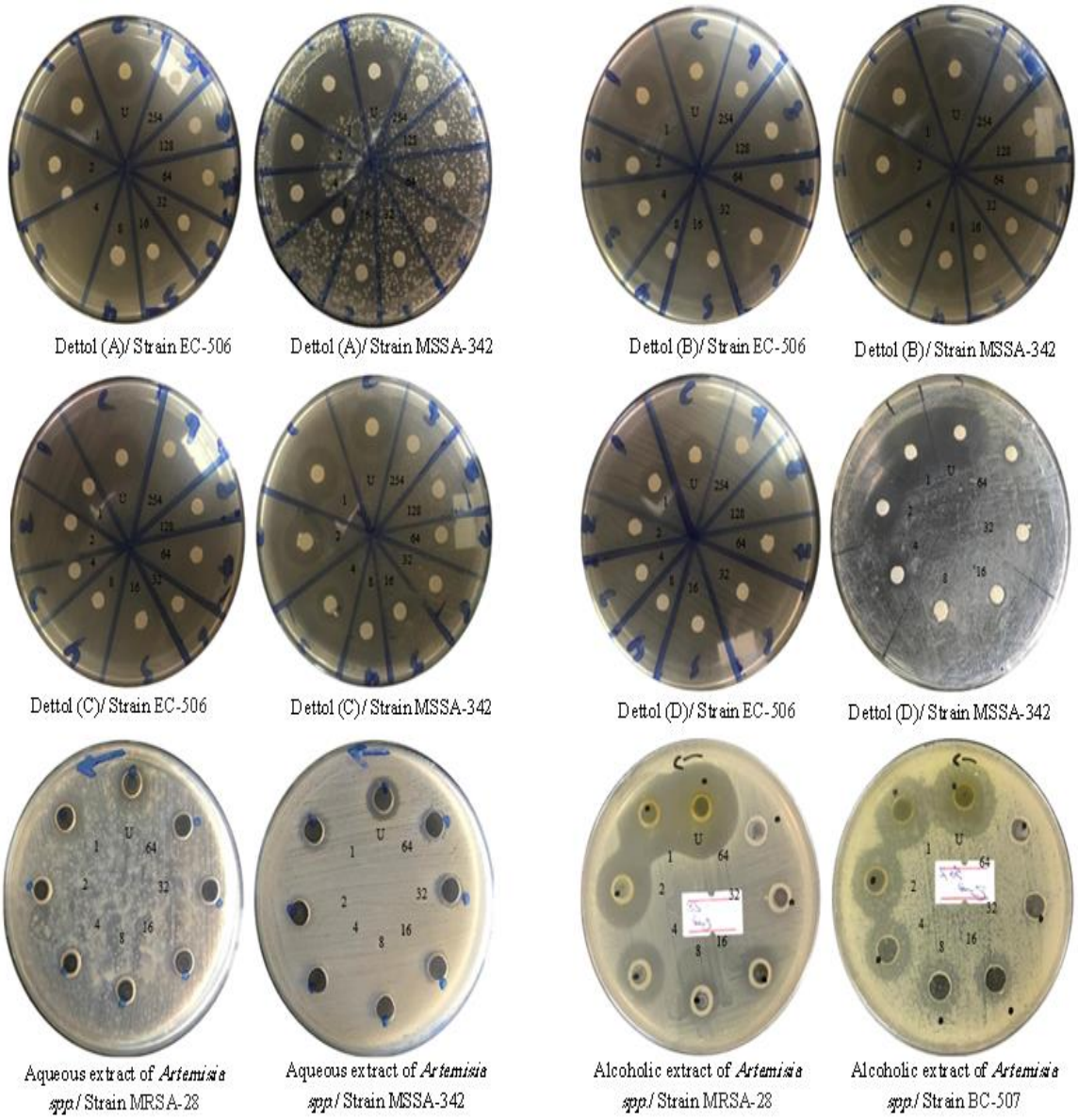


Figure 3. Shows the antimicrobial activity of Dettol products and the extract of *Artemisia spp.* against the bacterial strains using Agar well diffusion method. **Dettol (A)**: Dettolarabia-Citra, UEA; **Dettol (B)**: Green Planet, UEA; **Dettol (C)**: Royal Cosmetics, Egypt; **Dettol (D)**: Nagma, Libya. U, Undiluted; 1, 1:1; 2, 1:2; 4, 1:4; 8, 1:8 etc…

The antibacterial activity of Dettol (C) "Royal Cosmetics, Egypt" and Dettol (D) "Nagma, Libya" was less effective, especially against Gram-negative species, and was almost nonexistent against *P. aeruginosa* PA500, as shown in Table 1 And figure 3.

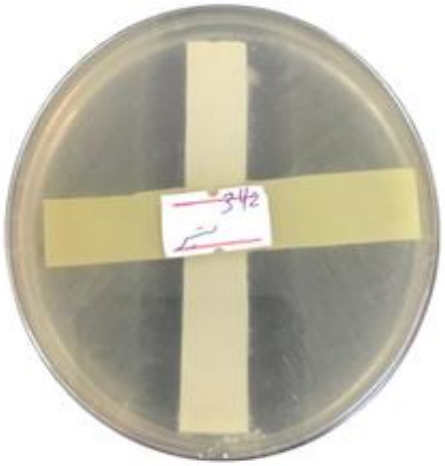
The interaction between Dettol (A) and Dettol (D) with the alcoholic extract of *Artemisia spp.* was found to be antagonistic, which indicates no synergistic action as shown in Table 2 And figure 4.

Table 2. Shows the Synergistic activity of Dettol and the alcoholic extract of *Artemisia spp.* against the bacterial strains using Crossed filter paper strips method on agar media.

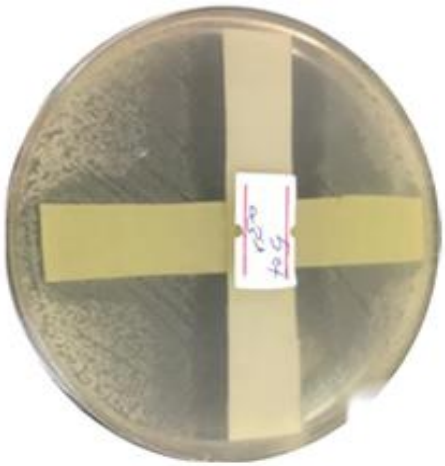
Antiseptic Combination	Bacteria - code	Synergistic activity calculation				
		a	b	c	a + b → c	Interact
Dettol (A) & Alcoholic extract of *Artemisia spp.*	*P. aeruginosa* PA-500	32	0	0	32 > 0	Antagon
	E. coli EC-506	33	0	0	33 > 0	Antagon
	B. cereus BC-507	30	0	0	30 > 0	Antagon
	S. aureus MSSA-342	26	0	0	26 > 0	Antagon
	S. aureus MRSA-28	53	22	60	75 > 60	Antagon
Dettol (D) & Alcoholic extract of *Artemisia spp.*	*P. aeruginosa* PA-500	24	0	0	24 > 0	Antagon
	E. coli EC-506	29	0	0	29 > 0	Antagon
	B. cereus BC-507	28	0	0	28 > 0	Antagon
	S. aureus MSSA-342	26	0	0	26 > 0	Antagon
	S. aureus MRSA-28	51	20	53	71 > 53	Antagon

Dettol (A): Dettolarabia-Citra, UEA; **Dettol (D)**: Nagna, Libya

a: Inhibition zone of Dettol; b: Inhibition zone of Alcoholic extract of *Artemisia spp.*; c: Inhibition zone between a and b.
A + B < C: Synergistic; A + B = C: Additive; A + B < C: Antagonistic activity.



Synergistic activity of Dettol (A) and the alcoholic extract of *Artemisia spp.* Against Strain MSSA-342



Synergistic activity of Dettol (D) and the alcoholic extract of *Artemisia spp.* Against Strain BC-507

Figure 4. Shows the Synergistic activity of Dettol and the alcoholic extract of *Artemisia spp.* against tested strain.

After examining the quality of Dettol using the Dettol emulsion stability test, it was observed that Dettol (A) and B produced a dense white emulsion that stayed stable for 72 hours with no formation of precipitates. After three months, Dettol (A) experienced a minor shift in color intensity but maintained overall stability. In contrast, Dettol (C) exhibited slightly lower density than Dettol (A) and (B) within 72 hours of preparation. Finally, Dettol (D) formed a light emulsion and precipitate within 72 hours as shown in figure 5.

First day:

On the first day, all Dettol types look the same - homogeneous, milky in color, and indistinguishable.

Second day:

After a day, variations in the stability of the Dettol emulsion are noticeable. Nagma Co.'s Dettol shows precipitation speed (1), and Royal Cosmetics Co.'s Dettol begins to precipitate (4), whereas Dettolarabia-Citra and Green Planet remain stable without any precipitation (2, 3).

Third day:

Variations arise in the emulsion's stability over time. Nagma Co.'s Dettol precipitates entirely (1), whereas Royal Cosmetics Co.'s Dettol precipitates distinctly (4), whereas Dettolarabia-Citra and Green Planet remain stable without any precipitation (2, 3).

Figure 5. Shows the emulsion stability of four types of Dettol: (1). Dettol (D), Nagma, Libya; (2). Dettol (A), Dettolarabia-Citra, UEA; (3). Dettol (B), Green Planet, UEA; (4). Dettol (C), Royal Cosmetics, Egypt.

4. Discussion:

Dettol has been widely used for many years as a sterilizer and disinfectant, and it is considered one of the most used products in healthcare and community systems to combat infection and the spread of pathogenic microorganisms. Although improvements have been made over the years, the basic formulation of Dettol and similar products has remained the same since the 1930s (Emsley, 2015). Infections, particularly those linked to healthcare systems, pose a significant challenge for numerous hospitals, affecting over 100 million patients globally annually (Taye and Taye, 2023). The most difficult infections are those caused by antibiotic-resistant microorganisms (Nimer, 2022). One reason for the rise and development of antibiotic-resistant bacteria is mutation and/or selection caused by the incorrect or excessive use of antimicrobials (Muteeb *et al*., 2023)
According to the study, Dettol (A) and Dettol (B) have higher efficiency at lower concentrations than other Dettol. They also showed greater efficacy against test strains and their antibacterial activity was more effective against Gram-positive than Gram-negative bacteria. These results are consistent with previous studies that Dettol is effective against gram-positive and gram-negative bacteria, fungi, yeast, mold, and even the dreaded “superbug” MRSA (Bruch, 1996). The study found that Dettol (A) and (B) were more effective against Gram-positive than Gram-negative bacteria as found in a study by El Mahmood and Doughari (2008), who stated that *E. coli* was more resistant than *S. aureus*. In contrast to the findings in the study, Olasehinde *et al*. (2008) reported that Dettol was effective against all tested strains, which were all Gram-negative bacteria. In addition, the antibacterial susceptibility of tested species against Dettol products varied

consistent with previous studies that have demonstrated that bacterial species have varying degrees of sensitivity to disinfectants (Al-Talib *et al*., 2019).

The study revealed that Dettol (C) and (D) were less effective than other types, showing no impact on Gram-negative bacteria. This aligns with Köhler *et al*.'s (2019) finding that certain disinfectants are less effective against such bacteria. Russell and Day (1996) also noted that while Dettol is effective against bacteria, it lacks efficacy against *P. aeruginosa* and numerous fungi, the study found this, as Dettol was ineffective against *P. aeruginosa* when using these products. This may explain why using low-quality antiseptic and sterilizer products has led to the development of antibiotic-resistant microbial strains, particularly within healthcare systems. According to a local study, *P. aeruginosa* is a significant cause of nosocomial infections, especially hospital-acquired surgical site infections, and has emerged as a challenging Gram-negative pathogen. Additionally, patients' hands were discovered to be colonized by different bacteria strains, showing high resistance to multiple antibiotics (Rishi *et al*., 2013). In a similar context, the research by Daw *et al*., (2023) concentrated on conducting a thorough examination of the biggest hospitals in the nation. Their findings indicated elevated levels of healthcare-associated infections in Libyan hospitals, posing a significant burden at local and regional levels.

The decrease or loss of effectiveness of some Dettol products may result from imprecise ingredients or inadequate storage and handling. The main ingredient constituent of Dettol is Chloroxylenol that has bactericidal properties. Although its mechanism of action is not fully understood, it is believed to affect microbial membranes due to its phenolic nature (Hugo and Bloomfield, 1971; Russell and Day, 1996). This may explain the decrease in this component and other components, such as Ethylene alcohol, leading to a decrease in the efficiency of its action on the outer membrane of Gram-negative bacteria, mainly composed of Lipopolysaccharides (LPS). Consequently, the activity of products A and B decreased, while the activity of Dettol (C) and (D) was ineffective against Gram-negative bacteria. Understanding the action mode of Dettol could provide valuable insights into how it can be improved for maximum effectiveness. Studies have reported that poorly manufactured or diluted disinfectants can increase bacterial tolerance via genetic mutation, horizontal gene transfer, and phenotypic adaptation (Cloete, 2003). Studies have shown that the overuse and misuse of disinfectants can increase the prevalence of antibiotic resistance genes (Kim *et al*., 2018).

In this study, the alcohol extract of *Artemisia spp*. exhibited superior antimicrobial activity better than the water extract. This is what a study indicated that *Artemisia spp*. contains active compounds with antimicrobial, antifungal, antioxidant, anti-inflammatory, antitumor, antispasmodic, insecticidal, and antimalarial activities (Nigam *et al*., 2019). *Artemisia spp*. was also more effective against Gram-positive bacteria than Gram-negative ones. The findings align with previous research indicating that extracts from *Artemisia spp*. have the ability to inhibit the growth of tested bacteria. However, the extent of this antimicrobial activity is influenced by the test strains, the extraction method, and the solvent concentration, and the concentration of ethanol used as a solvent is a key factor affecting the antimicrobial activity of the extract (Hrytsyk *et al*., 2021).

The combination of biologically active compounds to increase effectiveness or/and reduce the toxic dose can result in three potential activities: synergistic, additive, or

antagonistic effects (Stermitz *et al*., 2000; Stermitz *et al*., 2002; Ulrich-Merzenich *et al*., 2010; Junio *et al*., 2011; Wagner *et al*., 2011). The results of the synergistic activity of the alcoholic extract of *Artemisia spp* and Dettol (A) showed that combining them produces an antagonistic action. This study revealed antagonism between the alcoholic extract of *Artemisia spp* and Dettol is important because it may contribute to the disadvantages of inappropriate use, especially when combining compounds that have an action when each one is separate.

5. Conclusion:

Generally, Dettol primarily shows antibacterial activity against Gram-positive bacteria, with decreasing effectiveness against Gram-negative bacteria. Poorly made Dettol products may not have this activity. Additional research is required to determine the underlying causes of the decreased efficacy of Dettol (C) and (D) on Gram-negative bacteria and identify alternative solutions. In addition, a random combination of Dettol products with other products or some plants have aromatic properties could nullify their effect and increase the risk of developing multi-drug-resistant bacteria.

6. Recommendation:

In light of the research results, we suggest broadening the investigation into disinfectants and sterilizers available in the Libyan market. This should include testing various organisms such as fungi, viruses, parasitic cysts, and worm eggs. Such an approach would provide a more comprehensive assessment of the efficacy of these products. Ensuring the quality of disinfectants and sterilizers and enhancing the performance of local products can help prevent the loss of many lives, particularly in intensive care units.

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