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Original Article

An Ethnobiological Study of Indigenous Knowledge about the Traditional Production of Coconut Sugar Within the Somongari Javanese Community

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Abstract

Background: *Coconut sugar is a traditional product widely consumed in Indonesia, including by the Javanese community of Somongari. Despite its importance, the knowledge of coconut sugar production in Somongari remains undocumented, as it is passed down primarily through oral tradition. This study seeks to explore the traditional coconut sugar-making practices of the Somongari Javanese community from an ethnobiological perspective.*

Methods: *This study employed a field exploration approach in Somongari Village, Indonesia, incorporating interviews, observation, and documentation. Twenty-four informants, comprising twenty sugar makers and four key informants, were interviewed.*

Results: *Coconut sugar is produced from the sap of coconut flowers (sajeng) and is cooked until thickened and molded. The natural remedy used in the production of coconut sugar is laru. Laru comprises enjet (limestone) and lathi manggis (sap of mangosteens). The manufacturing process utilizes traditional tools and techniques, comprising three stages: ndewan (coconut sap collection), genen (cooking the coconut sap until it thickens), and nitis (molding the coconut sap).*

Conclusion: *The indigenous knowledge of coconut sugar production embodies the close relationship between biodiversity and cultural heritage. The utilization of local plants contributes to both the production and consumption values, highlighting the need to preserve this practice through documentation and integration into educational and community learning to sustain ecological and cultural values.*

Keywords

biodiversity, biodiversity value, coconut, coconut sugar, cultural, ethnobiology, indigenous knowledge, laru, sajeng, Somongari Javanese community

INTRODUCTION

Coconut sugar, often used as a food ingredient and seasoning, holds significant importance in specific communities. In the Somongari Javanese community of Central Java, Indonesia, there is a rich hereditary knowledge about utilizing coconut trees to produce coconut sugar. In 2017, Indonesia was the world's leading producer of coconuts, followed by the Philippines, which ranked second (Credo & Valmoria, 2019). Coconut flower sap, extracted from the tree, is heated to produce coconut sugar, a process deeply rooted in traditional

ecological knowledge and cultural heritage, while simultaneously offering rich potential for scientific exploration in areas such as nutrition and processing techniques.

Coconut sugar presents an intriguing subject for study, encompassing a range of topics such as the quantity of lysine introduced to coconut sap (Haryanti & Sulistyo, 2022), the browning intensity and antioxidant activity of coconut sugar (Karseno et al., 2018), and the techniques employed in tapping and collecting coconut sap and their impact on the quality of the resulting sugar (Mustaufik et al., 2022). The quality of coconut tapping, collection, and processing technology (Somawiharja et al., 2018), as well as the efficacy of traditional and two drying methods (Nurhadi et al., 2018), have also been studied. Nevertheless, previous studies have yet to consider traditional coconut sugar production from the perspective of ethnobiology, including traditional tools and materials and local languages that differ from other dialects. Moreover, the traditional method of producing coconut sugar has yet to be linked to Western scientific practices regarding the value of biodiversity.

The traditional production of coconut sugar is an integral part of the indigenous knowledge of the Somongari Javanese community. Indigenous knowledge is defined as the knowledge that is passed down from one generation to the next. Indigenous knowledge is passed down through oral traditions by Indigenous people, serving as carriers of culture and word-of-mouth traditions (Yu & De Catalina, 2024). Indigenous knowledge can be expressed in various forms, including principles, skills, practices, rituals, and customs (Adam et al., 2019). Since this research examines orally transmitted knowledge, a systematic approach is necessary to ensure the reliability of the information. Therefore, data on coconut sugar production were obtained through interviews, direct observation, and documentation to enhance accuracy and consistency. Indigenous knowledge can be studied through the branch of ethnobiology. Ethnobiology is a transdisciplinary field that draws on diverse methods from biological taxonomy, cognitive science, political ecology, and indigenous studies (Ludwig, 2018). It focuses on the dynamic relationships between societies and their environment, spanning botany, zoology, anthropology, ecology, and history (Medeiros, 2016). Ethnobiology also studies indigenous knowledge, including the cultivation and processing of agricultural products. The field of ethnobiology offers a unique opportunity to examine the technological knowledge of past ancestors, encompassing not only tools and materials but also traditional methods for processing agricultural products such as coconut sugar.

The knowledge of coconut sugar production in the Somongari Javanese community has yet to be researched or documented because it is an oral and hereditary tradition. Traditional coconut sugar making can fill the knowledge gap related to biodiversity values. Evidence suggests that indigenous knowledge helps preserve and maintain biodiversity values (Ogar et al., 2020). The direct biodiversity value of coconut sugar production can be observed in two ways: firstly, in terms of its consumption or nutritional value (Costa et al., 2022; Gatti et al., 2022), and secondly, in terms of its production or economic value (Costa et al., 2022). It is also imperative to document the biodiversity value of traditional coconut sugar produced by the Somongari Javanese community to prevent the loss of indigenous knowledge.

Efforts are made to preserve indigenous knowledge by studying traditional coconut sugar production, including the tools and materials used, as well as the manufacturing process. The traditional coconut sugar-making knowledge of the Somongari Javanese community resulted in findings that can be linked to Western science. Integrating Western science and indigenous knowledge is necessary to gain a comprehensive understanding of the subject (Chakrabarty et al., 2022). Therefore, this research contributes to the advancement of science by producing an educational video on the traditional process of making coconut sugar. The educational video is intended to serve as a means of publication for the younger generation, providing them with an opportunity to learn about the traditional coconut sugar-making practices of the Somongari Javanese community.

The traditional knowledge of coconut sugar-making among the Somongari Javanese community is still passed down orally and has yet to be documented in scientific writing. This documentation helps protect indigenous knowledge that has begun to disappear and has yet to be discovered by the younger generation. Traditional coconut sugar production can also complement Western science in understanding the direct value

of biodiversity, specifically in terms of its impact on consumption and production. However, research has yet to examine such traditional coconut sugaring and link it to Western or modern science. Therefore, this article aims to explore the traditional coconut sugar-making practices of the Somongari Javanese community through the lens of ethnobiological principles. This knowledge is then analyzed by linking it to Western science, thus potentially completing the documentation of scientific knowledge.

METHODS

Study Design

The research method employed is exploratory research or a field study. This exploration is informed by the principles of ethnobiological research outlined in the book Methods and Techniques in Ethnobiology and Ethnoecology (Albuquerque et al., 2014). Although the knowledge examined in this study is transmitted through oral tradition, it is important to note that oral tradition serves as a primary channel through which indigenous knowledge is passed down across generations (Adam et al., 2019; Yu & De Catalina, 2024). Therefore, the researchers collected the data through field exploration, which involved interviews, direct observation, and documentation. This approach enabled the researchers to trace information from one informant to another and to observe traditional coconut sugar production activities as they occur in the community.

Study Site

The researchers conducted this study in the Somongari Javanese community in Somongari Village, Kaligesing Subdistrict, Purworejo Regency, Central Java Province, Indonesia. The coordinates of Somongari Village are 7045'55 South latitude and 11004'18 East longitude (Pemdes Somongari, 2021). The research was conducted from March 2022 to February 2023.

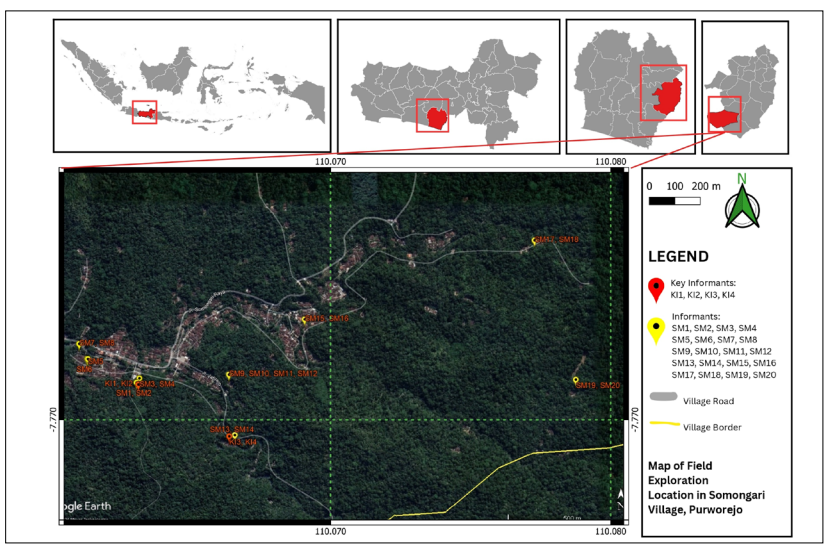

Figure 1. *Distribution of informants and research locations*

Data Collection Technique

The data collected included indigenous knowledge about the structure of coconut trees, ingredients and tools used in traditional coconut sugar making, and the manufacturing process. This study employed the local Javanese language to preserve traditional coconut sugar-making terminology, some of which cannot be translated accurately into English. The data collection techniques employed were interviews, documentation, and observation. Interviews were conducted with villagers who make coconut sugar.

The researchers selected informants using the snowball sampling technique. They interviewed 24 informants, comprising 20 sugar makers and four key informants. Sugar-making informants (SM) are individuals residing in villages who utilize coconut sugar production to sustain their livelihoods. The SM informants were assigned the codes SM1 to SM20. They possess sound knowledge, but are more focused on gaining practical experience in coconut sugar production daily. The key informants (KI) were assigned the codes KI1 to KI4. Key informants are individuals identified as village elders who have been producing traditional coconut sugar for an extended period. They possess in-depth and detailed knowledge of the coconut sugar-making process, including the use of traditional ingredients, ancestral techniques, and innovations that have significantly impacted the production process. They are usually respected figures in the community and serve as key references.

Observation is conducted by observing the process of making coconut sugar from start to finish, until the sugar is formed. Additionally, documentation techniques, including video and audio recordings, were employed during the interview and observation processes. Finally, observations were made by recording and observing the coconut sugar-making process from start to finish.

Data Analysis

Interview data was collected in the form of a table-free list. The researchers analysed the data qualitatively to reduce the data from the informants and describe the observations. An analysis of the link between indigenous knowledge and Western science was conducted using scientific articles and books related to the chemical and biological processes of coconut sugar production. They subsequently transformed findings of this study into an educational video designed to disseminate knowledge about the value of biodiversity in coconut sugar production.

RESULTS

The village of Somongari has an area of 8.95 km^2 and a total population of 2,809 people (Pemdes Somongari, 2021). Most villagers have yards planted with fruit trees, including mangosteen, durian, *duku*, and coconut. In addition to harvesting coconuts, villagers utilize coconuts to make coconut sugar, a traditional practice passed down through generations. The researcher obtained indigenous knowledge regarding coconut sugar production through local Javanese terminology and its explanation. KI4 emphasizes that "all parts of the coconut tree have very high beneficial value if processed properly, including in supporting traditional coconut sugar production."

The coconut parts related to coconut sugar production are blarak, janur, ketepes, mancung, papah, and *wala*. The *wala*, or coconut flower, is crucial to the production of *sajeng*, or coconut sap. SM4 explained, "Wala is the part that is cut during the nderes process to remove the sajeng and will become a coconut if left unattended." KI3 added, "Wala needs to be opened through the 'dar' process and cut using a rajang to ensure the flow of sajeng remains smooth." If not properly maintained, the *wala* can become infested with caterpillars, which hampers the production of *sajeng*. SM9 mentioned that the, "wala section needs to be cleaned regularly so that there are no caterpillars."

Wala, when young, is covered by *mancung*. KI3 explained that "mancung serves to protect the coconut flower (wala) and is often used to make rope after being thinly sliced." This statement is supported by SM13, who stated, "mancung can be processed into a rope to tie bumbung or other equipment in the nderes process." Another part of the coconut used to support the collection of coconut sap is the *ketepes*. KI4 mentions that "Ketepes are used to cover the coconut flowers so that they are not exposed to rain or disturbance from animals." A summary of interviews with informants about the parts of the coconut related to the coconut sugar-making process, using local Javanese terms, is presented in Table 1.

The anatomy of the coconut tree has been extensively studied in Western scientific research on coconut morphology and structure. *Cocos nucifera* L., commonly known as the coconut tree, is a palm tree that belongs to the *Arecaceae* family (Bharath et al., 2019; Kuttankulangara Manoharan & Megalingam, 2019). Figure 2 illustrates the components of the coconut tree that are essential in producing coconut sugar.

Table 1. *Coconut Tree Parts Related to Coconut Sugar Making*

The term	Indigenous Knowledge	Western Science
Blarak	The mature coconut leaves start dark green and turn brown over time. Informants utilize the *blarak* as fuel, and the leaf bones become sticks.	Coconut trees possess alternate leaves that attach to the trunk and progress into a pinnate form (Broschat & Crane, 2020; Chan & Elevitch, 2006; Kuttankulangara Manoharan & Megalingam, 2019).
Janur	Young coconut leaves range in color from yellow to light green. The participant applies janur to cover the blengker, a coconut sugar molding tool.	Young leaves are entire rather than pinnate (Chan & Elevitch, 2006) and clustered in the crown's center (Kuttankulangara Manoharan & Megalingam, 2019).
Ketepes or angkup	Woven fibers are present at the base of the leaf midrib, with shades ranging from ash brown to black. The informant utilized ketepes as a covering for the bumbung, a container used to collect sap from coconut flowers.	The mat-like natural fibers from coconut leaves (Bharath et al., 2019), comprise fine and coarse fibers composed of amorphous hemicellulose (Obi Reddy et al., 2010).
Mancung	The cover of the coconut flower is hard and yellow-green when it is young. The informant used mancung as the rope to tie the coconut flowers together.	When the coconut flower is young, it is often called the spatha, which is its protector (Hebbar et al., 2015).
Papah or blongkeng	The widened base of coconut leaves is dark green to blackish-brown. According to the informants, papah served as firewood.	An extended petiole provides a strong attachment of the leaf to the stem and can be green or bronze in color (Broschat & Crane, 2020; Chan & Elevitch, 2006).
Wala or manggar	The mancung initially covers the coconut tree's flowers and requires opening and tapping to release the sap. Informants suggest that typically 1-2 *wala* are present. If left unattended, the *wala* develops into a coconut fruit.	The growth and maturation of coconut flowers (spadix) within the spatha, measuring approximately 60 cm long, have been documented (Hebbar et al., 2015, 2022). Each tree can produce one to three inflorescences (spadix), according to Somawiharja et al. (2018).

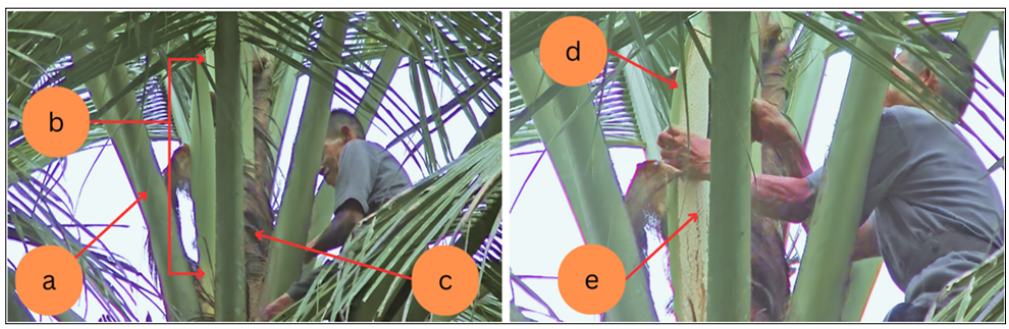

Figure 2. *Structure of the upper part of the coconut tree. (a) papah/blongkeng; (b) wala with unopened mancung; (c) ketepes; (d) mancung dan; (e) wala that has been opened from mancung. The images have been granted permission to be published by Informan.*

KI2 stated, "Without a healthy wala, sajeng production will be drastically reduced as the coconut flowers will not release sap." According to informants, the weather and temperature in the village significantly influence the quality and quantity of coconut flower sap, also known as *sajeng*. SM15 stated that "sajeng is obtained from the results of morning and evening nderes, the quality is very dependent on the tree's condition and the weather." This statement was reinforced by KI3, who added that "the age of the coconut tree affects the yield of sajeng, where older trees tend to produce more sap."

Coconut sap can change its taste and color, which informants refer to as *sayup*. *Sayup* is the abnormal, slimy, bad-smelling, and sour-tasting condition of coconut flower sap. SM4, SM8, and SM9 stated, "Sajeng that is left too long will go stale and cannot be processed into sugar." Meanwhile, SM3 highlighted the importance of keeping the coconut sap container clean, as dirty tools can accelerate *sajeng* from becoming stale. KI4 reinforces that "reheating and cleanliness of equipment is an effective solution to prevent canning, especially if left in damp or open conditions."

Henceforth, the use of preservatives is necessary. SM1 and SM15 stated, "Sajeng will spoil quickly if not mixed with laru, a mixture of mangosteen sap and enjet, which serves to maintain the quality of the coconut sap." This statement was reinforced by KI1, who emphasized the importance of using *laru* immediately after the *sajeng* is taken to prevent it from stretching or spoiling. Terms related to the ingredients used in the production of coconut sugar, as summarized from informant interviews, are presented in Table 2.

The *laru* (Figure 3.c) is a natural preservative to maintain the quality of coconut sap—limestone-white (Figure 3.a), which is commonly bought at the market, and mangosteen sap (Figure 3.b). During the mangosteen season, informants in the village collect the yellow sap of the mangosteen fruit. See Figure 3 for the *laru* utilized by the informants.

Table 2. *Coconut Sugar Making Ingredients*

Ingredients	Explanation
Enjet	Limestone is utilized as a combination of *laru* for preservation purposes. *Enjet* is a white solid that is melted with hot water and then added to mangosteen sap. Informants claim that enjet prevents the spoilage of coconut flower sap.
Laru	Limestone and mangosteen sap are mixed and dissolved in hot water in a container. The resulting substance, called *laru*, has a yellow-brown hue. A small amount of *laru* is added to the container, or bumbung, to keep the coconut flower sap from going stale. Some informants referred to *laru* as jantu. Jantu is another term for medicine.
Lathi Manggis	The color of the sap ranges from yellow-orange to blackish-brown. Informants collect the yellowish sap derived from mangosteen fruit, which hardens over time.
Sajeng	The sap from the coconut flower is either clear brown or golden white and has a sweet taste and a distinct aroma. The informant utilized *sajeng* as the primary component of coconut sugar.

Figure 3. *Laru is used as a preservative. (a) enjet, or limestone; (b) lathi manggis, or mangosteen sap; (c) laru (a solution of limestone and mangosteen sap)*

Most of the tools utilized in producing coconut sugar are crafted from natural materials sourced from the surrounding villages. The production of coconut sugar requires various tools, primarily crafted from natural materials such as bamboo, coconut shells, wood, and clay. *Bumbung*, as a container, is used to hold *sajeng* or coconut sap taken from coconut flowers. SM1 stated, "We prefer to use bamboo baskets because they are considered better at maintaining the quality of sajeng than plastic baskets." This statement was confirmed by KI2, who added that "pring petung type bamboo baskets are more durable and do not affect the quality of sajeng." In addition, SM7 emphasized that "coconut shells are often used as sugar molding tools because they are simple and easy to obtain." This statement was reinforced by KI4, who stated that "bathok, as a traditional mold, is still maintained because the mold is solid and neat." Refer to Table 3 for a list of tools explicitly used in producing coconut sugar in Somongari Village.

Most informants utilized tools handed down from previous generations. Tools like *bumbung, bathok, luweng, blengker, iket,* and *ancak* were commonly handmade, while others could be purchased from markets. Although the shapes of modified tools may differ, they serve the same purpose. The informants themselves modify some tools to suit their needs. Figure 4 illustrates the tools used in the production of coconut sugar.

Table 3. *Coconut Sugar-Making Tools*

Tools	Explanation
Ancak	Thinly cut and square-shaped bamboo places the *bathok* and *blengker* molds.
Bathok or bethok	Half of the coconut shell is used to mold thickened coconut flower sap into a cone or half ball.
Blengker	A bamboo circle is utilized to mold the condensed sap of coconut flowers, which can be fabricated from bamboo or other materials.
Bumbung	Petung bamboo, specifically *Dendrocalamus* sp., is cut cylindrically to collect coconut flower sap.
Iket	A rope made of mancung is typically used to tie coconut flowers or *wala.*
Irus	A cooking stirrer made from coconut shells and bamboo.
Kalo	A woven bamboo or other materials filter removes impurities from coconut flower sap before cooking.
Luweng	Clay can also form bricks designed for a wood-fuelled stove.
Rajang	Cutters for slicing coconut flowers made of metal and wood.
Wajan	A cooking utensil with circular basins is typically crafted from aluminium or metal.

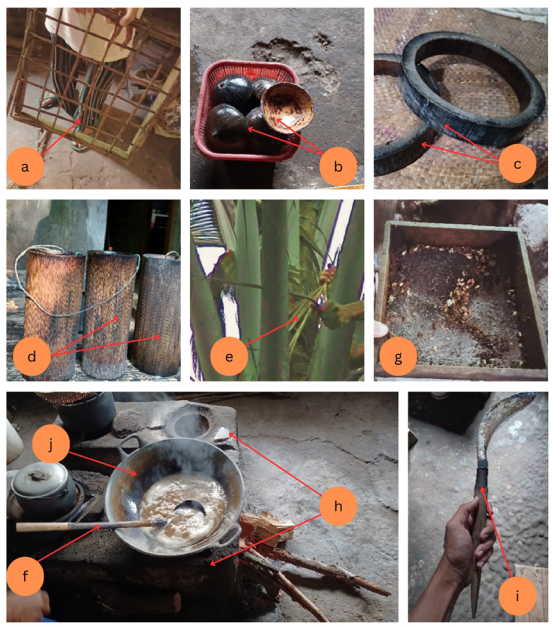

Figure 4. *Tools used to make coconut sugar. (a) ancak; (b) bathok or bethok; (c) blengker; (d) bumbung; (e) iket; (f) irus; (g) kalo; (h) luweng; (i) rajang; and (j) wajan*

The coconut sugar production process consists of three stages: *ndewan, genen, and nitis*. Generally, male informants are responsible for *ndewan* (slicing the coconut flowers and collecting the sap), while female informants are responsible for genen (cooking the sap). The process of *ndewan,* or *nderes*, is tapping coconut sap from unblossomed coconut flowers, done by a *penderes*. *Penderes* is a person who taps the sap from the coconut flowers. The coconut flower must be opened and then sliced with a *rajang* tool. The *wala* cannot be bent directly, so it has to be bent daily, or, in the local language, called *diluk*. After 5-7 days, the coconut sap can be collected in a bumbung or container. The bumbung is first given a little *laru* to prevent the sap from weakening.

SM4 explained, "Underes is done in the morning and evening by climbing the coconut tree and installing a bumbung at the end of the coconut flower." SM 17 and 18 refer to *nderes* as *ndewan*. This statement was clarified by KI3, who stated that "the underes technique needs to be done carefully so that the sajeng can flow smoothly and produce more nira." The interview results indicated that generally, penderes perform the task

in the morning from 5:00 to 7:00 a.m. and from 3:00 to 5:00 p.m. When the *penderes* take the *bumbung* that already contains coconut sap, they return another bumbung that has been given *laru* to replace the *bumbung* that contains the coconut sap. The coconut sap then enters the *genen* process.

Genen is heating the coconut sap to make it thicker by evaporation. *Genen* begins with the siling process. After the *sajeng* is collected, SM14 stated, "the sajeng is filtered using a kalo or sieve to remove impurities before cooking." This statement was confirmed by KI2, who emphasized that "sajeng screening is an important step to maintain the quality of the sugar from impurities." The extracted coconut sap is immediately poured into the wajan by first filtering it with kalo to separate the coconut sap from the dirt and animals (insects) in the coconut sap. The bumbung is then washed thoroughly with warm water to keep it free of microbes. However, some *penderes* use ordinary, clean water without warm water.

SM5 mentioned that, "the genen or sajeng heating process takes about 3 to 4 hours depending on the fire conditions," KI4 stated that "steady heating with firewood determines the final sugar yield." SM2 adds a statement that genen also depends on the amount of *sajeng*. The following process involves boiling the coconut sap to produce *mumbuk*, a thick, bubbly, dark brown liquid with a distinctive aroma. During boiling, SM8 stated, "the coconut sap is stirred with an irus." Under certain conditions, coconut sap begins to boil, resulting in an increase in the number of bubbles. Another procedure could be to add a few drops of cooking oil to avoid excessive foaming (Saraiva et al., 2023). When the sajeng starts to thicken, SM6 explains that, "this condition is called mumbuk, and at this stage, the sajeng must be stirred using an irus to avoid burning." KI4 emphasized that "good stirring at the mumbuk stage will produce sugar with the right consistency." SM9 and SM19 mentioned that, "grated coconut is added when the sajeng starts to thicken to help solidify the sugar," and KI4 stated that "the addition of grated coconut makes the sugar denser and keeps the sajeng from overflowing out of the pan." After it is thick, it enters the following process: *nitis*.

The *nitis* process forms the thickened coconut sap into ready-to-eat coconut sugar. Once thickened, the coconut sap is not reheated but transferred to the *kupluk* process. SM8 and SM11 stated, "Irus is used to stir the sajeng, which is starting to thicken and become solid during the kupluk process so that it can be molded later," and this was clarified by KI4, who emphasized that "the kupluk process with irus helps maintain the consistency of the sugar before it solidifies completely." The thickened coconut sap is molded using bathok and blengker molds as needed. After coarse hardening, the hardened coconut sugar can be released from the mold. SM3 states, "the process of molding the sajeng into the mold and allowing it to harden," and KI4 confirms that, "the nitis stage ensures the sugar has a good final shape and is ready for market." Local Javanese language terms for making coconut sugar are listed in Table 4 and Figure 5.

Figure 5. *The process of making coconut sugar. (a) menek; (b) dar; (c) pagas; (d) tadhah; (e) siling; (f) udhak or kebur; (g) bedhake; (h) ipahi; (i) kir; (j) kupluk; (k) keruk and cithak; and (l) tumplek. The images have been granted permission to be published by Informan.*

Table 4. *Coconut Sugar-Making Process*

Stages	Indigenous Knowledge	Western Science
Ndewan or nderes	Take coconut sap sliced by *rajang* and collected in a bumbung or container. This stage consists of *Menek, Dar, Pagas, and Tadhah*.	Coconut flower sap is released from the phloem vessels by cutting 1-2 mm of the spadix (Saraiva et al., 2023). The optimal tapping time to maintain the quality of coconut sap from morning to noon without the addition of natural preservatives is 6 hours (06:00–12:00), and with the addition of natural preservatives is 8 hours (06:00–14:00) (Mustaufik et al., 2022). The differences in tapping time and preservatives' use significantly impact coconut flower sap's chemical properties (Haryanti et al., 2016).
Menek	Climb a coconut tree by placing a foot on each level of the coconut trunk. A *tataran* is a foothold made by the informant on the coconut tree because the texture of the coconut tree trunk is slippery.	
Dar	Peel the *wala* from the *mancung* and tie the *wala* with an *iket*.	
Pagas	Slice the *wala* using a *rajang*.	
Tadhah	Collect the coconut juice from the sliced *wala* using a *bumbung* or container.	
Genen	Cook the liquid coconut sap to thicken it using a wood-fired stove. This stage consists of *Siling, Udhak or Kebur, Bedhake, and Ipahi*.	Coconut sap is evaporated to turn the liquid into a sticky brown sugar substance (Nurhadi et al., 2018; Saraiva et al., 2023; Thumrongchote, 2021). Additionally, this process is employed to reduce microorganisms (Nurhadi et al., 2018). Coconut sap usually contains impurities such as insects, ants, pollen, and flower remains (Somawiharja et al., 2018). Coconut sap contains 14–16% sucrose, which, after heating at 90–95°C, turns into long threads when stirred (Hebbar et al., 2022), and the color of coconut sap becomes milky white (Kowsalya et al., 2023). Bubble formation occurs when the surface temperature exceeds the liquid temperature at saturation pressure (Sattari & Mahdavian, 2019). Caramelization occurs after 35 to 40 minutes of heating for 1000 mL of coconut sap, resulting in a brown semi-solid sugar syrup (Kowsalya et al., 2023). The brown color of the sugar is attributed to the Maillard reaction, a non-enzymatic browning process (Karseno et al., 2018). Commonly added foaming agents include grated coconut, cooking oil, and coconut milk (Wrage et al., 2019; Zulfia et al., 2022).
Siling	Filter coconut sap from res-res (impurities) using *kalo*. Res-res is the debris from filtering the coconut flower sap, which includes fallen coconut flowers, dust particles, and organisms trapped in the container.	
Udhak or Kebur	Stir the liquid coconut sap during the cooking process using an *irus*.	
Bedhake	Make coconut sap into *mumbuk*. *Mumbuk* is formed when the coconut sap is boiled, slightly thickened, dark brown, and has a distinctive aroma, and *umpluk* is formed. *Umpluk* is the white foam that forms when the coconut sap is boiled. The time required depends on the size of the fire and the amount of coconut sap, usually 2 to 4 hours. The boiling process takes longer during the rainy season than during the dry season.	
Ipahi	Grate the coconut to keep the coconut sap in liber condition. Only one informant used oil to make *dodol jenang*. Liber is spilling coconut flower sap from the cooking place (wajan) due to the boiling process that forms bubbles.	
Nitis	Mold the thickened coconut sap into coconut sugar. This stage consists of *Kir, Kupluk, Keruk and Cithak, and Tumplek*	During heating, the moisture in the coconut sap evaporates, increasing the product's solid content (Kowsalya et al., 2023). Once a thick, moderately viscous hot syrup with a Brix content of 75°–80° is formed, heating is stopped (Asghar et al., 2021). The sticky brown sugar is then poured into a container for cooling while stirring continuously (Asghar et al., 2021; Thumrongchote, 2021). The color of coconut sugar still varies from light brown to dark brown (Zulfia et al., 2022).
Kir	Remove the pan of thickened, mashed, brown coconut sap from the stove to begin *kupluk*.	
Kupluk	Stir the slightly thickened sugar using an *irus* back and forth.	
Keruk and Cithak	Remove the thickened sugar from using coconut shell flakes and place it in the molds on *bathok or blengker*.	
Tumplek	Remove the hardened sugar from its container, such as *bathok or blengker*.	

DISCUSSION

Coconut sugar is produced from coconut flower sap, phloem sap that emerges from unopened clusters of coconut flowers (Asghar, Yusof, Mokhtar, Yaacob, Ghazali, Chang, et al., 2020; Haryanti, Supriyadi, et al., 2018). Coconut flower sap, or *sajeng*, is characterized by its sweet taste, unique aroma, and transparent appearance when freshly extracted (Adisetya & Krisdiarto, 2022). Sometimes, the sap may appear golden without unpleasant

odors (Hebbar et al., 2015). Additionally, it is rich in sugar, vitamins, and minerals (Haryanti & Sulistyo, 2022), as well as protein, amino acids, phenolics, and antioxidants (Hebbar et al., 2015, 2022; Kowsalya et al., 2023); phytochemicals (Asghar et al., 2021), and aromatic and phenolic compounds (Saraiva et al., 2023). Coconut flower sap contains high sucrose, glucose, and fructose, contributing to its sweet taste (Adisetya & Krisdiarto, 2022; Haryanti, Karseno, et al., 2018). Coconut flower sap can be used in traditional beverages, as research by Agaton (2022) has examined the use of coconut sap as a traditional beverage ingredient in Tuba culture.

The quality of coconut flower sap significantly impacts the quality of coconut sugar (Adisetya & Krisdiarto, 2022; Hebbar et al., 2022; Mustaufik et al., 2022). The quality of coconut flower sap is influenced by temperature, humidity, rainfall, solar radiation, and solar heat (Mustaufik et al., 2022). Fresh coconut flower sap will ferment when stored at room temperature for several hours (Hebbar et al., 2015). Enzymatic and microbial fermentation naturally occur in coconut sap at room temperature (Asghar, Yusof, Mokhtar, Yaacob, Varith, et al., 2020; Kowsalya et al., 2023). The nutritional content of coconut sap provides an optimal habitat for the growth of microorganisms (Adisetya & Krisdiarto, 2022; Haryanti & Sulistyo, 2022). Freshly harvested coconut flower sap typically has a pH exceeding 7 (Hebbar et al., 2015). If the pH level drops below 6.5, the occurrence of slimy clumps cannot be ruled out (Hebbar et al., 2022). The decay of coconut sap is associated with a reduction in pH due to the conversion of sugar into organic acids by microbes, specifically *Saccharomyces* sp. yeast and *Acetobacter* sp. bacteria (Novarianto et al., 2021).

Laru, which consists of limestone and mangosteen sap, is used as a natural preservative to maintain the quality of coconut sap. Limestone can increase the pH value of coconut sap, but other preservatives must be added for optimal effectiveness (Haryanti, Supriyadi, et al., 2018). The sap is produced by the mangosteen fruit when it undergoes physical forces such as impact, friction, and puncture (Adisetya & Krisdiarto, 2022). Rich in terpenoids, flavonoids, and tannins (Dorly et al., 2008), the mangosteen yellow sap contains xanthones, a class of flavonoids with antimicrobial, anti-inflammatory, antibacterial, and anticancer properties (Gutierrez-Orozco & Failla, 2013; Haryanti et al., 2016). These properties may be helpful as preservatives (Adisetya & Krisdiarto, 2022).

The sap is filtered through a filter cloth and poured into a large pot (Thumrongchote, 2021). Next, the *sajeng* is cooked or heated. Improper heating procedures for coconut sap can lead to failure in sugar production (Haryanti & Sulistyo, 2022). The coconut sap is boiled at 90–100°C for approximately 3–4 hours until it reaches a concentration of dissolved solids (Somawiharja et al., 2018). Coconut sap obtained during heavy rainfall contains more water, which reduces the total soluble solids (Haryanti, Supriyadi, et al., 2018). The bubbles contain a mixture of gases produced by the electrochemical decomposition of water, accompanied by a rapid change in voltage polarity (Svetovoy et al., 2016). Coconut juice thickens during heating, and browning generally occurs (Haryanti & Sulistyo, 2022). This process is strongly influenced by pH and temperature (Karseno et al., 2018).

Indigenous knowledge of coconut sugar and its production is a testament to the value of biodiversity. The apparent biodiversity value is consumption or nutritional value and production or economic value. Consumption value is derived from the use of sugar for food purposes, including food mixes, beverages, and direct consumption of sugar. The production value is shown because coconut trees can be harvested for their sap to make coconut sugar. This coconut sugar can be sold, providing economic value to the sugar-producing community. Understanding the direct value of biodiversity is essential, especially for students. Understanding the value of biodiversity can help them realize the importance of protecting natural resources through sustainable agroecosystems (Costa et al., 2022; Gatti et al., 2022).

A genuine effort to teach the value of biodiversity, informed by the insight of indigenous knowledge of sugar production, is exemplified in the production of educational videos. Educational videos are used as a tool to convey messages to students. The educational video consists of three storylines: the introduction, the content about the structure of the coconut tree, tools, materials, and the process of making traditional coconut sugar, and the conclusion. The video is in Indonesian and runs for 14 minutes and 41 seconds. Adding

a subtitle can facilitate better understanding, even when the Indonesian video is being played. However, an English translation is included at the end of the video. Text in the video is included to clarify information for deaf students. The educational video was uploaded to YouTube through the link https://youtu.be/eo0_SpkiHxs. Furthermore, students may be encouraged to research coconut sugar production as part of an institutional commitment to promoting a culture of research. This phenomenon aligns with Sanchez's (2022) assertion that schools should cultivate a culture of scientific inquiry within their respective academic settings.

From the author's perspective, such differences are reasonable, as Indonesia's diverse languages and geographical conditions can influence how coconut sugar is produced, including the terms used and the equipment employed. As noted by Huisman et al. (2021), linguistic diversity across regions is naturally shaped by geographical distance, population characteristics, and sociocultural factors. Therefore, future ethnobiological research is encouraged to expand the regional scope to enable comparisons of indigenous knowledge across different areas. Additionally, the factors contributing to the success or failure of coconut sugar products remain largely unexplored and warrant further investigation. Regarding modern technological innovations, the study suggests adopting the traditional method of producing coconut sugar, as some younger people in Somongari village are no longer willing to do so. Shephard et al. (2023) found a noticeable decline in traditional skills among younger participants, indicating reduced opportunities and willingness to learn these practices.

The risk of falling when harvesting coconut sugar, such as when climbing coconut trees, is a factor that discourages some people from continuing the tradition of producing coconut sugar. SM4 stated, "Climbing tall, rain-slick coconut trees daily is extremely dangerous." This statement was reinforced by KI3, who explained that "Penderes must have special skills to balance their bodies at heights while cutting coconut flowers, as the risk of falling is always lurking." In addition, SM5 noted that adverse weather conditions, such as strong winds or heavy rain, can make this work even more hazardous, yet they still do it due to economic necessity.

The main reasons why sugar makers continue to do this work are due to hereditary tradition and economic dependence. SM10 mentioned that "the proceeds from selling coconut sugar are used to fulfill daily needs, so this job is the main source of income for the family." This statement was affirmed by KI1, who stated that "Despite the risks, coconut sugar making is a legacy from the ancestors that must be maintained because it has become part of the community's identity and livelihood." In addition, SM15 emphasized that limited skills and other job opportunities in the area led them to persist in this work, despite being aware of the risks. KI4 added that apart from economic factors, there is a sense of pride for penderes and coconut sugar makers in keeping this tradition as part of their lives.

The findings of this study reveal a strong connection between indigenous knowledge and biodiversity, as exemplified by the traditional Somongari community, which produces coconut sugar. This knowledge has been passed down orally through generations and holds significant educational value, particularly in helping schools incorporate local culture into environmental learning. When students learn through familiar, real-life practices, it can strengthen their understanding of nature, biodiversity, and cultural identity. Documenting and appreciating this traditional knowledge also supports community-based conservation, where local people play a key role in caring for their environment. In rural development, preserving this tradition helps support local incomes and provides ideas for development programs that respect local culture while building economic strength.

Integrating indigenous knowledge with Western science has the potential to be applied in other cultural traditions, as Indonesia is rich in culture and tradition. The cultural heritage of Indonesia offers a wealth of opportunities for the advancement of scientific knowledge (Zubaidah & Arsih, 2021), such as Randai art (Arsih et al., 2019), medicinal plants (Azis et al., 2020; Lestari et al., 2020; Silalahi & Nisyawati, 2018), utilization of plants and animals for ritual ceremonies (Adinugraha et al., 2024), and animals for medicine (Supiandi et al., 2023). Indigenous knowledge can be incorporated into educational institutions by implementing local wisdom and

cultural approaches (Adinugraha, 2022). The acquisition of traditional sugar-making knowledge is anticipated to facilitate the integration of Western or modern scientific knowledge and cultural preservation.

CONCLUSION

Coconut sugar is derived from the sap of coconut flowers (*sajeng*), which is evaporated until it becomes thick and brown, using ingredients such as coconut sap, *laru* (a mixture of limestone and mangosteen sap), and grated coconut. Its production involves traditional tools and three main stages—nderes (collecting sap), genen (cooking), and nitis (shaping)—and represents a direct biodiversity value through consumption and economic benefits. In Somongari Village, traditional coconut sugar making is a cultural heritage that embodies indigenous knowledge, hereditary practices, and a harmonious human–nature relationship, while also supporting the local economy and reinforcing community identity. As a living cultural expression, it reflects how indigenous knowledge continues to shape local livelihoods and cultural resilience. From an ethnobiological viewpoint, this practice illustrates the interconnectedness between people, biodiversity, and cultural traditions. Integrating these values into educational videos can help strengthen students' awareness and contribute to efforts to prevent biodiversity loss.

Author Contributions

F. Adinugraha: Conceptualization, Methodology, Software, Data curation, Visualization, Investigation, Writing-Original draft; **S. Zubaidah:** Data curation, Writing-Original draft preparation, Investigation; **S.R. Lestari:** Supervision, Validation, Writing-Reviewing and Editing.

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Ethical Approval

Not applicable.

Competing interest

The authors declare no conflicts of interest.

Data Availability

Data will be made available by the corresponding author on request.

Declaration of Artificial Intelligence Use

In this work, the authors did not utilize artificial intelligence (AI) tools and methodologies in writing the manuscript.

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