

Evaluation of chemical composition of seed oil and oil cake of *Ailanthus excelsa* (Roxb.) and its application[☆]

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Abstract – The purpose of this investigation was to examine the antibacterial activity of oil derived from *Ailanthus excelsa* (Roxb) as well as the chemical composition of seed oil and the proximate analysis of oil cake. The oil content of the seeds is ~ 17%. The seed oil was analyzed using GC-MS/FID, and the results showed that it contained a variety of fatty acids, such as linoleic acid, oleic acid, and palmitic acid. When employed with 100 μ L, the oil did not demonstrate any antibacterial activity against the bacteria *Staphylococcus aureus*, *Salmonella typhi*, *Escherichia coli*, *Pseudomonas aeruginosa*, and *Bacillus subtilis*. The oil does not possess any antifungal action against *Candida albicans* and *Aspergillus flavus*. The oil cake is rich in protein and minerals. These findings imply that *A. excelsa* seed oil and oil cake have the potential to be used in the food and pharmaceutical industries after ascertaining its non-toxic nature and absence of antinutrients. The oil is not having antibacterial activity hence it can be used as a part of nutrient media for bacterial cultures.

Keywords: *Ailanthus excelsa* / seed oil / chemical composition / antibacterial activity / antifungal activity

Résumé – Évaluation de la composition chimique de l'huile de graines et de tourteau d'*Ailanthus excelsa* (Roxb.) et son application. Le but de cette étude était d'examiner l'activité antibactérienne de l'huile issue d'*Ailanthus excelsa* (Roxb) ainsi que la composition chimique de l'huile de graines et l'analyse du tourteau. La teneur en huile des graines est d'environ 17 %. L'huile a été analysée par GC-MS/FID et les résultats ont montré qu'elle contient une palette d'acides gras, dont l'acide linoléique, l'acide oléique et l'acide palmitique. À la dose de 100 μ L, l'huile n'a démontré aucune activité antibactérienne contre les bactéries *Staphylococcus aureus*, *Salmonella typhi*, *Escherichia coli*, *Pseudomonas aeruginosa* et *Bacillus subtilis*. L'huile ne possède aucune action antifongique contre *Candida albicans* et *Aspergillus flavus*. Le tourteau est riche en protéines et en minéraux. Ces résultats impliquent que l'huile et le tourteau d'*A. excelsa* ont le potentiel d'être utilisés dans les industries alimentaires et pharmaceutiques après avoir vérifié leur nature non toxique et l'absence de composés anti-nutritionnels. L'huile n'a pas d'activité antibactérienne et peut donc être utilisée comme milieu nutritif pour les cultures bactériennes.

Mots clés : *Ailanthus excelsa* / huile / composition chimique / activité antibactérienne / activité antifongique

[☆] Contribution to the Topical Issue "Minor oils from atypical plant sources / Huiles mineures de sources végétales atypiques".

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1 Introduction

A huge population (80%) of the world depends on traditional medicine for primary healthcare (World Health Organization, March 2022). About 70–90% of people in developing countries still use medicines made from plants and plant extracts (Chin *et al.*, 2006). The plants have a lot of phytochemicals, which have anti-aging, anti-inflammatory, and antimicrobial properties (Cos *et al.*, 2006) and are very interesting to the pharmaceutical industry. Antibiotics are generally target-specific as they affect cell wall synthesis, DNA replication, and the translational machinery of the bacterial cell (Krebs *et al.*, 2017). Despite antibiotics' target functions, bacteria have evolved resistance mechanisms. Over the last decades, the exhaustive over prescription and self-medication of clinically available antibiotics and long-term exposure of pathogenic microorganisms to these antibiotics have led to the development of antibiotic resistance (Harbottle *et al.*, 2006). Currently, more than 70% of pathogenic bacteria are reported to have acquired resistance against antibiotic therapies (Harvey *et al.*, 2006; Anand *et al.*, 2019). Plants have been extensively used as a source of antibiotic, antineoplastic, analgesic, cardioprotective agents, etc. Natural products and their derivatives contribute to more than half of Food and Drug Administration (FDA)-approved drugs (Chavan *et al.*, 2018). The development of novel, efficient, cost-effective, and non-cross-resistant antibiotics has become the only alternative to treat bacterial diseases and remains a great challenge for the pharmaceutical industry (Chouhan *et al.*, 2017). The oils have been reported to possess significant antiseptic, antibacterial, antiviral, antioxidant, anti-parasitic, anti-fungal, and insecticidal activities as these plant products contain bactericidal as well as bacteriostatic agents (Benjilali *et al.*, 1986).

The seed oils have a variety of phytochemicals that have medicinal and nutraceutical properties. Many seed oils have been reported to have antibacterial properties. When bacteria were treated with 100 mg/mL neem oil, it created 11.7 mm and 13.0 mm of zone of inhibition for *Escherichia coli* and *Staphylococcus aureus* respectively (Sandanasamy *et al.*, 2013). When *Carnobacterium maltaromaticum*, *Brochothrix thermosphacta*, *Escherichia coli*, *Pseudomonas fluorescens*, *Lactobacillus curvatus*, and *Lactobacillus sakei* were treated with 10 μ L (by disc diffusion test) neem oil, it resulted in a minimum 89% growth reduction in each case (Del-Serrone *et al.*, 2015). According to Khoobchandani *et al.* (2010) the seed oil of *Eruca sativa* has antimicrobial activity against Gram-negative (*Shigella flexneri*, *Escherichia coli*, and *Pseudomonas aeruginosa*) and Gram-positive (*Bacillus subtilis* and *Staphylococcus aureus*) bacteria. Seed oil presented the maximum zone of inhibition (74–97%) for Gram-negative bacteria and 97% for Gram-positive bacteria.

The seed oil cake is a by-product of the oil extraction process. Several studies have shown that it is a rich source of nitrogen, phosphorous, and potassium. Some seed oil cakes are rich sources of protein, minerals, and crude fibers. *Jatropha curcus* seed oil cake can be used as fertilizer in the tuber, leafy vegetable, and fruit crops as green manure (Kumar and Sharma, 2008). The seed cake of *Bhlgia sapida* is rich in starch (44.2%), protein (22.4%), and fibre (15.6%) (Djenontin *et al.*, 2009). The oil cake also has a good amount of minerals like K, Ca, and Mg.

Ailanthus excelsa (Roxb.) is a multipurpose tree that belongs to the family Simaroubaceae. It is distributed in semi-arid and subtropical regions. Traditionally, it has been used in the treatment of bacterial and fungal diseases. Various extracts of the root, stem, bark, and leaf of *Ailanthus excelsa* were analysed for their phytochemicals and used against various human pathogens (Lavhale and Mishra, 2007). The bark of *A. excelsa* may be recommended as a potential antimicrobial agent (Malviya and Dwivedi, 2019). The seed oil of *A. excelsa* has been studied for its chemical composition and its application in biodiesel (Devi *et al.*, 1984; Kundu and Laskar, 2007; Anjaneyulu *et al.*, 2017). Devi *et al.* (1984) reported 18% fat in kernel weight in *Ailanthus excelsa* from Andhra Pradesh (India). Similarly, the seed oil has been reported to be 32.3% in *Ailanthus excelsa* from the same state (Anjaneyulu *et al.*, 2017). Kundu and Laskar (2007) reported seed oil to be 65 g/kg from West Bengal (India). The fatty acid composition of the seed oil has also been worked out, and it was found that the oil is rich in oleic acid (Kundu and Laskar, 2007; Anjaneyulu *et al.*, 2017). However, to the best of our knowledge, there has been no report on the antimicrobial activity of the seed oil of *A. excelsa*. Similarly, the seed oil cake of *A. excelsa* has yet to be explored.

In this study, oil from *A. excelsa* seeds has been extracted, and its fatty acid and phytochemical composition have been analyzed using gas chromatography with a flame ionization detector (GC-FID) and gas chromatography coupled with mass spectrometry (GC-MS) respectively. The antimicrobial activity of the oil has been explored against selected bacterial and fungal strains. In this study, we have also carried out a proximate analysis of seed oil cake and tried to present its potential applications.

2 Materials and methods

2.1 Plant material

Mature fruits of *A. excelsa* were collected from the Amity University Rajasthan campus located in Jaipur, India. The seeds were separated from the fruits by a mechanical method. To find out the moisture content in seeds, 10 g seeds were kept in a hot air oven at 65 °C. After 24 h, the seed weight was recorded. This experiment was replicated thrice. The average moisture content was found to be 18.67% (w/w).

2.2 Oil extraction from seeds

The seeds of *A. excelsa* were crushed with a mortar and pestle into a fine powder. The oil was then extracted using the soxhlet apparatus using n-Hexane as a solvent (boiling point: 67–68 °C) (Saini *et al.*, 2019). The oil was then kept at room temperature in a sealed glass vial until it was used to study its chemical composition and determine its antimicrobial activities.

2.3 Phytochemicals in seed oil

A. excelsa seed oil was analyzed by GC-MS (Agilent 8890/5977B series Agilent 5977B EI/CIMSD) at a pressure range of 0.001 to 13.886 psi with 0.01 to 100 psi resolution, with a 30 m \times 250 μ m \times 0.25 μ m DB 5 MS column front SS inlet

Table 1A. Antibacterial activity of seed oil of *Ailanthus excelsa*.

S. No.	Compounds concentration	Zone of inhibition (mm)			
		<i>Staphylococcus aureus</i> ATCC 25923	<i>Salmonella typhi</i> ATCC 733	<i>Escherichia coli</i> ATCC 25922	<i>Pseudomonas aeruginosa</i> ATCC 27853
1	1X	0	0	0	Very poor
2	0.5X	0	0	0	0
3	Negative control (n-Hexane)	0	0	0	0
4	Positive control	20 (Streptomycin)	26 (Chloramphenicol)	20 (Streptomycin)	26 (Ceftazidime)

Table 1B. Antifungal activity of seed oil of *Ailanthus excelsa*.

S. No.	Compound concentration	Zone of inhibition in different organisms (mm)	
		<i>Candida albicans</i> ATCC 14053	<i>Aspergillus flavus</i> (clinical isolate: 46047918)
1	1X	0	0
2	0.5X	0	0
3	Negative control (n-Hexane)	0	0
4	Positive control (Itraconazole)	22	25

with nitrogen as the carrier gas and the same in the back SS inlet with helium as the carrier gas, which flowed 1 mL/min for 50 minutes, the temperature range was set at 160–300 °C. Oil was diluted in hexane at 0.1 mg/mL with a molecular weight of less than 500 g/mol, and 1 µL solution was injected. The initial average velocity at 160 °C was 38.194 cm/s, and the hold-up time was 1.30 minutes. At the rear SS, a triple-axis detector with a high-energy dynode and electron multiplier autosampler had a temperature range of 114.3–300 °C and an electron mass of 236.3 Hz, which was connected to the TIC, MS library (NIST 20 L), and Agilent Mass Hunter.

2.4 Fatty acids composition study

For fatty acid composition, gas chromatography was used. FID No Trace 1300 with analytical column ZB FAME 30 mm × 0.25 mm MID × 0.24 m was used for fatty acid analysis. The oil was converted to fatty acid methyl ester (FAME), and 1 µL of the sample was injected into the inlet column with the help of a syringe. Hydrogen was used as a carrier gas, and the flow rate was 1.2 µL/min, the initial temperature of the inlet column was 100 °C, the rise in temperature was 10 °C/min; the final temperature was 240 °C and the FID detector temperature was 260 °C with 2 minutes of hold time.

2.5 Antimicrobial assays

The antimicrobial activity of oil was studied against bacteria: *Bacillus subtilis*, *Staphylococcus aureus* ATCC 25923, *Salmonella typhi* ATCC 733, *Escherichia coli* ATCC 25922, *Pseudomonas aeruginosa* ATCC 27853, and fungi: *Candida albicans* ATCC 14053 and *Aspergillus flavus* (clinical isolate: 46047918).

2.5.1 Preparation of test sample

The seed oil was used directly (1X) and at 50% concentration by dissolving it into n-Hexane (0.5X).

2.5.2 Antibacterial assay

Bacterial cultures were resurrected using appropriate nutrient media. *Staphylococcus aureus* ATCC 25923, *Salmonella typhi* ATCC 733, *Escherichia coli* ATCC 25922, and *Pseudomonas aeruginosa* ATCC 27853 were streaked and incubated at 37 °C for 24 h. Cultured bacterial strains were activated and diluted aseptically with sterile peptone water to obtain 0.5 McFarland turbidity for working standard inoculum and then cultured on Muller-Hinton agar (MH) media. Similarly, an antibacterial study against *Bacillus subtilis*, *E. coli*, and *Pseudomonas aeruginosa* was carried out where the activated bacterial cultures with more than 0.6 optical density (600 nm) have been spread on Muller-Hinton agar (MH) media.

A hole with 8 mm internal diameter was created to add 100 µL sample (1X oil, 0.5X oil, n-Hexane, standard antibiotics) with the bacterial lawn (Tab. 1A). The oil was diluted to 0.5X using n-Hexane. A suspension of streptomycin (0.3 mg) was used as a positive control for *Staphylococcus aureus* ATCC 25923 and *Escherichia coli* ATCC 25922. A positive control for *Salmonella typhi* ATCC 733 was chloramphenicol disc (0.3 mg), and a positive control for *Pseudomonas aeruginosa* ATCC 27853 was ceftazidime disc (0.3 mg). As a negative control, n-Hexane was used. The cultures of *Staphylococcus aureus* ATCC 25923, *Salmonella typhi* ATCC 733, *Escherichia coli* ATCC 25922, and *Pseudomonas aeruginosa* ATCC 27853 were incubated at 37 °C for 24 h. Similarly, the cultures of *Bacillus subtilis*, *E. coli*, and *Pseudomonas aeruginosa* were incubated at 37 °C for 48 h. Then the diameter of the inhibition zone was recorded in mm.

Table 2. Phytochemical composition of seed oil of *Ailanthus excelsa* based on analysis performed using GC-MS.

Peak	Start	RT	End	Height	Area	Area %	Name of compound
1	22.625	22.810	22.918	9616309	52104858	03.97	n-Hexadecanoic acid
2	25.349	25.762	25.842	31775335	512125795	39.04	Oleic acid
3	25.842	25.928	26.003	20498920	74988519	05.72	Octadecanoic acid (stearic acid)
4	28.526	28.583	28.681	3677826	7997425	00.61	9-Octadecenoic acid, 2-Hydroxyethyl ester
5	29.028	29.092	29.258	2432327	8698038	00.66	1-Ethynycyclododecanol

Table 3. Fatty acid profile of seed oil of *Ailanthus excelsa* based on analysis performed using GC-FID.

S. No.	No. of carbon atoms: double bonds	Fatty acid	Nature of fatty acid	Percentage area under peak
1	C4:0	Butyric acid	Saturated	0.11
2	C6:0	Caproic acid	Saturated	0.01
3	C8:0	Caprylic acid	Saturated	0.02
4	C10:0	Decanoic acid	Saturated	0.01
5	C11:0	Undecanoic acid	Saturated	0.01
6	C13:0	Tridecanoic	Saturated	0.53
7	C14:0	Myristic acid	Saturated	0.98
8	C15:0	Pentadecanoic acid	Saturated	0.03
9	C15:1cis 1	Pentadenoic acid	Unsaturated	0.01
10	C16:0	Palmitic acid	Saturated	13.36
11	C17:0	Heptadecanoic acid	Saturated	0.01
12	C18:0	Stearic acid	Saturated	8.88
13	C18:1cis 9	Oleic acid	Unsaturated	40.55
14	C18:3cis 6	Gamma linolenic acid	Unsaturated	11.35
15	C18:3cis 9	Alpha linolenic acid	Unsaturated	7.03
16	C20:0	Arachidic acid	Saturated	4
17	C20:1cis 1	Eicosenoic acid	Unsaturated	7.69
18	C21:0	Heneicosanoic acid	Saturated	0.34
19	C20:3cis 8	Eicosatrienoic acid	Unsaturated	1
20	C20:3cis 11	Eicosatrienoic acid	Unsaturated	0.18
21	C20:4cis 5	Arachidonic acid	Unsaturated	0.06
22	C20:5cis 5	Eicosapentaenoic acid	Unsaturated	0.03
23	C22:2cis 1	Docosadienoic acid	Unsaturated	0.98
		Total		100:00

2.6 Antifungal activity

Fungal cultures were revived on Sabouraud dextrose agar plates. *Candida albicans* ATCC 14053 and *Aspergillus flavus* (clinical isolate: 46047918) were streaked and incubated at 27°C for 2–3 days. For the antifungal activity study well diffusion method was used with Sabouraud dextrose agar medium. The standard 0.5 McFarland turbidity value for each culture was obtained as mentioned in the earlier method. The culture was swabbed on a Sabouraud dextrose agar surface, and wells were created with the help of sterile tips. 100 µL of each test sample (1X and 0.5X oil) was loaded into the respective well. A suspension of itraconazole in DMSO (5 µg/mL) was used as a positive control and n-Hexane as a negative control for both fungal strains. The plates were incubated at 27°C for 2–3 days for fungal growth, and then the diameter of the inhibition zone was recorded in mm.

2.7 Proximate analysis of seed oil cake

Proximate analysis refers to the quantitative analysis of macromolecules, a combination of different techniques such as extraction, Kjeldahl, and NIR (near infrared) are used to determine protein, fat, moisture, ash, carbohydrate, and mineral levels in a sample. The fat content of seed oil cake was determined using the BIOSOX automatic solvent extraction system IS 4684 (1975). Crude fibre, ash, and moisture content were determined by using the IS 7874, Part I, (1975). Phosphorous was determined using the ISO 6491 (1998) animal feed phosphorous determination method. The protein content of the sample was estimated using the BLOKJEL nitrogen estimation system IS 7219 (1996) and the FSSAI Lab Manual (2016). Potassium and zinc were determined according to the protocol for metals in food established by the AOAC in 2015 (Gill *et al.*, 2015).

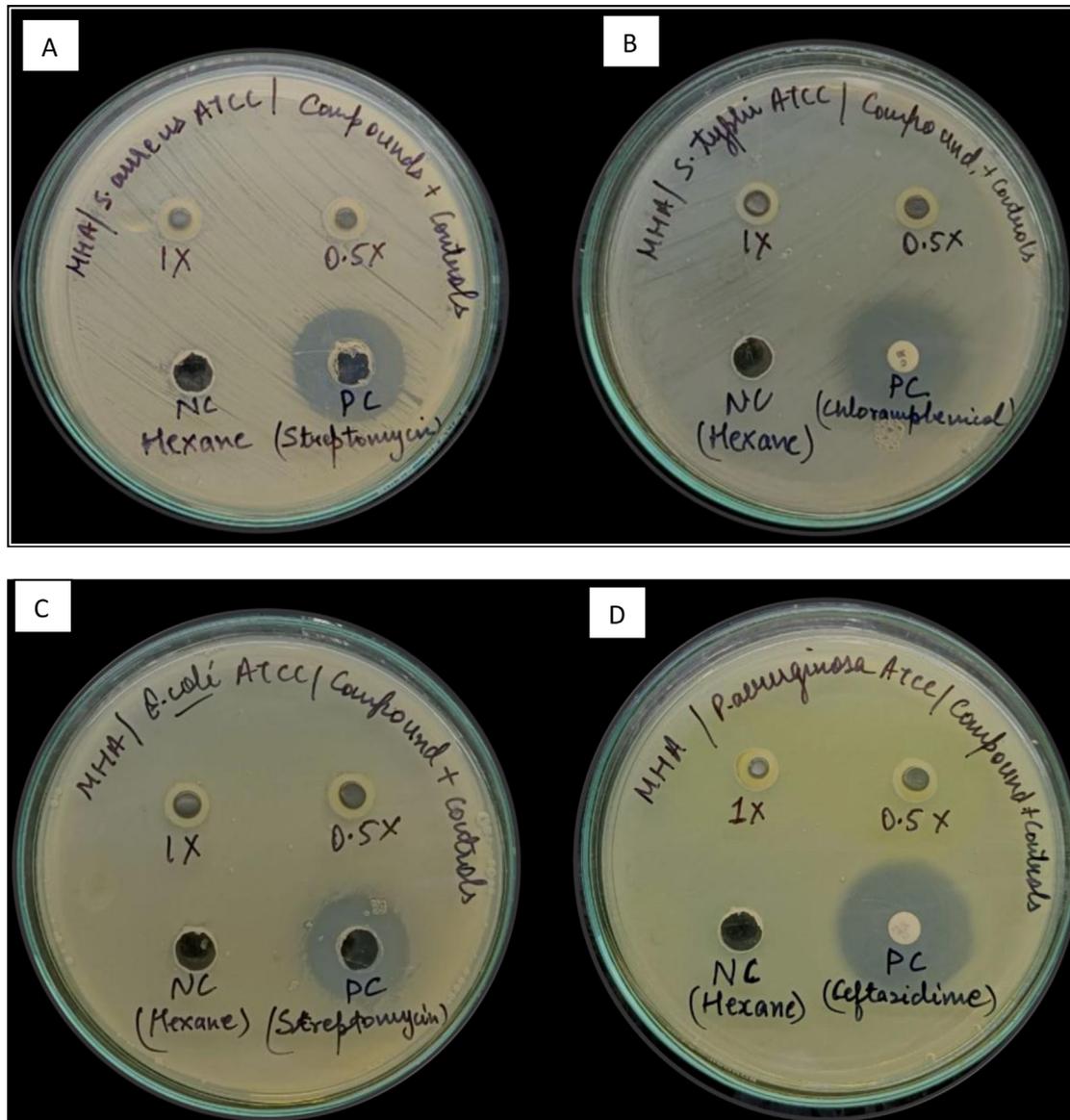


Fig. 1. Antimicrobial activity of seed oil of *Ailanthus excelsa* at different dilutions along with negative and positive control against (A) *Staphylococcus aureus* ATCC 25923, (B) *Salmonella typhi* ATCC 733, (C) *Escherichia coli* ATCC 25922 and (D) *Pseudomonas aeruginosa* ATCC 27853. NC: Hexane; PC: Streptomycin, Chloramphenicol and Ceftazidime.

The protein content was calculated using the following formula:

$$\text{Nitrogen(\%)} = 14.0 \times N(\text{Sample titre value} - \text{Blank titre value}) \times 100 \div 1000 \times \text{Sample weight.}$$

$$\text{Protein(\%)} = N \times 6.25.$$

3 Results and discussion

3.1 Seed oil and chemical composition

The oil content in the seeds of *Ailanthus excelsa* has been found to be 16.67% (w/v) when the seed moisture was 18.67% (w/w). These findings are a bit different from earlier reports of

oil/fat variation from 6.5% to 32.3% (Devi et al., 1984; Kundu and Laskar 2007; Anjaneyulu et al., 2017). This variation could be due to the seed material used, the extraction methods used, or a regional or climate effect.

This light-yellow oil was used to study chemical composition using GCMS, and the results are mentioned in Table 2. Based on the results, the oil is mostly consisting of oleic acid, n-Hexadecanoic acid, and octadecenoic acid. The oil is rich in oleic acid. The oil also contains 9-Octadecenoic acid, 2-Hydroxyethyl ester, and 1-Ethynycyclododecanol in addition to fatty acids. Our findings are in agreement with earlier reports where the oil has been found to be rich in oleic acid (Kundu and Laskar, 2007; Anjaneyulu et al., 2017).

Ailanthus excelsa seed oil was analyzed by GC-MS for its fatty acids after derivatization to FAME, and the results and observations are summarized in Table 3. It contains high levels

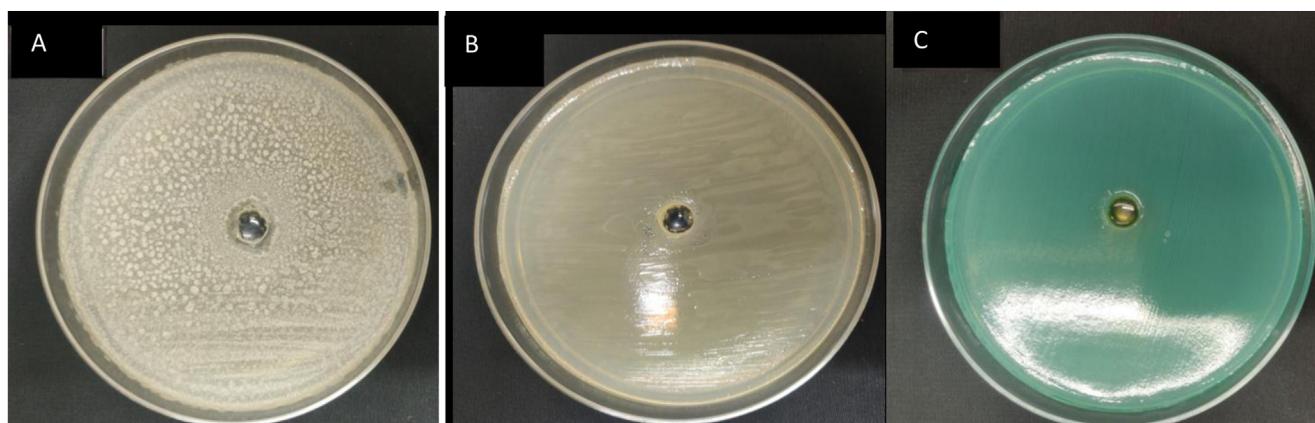


Fig. 2. Antimicrobial activity of seed oil (without dilution) of *Ailanthus excelsa* against (A) *Bacillus subtilis*, (B) *E. coli* and (C) *Pseudomonas aeruginosa*.

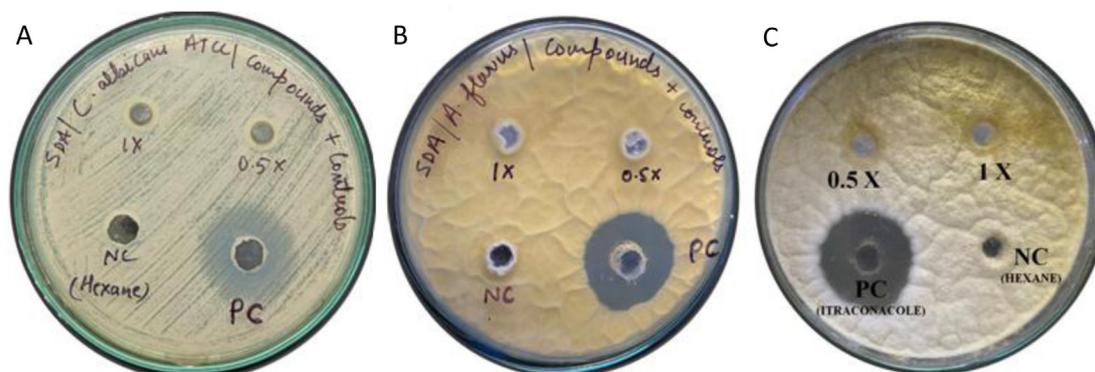


Fig. 3. Antimicrobial activity of seed oil of *Ailanthus excelsa* at different dilutions along with negative and positive control against (A) *Candida albicans* ATCC 14053 (Back View); (B) *Aspergillus flavus* (clinical isolate back view) and (C) *Aspergillus flavus* (clinical isolate front view) NC: DW; PC: Itraconazole.

of oleic acid (40.55%), palmitic acid (13.36%), γ -linolenic acid (11.35%), stearic acid (8.88%), eicosenoic acid (7.69%), and α -linolenic acid (7.03%) (Tab. 3). The other fatty acids include arachidic acid, eicosenoic acid, myristic acid, docosadienoic acid, butyric acid, caproic acid, caprylic acid, decanoic acid, undecanoic acid, tridecanoic acid, pentadecanoic acid, pentadecanoic acid, heptadecanoic acid, heneicosanoic acid, and arachidonic acid. The oil contains 28.27% saturated fatty acids, 48.19% monounsaturated fatty acids, and 23.40% polyunsaturated fatty acids indicating a major part of the fatty acid to be unsaturated. Our findings agree with an earlier report by Kundu and Laskar (2007) where they reported that the *Ailanthus excelsa* seed oil contains oleic acid (37.72%), linoleic acid (25.83%), palmitic acid (13.79%) and stearic acid (9.12%). Kundu and Laskar (2007) also reported the presence of DHA, eicosenoic acid, and arachidonic acid as minor fatty acids. A bit more varied composition has been reported by Anjaneyulu *et al.* (2017) where they found varied oleic acid (65.6%), saturated fatty acid (21.3%), and unsaturated fatty acid (78.5%). This variation may be due to variations in the genetic makeup and ecological factors of the source plants.

3.2 Antibacterial activity

The antimicrobial activity of *Ailanthus excelsa* seed oil against *Staphylococcus aureus* ATCC 25923, *Escherichia coli* ATCC 25922, *Salmonella typhi* ATCC, and *Pseudomonas aeruginosa* ATCC 27853 was investigated, and the results are shown in Table 1A and in Figures 1 and 2. The results indicate that the oil has no antibacterial activity against *Staphylococcus aureus* ATCC 25923, *Escherichia coli* ATCC 25922, and *Salmonella typhi* ATCC 733. Similarly, no antibacterial activity of the seed oil has been recorded against *Bacillus subtilis*, *E. coli*, and *Pseudomonas aeruginosa*. However, low-level antimicrobial activity against *Pseudomonas aeruginosa* ATCC 27853 has been found with 1X seed oil with a very poor zone of inhibition, while the standard antibiotic Ceftazidime could create a zone of inhibition with a diameter of 26 mm (Tabs. 1A and Figs. 1 and 2). The antibacterial property of the seed oil depends on its chemical composition. The seed oil of *A. excelsa* seems to have no such phytochemicals that can inhibit bacterial growth, or the concentration of such compound(s) is too low to be toxic for

Table 4. Proximate composition of seed oil cake of *Ailanthus excelsa*.

S. No.	Parameters	Quantity	Unit
1	Fat	4.46	%
2	Crude fibre	7.22	%
3	Protein	51.38	%
4	Moisture	3.99	%
5	Total ash	10.87	%
6	Phosphorous	0.22	%
7	Potassium	18.757	g/kg
8	Zinc	0.325	g/kg

the bacterial strains under study. However, seed oils obtained from *Leuconia leucocephala*, *Callophyllum inophyllum*, *Moringa oleifera*, *Balanites aegyptiaca*, *Prosopis* spp., *Eruca sativa*, and *Azadirachta indica* have been found to have significant antibacterial activities (Khoobchandani *et al.*, 2010; Aderibigbe *et al.*, 2011; Chothani and Vaghasiya, 2011; Saadabi and Zaid, 2011; Sandanasamy *et al.*, 2013; Adewuyi *et al.*, 2014; Imam *et al.*, 2019).

3.3 Antifungal activity

The observations of the antifungal activities of the seed oil of *Ailanthus excelsa* against *Candida albicans* ATCC 14053 and *Aspergillus flavus* (clinical isolate: 46047918) are presented in Table 1B and Figure 3. The seed oil of some plants had antifungal properties. Aderibigbe *et al.* (2011) reported that the seed oil of *Leuconia leucocephala* had antifungal activity against *Aspergillus niger*, *Rhizopus stolon*, *Penicillium notatum*, and *Candida albicans*. Antifungal activity of *Hyptis suaveolens* (Poit.) seed oil from Kalagarh region (Uttarakhand State, India) was tested against fungal strains of *Candida albicans* MTCC 227 and *Candida tropicalis* MTCC 227, which show minimal inhibitory concentrations of 0.125 mg/mL and 0.25 mg/mL, respectively (Bachheti *et al.*, 2015). This variation in antifungal activity in the seed oils can be due to variations in the chemical composition of the seed oil, which is determined by the genus of the plant species and climatic conditions.

3.4 Potential applications of the seed oil of *A. excelsa*

The phytochemicals present in *A. excelsa* seed oil can be used to treat health problems. Aparna *et al.* (2012) and Ravi and Krishnan (2017) reported that n-Hexadecanoic acid has anti-inflammatory and anti-cancer properties. According to their molecular docking analysis, n-Hexadecanoic acid interacts with topoisomerase I (a DNA replication and repair enzyme). They observed significant cytotoxicity against human colorectal carcinoma cells (HCT-116) with an IC₅₀ value of 0.8 µg/mL. The seed oil of *A. excelsa* is also rich in n-Hexadecanoic acid. Hence, it may be used for anti-inflammatory and anti-cancer purposes. Oleic acid may be utilized for anti-inflammatory, anti-androgenic, anti-cancer, preservative, and hypocholesterolemic properties (Sree Kumar *et al.*, 2014). The seed oil of *A. excelsa* can also serve the same

purpose due to the presence of oleic acid in it. Other seed oil constituents (octadecanoic acid, 9-Octadecenoic acid 2-Hydroxyethyl ester) have antioxidant, anti-inflammatory, antimicrobial, and diuretic activity Hussein *et al.* (2016), Osuntokun (2021) and Burt (2004) reported that some of the oil constituents can be used for the cosmetic, sanitary, food industry, and antimicrobial activity. These properties of oil components indicate potential applications of the seed oil of *A. excelsa* for various purposes.

3.5 Proximate composition of seed oil cake

Table 4 shows the approximate composition of *A. excelsa* seed oil cake. The proximate analysis of *A. excelsa* seed oil cake shows that it is a good source of protein (51.38%), fibre (7.22%), and ash (10.87%), which is higher than the oil cake of *Balanites aegyptiaca* where protein, crude fibre, and ash contents are 17.7%, 5.95%, and 9.1% respectively (Ogori *et al.*, 2017, 2018). The oil cake of *A. excelsa* can be used as feed for livestock and as a protein source for humans after assuring the absence of any toxic substance(s) or antinutrient(s). *Swietenia mahagoni* seed oil cake had 8.76% protein and 19.60% crude fibre (Mostafa *et al.*, 2011). Protein quantity varies in seed oil cakes in different species, like *Cucurbita pepo*, *Cannabis sativa*, and *Linum usitatissimum*, which were reported to have 38.27%, 24.77%, and 32.83% of protein, respectively (Budzaki *et al.*, 2018). The high ash content (10.87%) makes it a good source of minerals for animals and biofertilizers.

4 Conclusion

The oil from the seeds of *Ailanthus excelsa* was analyzed using GC-MS, and it was found to contain the following compounds: n-Hexadecanoic acid, oleic acid, octadecanoic acid (stearic acid), 9-Octadecenoic acid, 2-Hydroxyethyl ester, and 1-Ethynycyclododecanol. The fatty acid composition study reveals the predominance of oleic acid followed by linolenic acid in the oil. The oil has antibacterial activity against *Pseudomonas aeruginosa*. However, the oil has been found to have no cidal activity against *Staphylococcus aureus* ATCC 25923, *Salmonella typhi* ATCC 733, *Escherichia coli* ATCC 25922, *Candida albicans* ATCC 14053, and *Aspergillus flavus*. The seed oil cake has a high protein content (> 51%)

and is also rich in ash and fibres. So, it may be used as a feed or food after assuring its nontoxic nature and absence of antinutrients.

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Conflicts of interest

The authors declare that they have no conflicts of interest in relation to this article.

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Authors' contributions

Vijay Pal: Conducted experiment and recorded the data. Vinod Singh Gour and Joginder Singh: Conceptualized the idea and designed experiment. Paras Sharma: Carried out fatty acid analysis. Bhagwan Rekadwad: Carried out antimicrobial study. Aarti Choudhary and Kanta Rani: Helped in writing manuscript.

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