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Ethnobotany of *Pelleng*, a Pakpak Batak Spiced Rice from Bakal Julu Community, and Its Application in Biology Learning through Educational Posters

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Abstract

Traditional food, Pelleng, is a spiced rice dish served during the traditional ceremonies of the Pakpak Batak community in North Sumatra, symbolizing strength, blessing, and unity. One of its main ingredients is Andaliman (Zanthoxylum acanthopodium), an endemic spice of the Toba Highlands known for its distinctive flavor, ecological value, and cultural significance. Despite its rich heritage, no prior studies have documented the ethnobotanical composition of Pelleng or linked it to biodiversity learning. Therefore, this study aims to identify the plant species used as spices in preparing Pelleng rice and to explore their cultural and symbolic meanings within the Pakpak Batak community., interpret their cultural meanings, and make an educational poster connecting traditional food heritage with Grade X biodiversity topics. Field exploration and surveys were conducted in Bakal Julu Village, Siempat Nempu Hulu Subdistrict, Dairi Regency, using semi-structured interviews with four key informants (traditional leaders, traditional cooks, elders, and homemakers), complemented by field surveys and photographic documentation. Data were analyzed qualitatively and descriptively to determine the ecological and cultural values of each species. The study identified 17 plant species from 11 families used as spices in Pelleng preparation, including food crops, spices, and medicinal plants. Andaliman emerged as a cultural keystone species whose sensory and symbolic roles are irreplaceable. Integrating Pelleng's ethnobotanical knowledge into instructional media—such as a thematic biodiversity poster—offers a meaningful approach to bridging indigenous knowledge and science education. This research is expected to enrich biology teaching materials with culturally relevant content, raise students' awareness of biodiversity, and support the preservation of cultural heritage through the documentation and educational integration of ethnobotanical knowledge.

Keywords

Pelleng, Pakpak Batak, ethnobotany, traditional food, andaliman, educational posters

Introduction

Traditional food is an integral part of intangible cultural heritage, reflecting a system of values, beliefs, and human relationships with the surrounding natural environment. It not only serves as a fulfillment of biological needs, but is also loaded with symbolic and social meanings that strengthen ethnic identity and social cohesion in the community (Fitriani & Putra, 2022).

Indonesia, as a megadiverse country, harbours a wealth of culinary traditions formed through long-standing interactions between humans and ecosystems, illustrating the sustainable use of biodiversity (Hidayat & Kurnia Priambodo, 2023). In this context, ethnobotanical studies are crucial for documenting local knowledge of plant use for food, medicine, and ceremonial purposes. A sub-field, food ethnobotany, focuses on plant species in traditional culinary systems that often remain undocumented despite their ecological, nutritional, and cultural value (Nurchayati & Ardiyansyah, 2019)

The Pakpak Batak sub-ethnic group in Dairi and West Pakpak Regencies, North Sumatra, maintains a distinctive culinary heritage, one of which is *Pelleng*, a ceremonial spiced rice dish symbolizing strength, protection, and gratitude. This dish is composed of locally sourced plant species—many of which have ecological significance and cultural symbolism—making it directly relevant to biodiversity studies. Research on *Pelleng* has been conducted by Olivia et al. (2025), showing that the *Pelleng* tradition as a symbol of blessings and parental prayers in Pakpak culture is still practised. However, its sacred meaning has begun to fade, and the younger generation tends to regard it merely as an ordinary dish. However, research linking traditional foods like *Pelleng* with ethnobiology and biodiversity education remains limited, creating a gap between ethnobotanical documentation and its integration into biology learning.

In the era of modernization and globalization, younger generations are increasingly turning to instant foods, and oral traditions conveying such knowledge face the risk of being lost (Yulianti et al., 2023). Ethnobotanical research on *Pelleng* can serve not only as cultural documentation but also as an educational resource to contextualize biodiversity concepts—such as species identification, plant utilization, and ecosystem services—within a culturally familiar framework (Has et al., 2020). Such integration strengthens cultural preservation while supporting biodiversity conservation goals.

Previous researchers have not conducted the study of *Pelleng* and its integration into biology learning. Therefore, this study aims to identify the plant species used as spices in preparing *Pelleng* rice and to explore their cultural and symbolic meanings within the Pakpak Batak community. Furthermore, the findings will be transformed into educational posters that integrate biodiversity concepts with indigenous knowledge, promoting both cultural heritage and biodiversity conservation through biology learning. Educational posters can also be an effective medium for non-verbal education and outreach (Rahmawati & Salman, 2022). Educational posters can also be linked to knowledge of biodiversity (Andumeha et al., 2023).

Materials and Methods

Method

This research began with a field exploratory study, followed by a survey that applied ethnobotanical principles, utilizing both descriptive qualitative and quantitative approaches. This research was conducted from March to April 2025 in Bakal Julu Village, Siempat Nempu Hulu Subdistrict, Dairi Regency, North Sumatra Province. Geographically, Bakal Julu Village is located at coordinates approximately 2°47' North Latitude and 98°16' East Longitude—an area inhabited by the Pakpak Batak indigenous people, renowned for preserving the tradition of preparing *Pelleng* across generations. The locations and positions of the informants in the study are presented in **Figure 1**.

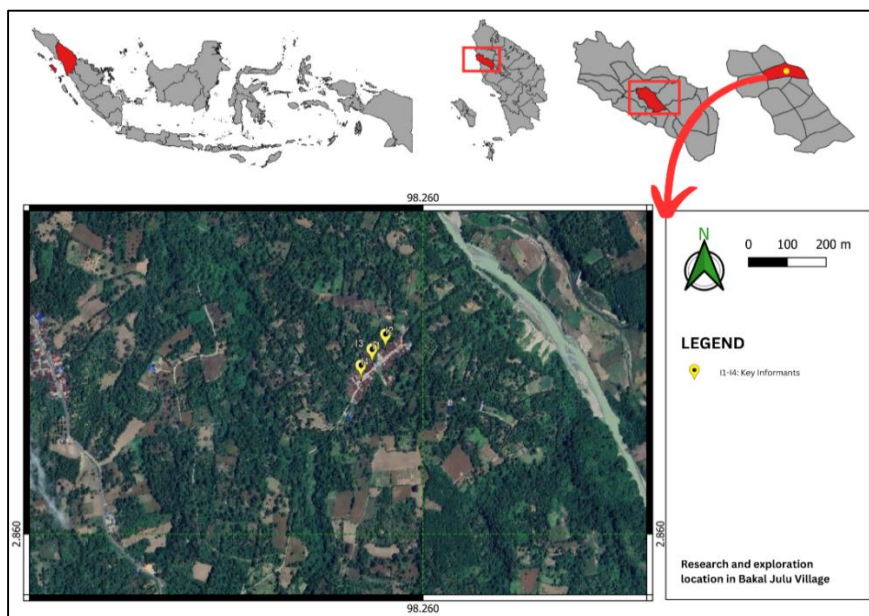


Figure 1. Research Location in Bakal Julu Village, Siempat Nempu Hulu Sub-district, Dairi Regency, North Sumatra Province

Data Collection

Data collection was conducted using three methods: interviews, documentation, and surveys. Semi-structured interviews were conducted with four deliberately selected key informants, consisting of traditional leaders, traditional culinary practitioners, housewives, and community leaders. The informants included: Informant 1 (male, 62 years old) worked as a farmer with a junior high school education; Informant 2 (female, age 58) is a housewife with a high school education; Informant 3 (male, age 71) works as a farmer with an elementary school education; and Informant 4 (male, age 55) also works as a farmer with a high school education. All informants were key informants, consisting of 4 individuals (Figure 1). The interviews were designed to explore information about the types of plants used in the production of *Pelleng*, the parts of the plants that are used, the processing methods, and the cultural and symbolic meanings associated with this food.

Documentation in the form of photographs was also collected to complement the research findings and to serve as visual material for developing educational posters on *Pelleng* and its associated plant biodiversity. The survey involved 20 respondents from the general public residing in the research village, who completed questionnaires that included questions on the frequency of *Pelleng* consumption, knowledge of the plant ingredients used, and cultural perceptions of the dish. This approach was intended to capture the community's collective perception regarding the sustainability of their traditional food.

Data analysis

Interview data were analyzed qualitatively through data reduction to identify key themes and patterns related to plant use and cultural meanings. Documentation data, consisting of photographs and videos, were analyzed using descriptive qualitative methods to complement

narrative findings and provide visual evidence. Survey data were analyzed using descriptive statistics, supported by two ethnobotanical indices.

The Use Value (UV) Index was applied to measure the relative importance of each plant species based on the number of uses mentioned by informants, following the formula adapted from Albuquerque et al. (2006), $UV = \frac{\sum U_i}{n}$.

where UV is the use value of the plant species, U_i is the number of uses cited by each informant, and n is the total number of informants. A higher UV value indicates greater utilization and relevance of the species in the community's traditional culinary system.

The Cultural Significance Index (CSI) was used to assess the socio-cultural importance of each plant species, based on a modification of Turner's method (1988) and Phillips & Gentry, (1993) approach. CSI calculation considered three main components: q = quality of use (score 1–5), i = intensity of use in daily life and traditional ceremonies (score 1–5), and e = exclusivity of species used in local traditions (score 1–2). A high CSI value reflects strong symbolic meaning and cultural attachment.

All UV and CSI data were tabulated and analyzed descriptively to identify species with high frequency of use, notable contributions to taste and aroma, and significant roles in reinforcing local culinary identity. These results also informed conservation assessments for culturally important species with limited availability, such as Andaliman (*Zanthoxylum acanthopodium*).

Results and Discussion

Ethnobotany: Plants Used for Spice in Making *Pelleng* Rice

Pelleng is made from rice (*Oryza sativa* L.) and involves the use of 17 different plant species as spices in its preparation, reflecting its role as a traditional food typical of the Pakpak Batak sub-ethnicity, commonly served in various cultural events and thanksgiving ceremonies. Quantitative analysis using the Use Value Index (UVs) and Cultural Significance Index (ICS) revealed that the most important species in terms of both use and cultural relevance were *Capsicum frutescens* (Cabai rawit), *Curcuma longa* (Kunyit), *Zingiber officinale* (Jahe), *Allium cepa* (Bawang merah), and *Allium sativum* (Bawang putih), each exhibiting UVs ranging from 0.65 to 1 and ICS values up to 18 points, as detailed in **Table 1**.

Table 1. Plants Used for Spice in *Pelleng* Rice and Its Values (UT, UVS and ICS)

Local name (in Pakpak)	Species	Family	Part Used	UT	UVs	ICS
Koning	<i>Curcuma longa</i> L.	Zingiberaceae	Rhizome	19	0,95	18
Jahe	<i>Zingiber officinale</i> Roscoe	Zingiberaceae	Rhizome	13	0,65	18
Cina Rawit	<i>Capsicum frutescens</i> L.	Solanaceae	Fruit	20	1	18
Pangir	<i>Citrus hystrix</i> DC.	Rutaceae	Leaves	12	0,6	8
Gembiri	<i>Aleurites moluccanus</i> (L.) Willd.	Euphorbiaceae	Seeds	17	0,85	8
Neur	<i>Cocos nucifera</i> L.	Arecaceae	Fruit (meat, coconut milk)	17	0,85	6
Lada	<i>Piper nigrum</i> L.	Piperaceae	Fruit	7	0,35	1
Salam	<i>Syzygium polyanthum</i> (Wight) Walp.	Myrtaceae	Leaves	10	0,5	2

<i>Cenur</i>	<i>Etlingera elatior</i> (Jack) R.M.Sm.	Zingiberaceae	Flower, Stem	12	0,6	6
<i>Serre</i>	<i>Cymbopogon citratus</i> (DC.) Stapf	Poaceae	Stem	14	0,7	6
<i>Lawang</i>	<i>Illicium verum</i> Hook.f.	Schisandraceae	Flower	8	0,4	1
<i>Pala</i>	<i>Myristica fragrans</i> Houtt.	Myristicaceae	Fruit, seed	11	0,55	2
<i>Bawang Merah</i>	<i>Allium cepa</i> L.	Amaryllidaceae	Bulbs	17	0,85	18
<i>Bawang Putih</i>	<i>Allium sativum</i> L.	Amaryllidaceae	Bulbs	18	0,9	9
<i>Lengkuas</i>	<i>Alpinia galanga</i> (L.) Willd.	Zingiberaceae	Rhizome	9	0,45	4
<i>Tuba</i>	<i>Zanthoxylum</i> <i>acanthopodium</i> DC.	Rutaceae	Fruit	8	0,4	3
<i>Cina Mbara</i>	<i>Capsicum annum</i> L.	Solanaceae	Fruit	15	0,75	12

UT (Quantity Used), UVS (Species use value), ICS (Index of Cultural Significance)



Figure 2. Pelleng rice spices (a) Andaliman; (b) Kemiri; (c) Jeruk purut; (d) Bawang merah; (e) Garam; (f) Cabai merah; (g) Cabai rawit; (h) Jahe; (i) Kunyit

The spices used in the preparation of *Pelleng*, as presented in **Figure 2**, originate from various plant families, with the Zingiberaceae family dominating, comprising four species (26.7% of the total): *Curcuma longa*, *Zingiber officinale*, *Etlingera elatior*, and *Alpinia galanga*. Another family with a considerable contribution is Rutaceae, represented by two species (13.3%), namely *Histrix orange* and *Zanthoxylum acanthopodium*. Most other families, such as Solanaceae, Euphorbiaceae, Arecaceae, Piperaceae, Myrtaceae, Poaceae, Schisandraceae, Myristicaceae, and Amaryllidaceae, are represented by only one species each (6.7% each). This diversity of families suggests that *Pelleng* is a traditional dish that utilizes biological resources from various botanical groups to produce its distinctive flavour and aroma.

The plant parts used in the preparation of *Pelleng* include rhizomes, fruits, leaves, seeds, coconut flesh and milk, stems, flowers, dried flowers, seed membranes, and bulbs. The parts of food plants that are commonly used or consumed as food ingredients include leaves, fruit, seeds, tubers, flowers, and stems (Retnaningati, 2023). **Table 1** shows that the plant is not only widely used by the community but also has an important role in structuring the flavour, aroma, and symbolic meaning of *Pelleng*. As explained by Salampessy (2017), species selection in

traditional culinary systems reflects local ecological knowledge that has been passed down across generations and is bound by the socio-cultural meanings of the community.

Turmeric (*Curcuma longa*), for example, is used to give *Pelleng* rice its yellow colour, which symbolically represents strength, courage, and good luck in Batak culture (Sitanggang et al., 2022). This yellow color is not just a visual aesthetic, but is also part of the cultural narrative in every presentation of *Pelleng*, especially when releasing children to migrate or welcoming honored guests. This finding aligns with the research of (Wachidah et al., 2025), which suggests that traditional foods in indigenous communities serve as "cultural texts" that convey collective symbolic messages.

Another important local spice in *Pelleng* is Andaliman (*Zanthoxylum acanthopodium*), which, despite having relatively lower UVs and ICS values compared to other species (UVs = 0.4; ICS = 3), still has an essential position due to its unique flavour and identity value. Andaliman is known for its spicy-tart sensation, which is not found in other spices, as well as a distinctive aroma derived from limonene and geraniol compounds (Anggraeni, 2020). This flavour characterizes Batak cuisine in general and the Pakpak region in particular. In ethnopharmacological studies, andaliman is also known to possess significant antioxidant and antibacterial activities, confirming its dual role as both a spice and a health support (Adrian et al., 2023). Andaliman is known to contain essential oils and other bioactive compounds that offer pharmacological benefits, including antioxidants and antimicrobial properties (Hutapea et al., 2024).

Andaliman (*Zanthoxylum acanthopodium*), a member of the Rutaceae family, is extensively utilized as both a culinary spice and a traditional medicinal plant, particularly among the Batak people of North Sumatra (Silalahi & Lumbantobing, 2021). However, the low ICS value of andaliman is due to the limited geographical distribution of this plant and the lack of knowledge regeneration among the younger generation. As noted by (Silalahi et al., 2024), modernisation and shifting lifestyles have led to the increasing marginalisation of local knowledge, including that of spices. The younger generation is more interested in practical fast food, shifting the role of traditional food as a guardian of cultural identity.

The importance of preserving *Pelleng* and its constituent local plants extends beyond maintaining cultural heritage to supporting biodiversity conservation, which is threatened by land conversion and climate change. Research by demonstrates that the documentation and revitalization of traditional food systems are effective strategies for integrating cultural and ecological preservation in a holistic approach.

Furthermore, within the framework of creative economy and cultural tourism development, the utilization of local spices, such as andaliman, has the potential to be developed into high-value culinary products. Nurfitriyani et al. (2024) noted that andaliman-based product innovations, such as chili sauce, essential oil, and herbal tea, have opened business opportunities for communities in North Sumatra. Therefore, this research also provides an important basis for indigenous knowledge-based community empowerment programs.

In addition to spices and plant-based ingredients, *Ayam kampung* (*Gallus gallus domesticus*) is an essential component in the preparation of *Pelleng*, as its meat has a firmer texture, a chewy consistency, and a natural savory flavor that blends well with the spices (**Figure 3**). Free-range chicken is high in protein with relatively low fat and cholesterol compared to commercial broilers, making it a healthier option (Setiadi et al., 2020). In Pakpak Batak tradition, this chicken also carries symbolic meaning as a representation of respect, prosperity, and blessings.

Tribudi et al. (2025) highlighted its nutritional, economic, and social importance in rural areas, including environmental adaptability and disease resistance.

Pelleng is often served with *lalapan* or garnish, which consists of fresh vegetables such as cucumber (*Cucumis sativus* L.), lettuce (*Lactuca sativa* L.), and tomato (*Solanum lycopersicum* L.) (**Figure 3**). These accompaniments are optional and their use depends on the preference of the preparer. *Lalapan* not only enhances visual freshness but also provides a crisp texture and essential nutrients such as dietary fiber, vitamin C, and vitamin A, enriching the overall culinary experience (Cahyanto et al., 2018; Rahayu et al., 2024).

Overall, the results of this study confirm that *Pelleng* is a concrete example of how traditional culinary systems function as spaces of integration between botanical knowledge, cultural practices, and people's collective identities. The ethnobotanical approach becomes an important tool not only to understand the use of plant species but also to unpack the symbolic and philosophical values contained within local foods (Has et al., 2020). *Pelleng* is usually served as shown in **Figure 3**.

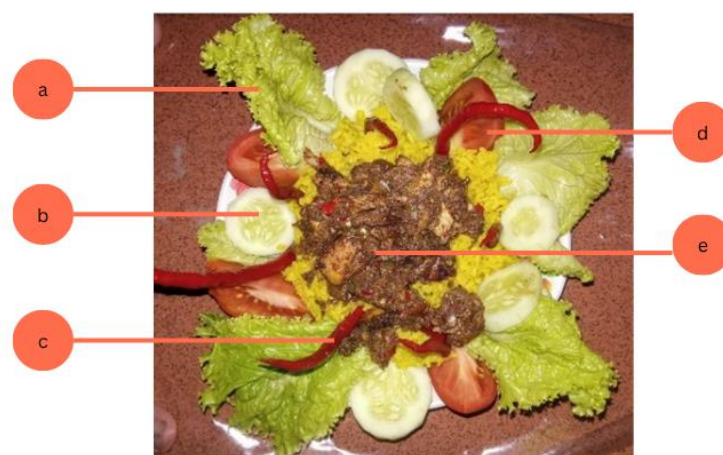


Figure 3. Presentation of Pakpak Rice *Pelleng* (a) *Selada*, (b) *Timun*, (c) *Cabe Merah*, (d) *Tomat*, (e) *Ayam Kampung*.

***Pelleng* Rice Educational Poster to Support Biodiversity Understanding**

Figure 4 shows the relationship between biodiversity, *Pelleng* Rice, and biology learning through an ethnobotanical perspective. Ethnobotany serves as a central link, demonstrating how biological richness and traditional knowledge can be utilized in a learning context. Through this approach, scientific knowledge is not only studied theoretically but also linked to local practices and culture, resulting in a more meaningful learning experience.

Section a (Biodiversity and Ethnobotany). This section demonstrates the close relationship between biodiversity and ethnobotany, where biodiversity serves as a primary source of knowledge for local plant use. Ethnobotany documents, studies, and analyzes how plant species are used, whether as food, medicine, or for cultural purposes, ultimately strengthening biodiversity conservation efforts.

Section b (*Pelleng* Rice and Ethnobotany). This section illustrates the connection between *Pelleng* Rice and its traditional culinary heritage, as well as its ethnobotanical significance. The process of making *Pelleng* Rice involves various local plant species, the use of which is based on the traditional knowledge of the local community. It shows that traditional dishes are a tangible manifestation of the application of ethnobotanical knowledge in everyday life.

Section c (Biology Teaching and Learning and Ethnobotany). This section illustrates the connection between biology and ethnobotany, where knowledge about the use of plants in local cultures can serve as contextual teaching materials. Through this integration, students can learn the concepts of biodiversity, ecology, and conservation through real-life examples from their environment. This approach not only enhances understanding of scientific concepts but also fosters a sense of pride and responsibility for preserving indigenous knowledge.

The arrows in **Figure 4** illustrate the reciprocal relationship between the three main components: biodiversity, Nasi *Pelleng*, and biology learning, all of which are interconnected through ethnobotany. The arrow from biodiversity to Nasi *Pelleng* indicates that biodiversity is the primary source of ingredients in this traditional dish. The arrow from biodiversity to biology learning indicates that biodiversity material is an important part of the school science curriculum. Meanwhile, the double arrow between Nasi *Pelleng* and biology learning illustrates a two-way relationship, where traditional dishes can serve as a learning medium, and biology learning can deepen students' understanding of the ecological and cultural values associated with Nasi *Pelleng*.

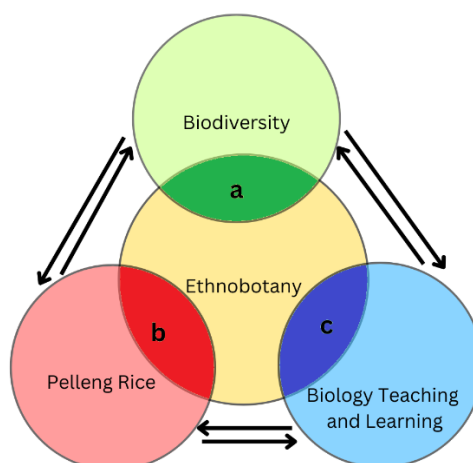


Figure 4. The Relationship Between Biodiversity, *Pelleng* Rice, and Biology Teaching and Learning

As society continues to evolve, the need to adapt classroom learning media content to emerging and widely discussed socio-scientific issues is also increasing (Abrori et al., 2024). One way to address socio-scientific issues related to biodiversity, *Pelleng*, and biology learning is through the creation of educational posters. These posters display information about the types of plants used in making *Pelleng*, their biodiversity value, and their relationship to the concept of ethnobotany. These posters typically contain a combination of text, images, and illustrations designed to be easily understood by the audience (Pangestu et al., 2022).

Educational posters are visual media designed to convey information or educational messages concisely, clearly, and engagingly (Prawesti et al., 2024). With engaging visuals, educational posters can help students contextually understand the material while introducing indigenous knowledge. These posters not only strengthen understanding of scientific concepts but also raise awareness of the importance of preserving biodiversity and local culture. The posters can be viewed in Figure 5 or downloaded via the following link: <https://bit.ly/pellengrivaldi>.



Figure 5. Poster on Pelleng Ethnobotany, Pakpak Batak Spiced Rice from the Bakal Julu Community

The link between biodiversity, *Pelleng*, and biology learning through educational posters has excellent potential to enhance contextual learning. However, to date, no direct effectiveness testing has been conducted in the classroom to assess the extent to which this media truly impacts conceptual understanding. Therefore, it is necessary to test the effectiveness of these educational posters in a real-life classroom context.

The development of learning media related to indigenous knowledge and biodiversity can be expanded beyond just *Pelleng* rice. Research is needed to explore areas such as medicinal plants (Silalahi & Nisyawati, 2018; Suciwati & Retnaningati, 2024), ubarampe or offerings (Adinugraha, 2024; Adinugraha et al., 2024), etnozoology (Zukmadini et al., 2024), and etnoecology (Sabasti et al., 2024). The connection between modern and past knowledge is necessary to complement the learning content. It approaches innovatively preserves Indonesian culture while linking it to scientific knowledge (Muttaqin et al., 2025). By learning about biodiversity and *Pelleng* rice, students can simultaneously learn about the topic and develop a love for the culture.

Conclusions

Pelleng is made from rice (*Oryza sativa* L.) and involves the use of 17 different plant species, including spices, in its preparation, with the Zingiberaceae family being the dominant group. Several species used as spices, including *Capsicum frutescens* (UT 20, UVs 1, ICS 18), *Curcuma longa* (UT 19, UVs 0.95, ICS 18), *Zingiber officinale* (UT 13, UVs 0.65, ICS 18),

Allium cepa (UT 17, UVs 0.85, ICS 18), and *Allium sativum* (UT 18, UVs 0.9, ICS 9), recorded the highest UVs and ICS values, indicating their significant role in flavor composition and cultural significance. Interestingly, *Zanthoxylum acanthopodium* (UT 8, UVs 0.4, ICS 3) (Andaliman), despite having relatively lower UVs and ICS values, holds a unique position as the primary identity marker of Pakpak Batak cuisine due to its distinctive spicy-sour taste and aromatic profile, as well as its proven antioxidant and antimicrobial properties. In addition, *Ayam kampung* (*Gallus gallus domesticus*) is an essential component in the preparation of *Pelleng*. Ethnobotanical findings indicate that *Pelleng* is not merely a traditional dish but also a medium for conveying indigenous knowledge, a symbol of cultural identity, and a manifestation of the utilization of biodiversity. Integrating these findings into biology education through educational posters (<https://bit.ly/pellengrivaldi>) enables students to understand biodiversity concepts in a contextual manner while fostering awareness of the importance of preserving both indigenous knowledge and biological resources. This study provides a foundation for developing culture-based educational media, although classroom effectiveness testing is still needed to assess its impact on student learning outcomes and attitudes.

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