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Herbal soap formulation with *Senna auriculata* (L.) Roxb. floral extract

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Abstract

Natural medicines are intriguing, which have been the foundation of human healthcare for thousands of years, are often labelled as "alternative medicine." In reality, these natural remedies are the original medicines that humanity has relied upon long before modern pharmaceuticals existed. Nature offers an abundance of tangible and intangible benefits, particularly through plants, which possess rich medicinal and cosmetic properties. Despite the availability of various organic products on the market, many wildflowers remain underexploited for their diverse uses. One such plant is *Senna auriculata* (L.) Roxb. normally identified as Tanner's cassia (Tamil Avaram), which comes under the family Caesalpiniaceae. This shrub, adorned with large, bright yellow flowers, is found throughout the hot deciduous forests of India. *S. auriculata* holds a significant place in traditional Ayurvedic and Siddha medicine, where it is valued for its various therapeutic properties. The wonder herb has many medicinal properties, *viz*., antipyretic, antidiabetic, antiperoxidative, antitanning, antiageing and microbicidal activities. Traditionally, the floral powder of *S. auriculata* has been used as a facial application to enhance skin glow. While commercial flowers are widely used in the cosmetic industry, wildflowers like *S. auriculata* are often overlooked despite their potential. In this study, we formulated an herbal soap using the floral extracts of *S. auriculata*. The resulting soap exhibited significant antimicrobial activity, demonstrating its potential as both an effective antimicrobial agent and a valuable cosmetic product. This highlights the untapped potential of wildflowers in the development of natural, herbal based skincare products.

1. Introduction

Nature provides numerous benefits to the humankind. A plant having medicinal, pharmaceutical and cosmetic potential, can be exploited to design innovative products. There are various organic products in the market. Still the wild flowers are being underexploited and still remains enlarge. Natural products are commonly used to treat various diseases and skin conditions because of their medicinal properties, affordability, ease of use and widespread acceptance (Saikia *et al.,* 2006). The wild fruits have been found to contain higher amount of polyphenols or phytochemicals with strong antioxidant and free radical scavenging abilities which are largely recognized as anti-inflammatory, antiviral, antimicrobial and antioxidant agents (Thakur, 2023)

The active compounds responsible for the medicinal properties of natural products are often extracted and applied topically in creams, soaps, oils and ointments to treat various skin conditions, including acne, wounds, eczema and ringworm (Batubara *et al*., 2009). These compounds are also valued for their antimicrobial effects and cosmetic benefits (Gray and Flatt, 1999). Plants such as *Cassia alata* (Benjamin and Lamikanra, 1981), *Acalypha wilkesiana, Acacia senegal and Phyllanthus emblica* (Chaudhuri, 2002) are commonly used for skin rejuvenation. Various formulations, both in medical applications and cosmetic lines, are utilizing the medicinal properties of plants.

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Photochemical in plants, though nonnutritive, offer protective effects against various diseases and disorders (Gurudevan, 2013). Development, formulation and evaluation of hydrogel for topical drug delivery of *Zingiber officinale* Rosc. and *Withania somnifera* (L.) Dunal to increase the bioavailability of oils for the treatment of arthritis can be used as an effective complimentary or alternative medicine in treatment of arthritis (Dheeraj Singh Attri *et al.,* 2023).

Senna auriculata (L.) Roxb. belonging to the family Caesalpiniaceae, is an ethno botanically important shrub with striking yellow flowers, generally known as "Avaram" in Tamil (Thulasi *et al*., 2012). The above ground parts of the plant are customarily used in medicine to treat various conditions, including diabetics, conjunctivitis and rheumatism, as well as serving as antivenom and medication for eye problems, body odor, leprosy and liver disorders (Anandan, 2011). Several reports highlight the plant's antidiabetic, acute toxicity, hyperlipidemic, cardioprotective, antioxidant, antimicrobial and hepatoprotective activities (Chauhan *et al.,* 2009; Raj *et al.,* 2012). Different parts of the plant have been reported to contain chemical constituents such as proteins, carbohydrates, alkaloids, flavonoids and tannins (Purushotham *et al.,* 2014).

Rhododendron (*Rhododendron arboreum* Sm.), a wildflower found in Himachal Pradesh, India, has considerable economic potential due to its high antioxidant content, vibrant color pigments and other valuable qualities, along with its medicinal properties (Thakur *et al*., 2021). Most of the polyphenols are obtained using petroleum ether as solvent for extraction in the Soxhlet apparatus. Juvekar and Halade (2006) investigated the flowers of *S. auriculata* which discovered the presence of anthroquinones, aloeemodin and sitosterols. The medicinal properties of black cumin seeds (*Nigella sativa* L.), celery seeds (*Apium graveolens* L.) and chicory root (*Cichorium intybus* L.) have been extensively documented (Ahmad Ali, 2020). Anti-inflammatory activity of *Callicarpa tomentosa* L. leaf and leaf derived callus extracts were used as traditional medicine for the treatment of inflammatory and microbial diseases. Methanol extracts of the leaf and leaf derived callus showed significant anti-inflammatory capacity (Shrilakshmi *et al*., 2022). Phytochemical screening of Tamarind indicated the presence of phytochemicals like alkaloids, amino acids, phenols and flavonoids. The methanol extract of leaves was found superior over the extracts prepared with chloroform and petroleum ether (Bhawana Sharma *et al.,* 2021). In the present study, we used Senna floral extracts with potential antibacterial activity, thereby establishing them as a potent antimicrobial agent in the formulation of herbal soap. Skin, especially hands are needed to protect from bacterial pathogens as they are the most exposed part of the body (Jayant Londhe *et al.,* 2015).

2. Materials and Methods

2.1 Plant material

The flowers of *Senna auriculata* (L.) Roxb. a leguminous tree from the subfamily Caesalpinioideae, were collected from the Jackanari Reserve Forest located in the foothills of The Nilgiris. The plant specimen was botanically authenticated by Dr. P. Devanand, Associate Professor (Plant Breeding and Genetics) in the Department of Forest Biology and Tree Improvement at the Forest College and Research Institute, Mettupalayam. It has been assigned the identity of Specimen Voucher Number 820809. The sample has been deposited to the Department Herbarium Collection Centre. It is commonly known by its local names Matura tea tree, Avaram or Ranawara. The plant was collected and the flowers were sorted, cleaned and dehydrated in the shade for one week. The dried flowers were then finely powdered using an electronic mixer grinder and sieved. The fine powder of the flowers of Avaram was stored in an air tight container.

2.2 Plant extract preparation

For the solvent extraction process, 25 g of the finely powdered flowers were placed in the thimble of a Soxhlet apparatus and extracted using petroleum ether and methanol as solvents. The extraction was carried out for 4 h at 55°C. The solvent extracts obtained were collected separately in airtight containers and stored in a refrigerated condition at 5°C for further use. Before starting the extraction, the initial weight of the floral powder was recorded. After extraction, the remaining residues were oven dried and weighed. The difference between the initial and oven dry weights was calculated to determine the amount of saponin extracted.

2.3 Preparation of adjuvants

Organic soap base of glycerol is made and stored in refrigerator. Rose water was prepared and kept in air tight containers and stored in refrigerator for further use. Turmeric powder was prepared by drying turmeric followed by powdering using electric mixer grinder and sieved using 100 mesh sieve.

2.4 Examination the foaming properties

Prepared soap is taken and gently rubbed using both hands. Glycosides present in the floral extract create foaming when added with water. This enhances the quality of soap. If, the foaming covers full area of in hand, then it is considered as 100% foaming. If, 80% of the palm area is covered with foam, then foaming % is considered as 80%.

2.5 Evaluating the yield of saponin from flower powder using different extraction methods

Yield of saponin was determined following extraction methods, *viz*., normal water, water bath, cold water, 10 g of Senna floral powder was autoclaved to be used for each method. For each extraction, 250 ml of water was added. The sample was sterilized in autoclave at 120°C for 15 min under 15 PSI pressure and heated in water bath for 90 min. For normal and cold water extractions, the sample was left in the respective conditions without additional heating. After extraction, the left over residues were oven dried and weighed. The yield of saponin was obtained by working out the difference between the initial weight and the oven dried weight of the residues.

2.6 Quantitative phytochemical analysis using GC-MS

Quantitative photochemical analysis was conducted using standard GC-MS methodology, an advanced diagnostic procedure that combines gas chromatography and mass spectrometry to classify and enumerate different substances within a sample. This method is capable of detecting trace elements even in materials that may have otherwise disintegrated beyond detection. Similar to liquid chromatography mass spectrophotometry, GC-MS is effective for analyzing and detecting even minute quantities of substance 3 ml of methanol extract from *S. auriculata* flowers was subjected to GC-MS to quantify the photochemical present in the floral extract.

2.7 Microbial evaluation

The standard agar well dispersion method was employed to evaluate the antimicrobial activity of *S. auriculata* floral extracts. The extracts were placed to discs on the top of agar plate and the span of the inhibition around each disc was calculated to evaluate the efficacy of the extracts.

2.8 Final product preparation

Collection of flowers of *S. auriculata* from the different blocks of Forest College

↓

Shade drying of flowers for 2-3 days under room temperature

↓

Dried flowers are powdered using mixer grinder

↓

Flower powder is subjected to Soxhlet apparatus for floral extract

↓

Floral extract is analyzed for Phytochemical and Antimicrobial properties

↓

Phytochemicals in the extract are quantified under GC-MS (Gas chromatography mass spectroscopy)

↓

Glycerol soap base is made and stored in refrigerator

↓

Base soap is melted and mixed with flower extract + rose water and a pinch of turmeric extract is added for coloring

↓

All ingredients are mixed under heat and poured in soap mould

↓

Soap (Final product)

3. Results

3.1 Effect of solvents on the yield of saponin

The saponin extract from pericarp powder was evaluated using two different extraction methods: petroleum ether and methanol. The results are summarized as follows, *viz*., petroleum ether extract and methanol extract. The petroleum ether extraction yielded 44.0% saponin. This method appears to be highly effective for extracting saponin from the pericarp powder as indicated by the relatively high percentage yield. Petroleum ether is a nonpolar solvent, which suggests that the saponin in the pericarp are likely soluble in nonpolar solvents, leading to a substantial extraction.

The methanol extraction resulted in a lower saponin yield of 13.20%. Methanol is a polar solvent and while it is generally effective for extracting a wide range of phytochemicals, the lower yield suggests that saponins in the pericarp powder are not as soluble in methanol as they are in petroleum ether. The results indicate that petroleum ether is more effective than methanol for extracting saponins from pericarp powder as evidenced by the higher saponin yield. This suggests that saponins in the pericarp are better extracted with nonpolar solvents. Further studies could explore other solvents or methods to optimize saponin extraction from the pericarp (Table 1).

3.2 Results of phytochemical quantification of methanol floral extracts of *S. auriculata* using GC-MS

The studies show that conformation of various phytochemical properties quantitatively on methanol extract of *S. auriculata*. (Table 2). This data represents a list of compounds identified by gas chromatography (GC), with their retention times and peak area percentages. Retention time, indicates how long a compound took to travel through the chromatographic column and reach the detector. Peak area (%) represents the percentage of the total detected signal attributed to each compound, giving an idea of the relative concentration. The compound mome inositol has the largest peak area at 43.44%, indicating it is the most abundant compound in the sample. 1,3 benzenediol is the next most abundant compound at 19.37%. Other notable compounds include dibutyl phthalate (8.61%) and methyl commate D (8.48%). This data is useful for understanding the composition of the sample in terms of the relative amounts of each detected compound.

Table 1: Saponin recovery from the extract using different solvents

S. No.	Pericarp powder	Initial weight of pericarp powder	Oven dry weight	Saponin recovery	Saponin recovery percentage
1.	Petroleum ether extract	25 g	14 g	11 g	44.00
2.	Methanol extract	25 g	21.7 g	3.3 g	13.20

The results clearly indicate that petroleum ether is more effective in extracting saponins from pericarp powder compared to methanol. The yield percentage of 44.00% for petroleum ether is significantly higher than the 13.20% obtained with methanol. This efficiency difference can be attributed to the solvent properties petroleum ether's non-polarity is more compatible with the chemical nature of saponins, whereas methanol, being polar, may extract a wider range of substances but not as effectively target saponins. Petroleum ether is the preferred solvent over methanol for the purpose of maximizing saponin yield from pericarp powder as it results in a higher yield and a more concentrated extraction of saponins.

Table 2: Results of phytochemical quantification of methanol floral extracts of *S. auriculata* using chromatographic studies

S. No.	Retention time	Compound	Peak area (%)
1	2.602	2,2-Dimethoxybutane	0.60
2	5.625	Dichlorobenzoyl peroxide	0.40
3	8.490	Naphthalene	0.79
4	9.837	4-Vinylphenol	1.83
5	10.309	Cyclohexane	0.42

6	10.760	1,3-Benzenediol	19.37
7	12.191	1-(2-oxiranyl)-1-dodecanol	0.47
8	12.511	1-Tetradecene	1.31
9	15.198	Cetene	2.82
10	16.109	Mome inositol	43.44
11	17.604	1-Docosanol	2.33
12	19.399	Dibutyl phthalate	8.61
13	19.779	1-Hexacosanol	1.10
14	20.852	Heneicosane	0.33
15	22.605	Methyl commate D	8.48
16	22.745	Pentacosane	2.09

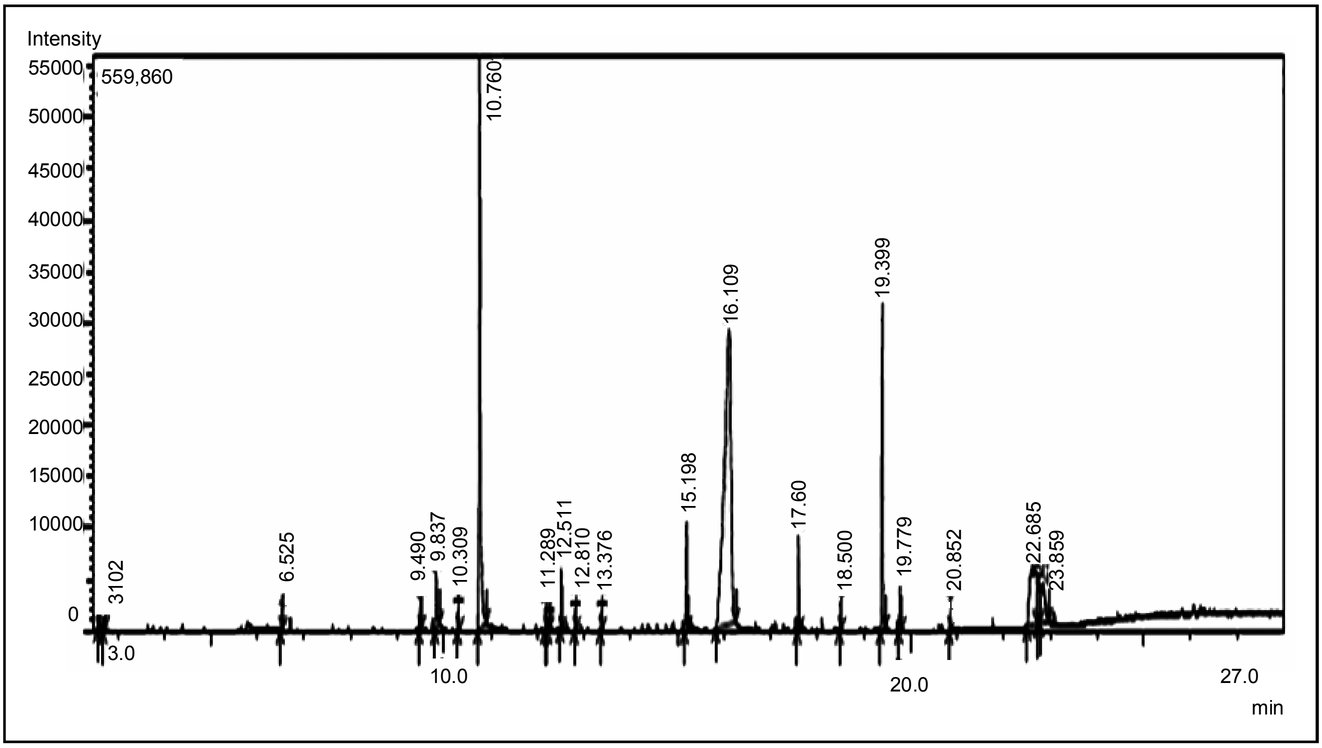

Figure 1: GC-MS chromatogram of methyl extract of *S. auriculata* flower.

The GC-MS analysis indicates that the sample is rich in bioactive compounds with Mome-inositol and 1,3 benzenediol being the most prominent. These compounds contribute significantly to the biological and potentially therapeutic properties of the extract. The presence of other compounds like dibutyl phthalate and methyl comate D adds complexity to the extract's profile, possibly affecting its overall effectiveness in applications like skincare or antimicrobial products. The high percentage of Mome-inositol (43.44%) suggests that the extract could be particularly effective in formulations aimed at skin protection and soothing, while the notable concentration of 1,3 benzenediol (19.37%) supports its use in skin lightening products. The remaining compounds, though present in smaller amounts, may enhance the extract's utility in various formulations or offer specific targeted benefits.

3.3 Studies on antimicrobial activity of floral extractives and soap

3.3.1 Agar well diffusion method of bacteria soap

The zone of inhibition shows uptrend with soap concentration. There is a progressive increment in the inhibition zone as concentration of the soap rises from 6 µl to 10 µl. At 10 µl, the zone of inhibition is 1.1 cm. The measurements show a consistent increase in the zone of inhibition with higher concentrations, indicating a dose dependent effect. The standard deviation (± 0.1 cm) suggests some variability, but the overall trend is clear. The results suggest that the soap's antimicrobial activity increases with higher concentrations. This implies that elevated concentrations of the soap are more effective in preventing microbial growth. The data indicates a positive correlation between soap concentration and inhibition zone size, highlighting the effectiveness of the soap in higher concentrations. Further studies could help determine the optimal concentration for maximum antimicrobial efficacy.

Table 3: Studies exhibiting zone of inhibition using soap for bacteria and fungus

S. No.	Concentration of soap (µl)	Bacterial zone of inhibition (cm)	Fungal zone of inhibition (cm)
1.	6	0.7 ± 0.1	0.8 ± 0.1
2.	7	0.9 ± 0.1	0.9 ± 0.1
3.	8	0.9 ± 0.1	0.10 ± 0.1
4.	9	0.10 ± 0.1	0.11 ± 0.1
5.	10	0.11 ± 0.1	0.13 ± 0.1

Table 4: Studies exhibiting zone of inhibition for bacteria and fungus using Senna floral extract

S. No.	Concentration of floral extract (µl)	Bacterial zone of inhibition (cm)	Fungal zone of inhibition (cm)
1.	6	0.8 ± 0.1	0.9 ± 0.1
2.	7	0.8 ± 0.1	0.10 ± 0.1
3.	8	0.9 ± 0.1	0.13 ± 0.1
4.	9	0.11 ± 0.1	0.17 ± 0.1
5.	10	0.13 ± 0.1	0.19 ± 0.1

3.3.2 Antimicrobial studies with reference to fungi using soap

The data in the table shows the relationship between the concentration of soap (in µl) and the corresponding zone of inhibition (in centimeters). As the concentration of soap increases from 6 µl to 10 µl, the zone of inhibition also increases. This suggests that higher soap concentrations enhance its antimicrobial activity, leading to larger zones where bacteria cannot grow. From 6 µl to 7 µl, the zone of inhibition increases from 0.8 cm to 0.9 cm. From 9 µl to 10 µl, the zone increases from 1.1 cm to 1.3 cm, further confirming the increasing effectiveness with higher concentration. Agar well diffusion method for fungi and Bacteria using methanol extract of *S. auriculata.* Senna flower extract exhibited the higher inhibition zone of 2 cm at concentration of 10 µl of floral extract on fungal plates (Tables 3 and 4)

The above table clearly shows that the antimicrobial efficacy of the soap increases with higher concentrations, reaching a peak at around 10 µl. The results suggest that to maximize the antimicrobial benefits of the soap, it should be used at or above this concentration as effective dosage in practical applications, such as in formulations for disinfectants or therapeutic soaps. The zone of inhibition has positive correlation with concentration. This infers that elevated concentrations of soap possess greater antimicrobial activity, effectively inhibiting microbial growth over a larger area. There is absolutely no change in using 7 µl and 8 µl indicating plateau effect that the antimicrobial agents in the soap have reached a point where additional concentration does not significantly enhance their inhibitory action, possibly due to saturation effects or the presence of other limiting factors in the assay environment.

Using 8 µl to 9 µl reaches a threshold concentration, where in, the soap's antimicrobial components become more effective, potentially due to higher concentrations of active ingredients overwhelming the microbial defense. Therefore, using soap at concentrations closer to 10 µl may provide optimal antimicrobial protection.

4. Discussion

The extraction and identification of phytochemicals from plant materials play a significant role in fields such as cosmetics, pharmaceuticals and the food industry. This study highlights several key aspects of saponin extraction and the characterization of bioactive compounds from a plant extract using gas chromatography mass spectrophotometry (GC-MS) and its effectiveness as antimicrobial agent.

The extraction of phytochemicals from plant materials often yields varying quantities depending on the solvent employed. Saponins, a class of naturally occurring glycosides are known for their diverse biological properties, such as antimicrobial, anti-inflammatory and ant carcinogenic effects. The choice of solvent is crucial in determining the quantity and quality of phytochemicals extracted from plant materials and this study demonstrates how different solvents can yield varying amounts of saponins. In this study, saponin was obtained using two different solvents petroleum ether and methanol. The results showed that petroleum ether yielded significantly higher saponin content (44.0%) compared to methanol (13.2%). This suggests that petroleum ether, being nonpolar, is more effective in extracting saponins, which may contain nonpolar aglycone parts that are more soluble in nonpolar solvents (Harborne,1998; Houghton and Raman, 1998). Chromatography and spectrophotometry (GC-MS) studies segregated 16 compounds in fraction 1 of the extract, with peak areas ranging from 0.33% to 43.44%. The most prominent phytochemicals identified were,

Mome-inositol. This compound is frequently used in skincare products. It can be applied to both 'before tanning' formulations, such as sunscreens and day creams, as well as 'after tanning' products like tan prolonging lotions and after sun creams. Mome-inositol's ability to soothe skin and maintain its health under sun exposure is well documented in cosmetic science (Arct and Pytkowska, 2008). 1, 3 benzenediol is known for its powerful skin lightening properties and inhibits melanin synthesis. This makes it a valuable ingredient in products aimed at reducing hyperpigmentation, providing a stable and safe option for skin lightening (Briganti *et al.*, 2003).

Cetene: This antioxidant plays a crucial role in protecting the body's cells from oxidative stress, a process that contributes to ageing and various diseases. Its inclusion in formulations enhances the protective and antiageing properties of the product (Rice Evans *et al*., 1997).

The antimicrobial properties of the floral extract were evaluated by measuring the inhibition zones in petri dishes. The extract exhibited an inhibition zone of 1.3 cm against bacterial culture and 1.9 cm against fungal culture. When incorporated into soap, these bioactive compounds resulted in inhibition zones of 1.1 cm for bacteria and 1.3 cm for fungi. This demonstrates that the phytochemicals present in the floral extract, particularly Mome-inositol, 1,3 benzene diol and cetene, contribute to the antimicrobial efficacy of the soap (Cowan, 1999).

5. Conclusion

Herbal soap made with Senna offers a natural and appealing alternative to conventional soaps, which often rely on chemical ingredients. Its rising popularity stems from its skin friendly and eco conscious attributes. Without the use of harsh chemicals or artificial fragrances, Senna herbal soap is particularly beneficial for individuals with sensitive skin. Its natural ingredients not only make it gentle but also environmentally sustainable, attracting those who value ecofriendly personal care options.

Made from biodegradable, plant based components, herbal soaps are a green alternative that minimizes environmental impact. Additionally, they are cruelty free, as no animal products or by products are used in their formulation, making them an ethical choice for mindful consumers. The use of herbs in these soaps offers a range of advantages, such as calming and nourishing the skin, providing pleasant natural scents and promoting relaxation through aromatherapy. Many of the natural elements in herbal soap have antibacterial, antifungal and anti-inflammatory properties, which help to deal with skin acne, eczema and psoriasis. Available in an array of natural fragrances and formulas, herbal soaps cater to a variety of preferences and skin needs. Each herb used in these soaps, *viz.,* Turmeric and Avaram have distinct benefits, enhancing both skin health and overall wellbeing. As more people become concerned about the synthetic chemicals found in many personal care products, herbal soap continues to gain recognition as a safe, sustainable and beneficial alternative.

Conflict of interest

The authors declare no conflicts of interest relevant to this article.

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