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DISTRIBUTION OF GENUS *Cookeina* AND ETHNOMYCOLOGY IN INDONESIA

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ABSTRACT

Wild edible mushrooms are germplasm which widely consumed by various local communities around the world. One of the wild mushroom genera that grows wild and used as food is *Cookeina*. This mushroom has the shape of bowl, glass, or cup which grows saprophyticly on the stems or seeds of forestry plants. However, the information of *Cookeina* potency as an alternative food is scarce in Indonesia. This is due to the lack of reports on the use of this macrofungi for consumption in Indonesia. In addition, most of the reports are not provided with the descriptions of the mushrooms. As the result, it as a serious constrain to non mycologyst person or mushroom hobyyist to study *Cookeina*. This manuscript aimed to provide the information on the distribution of this mushroom in Indonesia, the description of the morphological characters, and examples of the use of *Cookeina* as food by local communities (ethnomicology). This macrofungi have been reported 16 times in Indonesia, spread over 10 different provinces. The species which have been reported are *C. colensoi*, *C. speciosa*, *C. sulcipes*, and *C. tricholoma* in Indonesia. However, only *C. speciosa*, *C. sulcipes*, and *C. tricholoma* which used ad food and medicine by indigenous peoples in Indonesia. Several studies in various countries have proven that *Cookeina* contains bioactive ingredients in the form of β-glucan which are good for health. It is hoped that the level of awareness of the Indonesian people will increase regarding the potential use of edible wild mushrooms in order to achieve the food sovereignty.

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INTRODUCTION

Fungi, being the second largest group of organisms, is estimated to have a million species. However, only a few of these species have been thoroughly studied so far. The vast diversity of fungi, coupled with varying climatic conditions and their widespread distribution, has led to their recognition as a prime source of natural compounds. These compounds have the potential to significantly influence human health, the economy, and the environment. One type of fungi, called mushroom, is a potential natural resource for human life. Mushrooms are a group of macroscopic fungi that are distributed across various ecosystems with diverse lifestyles (Kirk et al. 2008). The number of fungal species continues to increase, with an estimated total of approximately 1.5 million species worldwide (Blackwell, 2011). To date, around 2,000 species of mushrooms are known to be edible and possess beneficial health activities (Lima et al. 2012). These edible mushrooms are generally wild species that can be found in a range of environments, from dense forests (Putra et al. 2017; 2019), tourist parks (Putra et al. 2018), campus forests (Putra et al. 2020), to residential areas (Putra, 2021). Wild edible mushrooms have long been collected and utilized by local communities during foraging (Boa, 2004), including Indonesia (Putra and Hafazallah, 2020; Putra 2020). In recent years, Indonesia has seen a noticeable rise in the consumption of wild edible mushroom (Putra and Hafazallah, 2020). However, the comprehensive documentation of wild mushroom consumption is currently limited in Indonesia, especially the taxonomical information which often lack of evidence.

One group of wild edible mushrooms consumed in various countries is *Cookeina* spp. (Boa, 2004). These mushrooms are usually eaten by many locals in Western Africa, Mexico, Guyana, and Brazil (Moreno et al. 2016). This Genus belongs to the phylum Ascomycota and is macroscopic in size. The genus *Cookeina* Kuntze belongs to the operculate discomycetes within the Pezizomycetes, with *Cookeina tricholoma* (Mont.) Kuntze as its type species. Currently, Index Fungorum noted 28 taxa and 24 species of this genus worldwide including: *C. afzelii, C. amonea, C. colensoi, C. colombiana, C. cremeirosea, C. discifera, C. garethjonesii, C. globosa, C. hindsii, C. indica, C. insititia, C. javanica, C. korfii, C. mundkurii, C. notarisiana, C. sinensis, C. speciosa, C. sulcipes, C. sumatrana, C. tetraspora, C. tricholoma, C.venezuelae,* and *C. viridirubescens*. *Cookeina* has a unique shape resembling a cup, goblet, or chalice, characterized by a distinct stalk at the base of its apothecium. The genus exhibits a variety of bright colors, exhibits very bright colors, ranging from yellow, orange, red, to pink (Ekanaya et al. 2016). In addition, some species display distinctive ornamentation on the surface of their apothecia. The edges of the ascocarps are typically adorned with fine or very thick long hair. in Guyana, some species of *Cookeina* is eaten by Patamona people and have been described to have a mild taste and a pleasantly crunchy texture (Moreno et al. 2016). In addition, Moreno et al. (2016) reported that the species *C. tricholoma* contains β-glucan, which has potential use as an antinociceptive agent in the medical field. In addition, there are also records of their use in treating ear infections in Cameroon (Zeng et al. 2023).

Traditional knowledge systems and practices of fungal utilization, passed down through generations via oral traditions, face significant risks of disappearing or deteriorating if not actively utilized, transmitted, or properly recorded (Putra, 2020). Factors such as urbanization, the advent and integration of modern technology, habitat loss due to extensive deforestation, and changes in language and culture threaten both biological and cultural diversity (Hussain et al. 2023). Preserving ethnomycological knowledge is crucial for potential pharmaceutical applications and validation through modern research methods. The emphasis in this field has shifted from purely descriptive studies to a more recent quantitative ethnobiological approach. Putra and Hafazallah (2020) reported that 35 species of wild mushrooms are utilized as food by various indigenous communities in Indonesia, including the *Cookeina*. Additionally, Putra (2020) mentioned in his report that wild edible mushrooms are an important seasonal commodity for local communities and a key driver of the economy on Belitong Island, Bangka-Belitung Islands Province. However, to date, various types of wild edible mushrooms, including *Cookeina*, are not widely popular among the general Indonesian population. This is due to the lack of detailed information on *Cookeina* mushrooms and their distribution in Indonesia. Therefore, this review aims to provide information on the distribution of *Cookeina* in Indonesia, morphological descriptions of the mushrooms, and examples of their use as food by local communities (ethnomycology).

MATERIALS AND METHOD

The exploration of *Cookeina* was conducted in Tamiang Layang Forest, Central Kalimantan, Indonesia. Observations were made using the opportunistic sampling method as described by O'Dell et al. (2004), involving local mushroom enthusiasts (Dayak Maanyan tribe). The tools used in this study were food dryer, sample bottles, sample plastic, tray, compound binocular microscope (Leica DM500), slide glass, cover glass, tweezers, tissue, razor, ruler, mobile phone camera. The materials used in this study were 70% alcohol, distilled water, and

immersion oil. The fruiting bodies of the mushrooms found were thoroughly photographed. Mushroom descriptions were created based on the explanations by Putra et al. (2018) with modifications. The recorded macroscopic identification characteristics included: growth habit, fruiting body shape, hygrophanous (changes in moisture level), cap color when young and mature, cap diameter, upper and lower cap shape, cap surface, cap edge, cap margin, moisture level, hymenophore type (lamellae, pores, teeth) including attachment to the stipe, spacing between rows, and margin. Other observed characteristics were stipe shape, stipe color (when young and mature), stipe surface, attachment position to the cap, stipe attachment type to the substrate, stipe cross-section, presence of rhizomorphs, partial veil, universal veil, fruiting body texture, smell, taste, and information on its use as food (consumed or not) through discussions with local communities to obtain information on the utilization of the found mushrooms. The mushrooms were then validated based on the descriptions obtained. Mushrooms were identified to the genus and species level (if possible) using macroscopic characteristics with several identification keys, including Largent (1973), Arora (1986), and Rokuya et al. (2011). The latest taxonomic position and identity of the found mushrooms followed the provisions of Mycobank and Index Fungorum. Additional information on the potential and distribution of mushrooms was obtained through literature studies from various related references.

RESULTS AND DISCUSSION

Description of *Cookeina*

The fruiting bodies of *Cookeina* were found growing in clusters with closely spaced fruiting bodies (gregarious) or with limited fruiting bodies on various substrates, such as *kobari* plant fruits (Figure 1A) and dead tree trunks (Figures 1B and 1C). These mushrooms have cup-shaped apothecia/ascocarps with diameters ranging from 0.5 to 3 cm. The apothecia are bright red with prominent hairs/trichomes on the margins of the fruiting bodies, which are particularly noticeable in *C. tricholoma* (Figures 1A and 1B), making it easily distinguishable from other species. *Cookeina speciosa* has ascocarps that are orange to yellow with a slight brownish tint (Figure 1C). Meanwhile, *C. sulcipes* has pink apothecia (Figure 1D). The ascocarps of these three species generally undergo color changes (hygrophanous) after being removed from the substrate, so proper characterization and documentation are necessary. The stipe of the *Cookeina* are cylindrical with uniform size down to the base. The stipe are typically white, smooth-surfaced, and range from 0.5 to 1 cm in length. The stipe attachment is central to the apothecium, with the stipe directly embedded in the substrate (basal tomentum), and the interior of the stipe is hollow. The fruiting bodies of *Cookeina* have a rubbery texture, a smell reminiscent of decayed wood, and a moist level of wetness.

The genus *Cookeina* is a cosmopolitan group found in subtropical to tropical regions, living as saprophytes (Ekanayaka et al. 2016). According to Index Fungorum, Cookeina is taxonomically classified under Sarcoscyphaceae, Pezizales, Pezizomycetidae, Pezizomycetes, Pezizomycotina, Ascomycota, Fungi. To date, only 27 species, subspecies, and varieties of *Cookeina* have been recorded worldwide (http://www.indexfungorum.org/Names/Names.asp , accessed in January 2025). Most species of *Cookeina* have appendages (hairs) of varying lengths on the edges of their apothecia. Only *C. cremeirosea* and *C. indica* are known to lack these additional structures (Maggio et al. 2021). However, accurate identification of the genus *Cookeina* to the species level should be conducted through observations of both macroscopic and microscopic characteristics, supplemented with molecular data if necessary. This is because some species within this genus exhibit differences in surface features, shape, ornamentation, and the presence of oil droplets on their ascospores (Ekanayaka et al. 2016; Maggio et al. 2021).

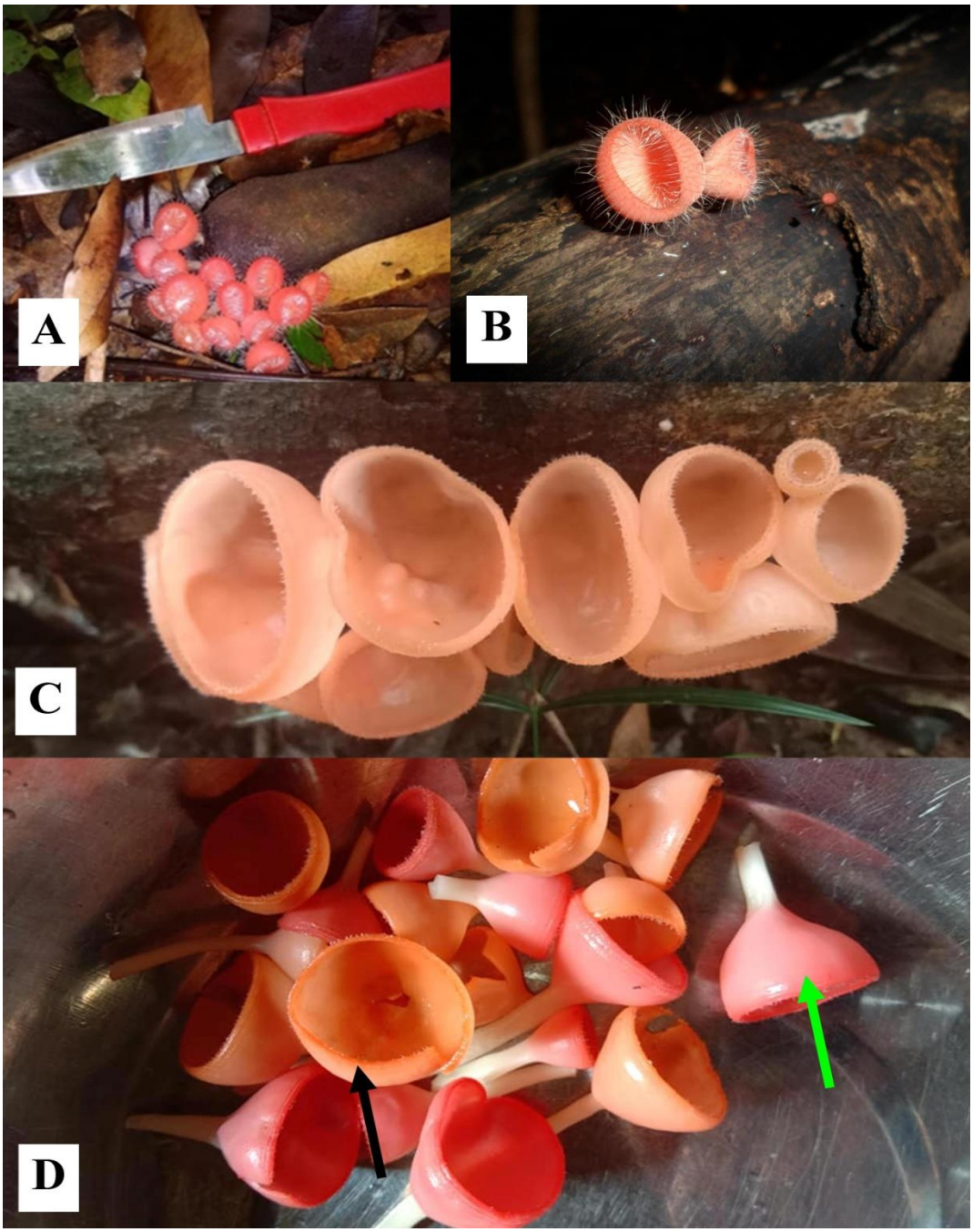

Figure 1. Macroscopic identification characteristics of *Cookeina*. A: C. tricholoma on kobari plant fruit. B: *C. tricholoma* on a dead tree trunk. C: *C. speciosa* growing on a dead tree. D: *C. sulcipes* (green arrow) mixed with young *C. speciosa* (black arrow).

The Distribution of *Cookeina* in Indonesia

To date, only 16 reports (including this paper) on the genus *Cookeina* have been documented from 10 provinces in Indonesia. These reports are exclusively from the islands of Sumatra, Java, and Kalimantan (Table 1; Figure 2), with no scientific publications on this mushroom from Central and Eastern Indonesia. Sumatra Island and Bengkulu Province have the highest number of records regarding the distribution of this genus in Indonesia (Table 1; Figure 2). This data reinforces the biodiversity records of Indonesia released by the Indonesian Institute of Sciences (LIPI, 2019), which indicate that most fungal publications (both macroscopic and microscopic) are still dominated by the western regions of Indonesia, particularly Java Island. According to the existing reports on *Cookeina* in Indonesia, the ascocarps of this genus are generally found on various types of dead wood, both on trunks and branches, and occasionally on forest fruits with a somewhat hard texture.

However, most of the existing reports lack complete descriptions of the mushrooms, with minimal information or without documentation of morphological characteristics. This makes the validation of *Cookeina* species or other mushroom species in Indonesia a complex task. For example, the report on *C. tricholoma* by Priskila et al. (2018) needs further review as the information presented does not align with the existing taxonomic identity.

Table 1. Distribution and Utilization Information of the Genus *Cookeina* in Indonesia

No	Species	Location	Reference	Description	Utilization
1	*C. speciosa*	Kalimantan Tengah	This study	Present	Food
2	*C. sulcipes*	Kalimantan Tengah	This study	Present	Food
3	*C. tricholoma*	Jawa Barat	This study	Present	-
4	*Cookeina* sp.1	Sulawesi Tengah	Yusran et al. 2021	Absent	-
5	*Cookeina* sp.2	Sulawesi Tengah	Yusran et al. 2021	Absent	-
6	*C. sulcipes*	Sulawesi Tengah	Yusran et al. 2021	Absent	-
7	*C. tricholoma*	Sulawesi Tengah	Yusran et al. 2021	Absent	-
8	*C. sulcipes*	Aceh	Nurchalidah et al. 2021	Present	-
9	*C. colensoi*	Bengkulu	Darwis et al. 2020	Absent	-
10	*C. speciosa*	Bengkulu	Darwis et al. 2020	Absent	-
11	*C. sulcipes*	Bengkulu	Darwis et al. 2020	Present	-
12	*C. tricholoma*	Bengkulu	Darwis et al. 2020	Absent	-
13	*C. sulcipes*	Banten	Noverita & Ilmi 2020	Absent	Food and Medicine
14	*C. tricholoma*	Banten	Noverita & Ilmi 2020	Absent	Obat
15	*C. tricholoma*	Aceh	Kusuma et al. 2020	Present	Obat
16	*Cookeina* sp.1	Kalimantan Barat	Kristin et al. 2020	Present	-
17	*Cookeina* sp.2	Kalimantan Barat	Kristin et al. 2020	Present	-
18	*C. tricholoma*	Jawa Barat	Putra & Khafazallah 2020	Present	-
19	*C. speciosa*	Kalimantan Tengah	Putra & Khafazallah 2020	Present	Food
20	*C. speciosa*	Jawa Barat	Putra & Khafazallah 2020	Present	Food
21	*C. tricholoma*	Jawa Barat	Putra et al. 2020	Present	-
22	*C. speciosa*	Sumatra Utara	Siahaan et al. 2019	Absent	-
23	*C. sulcipes*	Sumatra Selatan	Fitriani & Krisnawati 2019	Absent	Food
24	*C. tricholoma*	Sumatra Selatan	Fitriani & Krisnawati 2019	Absent	Food
25	*C. sulcipes*	Riau	Noverita et al. 2019	Absent	Food and Medicine
26	*C. tricholoma*	Riau	Noverita et al. 2019	Absent	Food and Medicine
27	*C. tricholoma*	Kalimantan Barat	Tanti et al. 2018	Present	-
28	*C. tricholoma*	Kalimantan Barat	Priskila et al. 2018	Present	Food
29	*Cookeina* sp.	Kalimantan Barat	Sumarni et al. 2017	Present	Medicine
30	*C. cremeirosea*	Bengkulu	Susan & Retnowati 2016	Present	-
31	*C. speciosa*	Bengkulu	Susan & Retnowati 2016	Present	-
32	*C. tricholoma*	Bengkulu	Susan & Retnowati 2016	Present	-

Figure 2. Infographic of Cookeina Distribution in Indonesia (numbers correspond to information in Table 1).

Ethnomycology of *Cookeina* in Central Kalimantan (Indonesia)

Until recently, only C. *speciosa, C. sulcipes,* and *C. tricholoma* have been utilized as food or medicine in Indonesia (Table 1). The author's observations indicate that *C. speciosa* and *C. sulcipe*s are frequently collected during foraging by the indigenous Dayak Maanyan community in Tamiang Layang, Central Kalimantan. The local community typically forages for *Cookeina* alongside other commonly consumed mushrooms, such as *Auricularia* spp. (wood ear mushrooms), *Laetiporus sulphureus*, *Tremella* spp., *Trichaleurina* cf. *javanica*, and *Oudemansiella* spp. (fat mushrooms). The bright colors of *Cookeina* fruiting bodies make them easy to spot on various substrates, especially on dead wood. This demonstrates that not all brightly colored mushrooms are toxic, contrary to common belief among Indonesians. Additionally, *Cookeina* ascocarps generally grow in large clusters, making them a favorite wild edible mushroom sought after by the local community.

The apothecia are typically collected directly without the use of special tools (Figure 3A) and gathered in baskets made of woven rattan or bamboo (Figure 3B). These containers have gaps that allow for air circulation, helping to keep the mushroom fruiting bodies fresh for a longer period and preventing excessive respiration. *Cookeina speciosa* and *C. sulcipes* (Figure 3C) are two species often collected together with the plant 'pohpohan' (*Pilea melastomoides*) by the local community. The collected apothecia are washed with water and then cooked by the local people with the main seasonings of shallots and garlic. The stipes are usually not cut and are cooked whole. Commonly prepared dishes include stir-fries (Figures 4A, 4B, 4D) or *Cookeina* cooked in coconut milk (Figure 4C). The two types of *Cookeina* are cooked together and mixed with chives (Figure 4A), coconut shoots (Figure 4B), or tomatoes (Figure 4D). The texture of *Cookeina* fruiting bodies remains chewy but not tough when cooked. Besides the report by Putra and Hafazallah (2020), this documentation is the only comprehensive ethnomycological information on *Cookeina* in Indonesia. It is hoped that this can serve as a medium for disseminating ethnomycological knowledge of *Cookeina* in Indonesia.

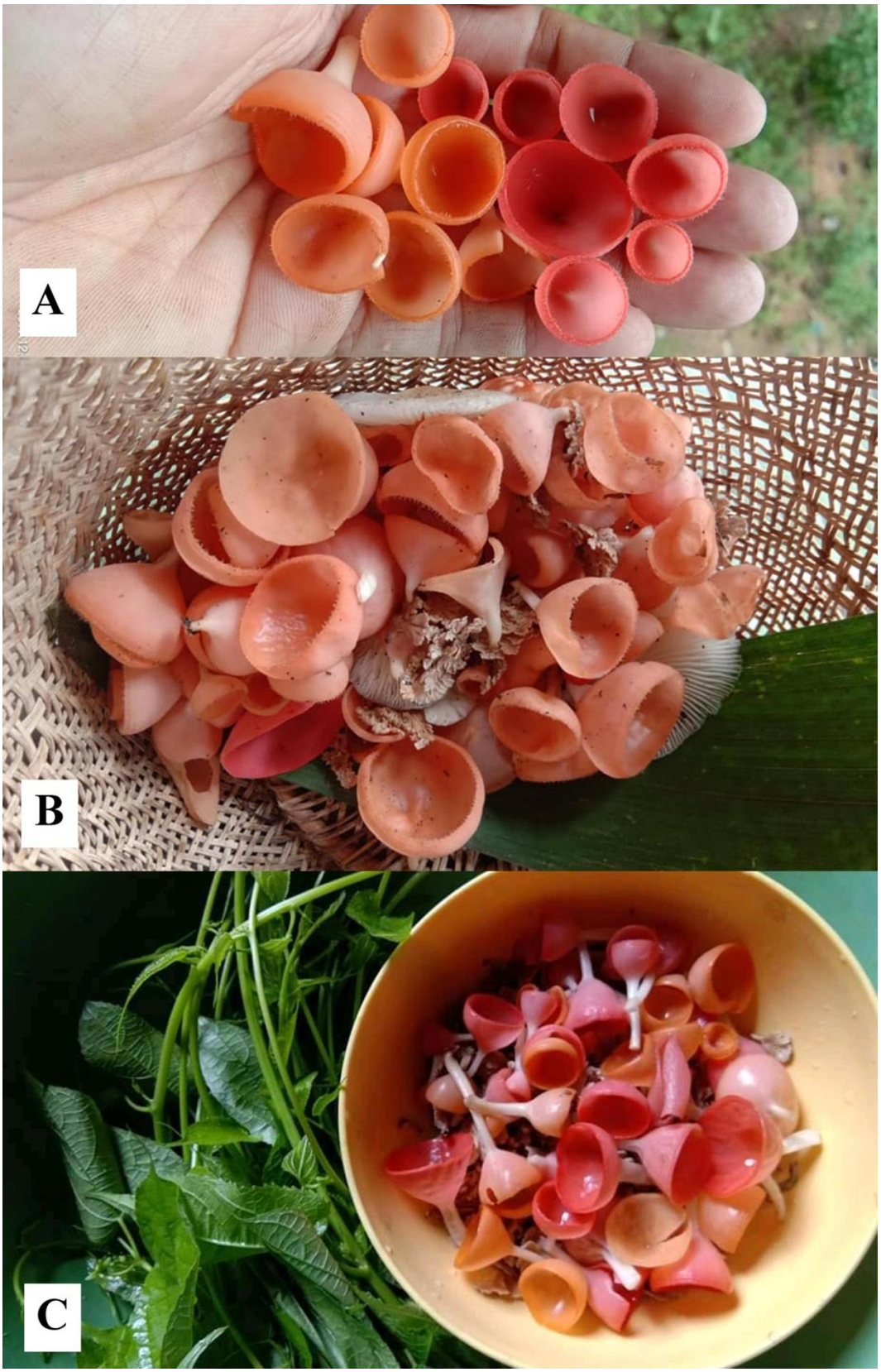

Figure 3. A: Ascomata of C. speciosa and C. sulcipes collected directly by hand. B: Fruit bodies collected together with other fungi and placed in a woven basket container. C: Fruit bodies collected are washed thoroughly along with the 'pohpohan' plant.

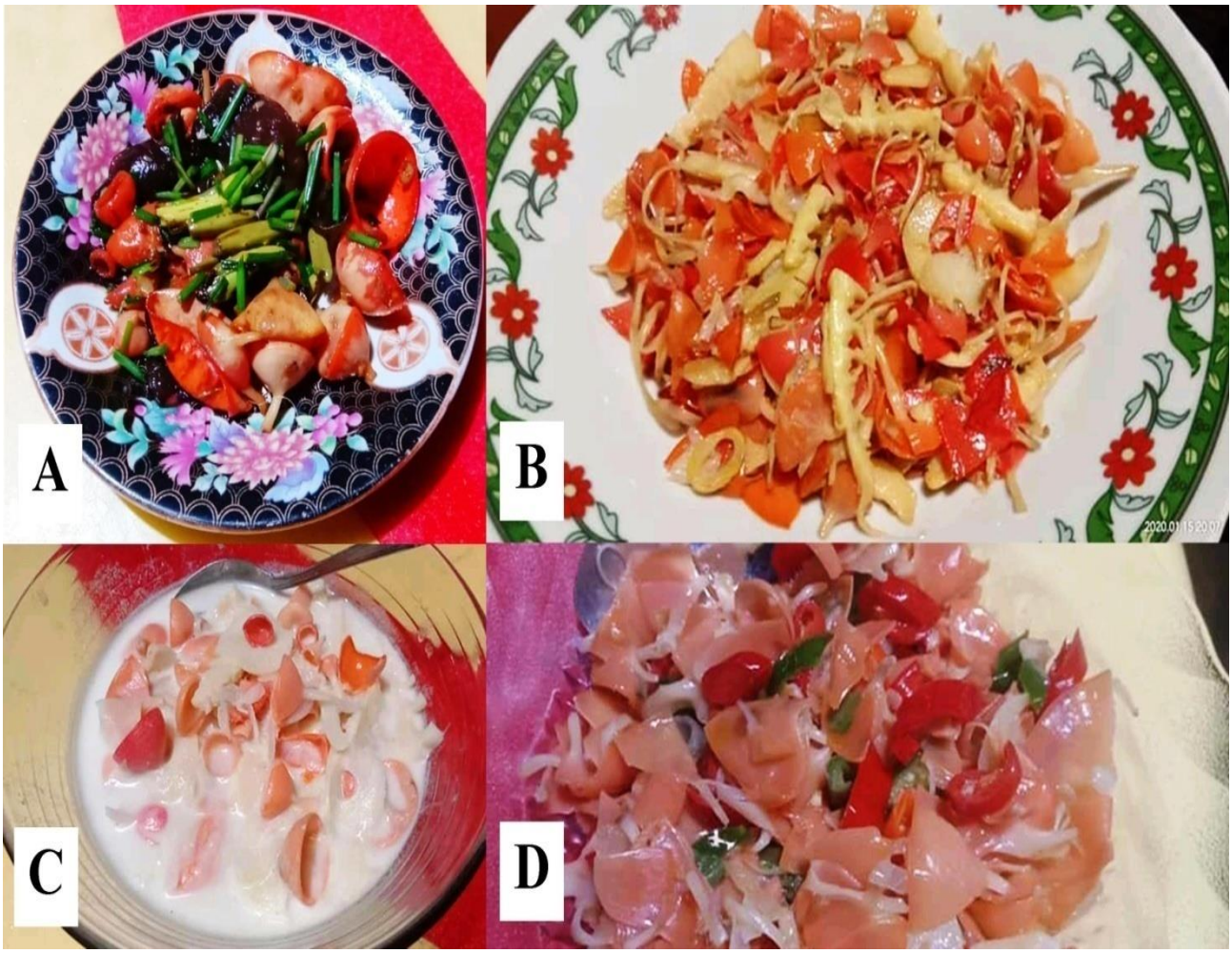

Figure 4. Culinary preparations of edible wild *Cookeina* by the Dayak Maanyan indigenous community. A: Stir-fried dish with chives. B: Stir-fried dish with grated coconut. C: Soup dish with coconut milk. D: Stir-fried dish with tomatoes.

Potency and Cultivation of *Cookeina*

Although some local communities (Table 1) have consumed *Cookeina*, there have been no reports on the nutritional content and medical potential of the genus *Cookeina* in Indonesia. Sanchez et al. (1995) reported that *C. sulcipes* is high in protein and phosphorus and low in fat. Additionally, they mentioned that this mushroom contains all essential amino acids, making it a potentially excellent functional food source for human health. Based on local knowledge that needs scientific validation, some indigenous communities in Indonesia also use *Cookeina* as traditional medicine. Sumarni et al. (2017) reported that the villagers of Ensaid Panjang, Siantang Regency, West Kalimantan, use *Cookeina* sp. as a remedy for toddlers who frequently urinate at night. The water collected in the mushroom's apothecia is given to the toddlers. Other researchers in various countries have analyzed the potential of *Cookeina* as a source of bioactive compounds in the medical field. Moreno et al. (2016) reported that *C. tricholoma* is a source of β-glucan, which has potential as an antinociceptive agent. Canthu-Jungles et al. (2018) successfully manipulated the activity of *Clostridium* in the human digestive tract using two types of β-glucans derived from the fermentation of *C. speciosa*. Despite its many benefits and potential as both food and medicine, there have been no reports on the cultivation of *Cookeina* in Indonesia or other countries. Local communities in Indonesia generally still collect these mushrooms from the wild, indicating a significant opportunity for the domestication of this mushroom.

CONCLUSION

Cookeina spp. is one of the wild edible mushrooms utilized by some local communities in Indonesia. This mushroom has been reported 16 times in Indonesia and is distributed across 10 different provinces. The reported species include *C. cremeirosea, C. speciosa, C. sulcipes,* and *C. tricholoma*. However, only *C. speciosa,*

C. sulcipes, and *C. tricholoma* are commonly used as food and medicine by indigenous communities in Indonesia. To date, there have been no nutritional analyses or cultivation efforts for this mushroom in Indonesia, presenting a significant opportunity for its domestication in the country.

AUTHORS' CONTRIBUTION

IPP designed and conducted the research, analyzed the taxonomical the data, and wrote the manuscript. HGRTM conducted the research, analyzed the ethnomycological data, and wrote the manuscript. All authors revise and approve the final manuscript.

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