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Improving Public Knowledge of the Antioxidant Potential of Gelam (Melaleuca leucadendron L.) and the Prevention of Microbial Contamination in Herbal Materials

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Abstract

Gelam (Melaleuca leucadendron L.) grows abundantly in the swamplands of South Sumatra, and its leaves have strong antioxidant activity. However, the public is largely unaware of this potential, and home-processed herbal materials are at risk of microbial contamination when processing and storage are unhygienic. This community service activity aimed to improve public knowledge of the antioxidant potential of gelam and ways to prevent microbial contamination in herbal materials. The activity was held on 5 December 2025 at Universitas Kader Bangsa Palembang and involved 40 residents, consisting of housewives and home-based herbal drink producers. It included counseling, a qualitative demonstration of the DPPH antioxidant assay, a demonstration of microbial contamination testing, and practice of hygienic simplicia processing. Eight herbal drink samples from participants were tested for total plate count (TPC) and yeast and mold count (YMC). Knowledge was measured with a 15-item questionnaire before and after education. Three of the eight samples (37.5%) exceeded the TPC and YMC limits, and all three had been stored at room temperature for more than 24 hours or made from simplicia dried on the ground. The mean knowledge score increased from 45.0 ± 17.0 to 82.3 ± 11.4 ($p < 0.001$), with a mean N-gain of 0.69 (moderate). The proportion of participants with good knowledge rose from 7.5% to 70.0%. Education combined with laboratory demonstration effectively improves public knowledge of gelam utilization and safe herbal processing.
Keywords: *antioxidant; gelam; herbal materials; Melaleuca leucadendron; microbial contamination*

INTRODUCTION

The use of medicinal plants and herbal drinks remains an integral part of daily life in Indonesia. One plant that is easily found in South Sumatra is *gelam* (*Melaleuca leucadendron* L.), which grows abundantly in swampy areas. Traditionally, *gelam* has been primarily valued as a source of timber for construction, while the potential of its leaves and seeds for herbal applications has remained largely untapped. Research on *gelam* from South Sumatra indicates

that its extract contains alkaloids, flavonoids, steroids, saponins, and tannins, and exhibits strong antioxidant activity, with an IC50 value of 47.56 ppm (Ernia et al., 2025). Antioxidants play a role in neutralizing free radicals—which are linked to the aging process and various degenerative diseases—suggesting that *gelam* has the potential to be developed into a functional herbal beverage.

However, the use of herbal products must also account for safety. Herbal preparations made at home are at risk of contamination by bacteria, molds, and yeasts—particularly if the raw materials are not washed under running water, are dried directly on the ground, are stored in open containers, or if the final herbal drinks are kept at room temperature for too long. The Indonesian Food and Drug Authority (BPOM) has established the Total Plate Count (TPC) and the Mold and Yeast Count (MYC) as parameters for microbial contamination in traditional medicines (Indonesian Food and Drug Authority, 2019). These requirements were subsequently updated through regulations concerning the safety and quality of natural medicinal products (Indonesian Food and Drug Authority, 2023). Testing of traditional medicinal products has shown that some still fail to meet the established standards for microbial contamination (Arifin & Sulistyani, 2023).

Preliminary discussions with residents living near Universitas Kader Bangsa (UKB) reveal that many frequently prepare their own herbal decoctions or traditional medicines (*jamu*). However, they are largely unaware of the antioxidant potential of *gelam* and lack an understanding of how to properly process and store herbal ingredients to prevent microbial contamination. Therefore, the team from the Bachelor of Applied Science (D4) program in Medical Laboratory Technology and the Master's program in Public Health at UKB conducted an educational session that combined the team's research findings on *gelam* (a type of *Melaleuca* tree) with laboratory demonstrations. This activity aimed to (1) enhance public knowledge regarding the antioxidant potential of *gelam*, (2) improve understanding of how to prevent microbial contamination in herbal materials, and (3) provide insight into the level of microbial contamination present in herbal drinks prepared by the participants.

METHOD

Time, location, and target audience. The activity took place on Friday, December 5, 2025, at Universitas Kader Bangsa (UKB) Palembang. The target audience consisted of residents living near UKB—primarily homemakers and individuals who produce *jamu* (traditional herbal

medicine) or homemade herbal drinks—who were willing to participate in the entire program. A total of 40 participants completed the full activity. One week prior to the event, participants who produce their own herbal drinks were asked to bring samples of their products.

Implementation team. The activity was conducted by faculty members from the Bachelor of Applied Science (D4) program in Medical Laboratory Technology and the Master's program in Public Health at UKB, with assistance from students of the Medical Laboratory Technology program.

Stages of the activity.

1. Preparation. The team developed educational materials, a leaflet titled "Gelam: Antioxidant from the Swamps—Process It Hygienically," and a questionnaire. They also prepared samples of *gelam* leaves and *simplisia* (dried raw herbal material), as well as culture media—Plate Count Agar (PCA) and Potato Dextrose Agar (PDA)—for microbial contamination testing.
2. Microbial contamination testing. Eight samples of herbal drinks provided by the participants were analyzed in the laboratory prior to the event. Aerobic Plate Count (APC) was determined using the pour-plate method on PCA, incubated at 35–37 °C for 24–48 hours. Yeast and Mold Count (YMC) was assessed using PDA, incubated at 20–25 °C for 5 days. The results were compared against the contamination limits for liquid oral preparations: APC $\leq 10^5$ colonies/mL and YMC $\leq 10^3$ colonies/mL (Indonesian Food and Drug Authority/BPOM, 2019) [Note: Please verify these limits against the current BPOM Regulation Number 29 of 2023].
3. Pre-test. Participants provided demographic information, described their habits regarding the preparation of herbal ingredients, and completed a 15-item knowledge questionnaire.
4. Education. An interactive session lasting approximately 60 minutes covered the following topics: an introduction to the *gelam* plant; the active compounds and antioxidant activity of *gelam* leaves (based on the team's research findings); an explanation of free radicals and antioxidants; potential sources of microbial contamination in herbal materials; and hygienic methods for processing and storing herbal materials.
5. Demonstration. The team demonstrated a qualitative antioxidant assay using the DPPH method, showing the color change of a DPPH solution from purple to yellow upon the

addition of *gelam* leaf extract. The team also presented culture plates from microbial analyses (Total Plate Count/TPC and Yeast and Mold Count/YMC) performed on samples provided by the participants. Furthermore, they demonstrated the hygienic preparation of *simplisia* (dried herbal material): selecting the leaves, washing them under running water, slicing them, drying them—either on a clean surface covered with a thin cloth or in a low-temperature oven—and finally storing the dried material in an airtight container.

6. Evaluation. Participants completed a post-test (using the same questions as the pre-test), and the results of the microbial analyses were communicated to the respective sample owners, accompanied by recommendations for improvement.

Instruments and data analysis. The questionnaire consisted of 15 true-false items, with scores ranging from 0–100, categorized as good (≥76), fair (56–75), and poor (<56). The score differences followed a normal distribution (Shapiro–Wilk $p = 0.079$); therefore, they were analyzed using a paired t-test. The effectiveness of the education was assessed using the N-gain. The results of the microbial contamination tests are presented descriptively. Statistical significance was set at $p < 0.05$.

RESULTS AND DISCUSSION

Implementation of activities

The activity lasted for approximately 3.5 hours and involved 40 participants. A demonstration showing the color change of DPPH—from purple to yellow—captured the participants' attention, as it clearly illustrated the ability of *gelam* (paperbark tree) leaf extract to neutralize free radicals. Participants were also surprised to see the large number of bacterial and mold colonies on petri dishes containing samples of herbal drinks that had been stored for a long time. The most frequently asked questions concerned which parts of the *gelam* tree could be utilized, how long herbal decoctions could be kept, and whether herbal preparations that had developed mold were still safe to consume if re-boiled.

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Figure 1. Activity Documentation

Participant characteristics and habits

Table 1. Characteristics and habits of participants in preparing herbal ingredients

Characteristics	Category	n	%
Gender (n = 40)	Female	31	77,5
	Male	9	22,5
Age (n = 40)	20–35 years	12	30,0
	36–50 years	18	45,0
	>50 years	10	25,0
Regularly consuming herbal drinks (n = 40)	Yes	28	70,0
Preparing one's own herbal remedies/drinks (n = 40)	Yes	19	47,5
Processing habits (n = 19)	Wash the material with running water	11	57,9
	Dry with a clean, covered base	7	36,8
	Storing crude drugs in a tightly closed container	8	42,1
	Storing boiled food at room temperature for >24 hours	9	47,4

Most participants regularly consume herbal drinks, and nearly half prepare them themselves. However, many of the participants' preparation practices carry a risk of microbial contamination. Only 36.8% of participants dry their ingredients on clean, covered surfaces, and nearly half store herbal decoctions at room temperature for more than 24 hours.

Results of microbial contamination testing for herbal drinks

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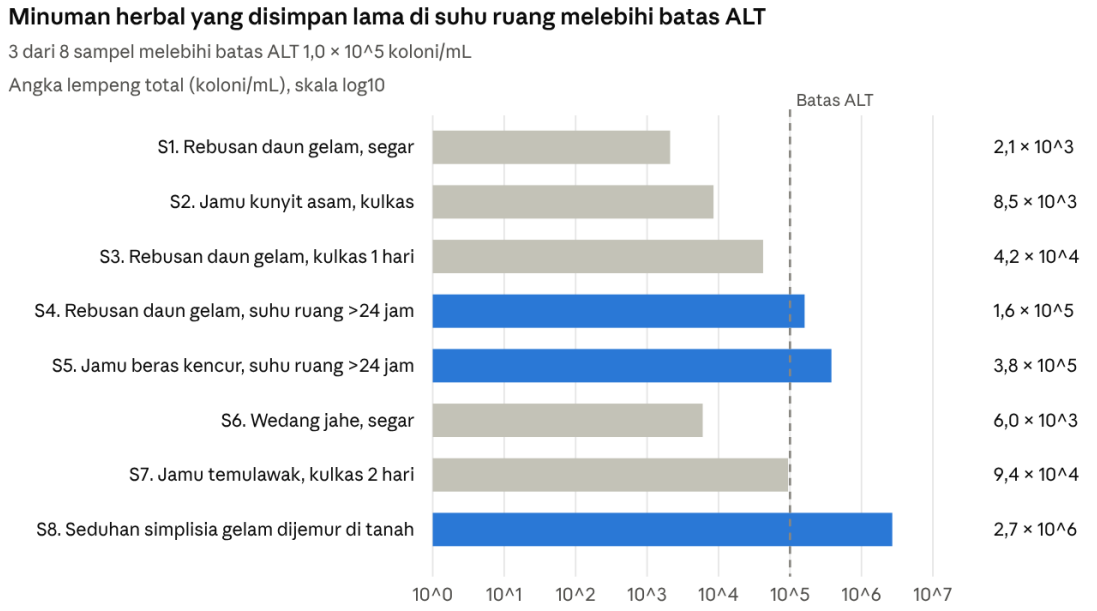


Figure 2. Total plate count (TPC) of eight herbal beverage samples from participants, compared against contamination limits.

Table 2. Results of ALT and AKK tests for participants' herbal drinks (n = 8)

Code	ALT (koloni/mL)	AKK (koloni/mL)	Information
S1	$2{,}1 \times 10^3$	<10	Qualify
S2	$8{,}5 \times 10^3$	$1{,}2 \times 10^2$	Qualify
S3	$4{,}2 \times 10^4$	$4{,}5 \times 10^2$	Qualify
S4	$1{,}6 \times 10^5$	$2{,}3 \times 10^3$	Not eligible
S5	$3{,}8 \times 10^5$	$5{,}1 \times 10^3$	Not eligible
S6	$6{,}0 \times 10^3$	$3{,}0 \times 10^1$	Qualify
S7	$9{,}4 \times 10^4$	$8{,}0 \times 10^2$	Qualify
S8	$2{,}7 \times 10^6$	$1{,}4 \times 10^4$	Not eligible

Limits: ALT ≤10^5 CFU/mL and AKK ≤10^3 CFU/mL for liquid oral medicinal preparations.

Three out of eight samples (37.5%) exceeded the limits for Total Aerobic Microbial Count (TAMC) and Total Yeast and Mold Count (TYMC). These samples consisted of a *gelam* leaf decoction and *beras kencur* herbal medicine—both stored at room temperature for over 24 hours—as well as an infusion prepared from *gelam* raw material (*simplisia*) that had been sun-dried directly on the ground. Conversely, beverages consumed on the day of preparation or stored in a refrigerator met the safety standards, although sample S7, which was refrigerated for two days, was approaching the TAMC limit. This pattern indicates that microbial contamination is determined more by processing and storage methods than by the type of plant used. Herbal

drinks rich in sugar and starch, such as *beras kencur*, also serve as favorable media for microbial growth. These findings align with reports indicating that some traditional medicinal products fail to meet microbial contamination standards (Arifin & Sulistyani, 2023). Therefore, maintaining hygiene at every stage—from the washing, drying, and storage of the raw plant material to the storage of the final beverage—is crucial to ensure that the antioxidant benefits of *gelam* are not overshadowed by the risk of microbial contamination.

Changes in participants' knowledge

Table 3. Knowledge scores and categories before and after education (n = 40)

Parameter	*Pre-test*	*Post-test*
Mean ± SD	45,0 ± 17,0	82,3 ± 11,4
Median (min–maks)	46,7 (13,3–80,0)	83,3 (53,3–100)
Good, n (%)	3 (7,5)	28 (70,0)
Sufficient, n (%)	8 (20,0)	11 (27,5)
Insufficient, n (%)	29 (72,5)	1 (2,5)
Mean difference (95% CI)	37,3 (33,0–41,6)	
Paired t test	t = 17,51; p < 0,001	
Average N-gain	0,69 (moderate)	
Score increased/remained the same/decreased	40/0/0	

The mean knowledge score increased by 37.3 points following the educational intervention (p < 0,001), with improvements observed across all participants. The proportion of participants with a good level of knowledge rose from 7.5% to 70.0%, yielding a mean N-gain of 0.69, which approaches the high category. Prior to the education, most participants were unaware that *gelam* leaves possess strong antioxidant activity—specifically an IC50 of 47.56 ppm (Ernia et al., 2025)—and many assumed that herbal substances are inherently safe simply because they are natural. Demonstrations using the DPPH assay and microbial test plates made these concepts easier to grasp, as participants could directly observe evidence of both the benefits and the risks.

Limitations

The antioxidant test in this activity served only as a qualitative demonstration, while the IC50 values were taken from the team's previous research. The number of herbal beverage samples was small and not selected randomly; therefore, the results do not represent the extent of microbial contamination in herbal beverages available to the general public. Specific tests for pathogenic microorganisms, such as *Escherichia coli* and *Salmonella*, have not yet been conducted.

CONCLUSIONS AND SUGGESTIONS

Conclusion. Education regarding the antioxidant potential of *gelam* (cajuput/paperbark) and the prevention of microbial contamination in herbal ingredients significantly increased participants' knowledge (from 45.0 to 82.3; $p < 0.001$; N-gain 0.69). Microbial contamination testing revealed that three out of the eight herbal drinks provided by participants exceeded the limits for Total Aerobic Microbial Count (TAMC) and Total Yeast and Mold Count (TYMC); these instances were linked to prolonged storage at room temperature or the drying of raw herbal materials (*simplisia*) directly on the ground.

Recommendations.

1. For the general public and home-based herbal business operators: wash ingredients under running water; dry raw herbal materials on clean, covered surfaces; store dried materials in airtight containers; and consume herbal drinks on the same day they are prepared, or store them in a refrigerator for no longer than one day.
2. For Universitas Kader Bangsa (UKB) and local government authorities: provide guidance on developing hygienic *gelam*-based herbal drinks and facilitate product quality testing prior to commercial distribution.
3. For future initiatives: assess the antioxidant activity of *gelam* drinks prepared by the community, incorporate testing for pathogenic microorganisms, and evaluate changes in the participants' processing practices.

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