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Ethno-Ecotourism Sumbawa Oil Festival: Chemical Content and Impact of Sustainable Environmental Tourism

Aliefman Hakim[1], Na Jiang[2], A. Farid Hemon[3], I Wayan Yasa[4], Jono Irawan[1], Riska Dia Sapitri[5]

[1]*Department of Chemistry Education, University of Mataram, Indonesia*

[2]*Shangrao Normal University, China*

[3]*Department of Agricultural Cultivation, University of Mataram, Indonesia*

[4]*Department of Civil Engineering for Water Resources, University of Mataram, Indonesia*

[5]*Master of Science Education, University of Mataram, Indonesia*

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KEYWORDS

Chemical Content, Ethno-Ecotourism, Sumbawa Oil Festival, Sustainable Environmental Tourism.

ABSTRACT:

Introduction: Cultural and natural tourism utilizes natural resources extensively and requires conservation in maintaining local plant ecosystems.

Objectives: The study aims to explore the intersection of cultural heritage, scientific knowledge, and environmental sustainability through the lens of ethno-ecotourism.

Methods: Sumbawa oil, traditionally used by local communities for its medicinal properties, was extracted using the maceration method to preserve its natural compounds. The chemical profile of the oil was analyzed using Gas Chromatography-Mass Spectrometry (GC-MS), revealing key bioactive components such as terpenoids and phenolic compounds that support its traditional uses. Antioxidant activity was tested using the DPPH method with a UV-Vis spectrophotometer. To evaluate the broader implications of the Sumbawa Oil Festival as an ethno-ecotourism event, a community-based perception survey was conducted using Likert-scale instruments, followed by descriptive and inferential statistical analysis.

Results: The findings indicate that Sumbawa oil and base ingredients have antioxidant activity. The festival positively contributes to cultural identity reinforcement, economic empowerment of local communities, and increased environmental awareness. However, it also highlights potential environmental impacts, such as increased waste generation, pressure on natural resources, and changes in land use.

Conclusions: These results suggest the need for integrated planning that balances cultural promotion with ecological preservation. The study underscores the importance of embedding scientific content, such as chemical literacy, into local tourism initiatives to foster educational value and sustainable environmental practices.

1. Introduction

Sumbawa oil, a traditional herbal remedy native to West Nusa Tenggara, Indonesia, has long been used by local communities for treating wounds, muscle pain, and general health care[1], [2]. Beyond its medicinal use, Sumbawa oil holds deep cultural significance and is valuable to the region's indigenous knowledge. In recent years, the *Sumbawa Oil Festival* has emerged as a community-based initiative to promote this local heritage through an *ethno-ecotourism* approach that blends cultural preservation with ecological awareness. The festival showcases the cultural importance of Sumbawa oil and presents a unique opportunity to contextualize scientific knowledge, particularly chemistry, by exploring natural bioactive compounds within traditional practices.

Despite the festival's promising cultural and educational value, there is a lack of scientific studies that systematically analyze the chemical composition of Sumbawa oil using advanced techniques such as Gas Chromatography-Mass Spectrometry (GC-MS) [3]. Additionally, the environmental and social impacts of the festival remain poorly documented, leaving a gap in our understanding of its sustainability. Without scientific

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validation of the oil's bioactive compounds and comprehensive assessments of the festival's influence on local communities and ecosystems, efforts to develop responsible and sustainable ethno-ecotourism may be hindered. Therefore, this study aims to investigate two main aspects: the chemical profile of Sumbawa oil using maceration and GC-MS methods and the socio-environmental impact of the festival through community perception surveys and quantitative data analysis.

This research is crucial as it contributes to two strategic areas: the scientific preservation of local cultural heritage and the development of sustainable tourism models. This study bridges the gap between traditional knowledge and modern science by adopting an interdisciplinary approach incorporating ethnobotany, analytical chemistry, and environmental impact assessment. Moreover, the expected output, publication in a reputable international journal, and academic manuscript production will strengthen the scientific documentation of Indonesia's local potential. This research is in the early conceptual phase, laying a vital foundation for future culture-based and environmentally conscious tourism development policies and innovations.

The chemical content of Sumbawa oil will be examined to validate its traditional medicinal claims through modern scientific methods. The extraction process will utilize the maceration technique to preserve the integrity of natural compounds, followed by analysis using Gas Chromatography-Mass Spectrometry (GC-MS) [4]. This method identifies key bioactive constituents such as terpenoids, phenolics, and other organic compounds contributing to the oil's therapeutic properties. The findings are expected to provide a scientific basis for the traditional use of Sumbawa oil, offering opportunities for its integration into contextual chemistry education and local product innovation.

In parallel, the study will assess the environmental and social impacts of the Sumbawa Oil Festival as a cultural tourism initiative. A structured questionnaire using a Likert scale will be distributed to local community members to gather perceptions on cultural preservation, economic benefits, and ecological consequences associated with the event. The data will be analyzed statistically to evaluate positive contributions, such as increased environmental awareness and community empowerment, and potential negative effects, including waste generation and pressure on natural resources. This analysis aims to support the formulation of sustainable tourism strategies that balance cultural heritage promotion with environmental conservation.

Previous studies on Sumbawa oil have primarily focused on its traditional uses and production methods. For instance, analyzed the chemical constituents of Sumbawa oils were analysed using GC-MS, identifying compounds such as fatty acids, esters, monoterpenes, and sesquiterpenes [3]. However, these studies did not explore the integration of Sumbawa oil into educational contexts or its role in sustainable tourism. In ethno-ecotourism emphasized the importance of utilizing nature and culture for sustainable tourism development is emphasized, highlighting the need for community involvement and environmental conservation [5], [6], [7]. Despite these insights, there remains a gap in research that combines chemical analysis of traditional products with assessments of their impact on sustainable tourism and environmental conservation [8], [9], [10], [11], [12].

This study introduces an interdisciplinary approach by combining chemical profiling of Sumbawa oil with an assessment of its role in sustainable ethno-ecotourism. Utilizing maceration extraction and GC-MS analysis, the research aims to identify the bioactive compounds present in Sumbawa oil, providing scientific validation for its traditional uses. Simultaneously, the study will assess the environmental and social impacts of the Sumbawa Oil Festival through community perception surveys and environmental impact assessments. This dual approach bridges the gap between traditional knowledge and modern science and offers a model for integrating cultural heritage into sustainable tourism practices. By doing so, the research contributes to developing educational content in chemistry and informs policy-making in sustainable tourism and environmental conservation.

In the subsequent phase, the research will shift toward developing a model for integrating the scientific findings, particularly the chemical content of Sumbawa oil, into contextual chemistry education and local environmental learning. An academic manuscript and policy recommendations will also be produced to support the sustainable development of cultural tourism. Limited trials of locally contextualized chemistry teaching materials based on the extract's chemical profile will be conducted in schools or community settings. The outcomes will be disseminated through national and international academic forums. They will be the

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foundation for a long-term roadmap to replicate this model in other regions with similar ethnobotanical resources.

2. Objectives

The primary objective of this study is to investigate the dynamic intersection between cultural heritage, scientific knowledge, and environmental sustainability within the framework of ethno-ecotourism. By positioning Sumbawa oil as a central element of inquiry, the research seeks to highlight how traditional practices can be contextualized through modern scientific analysis while simultaneously promoting sustainable ecological management. This objective underscores the importance of integrating multidisciplinary perspectives to demonstrate that cultural traditions, when supported by scientific validation, can contribute meaningfully to both environmental preservation and educational enrichment.

In addition, the study aims to examine the tangible and intangible impacts of Sumbawa oil ethno-ecotourism on the lives of surrounding communities. The research objective includes assessing how community livelihoods, cultural identity, and environmental awareness are shaped by tourism practices rooted in local wisdom. By analyzing socio-economic benefits alongside potential ecological challenges, the study aspires to provide an evidence-based understanding of how ethno-ecotourism can serve as a pathway for community empowerment, cultural continuity, and sustainable development.

3. Methods

This study employed a qualitative-quantitative descriptive approach involving laboratory analysis and a community-based survey [13], [14]. The chemical analysis of Sumbawa oil began with preparing the base material sourced from traditionally processed Sumbawa oil producers. The extraction process was done using the maceration method, wherein the raw oil was soaked in 96% ethanol solvent for three consecutive days at room temperature to maximise the dissolution of active compounds [15], [16]. After the maceration period, the solution was filtered to separate the liquid extract from residual solids. The resulting filtrate was then evaporated using a rotary evaporator to remove the solvent and obtain a concentrated extract.

The concentrated ethanol extract was subsequently subjected to Gas Chromatography–Mass Spectrometry (GC-MS) analysis. This technique identified and characterised the active chemical constituents in the Sumbawa oil, including terpenoids, phenolics, esters, and other volatile organic compounds. The data obtained from GC-MS were interpreted based on retention times and mass spectral comparisons with known compound libraries to determine the potential bioactive components contributing to the traditional medicinal efficacy of the oil.

Table 1. Criteria for the IC50 value [17]

Category	IC50 value range
Very strong	< 50 µg/mL
Strong	50–100 µg/mL
Moderate	(100–150 µg/mL
Weak	(150–200 µg/mL
Very weak	(>200 µg/mL

A structured questionnaire was distributed to residents, cultural practitioners, and tourism stakeholders to assess the sustainable environmental impact of the Sumbawa Oil Festival. The questionnaire used a 4-point Likert scale with the following ratings: 1 = Not Relevant, 2 = Somewhat Relevant, 3 = Quite Relevant, and 4 = Highly Relevant [18]. The indicators measured various dimensions of sustainability, including waste management, preservation of natural resources, ecological education, and cultural integrity. Collected data were analyzed quantitatively using descriptive statistics to identify trends, strengths, and areas of concern in implementing sustainable ethno-ecotourism practices. This analysis provided valuable insights into how local communities perceive the festival's long-term environmental and socio-cultural impacts.

Table 1. Research Instrument Rubric

Aspect	Number of Items
Destination image	1,2,3,4,5,6,7,8
Perceived value	9,10,11,12,13,14,15,16,17
Satisfaction	18,19,20,21,22,23
Quality of life	24,25,26,27,28,29,30

4. Results

The three simplicia showed typical dominant compounds accompanied by minor compounds that contributed to

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bioactivity. In ginger (Zingiber officinale Ros.), the largest compound was zingiberene (23.8%), while minor components were gingerol (<1%) and shogaol (1.7%) found in the dried sample. Javanese chilli (Piper retrofractum Vahl.) was dominated by β-caryophyllene (14.99%), with minor alkaloids such as piperine (2.1%) and piperidine, piperlonguminine, and guineensine (<1%). Areca nut (Areca catechu L.) had a major content of palmitic acid (25.1%), while minor compounds included arecoline (7.2%) and phenolics 2,6-di-t-butyl-4-methylphenol (5.41%) and 2,4-di-t-butylphenol (6.17%). The main compounds are markers of phytochemical dominance, while the minor compounds strengthen the specific bioactivity potential of each ingredient.

Table 2. GC-MS results of the active compound content of Sumbawa oil components

Natural ingredients	Class of compounds	% Area
***Zingiber officinale* Ros.**	Terpenoid	
	zingiberene, farnesene, and ar-curcumen	23.8% 9.7% 8.1%
	Fenolik	
	Gingerol, Shogoal	<1% 1.7%
***Piper retrofractum* Vahl.**	Seskuiterpen	
	β-karyofilen, α-humulen, germacrene, β-bisabolen	14,99% 10,25% 9,29% 7,55%
	Alkaloid	
	Piperin, piperidin, piperatin, piperlonguminine, and guineensine	2.1% <1% <1%
***Areca catechu* L. Fruite**	Alkaloid	
	Arecoline	7.2%
	Phenol	
	2,6-Di-t-butyl-4-methylphenol 2,4-Di-t-butylphenol	5.41% 6.17%
	Fatty acid	
	Palmitic acid (C16) Oleic acid (C18:1) Myristic acid (C14) Lauric acid (C12)	25.1% 16.3% 13.3% 5.6%

Table 3. IC50 antioxidant test results

Natural Ingredients	IC50 value (µg/mL)	Category	Time optimum (minute)
***Zingiber officinale* Ros.**	65.24	Strong	10
***Piper retrofractum* Vahl.**	120.35	Moderate	45
***Areca catechu* L. Fruite**	147.25	Moderate	45
Sumbawa Oil	116.68	Moderate	25

Based on the results of the antioxidant activity test using the DPPH method with methanol solvent, ginger showed the highest activity with an IC_{50} value of 65.24 µg/mL, which is included in the strong category, with a relatively fast optimum reaction time of 10 minutes. Meanwhile,

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Javanese chilli has an IC_{50} value of 120.35 µg/mL and areca nut of 147.25 µg/mL, both of which are included in the medium category, with a longer optimum reaction time of around 45 minutes. These data indicate that ginger has the potential to be a stronger antioxidant source than Javanese chilli and areca nut, characterized by a lower IC_{50} value and faster activity stability.

Table 4. The sustainable environmental impact of the Sumbawa Oil Festival

Aspect	Percentage
Destination image	78.4%
Perceived value	50.6%
Satisfaction	68.2%
Quality of life	30.8%

Based on the evaluation of the Sumbawa Oil Festival, several sustainability-related aspects show varying levels of impact. The destination image scores the highest at 78.4%, indicating that the festival is strongly associated with enhancing the attractiveness and recognition of Sumbawa as a cultural and environmental tourism destination. Satisfaction follows with 68.2%, suggesting that visitors and participants generally feel positively about the experience and activities provided during the event. Meanwhile, the perceived value is moderate at 50.6%, reflecting that although the festival delivers meaningful benefits, there is still room to increase participants' sense of worth and the benefits gained. The lowest score is found in quality of life, with 30.8%, which indicates that the long-term contribution of the festival to local well-being and sustainable community development is still relatively limited. Overall, while the festival effectively builds image and provides satisfaction, greater efforts are needed to enhance its perceived value and tangible impact on the community's quality of life.

5. Discussion

Active Compounds from Medicinal Plants

Ginger (Zingiber officinale) is rich in terpenoids, with zingiberene as the dominant component of its essential oil (±19–20% of the total; followed by β-cedrene, farnesene, and α-curcumene). Zingiberene and other terpenes contribute to its anti-inflammatory, antioxidant, and antibacterial activities; in animal models, ginger essential oil reduced the expression of COX-2, IL-6, and NF-κB and exhibited antioxidant and cytotoxic effects against several cancer cell lines [19]. A recent review also confirmed the antioxidant and immunomodulatory roles of ginger bioactive compounds in the context of metabolic health and inflammation [20].

In Javanese pepper (Piper retrofractum), β-caryophyllene (BCP) has been reported as one of the key sesquiterpenes in fruit volatiles at various stages of ripeness, along with sabinene, α-copaene, and linalool [21]. Pharmacologically, BCP is known to be a selective agonist of the CB2 receptor, thus explaining its spectrum of anti-inflammatory, analgesic, and immunomodulatory activities, mechanisms relevant to the ethnomedical uses of *Piper spp*. Thus, the presence of BCP in Javanese pepper can be viewed as a key driver of anti-inflammatory/analgesic bioactivity, potentially synergizing with other monoterpenes and sesquiterpenes in the whole extract [22].

Areca nut (Areca catechu) is prominent in the alkaloid arecoline and phenolic compounds (flavonoids/tannins such as catechins and proanthocyanidins). Modern compositions show 10–30% polyphenols and 0.3–0.7% total alkaloids by weight, with variations according to ripeness; arecoline is the main alkaloid in young fruit. Areca nut polyphenolic extracts exhibit potent antioxidant properties through activation of the Nrf2/HO-1 axis and suppression of ROS in macrophages [23]. However, safety concerns need to be emphasized: areca nut consumption and arecoline exposure are associated with the risk of oral cancer; recent studies have confirmed the role of arecoline/arecoline-N-oxide in carcinogenesis and comprehensively summarized its benefits and risks [23].

Teak leaves (Tectona grandis) are known to contain active compounds with antioxidant and antibacterial activity that are beneficial for improving digestion, lowering lipid levels, and helping regulate blood sugar. Seaweed is a natural source of polyphenols that contribute to thyroid health, digestive function, and the immune system [24]. Bird's nests (*Aerodramus fuciphagus*) are rich in glycoproteins, essential amino acids, and important minerals that play a role in strengthening the immune system, accelerating tissue healing, and supporting metabolism [25]. Meanwhile, honey contains flavonoids and polyphenols with high

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antioxidant activity, which provide anti-inflammatory effects [26].

Antioxidant Activity

Ginger's antioxidant potential is most active. This pattern is consistent with the literature that ginger (dominantly composed of sesquiterpenes such as zingiberene and phenolics such as gingerol) has been repeatedly reported to be a strong radical scavenger, while *P. Retrofractum exhibits intermediate antioxidant activity influenced by its* terpenoid and alkaloid composition. *Areca catechu* fruit is rich in polyphenols that contribute to cellular antioxidant activity through the Nrf2 pathway, a transcription factor that activates Heme Oxygenase-1 (HO-1) and antioxidant genes. The differences in IC_{50} and optimum time in the table are in line with the phytochemical characteristics and kinetics of antioxidant reactions described in the DPPH method [27], [28].

Sumbawa oil (IC_{50} 116.68 µg/mL; "moderate", optimum 25 minutes) could rationally have an additive effect by combining ginger, Javanese pepper (β-caryophyllene), and areca nut (polyphenol). Experimental evidence on essential oil mixtures suggests that multi-component combinations often lower the IC_{50} compared to single components due to synergistic interactions in radical scavenging and lipid peroxidation prevention. This is a plausible reason why the activity of Sumbawa oil is between that of pure ginger and other single extracts, reflecting the diffusion of components within the carrier oil matrix. Furthermore, β-caryophyllene itself has antioxidant activity that supports the role of Javanese pepper in the formulation. The formulation standard can influence the strength of the measured antioxidant activity [29], [30], [31].

Another important component of Sumbawa oil that plays a role in its free radical-scavenging activity is oil derived from coconut milk. This oil, when produced through a non-heating process, is known as Virgin Coconut Oil (VCO). VCO has been shown to have high antioxidant potential, with an IC_{50} value of 51.57 µg/mL, which is considered strong [32]. Although its antioxidant activity tends to decrease due to the heating process in traditional Sumbawa oil production, VCO still makes a significant contribution. The presence of VCO in Sumbawa oil formulations not only increases the richness of bioactive compounds but also strengthens the synergy with other components such as ginger, Javanese chilli, and betel nut, resulting in more stable antioxidant activity and health benefits.

Dampak ekowisata Minyak Sumbawa

The impact of Sumbawa Oil Tourism on environmental sustainability can be examined from four main aspects: destination image, perceived value, satisfaction, and quality of life. The destination image aspect received the highest positive score at 78.4%, indicating that the festival was able to build a strong destination image and enhance the attractiveness of tourism based on culture and local wisdom. Destination image can create a competitive advantage, attract tourists, and strengthen the sustainability of community-based tourism [33], [34].

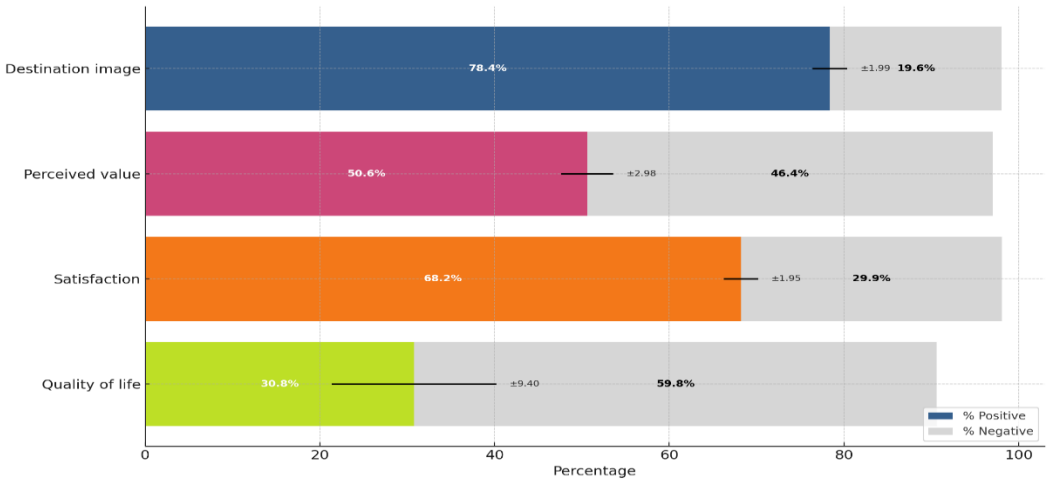

Figure 1. Impact value of the Sumbawa Oil Festival

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The satisfaction aspect scored 68.2%, indicating that visitors were satisfied with their travel experience. Tourist satisfaction plays a crucial role in destination sustainability as it is a key factor in revisit intention and positive word of mouth, thus supporting local economic growth and socio-cultural sustainability [35], [36]. Meanwhile, the perceived value score was 50.6%, relatively moderate, indicating that the benefits perceived by tourists are not yet fully optimized compared to the environmental conservation efforts undertaken. This value can be increased by providing educational experiences related to conservation and environmental management [37], [38].

The aspect with the lowest score was quality of life at 30.8%, indicating that the festival's direct impact on community well-being is still limited. Ideally, sustainable tourism should improve the quality of life of communities through economic well-being, environmental preservation, and strengthening cultural identity [39], [40]. While the Sumbawa Oil Festival has been successful in building a positive destination image and increasing tourist satisfaction, further strategies are needed to strengthen the perceived value of tourists and increase direct contributions to the quality of life of local communities.

The utilization of Sumbawa oil through an ethno-ecotourism approach not only strengthens cultural identity and improves the economic welfare of the community, but also has scientific value through the disclosure of the chemical profile and antioxidant activity that support its traditional use. The Sumbawa Oil Festival has been proven to contribute positively to environmental awareness and the preservation of local wisdom, although it has the potential to cause negative impacts in the form of pressure on natural resources and changes in land use. Therefore, integrated planning is needed that balances cultural promotion, scientific educational value, and environmental conservation. The integration of chemical literacy into local wisdom-based tourism activities is an important strategy for creating sustainable practices that benefit the community while maintaining ecosystem sustainability.

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